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Traditional Agroforestry Practice, Management and Determinants in Central Zone of Tigray, Ethiopia

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Traditionally, farmers have been practicing incorporation of different types of trees and shrubs with crops as well as animals in their farmland which is denoted as agroforestry. Such indigenous knowledge and practice have been the basis for scientific improvement and adoption of better land management option worldwide. This study was done with an objective of characterizing agroforestry management and determinants of traditional agroforestry expansion in Tigray. A purposive sampling was used to select peasant association based on their potential availability of agroforestry practices. A total of 152 household were selected and semi-structured questionnaires were used to collect data pertaining to traditional agroforestry systems in the region. The collected data were analyzed using SPSS version 20. Logistic regression model was applied to analyse the determinants for the farmers on expansion of agroforestry practice. The local farmers had highly preferred the indigenous trees while most of the farmers used wildlings only. The study found that homestead farm size and total number of livestock have impacted a positive and significant influence (5% level) to maintain and manage multipurpose tree species. Education is another factor that has positively impacted on homestead agroforestry (10% significance level) while in scattered

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agroforestry practice land size, marital status, and awareness had also impacted positively (5% significance) and, theft and distance of the crop land from the home station had affected negatively (significant at 5% level). This study concludes farmers are managing multipurpose trees based on the values of trees for crop production, animal fodder, wood product and integration of the traditional and modern agroforestry practices is needed.

Keywords: Agroforestry; determinant; homestead; multipurpose tree species.

1. INTRODUCTION

Agroforestry can be defined as: the integration of trees in farming systems and their management in rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability [1]. Agroforestry is an age-old tradition in Ethopia, where more than two-third of the country area is covered with dry land. The dominantly being practiced indigenous agroforestry systems are agrosilvopastural and silvopastural [2,3]. Some of the different agroforestry practices in Ethiopia include coffee shade tree systems, scattered trees on the farm land, home gardens, woodlots, farm boundary practices, and trees on grazing lands [4]. An understanding of farmers' knowledge and their perception of factors that influence their land management practices is of paramount importance for promoting sustainable land management. It is also desirable to know if and when farmers practice what they know and perceive [5]. The best designers of traditional agroforestry practices have been the farmers themselves. For hundreds of years, traditional farmers have developed a collection of complex agroforestry systems adapted to local conditions and designed to meet local needs [6]. These indigenous agroforestry systems and practice are rich sources of knowledge about the cultivation of woody perennials in different time and space arrangements with annual crops [7]. Farmers retain trees according to the available spaces compatibility with agricultural crops and household objectives [8]. In recent years there is a tendency to scaling up and promotion of agroforestry at small scale farmers but facing different socio economic and environmental challenges [9].

In Tigray, there is a trend to practice traditional agroforestry and therefore, farmers incorporate multipurpose trees on their farm lands. These farmers have their own indigenous knowledge, from experience, on how to manage, integrate multipurpose trees with crops and animal but it is not well studied and documented. It needs support by integrating their indigenous knowledge and science of agroforestry. From time to time there is also a trend on decreasing of vegetation cover of the communal areas of dry land areas due to socio economic and ecological factors [3]. The overall objective of this study was to examine indigenous management knowledge of traditional agroforestry practices and identifying major determinants for expansion of agroforestry practice.

2. METHODOLOGY

2.1 Site Description

The study was carried out in the areas of Kola-Temben Wereda located in Central zone of Tigray, (Fig. 1) Northern Ethiopia where traditional agroforestry practice is widely accepted by the farmers. The latitude and longitude is N 13^0 37' 23" and E 39^0 00' 05" [10]. The projected population of Kola-Temben Wereda in 2017 was 148,802 of which 73,484 were males and 75,318 were females [11]. The rainfall was low and erratic 450-550mm per year. The Wereda was lowland dominated consists of plateaus and hilly areas. The average annual temperature of the Wereda is 25-30 ^{0}C and it is located at an altitude between 558-2400 m.a.s.l.

The study site was selected purposely [12], based on potential availability of traditional agroforestry practices in the Wereda through focus group discussion with agricultural experts of the Wereda to select the most available dominant traditional agroforestry practice. Three Peasant Associations (PA) were purposely selected from the Wereda, such as Debretsehay, Begashika and Merere that have been potentially practicing traditional agroforestry.

2.2 Data Collection

An ocular survey of the study site was initially undertaken to determine the extent and type of agroforestry practices/system of the farmers in the area. After selection of the three PAs, a

reconnaissance survey was conducted to obtain an overview of the selected study area [12]. During the reconnaissance visit, key informant interviews and focus group discussions were also conducted. Transect mapping of the three study site were conducted to determine the biophysical components of the landscape. Data collection methods were applied using structured and semi structured questionnaire for the indigenous knowledge of management and determinants of agroforestry practice in the region.

Household (HH) survey: To collect qualitative as well as quantitative data on the different traditional agroforestry practice household (HH) survey was used Households were stratified according to wealth category; (rich, medium, low income level). Accordingly, number of livestock (cattle and small ruminants) and the amount of yield grain in quintal per year were taking as leading criteria to set the wealth status ranking in the study area. The sample size of the households was determined using the formula of Taro [13].

$$n = \frac{N}{1 + N(e^2)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad Eq.1$$

Where; n = sample size; N = total population; e = level of precision (0.10)

In general using the above equation (Equation1) a total of 152 HH were selected for the interview (Table 1). These households were selected randomly from each wealth category. For better communication with respondents, questionnaire was pre-tested to evaluate its strength and weaknesses and necessary adjustments were incorporated.

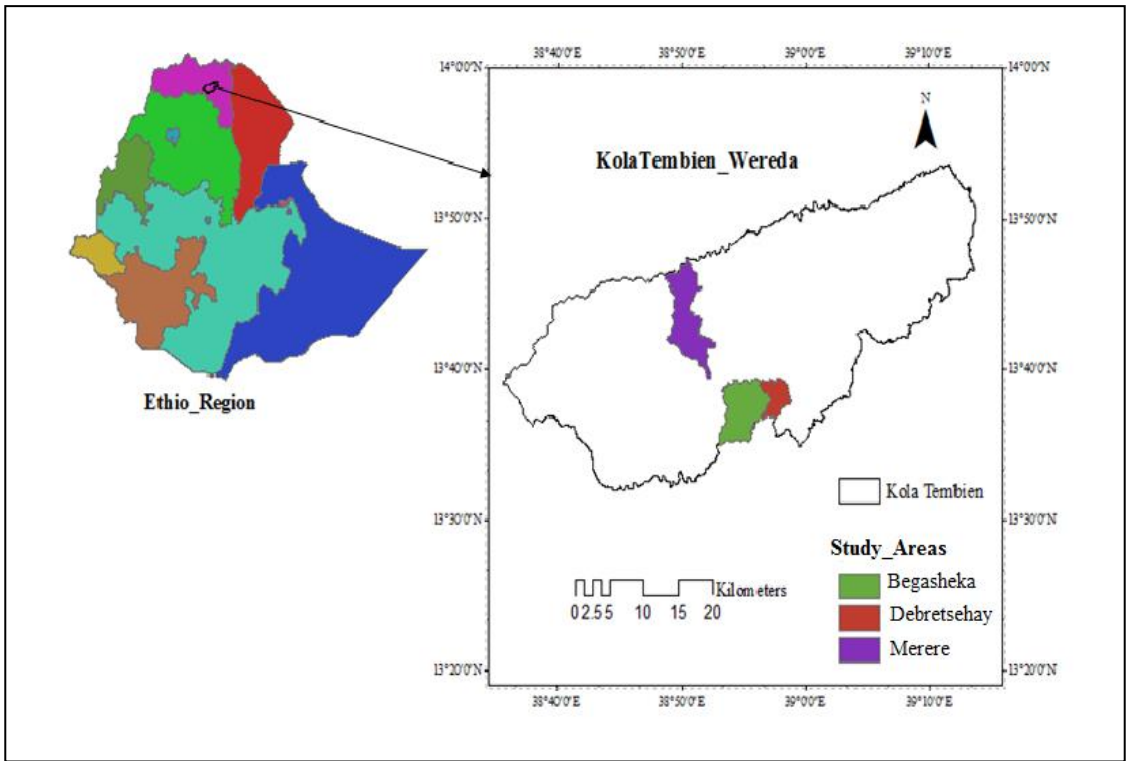

Fig. 1. Study area map (Kola-Temben Wereda)

Table 1. Total household sample from each Pas

Peasant Association (PAs)	Household (HH)_ (N)			Sample size _(n)		
	Male	Female	Total	Male	Female	Total
Debretsehay	296	109	405	15	5	20
Begashika	1084	298	1382	52	14	66
Merere	1098	284	1382	52	14	66
Total				**119**	**33**	**152**

Key Informants: These are individuals living in the area and experts that possess an overall and in-depth knowledge of the local settings and information on the indigenous knowledge of agroforestry practice and managements of the community level. The selected key informants include 2 (two) local men and 2 (two) local women leaders who have rich experience within the community, 10 (ten) elderly peoples and 1 (one) experts that have detail knowledge on the traditional agroforestry practice of the community. From the three selected PA a total of 45 key informants were systematically selected.

Focus group discussion: At first stage, focus group discussion was used to identify the PAs that have potential traditional agroforestry practice. In this stage the discussion were held with office of agriculture and rural development experts (experts of natural resource core process, experienced experts from crop and livestock core process) who know the study site. At second stage focus group discussion carried out at the PA level which involves local chairman of the PA, three development agents (DAs), four elders, and three model farmers, a total of 11 people. The respondents reflect easily their opinion concerning issues related to traditional agroforestry practices, management and determinant in the study area.

2.3 Data Analysis

Data were fed to Excel spread sheet and described in descriptive statistics, processed and analyzed using the software SPSS Version 21. Logistic regression model was used for the analysis of explanatory variables which are expected the main determinant of practicing agroforestry.

2.4 Logit Model Specification

Econometric Analysis of Logistic Model: In this study the dependent variable has binary/dichotomous response variable. The dependent variable is the probability of being traditional agroforestry practitioner (0= non practitioner and 1= practitioner). Therefore logit model was used to identify the determinants for practicing of the traditional agroforestry activities [14]. Logistic regression analysis examines the influence of various factors on a dichotomous outcome by estimating the probability of the event's occurrence [15].

The logit model has the form:

$$\text{Logit (Y) = natural log (odds)} = ln\left(\frac{\pi}{1-\pi}\right) = \alpha + \beta X$$

$$\log Y = \alpha+\beta X \ldots\ldots\ldots\ldots\ldots\ldots \text{Eq. 2}$$

Taking the antilog of Equation 2 on both sides, one derives an equation to predict the probability of the occurrence of the outcome of interest as follows:

$$\Pi = P(Y) = \frac{e^{\alpha+\beta x}}{1+e^{e^{\alpha+\beta x}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq. 3}$$

Where Π is the probability of the outcome of interest(Y =1); α is the Y intercept, β is the regression coefficient of the explanatory variables (constant of the equation), and e = 2.71828 is the base of the system of natural logarithms.

The dependent variable Y_{1i}; (=0 if household has not practicing agroforestry techniques and 1 if household has practicing agroforestry techniques)

Taking the log of Equation (2) we have the following logit model for estimating coefficients:

$$\ln\frac{P(Y=1)}{P(1-P)} = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \ldots \beta_nX_n \quad \text{Eq.4}$$

Finally, we estimated equation (4) using SPPSS statistical software to find the best linear combination of predictors to maximize the likelihood of obtaining the observed outcome frequencies. Interpretations are given in terms of odds ratios and not in terms of marginal effects. If the odds ratio, Exp (β), is greater than 1, we interpret it as the odds are 'exp (β)' times larger. If the odds ratio is less than 1, we take it as the odds are 'exp (β)' times smaller, holding all other variables constant [16].

3. RESULTS AND DISCUSSION

3.1 Socioeconomic and Demographic Characteristics of the Households

In this study, 78.3% male and 21.7 % female household respondents and majority of the respondents (81.6%) were found married. The mean age of the respondents was 45.3 year and had a range between 20 and 74 years (Table 3). Age is an indicator of experience and accumulation of knowledge in farming activities practically obtained through experience. The dominant respondent's age was between 31-40

(31%) and 41-50 (23%). At the age of 46 – 55 the best working age being in the active stage and strong to handle hard manual work as the management of agroforestry practices needed [17].

Farmers in the study area pursued mixed farming in which crop cultivation, and livestock production are major component. Farm size in this case refers to area which is owned by the respondent in different land use type (Homestead, scattered trees/shrubs on crop fields, wood lots etc.). The result of this study shows that average land holding at homestead, scattered trees/shrubs on crop fields, wood lots was 0.59ha, 0.41ha, 0.04ha respectively. There was different crop type cultivating via integrating with trees and animal production. The dominant crop type in the study area was *Sorghum bicolor*, *Zea mays*, finger millet, barley (*Hordeum vulgare*), *Eragrostis tef* etc. The most common available traditional agroforestry practices are homestead, scattered trees, alley and silvopastoral/grazing land agroforestry practice. The study found trees scattered on croplands, boundaries planting and homegardens, alley cropping and woodlots are the most common agroforestry practice [18] Uwera, M. H., et al., 2023.

3.2 Indigenous Knowledge of Management in Traditional Agroforestry Practice

The local community practices incorporating of trees and shrubs with crops on their farmlands and 73% of the respondents replied that they perform from their own experience. 23.7% of the respondent gets directly and indirectly additional training service, information and awareness from extension workers on the importance and value of having trees and shrubs at farmland for their livelihood especially on *Faidherbia albida* and other animal fodder trees and shrubs (Table 4). The study of Grovermann et al [19]/Grovermann et al., 2023/ also indicate that extension access and training participation maximize awareness farmers on agroforestry practice.

Table 2. Socio-economic and demographic characteristic of the respondents

Variables	Category	Percent (%)	Mean
Gender	Male	78.3	
	Female	21.7	
Marital status	Married	81.6	
	Widowed / Divorced	18.4	
Family size	1-3	10.5	6
	4-6	55.3	
	7-8	26.3	
	>9	7.9	
Wealth status	Medium	33.6	
	Rich	37.5	
	Poor	28.9	

Table 3. Land size and livestock production

	Mean	S.D	Min	Max
Age	45.3	12.5	20	74
Educational status	4	2.97	0	10
Family size	5.8	1.8	2	10
livestock production	11	10.7	3	28
Total land size	1.14	0.4	0.5	2.25

Table 4. Source of knowledge for agroforestry practice

S.N	Source of knowledge	Percent
1	Indigenous/by own experience	73
2	Through extension service	23.7
3	Through formal training and through extension service	2
4	All	1.3
	Total	**100**

It is reported that there is an active practice of agroforestry dominantly of traditional origin. The local farmers maintain multipurpose trees based on the value of the trees and shrubs. 78.3% of the respondent maintains the important trees and shrubs intentionally on their farm areas, but 21.7 % of the respondent maintain both intentionally inside the farmland and unintentionally at border of the farmlands because these farmers had land access, enough borders site for trees/shrubs as well as unsuitable for crop production (Table 5). 64% of households surveyed in West Africa traditional agroforestry system were making deliberate efforts to plant tree species on their farmlands [20]. In this study, 78% of the respondents replied intentionally incorporation of multipurpose trees on their farm indicates their awareness on the value of traditional agroforestry practice for their livelihood. The local community has rich knowledge for the comparison on the value of the trees integrating with crops. The information gained from the key informants and group discussion indicates that the actual key points made the local community continue to have trees intentionally on their farms is the indigenous knowledge and clear understanding of the role of agroforestry practice for their livelihood [21]. Found households are more or less engaged with the management of trees at homestead gardens whereas others are not engaged.

Selection criteria for the multipurpose tree to maintain on their farm areas was based on characteristics of the trees and place of where they growing naturally. Most of the respondents (93%) prefers if the plant was naturally grown or planted at the border of the farm areas. 86% of the respondents also maintained haphazardly for plants that had no negative effect for crop production or advantageous for crop at farm areas or high value for market income like *Ziziphus spina-christi* and *Cordia africana* (Table 6). Some of the respondents also replied that trees that have fast growing behavior also maintained as an agroforestry tree inside farm areas.

The respondents used also different criteria to select the trees and shrubs type on their farm areas based on the purposes of the trees/shrub. The respondent selection criteria based on the benefits of the vegetation/plants were palatable leave by animals and source of bee fodder (84.9%), ability to increase soil fertility (83.6%), used for construction, fuel wood, edible and farm inputs (75.7%), used for shade and grass storing (46.1%), having low branch volume or minimum shade effect for crop (41.4%), unpalatable by animals used for fencing (38.8%) and some respondent used as a source of market income, spice and medicinal plant for their livelihood (Table 7). Report of Dulay [17] provides that, farmers to have trees and shrubs on farm land had different factors but the main dominant factor were trees for food product contribution, traditional medicine followed by market income, use of tree shade and for soil fertility improvement. As the study area was in the dry land limited with soil fertility, soil moisture and the farmers own different animals; most of the trees also were used as fodder for their livestock feed. Madalcho and Tefera [22] revealed tree characteristics such as, having deep root/shallow, competition for light and nutrient, allelopathic effect, contribution for nutrient improvement and rate of decomposition (from litter) are the main selection criteria for categorizing woody species as suitable.

Table 5. Retention of trees and shrubs at farm lands

Retention for multipurpose trees	Percent
Deliberately/intentionally	78.3
Unintentionally	21.7
Total	**100.0**

Table 6. Selection of appropriate site for Multipurpose Tree Species (MPTs) in the farm lands

Selection method for MPTs	Percent
If had positive/complementary impact for crop production	86
Difficult for management and aggressive	12.5
Fast growing	45
If it is at the border of the farm land	93

Table 7. Value of trees species to incorporate in the farm land

Selection criteria for MPTs	Percent
Palatable leave by animals	84.9
Ability to increase soil fertility	83.6
Having low branch volume	41.4
Used for construction	75.7
Used for shade	46.1
Unpalatable by animals	38.8
Densely growing	32.9
Market income	19.1
Edible fruit	25
Medicinal value	5.2

Table 8. Source of tree/shrub seedlings/wildlings

S.N	Source of tree/shrub seedlings	Percent
1	Naturally regenerated (wildlings)	46.2
2	Naturally regenerated and planted	63.8
Total		**100**

Table 9. Preference of the farmers to have an agroforestry places (Multiple choice were possible)

S.N	Multipurpose tree species	Percent (%)	Rank
1	Homestead	96.1	1st
2	Scattered trees inside farmlands	28.9	8th
3	Farm boundary	57.9	4th
4	Grazing lands	30.9	7th
5	Degraded lands (eroded) lands	34.9	5th
6	As live fence	67.8	2nd
7	Woodlot	33.6	6th
8	Gullies	61.8	3rd

Table 10. Identified negative impact of agroforestry trees and shrubs for crop production

S.N	Negative impact of trees for crop production	Percent (%)	Rank
1	Shading for crops and nutrient competition	89.6	1st
2	Harbor of insects and birds	46.1	2nd
3	Allopathic effect and Leaf toxicity	4	4th
4	Wind effect	2.8	3rd

Note: Results are multiple responses from the respondents

The local community has two sources of seedling which were from the naturally regenerated and raised seedlings from nursery sites to plant multipurpose tree on the required traditional agroforestry practice. More than 2/3 of the respondents (63.8%) maintain the trees and shrubs both from naturally regenerated and through plantation but 36.2% of the respondent maintain only from the naturally regenerated seedlings (Table 8). From the total respondent 96.1% were interested to maintain on their homestead agroforestry practice because this type of agroforestry is near to their home station and they can easily control and follow up from animal browsing or damaging, and from thief. In general the local community, from their experience, had an interest to manage and plant agroforestry tree species to use as live fence 67.8%), for gullies protection and rehabilitation (61.8%), at farm boundary especially to reduce competition for crop production and land shortage (57.9), at degraded lands (34.9%), woodlot, at grazing land, and as scattered trees inside farming areas (Table 9).

According to the key informants, plantation was done for fruit trees, some selected indigenous trees and cutting of *Euphorbia tirucalli* at homestead agroforestry. This study was in agreement with Negash [23] provides in Gedeo's agroforests, southern Ethiopia farmers manage trees at low cost through management from naturally regenerated seedlings. In the group discussion it was found that there were enough naturally regenerating seedlings at summer season at homestead and at cropland agroforestry types but the problem was related with free grazing at dry season. This result was confirmed with Guyassa et al [24] that most of *Cordia africana* were naturally regenerated in the selected provenance of EthiopiaThere was a trend of leaving favored seedlings from the naturally regenerated indigenous tree species at farmland and fenced until its maturity and to escape from animal browsing. The study of Zegeye et al [25] in southern Ethiopia also confirms 52% of the households plant trees from nursery site for their traditional agroforestry areas and the rest 48% uses from the naturally regenerated.

3.3 Agroforestry Tree Tending Operations

The local community has an experience of tending operation for tree found in their farm areas. Those trees have a great role for crop production, for animal feed and direct and indirect product from the trees for the livelihood of farmers. The respondents had an understanding of the agroforestry trees influence on yield reduction until there were no any tending operations applied. In the focus group discussion forwarded that under enough rainfall and in limited tree pruning management can be a problem for crop yield. The study of Bishaw and Abdelkadir [2] distinguish there is a positive and negative interaction of trees and crops on farm areas which was in line with this study. Majority of respondents (89.6%) examines there were an impact of trees for crop production under limited/zero tree tending operation. Less than half of the respondent (46.1%) states trees also can be as a harbor for insects and birds that affect for yield reduction, allopathic effect and Leaf toxicity (4%)of *Euphorbia tirucalli, Cordia africana* and *Croton macrostachyus,* (Table 10). However the local farmers had their own tending management for the trees and shrubs found at the farm areas. Selected trees are suitable for agroforestry practices in terms of nutrient return from green leaves [26]/Hasanuzzaman, M., & Hossain, M. (2023).

The study indicated that farmers had different type of tending operation applied to different trees/shrubs species. This management practices were for reduction of negative impact of trees and shrubs on crop production, to gain additional outputs from the trees and shrubs, for the sustainability and healthiness of the trees and shrubs found on their different traditional agroforestry types. Coppicing, pollarding and lopping, pruning, fencing, ash application, thinning, stick supporting the stems of seedling and sapling from wind blow and in some case watering were among the most important tree management practices identified and applied in the area. As the respondent replied the aim of coppicing was to increase number of stem (55.2%), to have new shoots and straight pole/timber (52%), for house construction and farm tools (48.1%) and 11.5 % for market (as source of cash income by selling to their neighbor and to the market wood works). Coppicing was applied highly for *Ziziphus spina-christi* and *Cordia africana* because of their sprouting behavior after cutting especially when the local farmers had high demand of logs/ pols for their home construction the whole tree was coppiced. Coppicing was practiced for aged tees at homestead agroforestry mainly to sprout new shoot. Lopping and Pollarding was practiced in the study area for most of the large trees. As in the study area *Ziziphus spina-christi* was used as source of income by selling its fruit and the farmers are not interested to lopping and pollarding since there was yield reduction until sprout again. In general from the total respondents this practice were applied 78% to reduce competition and number of branch, 74.1% for fodder purpose, 65.6% for fuel wood, 41% to reduce shade, disease effect and birds that can influences crop production, 22.7% for market income, and 21.4% for growth of new branch which intentionally used for local house construction and for farm inputs, and indirectly for the purpose of fencing and for fuel wood purpose.

In all type of the traditional agroforestry practice pruning was applied. In the respondents 100% of the local community practice pruning management for their multipurpose trees on homestead and scattered trees. The respondent replies pruning was used 87.8% to easily plough and manage, 83.8% to reduce competition and number of stem, 81.2% for growth fastening, 65% for animal fodder, 59.1% for fuel wood production, 30.5% for market income, 26% to reduce diseases, insects and birds that damage

for crop production. Pruning was used at whole season depending on the objective of the farmer.

Thinning/stock controlling also were type of management practices used in the study area for stock/density controlling and for the removal of unwanted species. According to the group discussion and from the key informants' response there was high natural regeneration of *Ziziphus spina-christi* in the homestead and at scattered trees. Stock controlling was made highly for *Ziziphus spina-christi* and the local farmers arrange the specific place of this tree along the terrace, dispersed in homestead or encircling around their house. This management was common practice and 88.3% of the household applied this management practice. The respondent implements thinning 71.4% to reduce competition for crop production and number of stem, 48.7% for fuel wood, 26% to re-growth, 27.3% for market income and 19.5% for fodder purpose. During selection of trees/shrub for thinning or stock control weak for seedling, shortest and any curved stem were removed. Supporting the regeneration of natural vegetation in agroforestry systems can also provide significant benefits for staple crops production. Farmer-managed natural regeneration (FMNR) of *Faidherbia albida* and leguminous trees in dry land parklands agroforestry in semi-arid and sub-humid Africa was a good example [27]. Fencing was applied for the multipurpose trees (MPTs) at young (seedling and sapling) stage to reduce from animal browsing and damage. In the scattered trees of crop land and at homestead 78 % of the household applied fencing for seedling and saplings during dry season. In the study area free grazing was common and small ruminants are common in most the household the farmers protect their seedling and saplings by fencing. There were new shoots sprouted from the coppiced and naturally regenerated trees and shrubs.

In the study area ash application around the root of the tree was a common practice for termite control and helps to increase number of shoots from the root. In the community ash application is highly common for *Ziziphus spina-christi* and *Cordia africana.* Few numbers of respondents had fruit trees on their homestead and apply natural fertilizer and weeding for these fruits and for *Ziziphus spina-christi*, *Eucalyptus camaldulensis* and *Rhamnus prinoides.* In the general study of [23], farmers use thinning, pollarding and lopping were among the most management methods used in southern Ethiopia. Madalcho and Tefera [22] revealed the common management practices on woody species include fertilizer application, pruning, coppicing, prescribed burning, thinning, pollarding, protection from animal damage, mulch application, crop residue application, and watering.

3.4 Determinants for the Traditional Agroforestry Practice

3.4.1 Determinants of homestead agroforestry practice

The result of logit analysis for homestead agroforestry practicing is presented in Table 11. The Omnibus test of model coefficients of this model reveal that the model for logistic regression of the independent variable is strong at 5% level of significance and with more than 79.6% correct predictions. The result of the logistic regression of the explanatory variable on the practicing of farmers on homestead agroforestry practice indicates homestead land size, number livestock and education status has a significant impact on the farmers to incorporate and practices multipurpose trees as agroforestry at homestead agroforestry. In this analysis result indicates homestead land size is positive statistical significant ($P<0.05$) determinant for expansion and managing of homestead agroforestry practice. By holding the other independent variable constant, in the sampled household with large homestead farm lands have more likelihoods on homestead agroforestry expansion 7.821 times more than those with small homestead farm area at 5% level of significance. In the study of Ethiopian highland Ewnetu and Bliss [28] reported that tree-grower household are found to have larger family size, larger land holding, and larger livestock herds.This result is also in line with the report of Kassa [29]total land holding was positively associated with the practice of fruit tree based agroforestry system in Wondo district, Ethiopia.

Number of livestock holding has a positive significant impact to practice homestead agroforestry. Households with the larger number of livestock will practice by more than 1.075 times than the household with lesser number of livestock holding other things constant (Table 11). This study agreed with Awe et al [30] /Awe et al., 2021/ as adoption of agroforestry practices was positively impacted by extension services, age, education, experience, and land size.

Table 11. Logistic regression estimation of determinants to practice homestead agroforestry

Variables	Estimated coefficient (β)	Standard error (S.E.)	Wald statistics	Sig.	Odds ratio (Exp(β))	Expected sign
Age	0.028	0.021	1.763	0.184	1.029	+
Marital status	-0.846	0.764	1.224	0.269	.429	+
Family size	0.096	0.160	0.357	0.550	1.100	+
Educational status	0.155	0.083	3.512	0.061**	1.168	+
Distance	-0.024	0.027	0.795	0.372	0.976	-
Homestead land size	2.057	0.753	7.470	0.006*	7.821	+
Cropland size	1.324	0.861	2.364	0.124	3.759	+
Number of livestock	0.072	0.024	9.041	0.003*	1.075	-
Free grazing	-0.398	0.474	0.706	0.401	0.671	-
Theft	1.239	0.771	2.581	0.108	3.452	-
Labor	0.725	0.480	2.284	0.131	2.065	+
GOs emphasis	-0.536	0.459	1.365	0.243	0.585	+
Market	0.317	0.462	0.472	0.492	1.373	+
Awareness	0.385	0.540	0.510	0.475	1.470	+
Constant	-0.898	0.179	25.207	0.00	0.407	
−2 Log likelihood			137.624			
Cox & Snell R2			0.258			
Nagelkerke R2			0.368			
Omnibus tests of model coefficients						
Chi-square			45.287			
Df			14			
Sig.			0.00			
% correct prediction			79.6			

**Significant at 10% level of significance (p < 0.10)*
***Significant at 5% level of significance (p < 0.05)*

Similarly Education also have a positive significant influence farmers to practice homestead agroforestry, the odds ratio of having an education for farmer is high with Exp (B) = 1.168. This odds ratio implies that holding other things constant, education for farmers have positive influence (more than 1 times) for farmers to practice agroforestry than illiterate farmers. The result of this study confirms with report of Zerihun et al [31] that education level of household and number of livestock affects positively for adoption of agroforestry in South Africa but land size has a negative impact for agroforestry technology adoption. Alebachew [32] revealed free livestock movement, land shortage, poor access of tree seedlings and termite hazard are the major bottlenecks recorded outside homesteads. Madalcho and Tefera [22] shows tree characteristics such as, having deep root/shallow, competition for light and nutrient, allelopatic effect, contribution for nutrient improvement and rate of decomposition (from litter) are the main selection criteria for categorizing woody species as suitable.

3.4.2 Determinants of scattered trees agroforestry practice

The result of logit analysis for scattered agroforestry practicing is presented in Table 12. The dependent variable is the probability of being scattered agroforestry practitioner (0 = non practitioner and 1= practitioner). The explanatory (marital status, homestead land size, crop land size, distance of the cropland from the home station of the farmers, and theft) variable over took a significant ($p<0.05$) impact on practicing of scattered agroforestry and also awareness has a significant impact at 10% level of significance (Table 12). The Omnibus test of model coefficients of this model revealed that the model for logistic regression of the independent variable is robust at 5% level of significance and with 75.7 % of correct predictions.

In this analysis result homestead land size is positively significant factor for the practicing of scattered agroforestry. The odds ratio of this variable (homestead land size) is 9.394.Holding the rest of the independent variables constant, the model predicts that household with large farm area at homestead has 9.394 times probability of maintaining multipurpose tree species for scattered agroforestry practice than farmers with small homestead area size.

Cropland size is positively significant factor for the practicing of scattered agroforestry. The odds ratio of this variable (crop land size) is 56.5, which is significant at 5% level of significance. Holding the rest of the independent variables constant, the model predicts that household with large farm area at cropland has good probability of maintain multipurpose tree species for scattered agroforestry practice 56.5 times than farmers with small farm area size in hectare. Marital status is positively significant factor for the practicing of scattered agroforestry. This model estimated that married household has higher likelihood of maintaining and practicing of scattered agroforestry 0.243 times than household which single or divorced/widowed at 5% significance level. Distance of the scattered agroforestry to home station is negative significant factor for the practicing of scattered agroforestry. This model estimated that as the distance of farm area from the home station of sampled farmers household increases the probability of maintain, managing and practicing of scattered agroforestry significantly ($p<0.05$) decreases 0.913 times as the other explanatory variable considered constant. Theft problem is negatively significant factor for the practicing of scattered agroforestry. This model estimated that theft problem is influencing the household 0.479 times not to practice scattered agroforestry on their farm areas. Those farmers considered the trees can easily take by anybody at any time at 5% significance level. Households with awareness on the value of maintaining and managing multipurpose tree species as scattered

Table 12. Logistic regression estimation of determinants for the practicing of scattered trees agroforestry techniques

Variables	Estimated coefficient (β)	Standard error (S.E.)	Wald statistics	Sig.	Odds ratio (Exp(β))	Expected sign
Age	0.008	0.019	0.194	0.659	1.008	+
Marital status	1.415	0.682	4.302	0.038*	0.243	+
Family size	-0.149	0.149	1.003	0.317	0.862	+
Education status	0.102	0.078	1.682	0.195	1.107	+
Distance	-0.091	0.025	13.023	0.0*	0.913	-
Homestead land size	2.240	1.042	4.621	0.032*	9.394	+
Crop land size	4.036	1.371	8.658	0.003*	56.574	+
Number of livestock	0.033	0.023	2.114	0.146	1.034	-
Land shortage	-0.138	0.535	0.067	0.796	0.871	-
Free grazing	0.052	0.544	0.009	0.925	1.053	-
Tree tenure	0.049	0.442	0.012	0.911	1.051	+
Theft problem	-1.294	0.547	5.603	0.018*	0.274	-
GO emphasis	0.040	0.404	0.010	0.921	1.041	+
Awareness	0.735	0.439	2.801	0.094**	0.479	+
Constant	0.318	0.164	3.758	0.053	1.375	
−2 Log likelihood			157.582			
Cox & Snell R2			0.277			
Nagelkerke R2			0.373			
Omnibus tests of model coefficients						
Chi-square			49.329			
Df			14			
Sig.			0.00			
% correct prediction			75.7			

**Significant at 10% level of significance (p < 0.10)*
***Significant at 5% level of significance (p < 0.05)*

agroforestry has probability of practicing of scattered agroforestry than household with limited awareness. The odds ratio of this variable (awareness) is 0.479, which is significant at 5% level of significance (Table 12). This odds ratio implies that holding other things constant, creating awareness for farmers have positive influence 0.479 times for farmers to practice scattered agroforestry. In the study of Anjulo and Mezgebu [33] reported that attitude of the farmers and training in natural resource management and/ or agriculture were the main positive determinant of agroforestry practicing at Fogera district, Northwestern Ethiopia. In dedo district, western Ethiopia, adoption decision and use intensity of soil and water conservation measures by smallholder subsistence farmers were correlated negatively on distance of the plot from home and positively on area of cultivated land [34].This study also aligned with the study of San et al [35] San et al.,2023 As small farmland size, insufficient information and a negative perception of raising trees in crop fields were the major factors limiting the adoption rates of agroforestry practices.

In Nigeria land shortage, technical knows – how, inputs, time and labor shortage were the major constraints preventing more tree planting and maintaining on farm agroforestry [36]. On farm exclosure type of agroforestry over grazing, illegal cutting of trees and water scarcity were most challenges in the dry Weinadegaagro-climatic zone of Tigray [37].

4. CONCLUSION

The study area has different type traditional agroforestry practice that can use as an alternative land use system. The local community understood their environment that they are investing highly on their homestead agroforestry practice for their subsistence production, for market income, fuel wood, animal fodder, and soil fertility. Farmers were practicing from their experience on management of multipurpose tree species at farmlands. In this study found that ownership has great impact on multipurpose trees management. Tree at homestead and scattered agroforestry has higher value as compared with silvopastural which is owned from the community. Tending operations were applied in the community to reduce negative effect of tree on crop and to take advantage from the tree products as supplementary value. Pruning, pollarding, lopping, coppicing, thinning/ stock controlling, watering, ash application and composting were the common indigenous tending operations. Size of farm land around the home station, education and total numbers of livestock have positively influence for the household to maintain and manage multipurpose tree species at homestead agroforestry practice. Scattered agroforestry is positively influenced by homestead land size, crop land size, marital status, and awareness and negatively influenced by theft and distance of the scattered agroforestry location from home station of the household. Since the population is increasing, attention is required to improve the practice of agroforestry on small land size for sustainability of agricultural production and livelihood improvement.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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