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Determinants of Agroforestry Practicing at Fogera District, Northwestern Ethiopia

Agena Anjulo[1*] and Amare Mezgebu[2]

[1]*Ethiopian Environment and Forest Research Institute, Addis Ababa, Ethiopia.*
[2]*Woreta College of Agriculture, Amhara Region, Ethiopia.*

Authors' contributions

This work was carried out in collaboration between the two authors. Both authors AA and AM designed the study, wrote the protocol, wrote the first draft of the manuscript, managed the literature searches, analyses of the study, performed the structural equation modeling and discussed the conclusion. Both authors read and approved the final manuscript.

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ABSTRACT

In Fogera district of northwestern Ethiopia, agroforestry land use systems are considered as sustainable and productive approaches as they have multiple benefits. Agroforestry systems in Fogera were developed by the farmers themselves over time; however, their distribution had remained to certain localities. Thus, this research answers why some farmers practice it while others not. To address this general question a study was conducted with the objectives to assess the major determinant factors affecting farmers' practicing of agroforestry and to identify dominant traditional agroforestry practices. Data collection was based on a household survey (N=150), focus group discussion (FGD) and field observations. Household and farm characteristics were analyzed using descriptive statistics. T-test and χ^2 were used to compare practitioners and non practitioners for continuous and discrete variables, respectively. The econometric analysis using logit model was also done to identify key factors that influence practicing of agroforestry. Fifteen variables were included in the model out of which five of them were found to affect agroforestry practicing significantly. Age (-) and attitude (+) at 1% significance level; land tenure security (+), erosion (+) and training in natural resource management and/ or agriculture (+) at 5% significance level

*Corresponding author: E-mail: agenaanj@yahoo.com;

affected practicing significantly. The dominant agroforestry practices identified in the district were farm boundary, farm woodlot and homestead tree integration mainly with *Eucalyptus camaldulensis*. Land shortage and free grazing were also found widely to hinder agroforestry practicing. Therefore, due emphasis should be given to capitalize on promising factors and also in addressing the obstacles before expanding the experience of practitioners and introducing new improved agroforestry technologies to other areas in Ethiopia.

Keywords: Agroforestry determinants; Fogera district; logit model; traditional agroforestry.

1. INTRODUCTION

Agroforestry has both biophysical and socio economic roles wherever it is practiced. The biophysical roles include enhancement of biodiversity, soil conservation and prevention of soil erosion by wind and water, improvement of soil fertility through fixation of nitrogen and protection as windbreaks/shelterbelts. Besides, increasing farmers' income and alleviation of poverty, creation of employment opportunity, provision of fuel wood, fodder and construction wood, provision of food and medicine are the socioeconomic roles of agroforestry [1].

In Ethiopia, integrating multipurpose trees with food crops and livestock in intimate association is an ancient activity [2] There are several types of traditional agroforestry practices in different parts of the country. Coffee shade based systems, scattered trees on farm lands, home gardens, woodlots, farm boundary tree planting, trees on grazing lands, etc for example are some of the known traditional agroforestry practices [3,4,5,6]. Nevertheless, in order to strengthen and make the existing practice effective, identification of the determinants is required.

According to [7], there may be various determinants that can influence practicing of agroforestry. Particularly, the major four groups include: i) household characteristics (age, education, gender and family size), ii) resource endowments (livestock size, off-farm income and farm size), iii) institutional and policy factors (visits by development agents, technical support, training, land tenure and market distance) and iv) biophysical factors (slope, level of soil fertility and type of soil erosion). [8] in his comprehensive review of studies on agroforestry adoption showed that empirical investigations into the influence of economic and farming aspects on adoption of traditional agroforestry systems are non-existent. He added that there is a tendency to emphasize on biophysical aspects and tree-based needs in design of agroforestry technologies, without reference to economic and farming aspects of households.

In Ethiopia's Amhara National Region, south Gonder zone particularly in Fogera district, agroforestry practices are the major sources for fuel wood, construction and income generation.

To identify the reasons for successful practicing of agroforestry, it is necessary to investigate why people carryout agroforestry practices in their farm land or constrained from planting and managing trees on their land holdings. Hence, determinants of agroforestry practicing and their relative impacts need to be determined and documented for its further expansion and on the other hand to provide scientific explanation for not practicing. The objectives of the study were to identify the major factors that affect farmers' practicing of agroforestry; to measure the level of factors affecting agroforestry practicing and to determine the dominant woody components in the traditional agroforestry practices in the study area.

2. METHODOLOGY

2.1 Description of the Study Area

The study was conducted at Fogera district which is located in south Gondar zone of the Amhara National Regional State in northwestern Ethiopia. It is situated in the north-east of the Blue Nile basin to the east of Lake Tana at 11°58'N latitude and 37°41'E longitude. The total area of Fogera is 117,414 ha out of which 51,472 ha is crop land, 26,999 ha grazing land, 2,190 ha forest land, 251 ha covered with perennials/fruit crops, 23,354 ha water bodies (Lake Tana), 7075 ha used for settlement and roads, 4375 ha unproductive land (hills)/wasteland and the rest 1698 ha is swampy area [9]. Total human population of the district is 251,714 out of which the rural population is estimated to be 220,421.

According to [10], there are three agro-ecological zones in Fogera with mean annual rainfall ranging from 974 to 1,516 mm and mean annual temperature ranges from 19-20°C. The district grows different types of crops and is suitable for different species of livestock. The ecological zones range from 1700 to 2400 masl. Fogera wetlands are known for their rich biodiversity. They had been sheltering the rare flamingoes and cranes which are now moving to Blue Nile valley [11]. Topographically, the flat area accounts for 76%, mountain and hills 11% and the valley bottom are 13%. According to [12,10], the dominant soil type in the Fogera plain is black clay soil (Pellic Vertisols), while the middle and high altitude areas are Orthic Luvisols. Specifically, [13] categorized the soil types of the district into 12% red, 20% brown, 65% black soils (vertisol), and 3% gray soils.

The most common tree species in Fogera are *Acacia abyssinica* Hochst. ex. Benth, *Adansonia digitata* L., *Albizia schimperiana* Oliv., *Cordia africana* Lam., *Croton macrostachyus* Del., and *Celtis africana* Burm [14].

Rice was introduced to the district in 1994, initially cultivated by 30 farmers in two kebele associations (KAs) on 6 ha of land [9]. Different agroforestry practices existed in the study area involving different arrangement of components (trees, crops, pastures, and livestock) in space and time. Trees on farm boundaries, homestead tree planting, retaining scattered trees in the farm lands, woodlots and trees planted in gully stabilization are the dominant practices. In terms of the availability of tree species in each practice, homesteads are likely the most important tree growing niches. *Eucalyptus camaldulensis*, *Euphorbia tirucalli*, *Euphorbia abyssinica*, *Sesbania sesban* and *Arundo donax* are the dominant tree species in the agroforestry systems preferred by farmers for their easy propagation. *Eucalyptus camaldulensis* is a common tree in farm boundaries and woodlots. Trees like *Acacia seyal*, *Cordia africana* and *Croton macrostachyus* are intercropped with crops.

2.2 Sampling Strategy and Data Collection

In communication with Fogera district Agricultural and Rural Development Office, among 29 kebele associations (KAs), the smallest administrative unit in Ethiopia, 10 were selected purposefully based on their experience and availability of traditional agroforestry practices. Here traditional agroforestry practices are defined as those practices which are designed, managed and utilized by the local farmers without the interference of external factors for their own demand (fuel wood, construction, income generation etc.) and satisfaction. These 10 KAs were stratified into two farming systems, the rice and other cereals based [10]. After this stratification, three KAs practicing agroforestry were selected randomly. As the number of KAs in other cereal farming is larger than the rice farming system, two KAs were selected from cereal farming system and one KA from the rice farming system. Thus, the study was conducted in three agroforestry practicing kebele administrations (KAs) of south Gonder zone of Fogera district. The three KAs for this study were Kidist Hanna, Quhar Abo and Quhar Mikael where Kidist Hana KA belongs to the rice farming system and Quhar Abo and Kuhar Mikael KAs to cereal farming system.

2.2.1 Sampling procedure

2.2.1.1 Sampling frame

The study populations were all the households in each of the selected KAs. The individual farm household was used as unit of analysis. The household list of each kebele administration in the selected study district constituted the sampling frame.

2.2.1.2 Sample size determination

The minimum sample size for this research was determined using the power analytic approach in which the following values for alpha, power, effect size and number of predictors as suggested by [15]. Alpha (α) was set at 0.05; desired statistical power level was set at 0.80, a value proposed by Cohen as appropriate for a wide range of behavioral research areas, as cited in [16].

$$\text{Effect size, } f^2 = \frac{R^2}{1 - R^2} \quad (1)$$

where f^2 was set at 0.15 following Cohen's suggested effect size values of 0.02, 0.15, and 0.35, which represent his operational definitions for the descriptors small, medium, and large, respectively obtained in behavioral sciences for corresponding R^2 values of 0.02, 0.13 and 0.26. Number of predictors (β) was set at 15.

Based on these values set for alpha, desired statistical power level, effect size and anticipated number of predictors, a sample size (n) of 150 households in the district, therefore, it was considered to be adequate to balance the required level of reliability and cost.

2.2.1.3 Sampling strategy

In order to represent the population with sufficient accuracy and to infer the sample results to the population, the target sample households were selected in a purposeful multistage sampling process. In the first stage, 10 kebele administrations (KAs) were purposefully selected among a total of 29 KAs having traditional agroforestry practices. In the second stage, among the 10 ones, three were randomly selected. From the randomly selected KAs, sample sizes for each KA were determined based on their household heads proportion.

This number of KAs in the study site was considered to be sufficient for statistical analysis and convenient to be surveyed with the available resources of finance, human resource and time. In the third stage, the households in the selected kebele administrations were stratified into male-headed and female-headed households. Individual household units were randomly selected from each stratum. A proportionate sampling technique [15] was used in order to determine the number of sample households relative to sizes of each KA.

Accordingly, nM = NM/N*n and nF = NF/N*n samples, where n is the total sample size for the study district and NM/N and NF/N are respective proportions of male-headed and female-headed household populations in the respective KA. The resulting sampling distribution of the study site by KA and gender of the household heads is shown in Table 1. The number of female headed households was purposively increased to have valid statistical output for gender analysis and hence 50 female household heads were interviewed.

2.2.2 Data collection

Different methods were used to collect the relevant data. These included household survey, field observation and focus group discussion.

2.2.2.1 Household survey

All the necessary data required for the study was gathered through a farm household survey. The questionnaire was pre-tested on randomly selected household heads before the formal survey was conducted and modified slightly for clarity.

2.2.2.2 Focus group discussion

Two focus groups were organized from the KAs for discussion. The composition of the village focus group members included male and female household heads. The focus group members in the KAs ranged from 6-8. The purpose of the focus group discussions was to generate in-depth information on some of the survey findings and other issues that may not have been adequately captured by the structured questionnaire survey.

2.2.2.3 Field observation

Direct field observation was carried out to learn from experience of the field and to get first hand information about agroforestry practices in the area of concern. Of 93 agroforestry practitioners, visits were made to 50 ones to observe the types of traditional agroforestry practices with their components, management aspects and spatial arrangements. Hence, these data were recorded and analyzed.

2.2.3 Data analysis

Descriptive analysis through frequency, mean, percentages and standard deviation were used to analyze the data by using computer software statistical package for social studies (SPSS version 16.0). In addition to descriptive analysis an econometric analysis using binary logit model which best fits the data for determinant factors that influence the practicing of agroforestry by individual households was employed.

2.2.3.1 Model specification

There are several methods to analyze data involving binary outcomes. However, logit and probit models are popular statistical techniques in which the probability of a dichotomous outcome (such as practicing or non-practicing) is related to a set of explanatory variables that are expected to influence the outcome. Logistic regression also referred to as logit modeling has no assumptions about the independent variables: they do not have to be normally distributed, linearly related or of equal variance within each group [17].

Hence, the logistic distribution function econometrically can be specified as:

$$\mathrm{pi} = \frac{1}{1 + e^{-z(i)}} \tag{2}$$

Where **p (i)** is a probability of deciding to adopt new ways of doing things for i^{th} farmer and $\mathbf{Z_i}$ is a function of **m** explanatory variables **(Xi)** and is expressed as:

$$Z(i)=\beta_0+\beta_1X_1+\beta_2X_2+.......+\beta_mX_m+ei \quad (3)$$

Where β_0 is the intercept and β_i is the slopes parameter in the model. The slopes tells how the log-odds in favor of deciding to develop new ways of doing things changes by unit changes in the predictor variables. The stimulus index, $\mathbf{Z_i}$**,** refers to as the logs of the odds ratio in favour of deciding to develop new ways of doing things. The odds is defined as, the ratio of the probability that a farmer develops new practice, $\mathbf{P_{i,}}$ to the probability that he will not, **(1-p$_i$).**

$$(1-\text{pi})=1-\frac{1}{1+e^{-z(i)}} \quad (4)$$

$$\left(\frac{\text{pi}}{1-\text{pi}}\right)=\frac{1+e^{z(i)}}{1+e^{-z(i)}}=e^{z(i)} \quad (5)$$

$$\frac{\text{pi}}{1-\text{pi}}=\frac{1+e^{z(i)}}{1+e^{-z(i)}}=e^{\beta 0}+\sum_{i=0}^{M}\beta iXi \quad (6)$$

Taking the natural logarithms of the odds ratio of equation (5) will result in what is called the logit model as indicated below.

$$\ln\left(\frac{\text{pi}}{1-\text{pi}}\right)=\ln[e\beta 0+\sum_{i=o}^{M}\beta iXi]=Zi=\beta o+\sum BiXi+ui \quad (7)$$

U_i is the error term with zero mean and constant variance. Finally this model was used to in the study area.

The logit model was used to identify factors affecting agroforestry practicing and to analyze the independent variables that were hypothesized to be determinants of agroforestry practicing. Prior to running the logit model, the presence or absence of multicolinearity was checked using Variance Inflation Factor (VIF) for association among the continuous explanatory variables.

2.2.3.2 Definition of hypotheses variables

A farmer's decision about agroforestry practicing can be conceived of having two components: whether to use agroforestry practices or not. Both of these components are assumed to be influenced by a number of factors that are related to a farmer's objectives and constraints. The dependent and independent variables employed in this analysis are defined and hypothesized below.

2.2.3.3 Dependent variable

Dependent variable is a variable that is said to be affected or explained by another variable/ variables. In this study, the dependent variable (Z_i) represented the practicing of agroforestry by the farmers and it was treated as a dichotomous dependent variable (1 for practioners and 0 otherwise).

2.2.3.4 Independent variables

Independent variables (X_i) represent factors that influence the use of agroforestry practices either positively (+) or negatively (-). The independent hypothesized variables were **preferences/ household characteristics** (age, education, attitude and sex/gender), **resource endowments (**farm size**,** livestock holding of the household, family size and market price of agricultural products), **biophysical factors** (distance of plot from the house, distance of market from the house of the household head**)** and **institutional factor** (land tenure security, farmers' associational membership, contact with extension agent and training) as well as presence or absence of erosion.

3. RESULTS AND DISCUSSION

3.1 Traditional Agroforestry Practicing

Kebele is the smallest administrative unit in Ethiopia. For this study, 150 male and female household heads (Table 1) were selected from three representative kebele administrations (KAs). Majority of the respondents in the study area accounting to 62% (n=93) practiced traditional agroforestry of various types. The proportion of respondents practicing traditional agroforestry was highest at Kidist Hana (45%) followed by Quhar Mikael (40%) and Quhar Abo (15%). The result of the woody perennials inventory in KAs (Table 2) shows that average numbers of tree and shrub species per farm are in the order Quhar Abo (623), Quhar Mikael (1,158) and Kidist Hana (1,273).

In the study area, agroforestry has been practiced for long mainly by involving *Eucalyptus* species and with some indigenous trees and shrubs on farm lands across different niches. Of all niches, farm boundary and homestead contained the highest number of trees and shrubs. *Eucalyptus camaldulensis* dominated the area; and the widest niche for this species was farm boundary and homestead (Table 2).

Farmers' reason for having more number of this species is attributed to its higher market price, use for fuel wood, construction and its growth performance in short rotation of 6 to 7 years for poles and posts. Similar report by [18] underscored that about 70% of the households in Wondo Genet and significant number of the settlers in Chemoga watershed in Ethiopian highlands planted trees around homesteads, farm boundaries, along roads, inside gullies and grazing lands. [19] also reported that *Eucalyptus* species were the dominant components of the farm boundary. [20] in his study on economic analysis and adoption determinants of fruit tree based agroforestry practice in Dilla zuria woreda, southern Ethiopia, revealed that farmers plant fruit trees in their homesteads but not as separate orchards in the farm land. These traditional agroforestry practices may have been competitive if trees influence for environmental resources is not managed properly for productive use; however, traditions in the area show that tree integration has been there for long as insurance in times of crop failure and as strategy of accessing different resources from their own land.

3.2 Econometric Results from the Binary Logistic Regression Model

This section identified the most important hypothesized independent variables that influence farmers' decision to practice agroforestry in the study area. The dependent variable was either practicing or not practicing of agroforestry. In this case, a farmer who carried out agroforestry practice was considered to be "a practitioner". Following [21], a VIF exceeding 10 was taken as an indicator of multicollinearity. Likewise, the degree of association among discrete variables was measured using contingency coefficient test. The results of contingency coefficient revealed the absence of multicollinearity problem among the discrete variables. Hence, all the discrete variables were entered into the logit analysis. All the hypothesized variables therefore were decided to be included in the model for analysis.

From all sample farmers, the correctly predicted practitioners and correctly predicted non practitioners of the model were 96.8% and 93.0%, respectively. Out of 15 explanatory variables that were hypothesized to affect farmers' decision to practice agroforestry or not, only five of them were found statistically significant (Table 3). These significant predictors include age of the household head (AGE), erosion (EROSION), land tenure security (LANDSECURITY), participation in natural resource management training (TRAINING) and attitude of farmers towards agroforestry (ATTITUDE). Sex, educational level of the household head, family size, farm size/landholding size, livestock size, market price attractiveness, extension contact and farmers' organizational membership were found to have positive effect on agroforestry practicing but not statistically significant. On the other hand, age, distance of farm plots and market from the settlement house were negatively related with agroforestry practicing but the relation was statistically not significant.

In the model summary (Table 3), over all model evaluation (likelihood ratio), statistical tests of individual predictors (Wald statistics), goodness-of-fit statistics (R2) are presented.

Table 1. Kebele administrations and number of household heads selected for the household survey

Name of KA	Total number of households in KAs					Number of households sampled* in KAs
	Male-headed		Female-headed			
	Number	%	Number	%	Total	Total
Kidist Hana	1527	80	364	20	1891	71
Quhar Abo	590	94	40	6	630	24
Quhar Mikael	1377	93	107	7	1484	55
Total	3494	89	511	11	4005	150

** Sample proportion = 0.037; Kebele Administration - the smallest administrative unit in Ethiopia (KA)*

Table 2. Mean number of homestead, boundary and scattered trees in the farmland in the selected kebele associations (KAs) of Fogera district, north Ethiopia (N=50)

Type of tree species	Quhar Abo (n=11)			Quhar Mikael (n=24)			Kidist Hana (n=25)		
	Homestead trees	Trees on farm boundary	Scattered trees in the farm	Homestead trees	Trees on farm boundary	Scattered trees in the farm	Homestead trees	Trees on farm boundary	Scattered trees in the farm
Acacia abyssinica	1	-	11	-	-	30	1	-	-
Adhatoda schimperiana	-	-	10	-	10	10	-	-	-
Albizia gummifera	7	-	-	2	-	-	-	-	-
Cajanus cajan	-	-	-	19	70	-	10	-	-
Carica papaya	24	-	-	20	-	-	5	-	-
Catha edulis	1	-	-	-	-	-	-	-	-
Coffee arabica	5	-	-	31	-	-	-	-	-
Cordia africana	10	-	8	3	-	60	-	-	-
Croton macrostachys	2	-	5	2	-	3	-	-	-
Eucalyptus camaldulensis	500	262	-	1000	97	-	1200	1737	-
Euphorbia tirucalli	-	15	-	-	30	-	-	-	-
Ficus sycomorous	2	-	-	-	-	-	-	-	-
Grevillea robusta	10	-	-	4	-	-	4	-	-
Mangifera indica	7	-	-	12	-	-	9	-	-
Persea americana	-	-	-	-	-	-	2	-	-
Psidium guajava	15	-	-	8	-	-	17	-	-
Sesbania sesban	2	50	-	-	150	-	4	-	-
Strychnos spinosa	6	-	-	10	-	-	6	-	-
Others	15	-	5	20	-	7	10	-	-
Total	607	327	39	1158	257	110	1273	1887	-

Table 3. Maximum likelihood estimates of the logit model

Variables	Estimated coefficient (B)	Standard error	Wald statistics	Odds ratio (Exp(B))
SEX	0.935	1.622	0.332	2.547
AGE	-0.141***	0.060	5.511	0.869
EDUCLEVEL	0.648	0.523	1.538	1.912
FAMSIZE	0.264	0.491	0.289	1.302
FARMSIZE	1.248	1.614	0.598	3.485
DISTANCFARM	-0.669	1.291	0.268	0.512
LIVESIZE	0.286	0.560	0.260	1.331
MARKETPRICE	1.625	1.536	1.119	5.079
EROSION	1.409**	0.834	2.856	4.093
MARKETDIS	-0.033	0.355	0.009	0.968
LANDSECURITY	2.693***	1.189	5.129	14.776
EXTCONTA	0.593	1.339	0.196	1.809
TRAINING	2.466**	1.243	3.939	11.779
FAS	0.336	1.168	0.083	1.399
ATTITUDE	0.148***	0.083	3.203	1.160
Constant	-7.489	5.063	2.188	0.001

Notes: Exp (β) shows the odds of a farmer being a practitioner for a given change in a predictor.
**** and ** show 1% and 5% significance levels respectively.*
*Chi-square = 166.499***; 2 Log likelihood= 32.720; R^{2} (Nagelkerke R^{2}) = .84*

The goodness of fit statistics, i.e., R^2 = 0.84 in the estimated model indicates that of the total variation in the dependent variable, 84% was explained by independent variables. The purpose of this section is to discuss the most influential hypothesized independent variables that govern the dependent one that is agroforestry practicing. The statistically influential variables include land tenure security, training in natural resource management/agriculture, erosion, attitude of the household head towards agroforestry and age of the household head.

3.3 Land Tenure Security

The logit model predicted that this variable influences agroforestry practicing positively and significantly at 5% significance level. This indicates that as farmers feel land tenure securities, they have more probability to devote on agroforestry practicing. Moreover, the coefficients and odds ratio of this explanatory variable were by far larger than other variables and they were 2.693 and 14.50, respectively. This odds ratio of the variable indicates that all other factors being the same, farmers who perceived the existing land tenure as secure were 14.50 times more likely to practice agroforestry. The endpoints of a 95% confidence interval (CI) of the odds ratio is (0.62, 4.87). This confidence interval suggests that agroforestry practicing among practitioners could be as little as 0.62 times to as much as 4.87 times more likely as non practitioner headed households.

In Ethiopia, including the study site usufruct right is allowed for farmers. According to [22], assessing land tenure systems and extension methods for agroforestry adoption in Uganda, 80% of the responding farmers preferred freehold land tenure systems for agroforestry adoption implying the positive influence of tenure security. [23] on his study for land management strategies and fuel wood collection in Panamá, documented that the integrated systems of agroforestry in Hato Horcón are practiced on hillsides under usufruct land tenure. [24] on their work for identifying factors affecting the adoption of agroforestry practices by farmers in Cameroon, revealed that security of land tenure influenced agroforestry adoption positively and significantly. [25] reported that education, land holding size, land tenure, income, credit, sources of information, extension activities, extension agent visits and membership of farmer organizations were found to be the important factors affecting adoption of recommended crop management practices in paddy cultivation in Kalutara district, Sri Lanka. [26] on their survey for agroforestry adoption in Haiti with particular consideration to the importance of household and farm characteristics, reported that farmers managed a greater density of trees, especially when the land was in secured tenure status. The present finding at Fogera is also in line with the work of [27] who found that renters displayed less conservation effort than owners did. As it is common in Ethiopia, the land belongs to the state in the study area. Farmers believe that no one can take their land from their hand. Their usufruct right is stated in their land certificate to use the land perpetually. On the other hand, they expressed that it is a must to grow trees/agroforestry trees/shrubs to reap different functions of agroforestry till worse/unexpected reforms are to come. Clear land ownership and community involvement in managing forest resources are key determinants in securing sustainable land management [28]. Studies from elsewhere [29,30,31] has shown that insecurity of tenure over land influences the adoption process of agricultural technologies negatively. [32] in investigating land tenure institutions and development of agroforestry, documented that increase in tenure security led to tree planting. [33] in their part stated that land tenure security positively influences household plot-level conservation investments in the highlands of northern Ethiopia. [34] in their evaluation on the impact of land tenure on agroforestry adoption, elucidated that land tenure security and its type has instrumental and significant impact on agroforestry practicing. [35] found evidence in Ghana that more secure land tenure is linked to land improvements. According to [36], farmers with secure land tenure that is who expect to hand down their fields to their children and live in villages with no recent land redistribution are both more likely to build stone terraces and less likely to build soil bunds. [34] in their assessment on socio-economic determinants of farmers' adoption of rotational woodlot technology in Uganda, reported that tenure security predicted wood lot technology adoption positively and significantly. [34] on their investigation for land tenure systems and extension methods to assess agroforestry adoption in Uganda, revealed that full perpetual ownership of land and free decision making could allow farmers to practice any agroforestry technologies irrespective of their long term nature.

3.4 Training

This variable influences agroforestry practicing positively and significantly implying being one of the incentives for practicing agroforestry. The coefficient and odds ratio of this variable were 2.45 and 11.48 respectively. Keeping other factors constant, when household heads tendency to get training in natural resource management/agriculture is increased, they could have 11.48 more likely to practice agroforestry.

[37] in a case study for agro-forestry technologies adoption among smallholders of Zimbabwe farmers, reported that the likelihood to adopt live fence was influenced significantly by training together with other factors. These authors further specifically stated that formally trained farmers adopted agro-forestry technologies more than informally-trained farmers. [38] reported that training of farmers regarding on-farm sustainable water resources management affected its adoption positively and significantly. [7] in their document for taking stock of agroforestry adoption studies, revealed that training, tenure security and assets exert the greatest statistical power for predicting agroforestry adoption than other factors. Generally, studies elsewhere documented that experience, social capital, training and membership in farmer cooperatives can play important roles in adoption behavior when the appropriate economic conditions are present [39,40,41,42].

3.5 Erosion

This variable influenced agroforestry practicing positively and significantly. The coefficient and the odds ratio of this variable were 1.42 and 4.13, respectively. The odds ratio indicates keeping other factors constant, as the perception of farmers on erosion increases, agroforestry practicing probability would be 4.13 more likely. The presence or absence of erosion matters whether or not to use soil and water conservation measures including agroforestry practices. In the two KAs namely Quhar Abo and Quhar Mikael, farmers use agroforestry trees for conservation purpose as they are hilly than Kidist Hana.

[43] reported that implementation of land consolidation programmes in Poland should preserve the existing land use mosaic (traditional agroforestry) in areas threatened by erosion (9.0–15.4% of the area). [44] in their work on determinants of farmers' adoption and adaptation of alley farming technology in Nigeria reported the same result. [45] in their investigation for social and economic factors affecting the adoption of soil and water conservation in Tanzania, revealed that the adoption of soil and water conservation technologies is likely to increase with a higher level of education, a good perception of erosion problems and a better security in land tenure.

3.6 Attitude

This variable influenced agroforestry practicing positively and significantly. The coefficient and odds ratio of this variable was 0.15 and 1.17 present, respectively. Its odds ratio indicates that as farmers' attitude total score towards agroforestry increases, the likelihood of agroforestry practicing would be 1.17 more likely keeping other factors constant.

[46] in their assessment on influencing factors of technology adoption of different land based enterprises of farmers under diversified farming system in India, stated that attitude of farmers towards farm diversification was positively and significantly predicting adoption. [47] on his study on farmers' awareness about land degradation and their attitude towards land management practices at Aleta Wondo of Sidama zone, documented that farmers' positive attitude towards land management practices including agroforestry was instrumental to apply different land management measures. [48] on their investigation on the effect of local cultural context on the success of community-based conservation interventions stated that projects delivering conservation education were positively linked with successful attitudinal outcomes. The study also corroborates with the works of [49,8] who reported the influence of socio-psychological factors on agroforestry planning in which attitude of farmers was of the instrumental ones. [50] also found that a favourable attitude towards agroforestry increased the adoption rate of agroforestry program in Kangra (Himachal Pradesh) and Srinagar (Jammu and Kashmir), India. [51] on their study about determinants of farmers' willingness to pay for soil conservation practices in the southeastern highlands of Ethiopia, reported a result which is in line with the present finding. [52] in their investigation for farmers' attitude on sustainable agriculture, reported that there were positive and significant relationships between farmers' attitudes and sustainable agriculture. [38] also reported that attitude of farmers towards on-farm sustainable water resources management affected its adoption positively and significantly. [13] on his assessment for farmers' evaluation and determinants of adoption of upland rice varieties in Fogera district, reported that those farmers who had higher attitude score towards improved upland rice varieties have adopted than those farmers who had lower attitude score towards the technology. In line with the present finding, his result showed that attitude was predicting positively and significantly probability of adoption of improved upland rice varieties. In the same vein, [59] reported positive influence of farmers' attitude after conducting a study on determinants of use of soil conservation measures by smallholder farmers in Jima zone of Ethiopia.

3.7 Age of the Household Head

The logit model result showed that age of the farm household heads negatively and significantly influenced agroforestry practicing at 1% significance level. The estimated coefficient and the odds ratio of the variable were -0.14 and 0.87 respectively. This means as the age of farmers increase by one year, agroforestry practicing tendency decreases by a factor of 0.87. This may be because younger farmers are often better disposed to devote in long term investments like agroforestry and have lower risk aversion and longer planning horizons to justify investments in tree-based technologies [53,54]. The current study with respect to age is consistent with the study results of many researchers. [55] on their study for predictors of agroforestry technology adoption and land conservation strategies in Uganda, stated that a younger farmer had a 50% higher probability of adopting agroforestry technology than an older farmer. The present study is also in line with the work of [49] who reported about agroforestry adoption and maintenance at Southern Bahia, Brazil. [44] also reported negativity of age in adopting alley cropping which was conducted in southwest of Cameroon. The study also supports the findings on live hedge in Burkina Faso [56] that younger farmers are more likely to adopt agroforestry. [57] reported that the youngest and middle-age group of farmers adopted *Sesbania sesban* in southern Malawi. Moreover, [41] in their assessment on agroforestry adoption in southern Malawi: the case of mixed intercropping of *Gliricidia sepium* and maize, reported that young farmers are to use this technology than older ones. [51] in their identification for determinants of soil conservation practices in the southeastern highlands of Ethiopia, documented that age is negatively and significantly influencing conservation measures. [58] in his assessment on adoption of improved maize and common bean varieties in Mozambique, reported that due to their long horizon, young farmers take risks. [60] in their investigation on factors influencing farmers' decisions to adopt agriculture practices with a particular focus on the adoption of conservation tillage, compost and chemical fertilizer, found a negative and significant impact of age on the likelihood of adopting conservation tillage, as well as compost but not on chemical fertilizer. [59] in their investigation on adoption decision and use intensity of soil and water conservation measures. Smallholder subsistence farmers in Dedo district of western Ethiopia, stated that age of respondents predicted adoption decision negatively. These authors further explained that older farmers have conservative outlook for new technologies and strategy related to natural resource conservation should target younger farmers.

4. CONCLUSION

Farm boundary planting, farm woodlot and home garden tree integration were dominantly practiced by farmers. The major reason for practicing agroforestry dominantly with integration of *Eucalyptus camaldulensis* was income generation through the sale of pole, post, and fuel wood to domestic and international market at the neighboring countries such as Sudan.

There was significant difference between agroforestry practitioner and non practitioner households in a number of demographic, resource endowment and economic variables. Agroforestry practitioners had higher human capital and higher resource endowments than non practitioner households. The present study identified variables that were strong determinants of the farmers' agroforestry practicing activities. Of 15 variables hypothesized to affect agroforestry practicing, only five: land tenure security, training, household heads attitude, soil erosion and age of household heads predicted it significantly with different signs.

Traditionally men have been responsible for agroforestry practicing and product harvest. Women played a minor role in tree husbandry which was confirmed by focus groups. Female headed households were found to be less frequent agroforestry practitioners than male-headed households due to land shortage. Focus group discussants, both male and female groups asserted that agroforestry practicing is less risky than other agricultural practices in terms of production and marketing. According to the discussants, from recent times possession of trees either in wood lots or farm boundaries is becoming one of the criteria for marriage. Land shortage and free grazing were found widely to hinder agroforestry practicing. Therefore, due emphasis should be given in addressing the obstacles before expanding the experience of practitioners and introducing new improved agroforestry technologies to other areas in Ethiopia.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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