

MANAGEMENT PRACTICES AND DETERMINANTS OF FRUIT TREE-BASED AGROFORESTRY PRACTICE IN MORET AND JIRU DISTRICT, NORTH SHEWA ETHIOPIA

ABERE KIBEB^{1*} AND MEKUANENT TEBKEW^{2*}

¹*Ethiopian Forestry Development, Central Ethiopia Center, P.O. Box 33042, Addis Ababa, Ethiopia, email: aberekibeb@gmail.com, aberek@efd.gov.et, ORCID ID: <https://orcid.org/0009-0002-0386-8537>*

²*Department of Forestry, College of Agriculture and Environmental Sciences, University of Gondar, Gondar, Ethiopia, email: mekuanntebkew@gmail.com. ORCID ID: <https://orcid.org/0000-0001-7711-4282>*

*Corresponding author email: aberekibeb@gmail.com

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ABSTRACT

Fruit tree-based agroforestry practice in Moret and Jiru was developed by the farmers themselves over time. However, their distribution had remained to certain localities. Thus, this research answers determinants of adoption and the management practices of fruit tree-based agroforestry practice in the study area. Therefore, this research aims to (i) assess management practices of FTBAFPs; ii) identify the determinants of smallholder farmers' adoption of FTBAFPs in the Moret and Jiru District, North Shewa Zone, Ethiopia. Data were collected in three purposively selected Kebeles using household survey (149 households), key informants (18), focus group discussion (3) and field observation due to the high potential of fruit production and accessibility to data collection. The collected data were analysed using descriptive statistics and binary logistic regression methods. The result revealed that common management practices employed by respondents for fruit trees included thinning, hoeing, fencing, pest and disease control, watering, weeding, and fertilizing. However, adoption of FTBAFP was positively and significantly influenced by age ($p=0.006$), and education ($p = 0.004$) at 1 % significance level; landholding ($p = 0.017$), labour ($p = 0.030$), and wealth status of households (0.042) at 5 % significance level. Therefore, due emphasis has to be given towards strengthening rural education for adults to increase number of agroforestry adopters by increasing awareness and an appropriate intervention such as variety improvement through research to reduce susceptibility by disease and pest of fruit tree-based agroforestry practice.

Keywords: management practices, determinants and adoption

INTRODUCTION

Small-scale agriculture has long been the primary source of income for the majority of people in rural Africa (Bishaw *et al.*, 2013). These smallholder farmers face many problems, such as low productivity, high dependence on rain-fed agriculture, insecurity of the traditional land tenure system, and environmental degradation (Zerssa *et al.*, 2021). As a result, poverty and food insecurity will be prevalent in this region (Bahiru *et al.*, 2023).

This situation can be particularly harsh in countries with large populations, such as Ethiopia. In Ethiopia, Farmers' are forced to continuously use the minimum amount of land, which are very susceptible to reduce soil fertility decline (Willy *et al.*, 2019). Agroforestry can be considered as an alternative to some exhausted land-use practices that occur (Bishaw & Abdelkadir, 2003; Kang & Akinnifesi, 2000).

Fruit tree-based agroforestry practice integrates the cultivation of agronomic crops, vegetable crops, fruit trees, and woody plants. This practice is widely popular among producers with limited resources worldwide because fruit trees have a relatively short pre-production phase, their products have high market value, and they significantly contribute to meeting household nutrition needs (Bellow, 2004; Do *et al.*, 2020; Manga, 2021).

Common management practices in traditional agroforestry practice in the Gununo Watershed, located in the Wolaita Zone of Ethiopia, include the application of fertilizers (mainly manure, but also DAP and urea), branch pruning and coppicing, prescribed burning, thinning, pollarding, protection from animal and human damage, the use of grass mulch and crop residues, and watering. The intensity of these management practices is primarily determined by their impact on agroforestry products (such as fruits and crops, especially in parkland systems) and their contribution to sustainable land management (Madalcho & Tefera, 2016). In the Merhabete District of North Shewa, Ethiopia, common management practices for fruit trees include thinning and fencing (Getachew & Asfaw, 2023).

In Ethiopia's Amhara Region State, North Shewa Zone particularly in Moret and Jiru district, fruit tree-based agroforestry practice are the major sources for income generation and food. Hence, management practice and determinants of fruit tree-based agroforestry practice need to be determined and provide scientific explanation for not practicing. Therefore, this research was carried out to generate evidence-based data by identifying management practices, and determinants of the adoption of fruit-based agroforestry practices in smallholder farmers.

MATERIALS AND METHODS

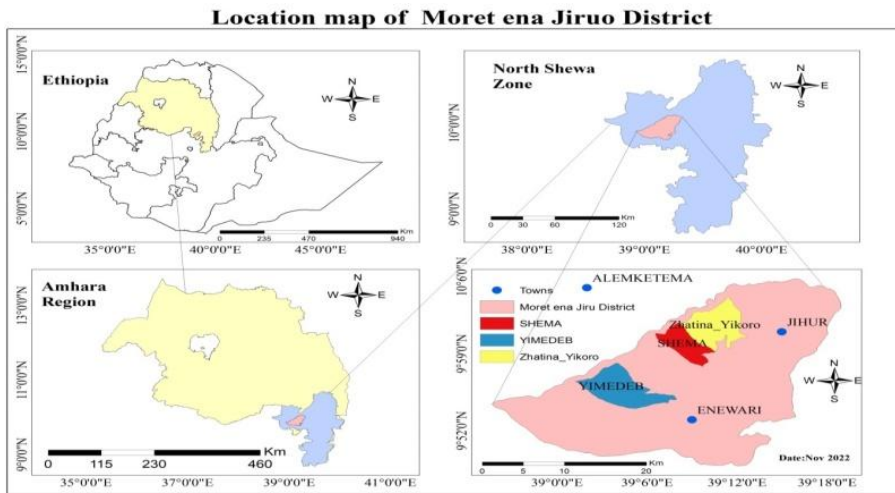
Description of the Study Area

Geographical location and topography

The research was conducted in Moret and Jiru District, North Shoa Zone, Amhara Regional State, Ethiopia. Moret and Jiru District is located 200 km North-West of Addis Ababa. Geographically, it is located at 9°59' 58" N -10 ° 0' 10" N latitude and 38 °55' 38" - 39 ° 9' 7" E longitude (Fig. 1). According to the Moret and Jiru district agriculture office, (2022) annual report, Moret and Jiru District has 21 Kebeles (19 rural and 2 small towns). The District covered an area of 661.16 square kilometres. The altitude ranges from 1,339 to 2692 m.a.s.l.

District is classified into three agro-climatic zones. These are; Dega (highland), which covers 60 % of the area and ranges from 2,400 to 2,692 meters above sea level (m.a.s.l.); Woina Dega (mid-altitude), ranging from 1,800 to 2,400 m.a.s.l. and covering approximately 25 % of the area; and Kolla (lowland), ranging from 500 to 1,500 m.a.s.l., which accounts for 15 % of the area (MJDAO, 2022).

Fig. 1: Map of Study area



Soil type and climate

The major soil types in the Moret and Jiru District are nitosols/ red soils, vertisols/black soils, and cambisols/ light brown; account for about 15 %, 50 %, and 35 % of the total area respectively. Vertisol is the dominant soil type in the study area. The mean annual rainfall of the District ranges from 900-1000 mm. The average annual temperature of 16-18 °C (MJDAO, 2022).

Livelihood activity, land use and vegetation

The community's livelihood activities in the district include crop production, forestry, livestock rearing, agroforestry, and the collection of other non-timber forest products. Other livelihood activities include non-farm activities (retailer, service, construction) and off-farm activities. These are the main sources of household consumption and cash sources for the communities. Common agricultural crops involve teff, wheat, maize, millet, lentils, and beans. Major fruit tree grown in the district are (*Citrus aurantiifolia* (Christm.) Swingle, *Citrus sinensis* (L.) Osbeck, *Mangifera indica* L, and *Musa paradisiaca* L and (onion, garlic, chilli, tomato, cabbage) are vegetables cultivated by farmers for income and household consumption. Livestock like cattle, sheep, goats, donkeys, and apiculture are common in the area (MJDAO, 2022). The land use pattern of the study area is (55 %) for annual crop, (3 %) for grazing, (25 %) as forest, (12 %) for fruit tree-based agroforestry practices, and (5 %) for other (MJDAO, 2022).

Sampling Techniques and Sample Size Determination

In this study, multi-stage sampling techniques were employed. First, Moret and Jiru district was purposively selected due to accessibility to data collection, and the presence of fruit trees-based agroforestry practices on farmers' farms. In the second stage, three Kebeles (the lowest administrative unit next to the district in Ethiopia) were purposively selected namely: Yimedeb, Shema and Zhat and Yikoro from nineteen rural Kebeles administration based on high fruit production and accessibility to data collection.

In the third stage, sample households were selected using stratified random sampling. The adoption category was used as a stratum for stratified sampling. From each stratum using a stratified random sampling technique, households were selected proportionally (Table 1). Finally, a simple random sampling method was employed to select the sample households (adopters, and non- adopters) to identify the determinants of smallholder farmers, and management practices of fruit tree-based agroforestry practice in the study area. For this study adopters; farmers integrate fruit tree such as *Citrus aurantiifolia*, *Citrus sinensis*, *Mangifera indica* (mango), *Musa paradisiaca* (Muz) and *Z. spina-christi* (Geba) with vegetables such as (onion, garlic, tomato, chilli, and cabbage) in the farmland. "Non-adopters " are farmers who do not integrate fruit trees with vegetables. This study applied a simplified formula provided by Yamane. (1967) to determine the required sample size at 95 % confidence level, degree of variability being 0.05 and level of precision 0.08.

$$n = N / [1 + N(e)^2] \dots\dots\dots \text{Eq}(1)$$

Where,

n= required sample size.

N= Total number of households in selected kebeles (3110)..

e=desired level of precision (8%).

$$n = 3110 / (1 + 3110(0.08)^2)$$

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For allocating of sample size at household from adopters and non- adopters of fruit tree based agroforestry practice the proportional allocation formula is used:

$$n_i = \frac{N_i \times n}{N} \dots\dots\dots \text{Eq}(2)$$

Where:

- ❖ n_i =is the determined proportional sample size
- ❖ N_i =The Households size i strata(adopters and non- adopters)
- ❖ n=The sample size
- ❖ N=The total number of households

Table 1: Kebeles and number of households interviewed in the study area

Kebele	Adopters	Non- adopters	Total	Sample size (adopters and non-adopters)
Yimedeb	590	675	1265	(29 +32)
Zhat and yikoro	461	695	1156	(22+33)
Shima	278	411	689	(13+20)
Total	1329	1781	3110	149 (64 +85)

Source: District office of agriculture, 2023. Unit of analysis is households

Data Collection

The primary data was collected using household survey, focus group discussions, key informants, and field observation. Both quantitative and qualitative data were collected. Secondary data was collected from review of literature and government organization.

Households survey

Structured and semi-structured questionnaires were developed, pre-tested, and delivered on a face-to-face interview basis to collect the primary qualitative and quantitative data. The questionnaires were prepared in English and translated in to Amharic language. Data were collected from households including; socio-economic characteristics of households, and its management practices.

Key informant interview

Key informants are individuals who are knowledgeable about management practices, and who have lived in the area for long period of times, active and knowledgeable their localities. The selection of key informants was done by using the snowball sampling method (Bernard, 2011).

The development agents of the three Kebeles provided information about the first key informant who fit the above-mentioned criteria. Based on information obtained from development agents the first key informants were selected in each Kebeles. Then, after the first key informant is known, he/she would suggest the second key informant with a background like him and the second would tell the third and so forth and the same procedure and method followed until six key informants were selected at each three kebeles. Finally, a total of 18 key informants were selected in the study area. The key informants were selected to classify households into those having adopters and non- adopters and also classify households in wealth status.

The key informants were also interviewed with a semi-structured checklist of questions. Data collected from key informants were management practices, and what should be done to improve the adoption of fruit tree- based agroforestry practice in the society. The insights derived from these key informants strengthen the findings of the household survey.

Focus group discussion

To make the process of data collection more effective, focus group discussions were conducted between selected groups (Mebrate *et al.*, 2022). A total of three focus group discussions (FGDs) were conducted in the sample Kebeles by 8 - 12 members, one from each Kebele, and a total of 28 members were involved. The groups were formed by including men, women, young, old, adopters, non- adopters, and development agents and Kebeles administration. Focus group interview was undertaken on management practices, and major bottlenecks that inhibit the adoption of fruit tree-based agroforestry practice, and what should be done to improve the adoption of FTBAFP in the society of the rural population of the district under study.

Field observation

Observation is one of the scientific instruments to collect qualitative data relevant to phenomena in natural settings (Zikargae *et al.*, 2022). Fruit tree-based agroforestry practice observation was made in Yimedeb, Shema, and Zhat and Yikoro Kebeles during data collection. During observation, their management practices were observed in the study area.

Data Analysis

Descriptive and econometric analyses were employed based on the objectives of the study. The Statistical Package for the Social Sciences (SPSS) version 26 was used to load and organize the quantitative data. The data obtained from FGD, key information and field observations were expressed in narrative forms. The assess management practices of fruit tree-based agroforestry practice in the Moret and Jiru District were analysed through descriptive static (percentage of the respondents were reported in table) and narrating in words.

A binary logit regression model and descriptive analyses were used to identify the determinants of smallholder farmers' adoption of fruit tree-based agroforestry practice. The binary logistic regression model were used because of the dependent variable was binary or dichotomous (had only two groups: adopters and non- adopters), and binary logistic regression model has been used by majority of agroforestry adoption studies to analyse dichotomous adoption decisions in which the dependent variable is binary: 1 if adopters, 0 otherwise (Mercer, 2004). The t-test was used to examine whether the mean values of continuous variables (age, labour, landholding and family size) differ significantly between adopters and non- adopters. Mean and standard deviation was reported from continuous variables. Additionally, a Chi-square test was used to determine the statistical significance of associations between independent variables (categorical variables) such as (wealth status, education, and marital status) and dummy variables (sex, extension service, and access to credit) and the dependent variable (adopters and non- adopters). Frequencies and percentages were reported for categorical and dummy variables (Table 4).

Model specification

In the binary logit model, the dependent variable is binary or dichotomous and has only two groups: adopters and non-adopters (1 if adopters, 0 otherwise). Whereas, the explanatory variables were continuous, categorical, or dummy (Table 2).

The logit model was used to identify factors affecting fruit tree-based agroforestry practices and to analyse the independent variables that were hypothesized to be determinants of fruit tree-based agroforestry practice using SPSS versions 26. Before running the logit model, the presence or absence of multicollinearity was checked using the Variance Inflation Factor (VIF) and tolerance for continuous explanatory variables. As shown below in appendix 1, the values of the VIF for all continuous variables were found to be small (i.e. VIF values less than 5) and tolerance >0.1 (Appendix 1). This indicates continuous variables have no serious problem of multicollinearity which implies that there is no strong correlation between continuous independent variables. Whereas the presence of multicollinearity for categorical variable and dummy variable checked using contingency coefficient < 0.70 (Appendix 4). The result implies that there is no strong correlation between discrete variables.

The goodness of fit of the binary logistic regression model determined by two ways. These are omnibus tests of model coefficient and hosmer and lemeshow test.

Omnibus tests of model: null hypothesis (H₀): Adding the variables to the model has not significantly increase our ability to predict the decision made by the respondents

Alternative hypothesis (H₁): adding the variables to the model has significantly increased our ability to predict the decision made by the respondents. The full model has significance prediction performance ($\chi^2 = 129.244$; $df = 10$; $p = 0.000$). The result showed that the model showing good fit (Appendix 2).

Hosmer and lemeshow test: null hypothesis (Ho): the model has adequately fit the data

Alternative hypothesis (H1): the model has not adequately fit the data. The result show that the model has also good fit since Hosmer and lemeshow test could not reject the hypothesis the model appropriateness as the chi-square value 2.825 and $p = 0.945$

Nagelkerke R Square ($R^2 = 0.779$ in the estimated model indicates that of the total variation in the dependent variable, 77.9 % was explained by independent variables. From all sample farmers, 90.6 % were correctly predicted in to adopters and non-adopters categories by the model (Appendix 3).

Adoption of fruit tree-based agroforestry practices by farmers as dependent variables, where by a value of 1, is given to households belonging to the adopters and 0 otherwise. Using the 10 explanatory variables (4 continuous and 6 categorical/dummy) for the adoption of agroforestry practices, the model was estimated by following the maximum likelihood estimation procedure.

Let $Y=1$, be the probability of the dependent variable (adopting fruit tree-based agroforestry practice), $Y=0$, the probability is not adopting FTBAFP. This relationship ($Y=1$) can also be presented as $P_i = E(Y=1/X_i)$ or $p(Y=1/x_i)$; where E is expectation. $Y=0$ can be expressed as $p(Y=0)/x_i$ or as $(1-P_i)$; the odds ratio (likelihood) in favor of $Y=1$ is given as;

$$(P_i/1-P_i \text{ or } e^B) \dots \dots \dots \text{Eq (3)}$$

If $(1) > 1$ - increased odds; $(1) < 1$ - reduced odds; $(1) = 1$ - equally likely odds. Thus taking Natural log of equation (3) above, the logit Y as $\ln p(Y=1/x_i)/p(Y=0)/x_i = \ln (P_i/1-P_i)$, so

$$\text{That } Y_i = \ln P_i/1-P_i = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n + U_i \dots \dots \dots \text{Eq (4)}$$

Where:

- Y_i is the dependent variable;
- X_1 - n are explanatory variables;
- β_0 is the intercept, the probability of the dependent variable when all explanatory variables are zero;
- β_1 - n is the coefficients to be estimated in the analysis;
- U_i is the error term with zero mean and constant variance

The final model of the decision to adopt FTBAFP can therefore be estimated by the equation below:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + U_i, \dots \dots \dots \text{Eq (5)}$$

X_i (explanatory variables). X_1 :-sex, X_2 :- Age, X_3 :- Wealth status, X_4 :- Education level, X_5 :- family size, X_6 :- marital status, X_7 :- landholding, X_8 :- labour, X_9 :- access credit, X_{10} :-extension service. Finally, this model was used in the study area.

Definition of Research Variables

Table 2: Hypothesized effects of independent variables on adoption of fruit tree-based agroforestry practice

No	Variables	Definition of variables	Hypothesized	Source
1	Sex	Sex of hh and It is a dummy variable (1=male, 0=female)	+/-	Ayichew, 2019
2	Age	Age of hh and it is a continuous variable	+	Solomon & Asfaw, 2018
3	Wealth status	Categorical variables = 1 if low/ poor; 2= medium; 3= rich	+	Zerihun <i>et al.</i> , 2014
4	Education	Educational status of the household head. It is a categorical variables (1 = illiterate, 2 = read and write, 3 = primary school(1-8), 4 = secondary and preparatory school (9-12))	+	Tajebe & Gelan, 2018; Ayichew, 2019
5	Family size	The total number of families in the households. It is a continuous variable	+	Gebbru <i>et al.</i> , 2019; Moronge & Nyamweya, 2019
6	Marital status	Marital status of household and it is categorical variable(1 = unmarried,2 = married, 3 =divorced, and 4 = widowed)	+/-	Gebbru <i>et al.</i> , 2019
7	Landholding	the total size of the farm in hectares that the HH head uses and it is continuous variables	+	Tajebe & Gelan, 2018; Ayichew, 2019
8	Labour force	The total number of family members (ages between 15 to 65)	+	Solomon & Asfaw, 2018
9	Access to credit	It is dummy variable 1 if access to credit, 0 otherwise	+	Matata <i>et al.</i> ,2010; LemlemTajebe & Asfaw Gelan, 2018; (Tega & Bojago, 2024)
10	Extension service	Extension service (1 = Yes, 0 = No)	+	Ayichew, 2019;Tega & Bojago, 2024)

RESULTS AND DISCUSSIONS

Demographic and Socio-Economic Characteristics of Households

The socio-economic characteristics of farmers examined in this study are sex, age, marital status, education level, wealth status, family size, labour, and landholding. The purpose of choosing these characteristics was to get general overview of what the sample households are composed of and how these characteristics could influence the adoption of fruit tree-based agroforestry practice. The average age of those who adopted FTBAFP was 50.09 ± 7.686 years, while the average age of non-adopters was 41.78 ± 5.109 years. This implies a statistically significance difference was observed in the mean age of respondents due to the adoption category ($t = 7.923, p = 0.000$). The mean land holding sizes of adopters were 1.616 ± 0.733 ha and non-adopters were about 0.984 ± 0.326 ha. The adopters average family size of the sample households of 5.38 ± 1.667 person where as non-adopters had

3.91±1.21. The average labour force (15–65 years) was 4.45±1.14 persons for adopters and 3.02 ±0.9 persons for non-adopters (Table 3).

Table 3: Household socio-economic characteristics (mean ± S.D) in the study area (N = 149)

Variables	Adopters (N = 64)	Non- adopters (N =85)	t-test	Sig level
Age	50.09±7.686	41.78±5.109	7.923	0.000***
Family size	5.38±1.667	3.91±1.21	6.232	0.000***
Labour	4.45±1.14	3.02±0.9	8.39	0.000***
Landholding	1.616±0.733	0.984±0.326	7.065	0.000***

Table 4 shows that (88.6 %) were male. More specifically, majority (71) of non-adopters were male whereas 61 of the adopters were male. According to the findings, the majority of the respondents were married 84.3 %. The result of the Chi-square analysis ($\chi^2= 0.904$) revealed that non-significant association between in marital status of the respondents between the fruit tree-based agroforestry practice adopters and non-adopters households.

Overall 45.6 % are illiterate, 34.9 % can read and write, 11.4 % have completed primary school, and 8.1 % have completed secondary school. More specifically, among adopters, 13 % are illiterate, 53 % can read and write, 20 % have completed primary school, and 14 % have completed secondary school. In contrast, 71 % of non-adopters are illiterate, with only 22 % able to read and write, 5 % having completed primary school, and 2 % having completed secondary school. The result of the Chi-square analysis indicates that there is significance association in education levels between adopters and non-adopters of fruit tree-based agroforestry practice (Table 4).

Out of the sampled households, 80 (53.7 %) have accessed extension services, Within the adopter group 30 households have accessed extension services, On the other hand, within the non-adopter group, 50 households have accessed extension service. The main sources of credit in the area were Tseday Bank and different private lenders.

Table 4: Analysis of categorical/ dummy variables by chi-square test

Variables	Farmers	Adopters		Non-adopters		Total		Chi ² –value
	Categories	N	%	N	%	N	%	
Sex	Male	61	95.3	71	83.5	132	88.6	0.035**
	Female	3	4.7	14	16.5	17	11.4	
Marital status	Single	1	2	3	3.5	4	2.7	0.364
	Married	58	90	68	80	126	84.6	
	Divorced	3	5	9	10.5	12	8	
Education	Widowed	2	3	5	6	7	4.7	0.000***
	Illiterate	8	13	60	71	68	45.6	
	Read and write	34	53	18	22	52	34.9	
	Primary school	13	20	4	5	17	11.4	
Wealth	Secondary	9	14	3	2	12	8.1	0.000***
	Poor	2	3	32	38	34	23	
	Medium	40	63	50	59	90	60	
Access credit	Rich	22	34	3	3	25	17	0.392
	Yes	8	12.5	7	8	15	10.1	
Extension Service	No	56	87.5	78	92	134	89.9	0.148
	Yes	30	47	50	59	80	53.7	
Service	No	34	53	35	41	69	46.3	0.148
	Yes	30	47	50	59	80	53.7	

Management Practice of Fruit Tree–Based Agroforestry Practice

The common management practices of the current study area were pruning, pollarding, coppicing, and watering, weeding, thinning, hoeing, fertilizing, fencing, and disease and pest control (Table 5). Farmers applied different management practices for different reasons such as for improving plant growth, reduce competition, prevent wind disturbance, fuel wood, improve soil fertility, conserve water, fencing, and reduce shading effect.

Pruning is mainly practiced for *Z. spina-christi* to enhance growth, reduce the shading effect on crops, and obtain fences and fuel wood. Similarly, previous studies have been reported that pruning of woody species was used for reducing the shading effect of trees on agricultural crops, getting fodder for animals, and collecting wood to be used for fencing, construction houses, firewood, and also for sales of fruit to generate income (Negash *et al.*, 2012; Fikir *et al.*, 2018).

Respondents in this study stated that pollarding was performed for *Z. spina-christi* to reduce the shading effect, and get fuel wood. This study was in line with the findings of Mamo & Asfaw (2017) who reported that pollarding was applied to get feed for animals, reduce the shading effect, improve soil fertility, and get fuel wood in Gemechis district, West Harage, Ethiopia.

Respondents have practiced coppicing for *Z. spina-christi* by cutting the tree down to the stump and allowing it to rejuvenate to maximize biomass production. Another study indicated that coppice was applied to rejuvenate old trees, generate new vigorous stems, and generate woody stems for firewood and other purposes (Tesfaw *et al.*, 2023).

Watering was applied for the early survival of planted seedlings of *Citrus aurantiifolia*, *Citrus sinensis*, *Mangifera indica*, and *Musa paradisiaca*. Likewise, farmers applied watering management practices for establishing and growing woody species including fruit species in Shashemene District, Ethiopia (Jegora *et al.*, 2019). The weeding was conducted to minimize intra-species competition and enhance their overall growth. Furthermore, according to respondents thinning was done rarely for fruit woody species initially at the sapling stage to enhance free space and to improve the growth of fruit woody species. Additionally, respondents reported that thinning was applied to remove or kill some trees to allow the remaining trees to continue growing. Respondents employed hoeing management practices to conserve water and increase the soil fertility for fruit tree species. This result was consistent with the findings of Wariyo & Negewo (2023) reported that farmers hoeing their coffee farms to conserve water and improve soil fertility for wood species and coffee plants.

Respondent applies fertilizers to their fruit trees at the seedling stage to improve soil fertility and offer a suitable situation for the growth of fruit tree species. Similarly, it was reported by Yakob *et al.* (2014) that the application of organic fertilizer was very essential for the sustainable management of land use types and for creating a suitable environment for the growth of woody species. On the other hand, respondents did practice fencing for the sapling of *Citrus aurantiifolia*, *Citrus sinensis*, *Mangifera indica*, and *Musa paradisiaca* to enhance the growth and to protect against damage by animals. Another study showed that fencing was done to protect seedlings from damage by animals in the Gimbo district, South West, Ethiopia (Yakob *et al.*, 2014).

Moreover, respondents pointed out that, disease and pest protection was done to the production and productivity of fruit tree species in the study area. Disease is one of the most serious constraints to seed production, which can affect the diversity of woody species as well as affect the structure and composition of woody species. Yakob *et al.* (2014) revealed that controlling disease and pests through biological or chemical methods was essential to enhance the productivity of woody species as well as fruit tree species.

Table 5: Percentage of respondents on management practices of woody species recorded in the study area

Species name	Local name	Management practices									Reason for management
		Pruning	Pollarding	Coppicing	Watering	Weeding	Thinning	Hoeing	Fertilizing	Fencing and disease and pest control	
<i>Citrus aurantifolia</i> (Christm.) Swingle	Lomi	-	-	-	92	94	42	55	62	25	1, 2,3,5,6
<i>Citrus sinensis</i> (L.) Osbeck.	Birtukan	-	-	-	90.3	80.6	10	42	54.8	16.1	1,2,3, 5,6
<i>Mangifera indica</i> L.	Mango	-	-	-	81.8	63.6	-	52.3	59.1	14	1,2,3,5,6
<i>Musa × paradisiaca</i> L.	Muz	-	-	-	84.3	46.9	66	-	53	9.4	1,2,3
<i>Z. spina-christi</i> (L.) Desf	Geba	46	12.5	25	-	-	8.3	-	-	-	1,2,4,5,6, 7,8

Note: Reason for management, 1 = for growth, 2= reduce weed competition, 3= to protect animal damage, 4 =for fuelwood, 5 = to increase soil fertility, 6= to conserve water, 7= fencing, and 8= to reduce shade effect

Determinants of Fruit Tree-Based Agroforestry Practice

The result showed that (education level, age, land holding, labour and wealth) positively and significantly influence farmers' decision to adopt fruit tree-based agroforestry practices. In contrast family size, marital status, access to credit, sex, and extension service did not influenced the adoption of fruit tree-based agroforestry practice in the study area (Table 6).

Table 6: Maximum likelihood estimates of the binary logit model for adoption determinants of fruit tree-based agroforestry practice in Moret and Jiru District

Variable	Estimated coefficient(B)	Standard Error	Walid stastics	Sign	Odds ratio Exp(B)
Sex	.463	1.377	.113	.737	1.589
Age	.240	.088	7.481	.006***	1.272
Wealth	1.594	.782	4.155	.042**	4.922
Education	1.179	.411	8.214	.004***	3.252
Family size	-.332	.326	1.038	.308	.718
Marital status	-.589	.802	.539	.463	.555
Land holding	3.013	1.26	5.694	.017**	20.35
Labour	1.066	.492	4.698	.030**	2.904
Credit	.351	1.096	.103	.749	1.421
Extension service	.882	.632	2.498	.114	2.717
Constant	-24.462	6.512	14.13	.000	.000

Source: household survey, 2023

Notes: Exp (B) shows the predicted changes in odds for a unit increase in the predictor *Omnibus Tests of model coefficient: chi-square 129.2; sign 0.000; -2 Log likelihood= 74.3 R² (Nagelkerke R²) = 0.779 (77.9 %); Percentage of correct prediction=90.6; Number of observation = 149; Degree of freedom = 10; and ** and *** Significant at 5% and 1 %, level of Significant, respectively

Age of households

The estimated coefficient and the odds ratio of the age were 0.24 and 1.272 respectively. This means as the age of farmers increases by one year, fruit tree-based agroforestry practices increase by a factor of 1.272. One of the possible reasons for our result was that traditional fruit tree-based agroforestry practices have existed in the area for a long, and elders might have acquired a longer and better experience with agroforestry practices than youngsters. As a result, farmers with old age have a better chance to recognize this benefit earlier than young aged farmers. This was supported by the finding of Tajebe *et al.* (2013) who reported a positive relation between the age of the household head and the adoption of apple-based agroforestry in the Dendi wereda, Oromia region. This finding contradicts the findings of Anjulo & Mezgebu. (2016) who reported that the age of the farm household heads negatively and significantly influenced agroforestry practice in Fogera, North Western Ethiopia. Younger farmers are often better disposed to devote themselves to long-term investments like agroforestry and have lower risk aversion and longer planning horizons to justify investments in tree-based technologies.

Land holding of households

The odds ratio of the variable indicates that farmers who unit increased land size were 20.356 times more likely to adopt fruit tree-based agroforestry practice. This could be attributed to the fact that farmers with large landholdings are more likely to adopt fruit tree-based agroforestry practices. These findings support those of Kassa (2015) reported that land size influences the probability of adopting a fruit tree-based agroforestry system at less than a 10 % significance level. The odds ratio for the land size indicated that other variables held constant the odds of practicing the fruit tree-based agroforestry system was increased by 3.24 when compared to those who don't practice in Wondo district, Ethiopia.

Furthermore, Geremew (2016) finding showed that an increase of farm size by one hectare increases the probability of adopting agroforestry Mecha district, West Gojam. Where there is surplus farmland the household can be interested to allot the additional farmland for cash-generating agroforestry practices. Moreover, land size is positively related to the area under agroforestry. This may have implications for per capita land holdings, which is consistent with other studies This is because, except for home garden agroforestry, agroforestry practices require sufficient land and hence farmers with large land sizes are more likely to adopt the technologies (Chinangwa, 2006; Beyene *et al.*, 2019).

Labour

The results indicate that the large number of labour force in the household have more probability of adopting fruit tree-based agroforestry practices than small number labour in the households. This is because; fruit tree-based agroforestry practice requires more labour force for management activities and harvesting. Moreover, the estimated coefficient and odd ratio of these explanatory variables were 1.066 and 2.904 respectively. These odds ratio of the variable implies that all other factor constant a unit increase labour were 2.904 times more likely to adopt fruit tree-based agroforestry practice. This result line Solomon & Zebene (2018) that households with larger labour force are more likely to adopt most of the agroforestry technologies than those with less labour force. This might be explained by the additional labour that most of the agroforestry technologies require for their management.

Education level of households

All factors being constant, those with more education tend to adopt more fruit tree-based agroforestry practices which are significant at less than a 1 % probability level and diversity of information on agriculture increases the likelihood to adopt FTBAFP. Furthermore, the estimated coefficient and odd ratio of these explanatory variables were 1.179 and 3.252 respectively. A positive estimated coefficient indicates that a unit increase in the education category increases the probability of adopting fruit tree-based agroforestry practices by a factor of 3.252. This implies that the more educated the farmers, the more likely the household would adopt the practices. On the contrary, illiteracy would result in a low adoption rate because education improves farmers' ability to understand and interpret information and more than transfer of knowledge, experience, and better understanding of FTBAFP and adopt these agroforestry practices better than less educated farmers, it is important for fostering human creativity.

Similarly, a study in Southern Tigray Ethiopia by Gebru *et al.* (2019) showed that educational level significantly ($p < 0.05$) influences the household's role in the adoption of agroforestry practices. Moreover, Tajebe & Gelan (2018) studied, that the formal education level of the household head as expected had a positive influence on the adoption of the apple-based agroforestry system in North Shewa Zone, Ethiopia.

Wealth status of households

The binary logistic regression analysis shows that there was a positive and significant ($p=0.042$) relation between wealth status and adoption of fruit tree-based agroforestry practice. This implies that rich households have more probability to adopt fruit tree-based agroforestry practices than medium and poor the households respectively. Moreover, the estimated coefficient and odd ratio of these explanatory variables were 1.594 and 4.922 respectively. A positive estimated coefficient indicates that a unit increase in the wealth category increases the probability of adopting fruit tree-based agroforestry practices by a factor of 4.922 This study line Zerihun *et al.* (2014) reported that wealth status affects the adoption of AF technologies in Eastern Cape Province, South Africa.

CONCLUSION AND RECOMMENDATION

Conclusion

The common management practices employed by respondents for fruit trees included thinning, hoeing, fencing, pest and disease control, watering, weeding, and fertilizing. Thinning helps in reducing competition for resources among trees while hoeing and weeding are crucial for maintaining soil health and reducing competition from unwanted plants. The management practices for *Z. spina-christi* were pruning, pollarding, coppicing, and thinning.

The present study clearly identified several critical determinants influencing farmers' adoption of fruit tree-based agroforestry practice (FTBAFP). Among these, age, educational level, landholding size, availability of labor, and overall household wealth emerged as statistically significant and reliable predictors of adoption. These factors collectively influence farmers' decision-making and draw attention to the socioeconomic processes behind the adoption of fruit tree-based agroforestry practice.

Recommendation

Based on the current findings of the study, the following recommendations are forwarded:

- ✓ As this study indicates, the educational level of the household head was positively related to the adoption of fruit tree-based agroforestry practices. Therefore, due emphasis has to be given towards strengthening rural education at adults to increase the number of agroforestry adopters by increasing awareness.
- ✓ And also, an appropriate intervention such as variety improvement (disease resistance species) either through research or extension service is essential to enhance fruit tree-based agroforestry practice.
- ✓ The present study focused on the management practice, and a determinant of fruit tree-based agroforestry practice has overviewed. Further research needed on the role of fruit trees for environmental and soil fertility.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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APPENDIX

Appendix 1: Variance inflation factor and tolerance for continuous independent variable

Continuous variable	Tolerance	VIF
Household age	.540	1.852
Family size	.416	2.404
Land holding	.852	1.173
Labour	.359	2.788

Appendix 2: Indicators of the model adequately fit the data well

Omnibus Tests of model coefficient		Chi-square	Df	Sig
Step1	Step	129.244	10	.000
	Block	129.244	10	.000
	Model	129.244	10	.000
Hosmer and Lemeshow Test				
	Step	chi-square	Df	sig
	1	2.825	8	0.945

Appendix 3: Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	74.344 ^a	.580	.779

Appendix 4: Farmers' fruit tree-based Agroforestry practice adoption Correlation Coefficients. (N= 149)

Spearman's rho		Sex	Wealth	Educatio	Marit Status	Credit	Extens
Sex	Coefficients	1.00					
	Sig.(2-tailed)						
Wealth	Coefficients	0.206*	1.00				
	Sig.(2-tailed)	0.012					
Education	Coefficients	0.053	0.387**	1.00			
	Sig.(2-tailed)	0.524	0.000				
Marital sta	Coefficients	-0.591*	-0.118	-0.181**	1.00		
	Sig.(2-tailed)	0.000	0.153	0.027			
Credit	Coefficients	-.020	-0.066	-0.120	-0.021	1.00	
	Sig.(2-tailed)	0.806	0.423	0.146	0.799		
Extension service	Coefficients	-0.132	-0.021	0.007	0.153	0.132	1
	Sig.(2-tailed)	0.107	0.801	0.932	0.063	0.109	

*Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed)