Agriculture, Forestry and Fisheries
2025, Vol. 14, No. 2, pp. 61-71
https://doi.org/10.11648/j.aff.20251402.15

Research Article

Determinant Factors for Farmers' Investment on Forest Landscape Restoration in Soddo Zuria, Southern-Ethiopia

Bisrat Hailemichael[1], Melaku Bekele[2], Tamirat Teshome[1, *]

[1]Ethiopian Forestry Development, Addis Ababa, Ethiopia

[2]Natural Resources and Environmental Department, Wondo Genet College of Forestry and Natural Resources Hawassa University, Hawaasa, Ethiopia

Abstract

Forest landscape degradation poses a significant challenge in southern Ethiopia, contributing to food insecurity and rural migration. Despite various intervention programs, effective management of this vital resource remains inadequate, resulting in declining agricultural productivity. This study investigates the impact of various environmental and socio-economic factors on the adoption of tree planting practices on degraded landscapes. Primary data were collected from 149 household heads through structured questionnaires. Both descriptive and inferential statistics were used for data analysis. The chi-square statistic (χ^2 = 1.96, p = 0.581) indicates that there is no statistically significant relationship between slope type and tree planting adoption. Result also showed that contact with extension agents significantly boosts adoption rates for tree planting. The chi-square value (χ^2 = 5.604) with a p-value of 0.018 indicates a significant relationship between contact with extension agents and the adoption of tree planting. Additionally, training on tree planting did not significantly impact adoption rates (χ^2 = 0.032, p = 0.865), indicating that personal beliefs and cultural practices may play a more vital role. The probit regression results highlight several critical factors influencing the adoption of tree planting among households. Notably, the significance of land certificates and farmers' perception of land tenure security underscores the importance of secure land rights in promoting sustainable agricultural practices. Larger farm sizes and livestock ownership also positively impact tree planting, indicating that resource availability plays a crucial role. In contrast, age, family size, education, and extension contact do not significantly influence tree planting behavior. This suggests that interventions aimed at enhancing tree planting adoption should focus on improving land security and providing resources rather than merely increasing educational outreach or extension services. The complexity of factors influencing adoption decisions highlights the importance of a nuanced policy-making approach that considers local contexts and individual circumstances, particularly regarding land rights and resource management.

Keywords

Certification, Land, Registration, Perception, Tenure Security

1. Introduction

Farmers' investments in forest landscape restoration are increasingly crucial for combating land degradation and ensuring ecological balance [8] Understanding the multifaceted nature of these investments requires a comprehensive analy-

*Corresponding author: tesh4040@gmail.com (Tamirat Teshome)

Received: 10 March 2025; **Accepted:** 26 March 2025; **Published:** 22 April 2025

sis of the various environmental conditions that influence them, alongside the role of extension services in facilitating these practices [10]. In many developing countries, including Ethiopia, where rural communities are heavily reliant on forest resources, the challenges of tenure insecurity and environmental degradation are particularly pronounced [11]. The unique physiographic characteristics of regions like Soddo Zuria Woreda such as soil type, slope, and climate play a significant role in determining the viability of restoration efforts [13]. These environmental factors not only affect the productivity of agricultural systems but also influence farmers' willingness to invest in forest restoration initiatives [20].

Cultural perspectives on land and resources also play a critical role in shaping farmers' approaches to forest landscape restoration [6]. In Ethiopia, where land is deeply interwoven with identity and livelihood, understanding local attitudes toward forest landscape restoration is essential [21]. The participation of different genders in restoration efforts remains underexplored, highlighting the need for research that captures the nuances of gender dynamics in decision-making processes related to environmental investments [22].

In the context of forest landscape restoration, extension services play a pivotal role in influencing farmers' investment decisions [23]. Various environmental factors, such as soil type, climate, and topography, significantly impact these investments. In regions like Soddo Zuria Woreda, Southern Ethiopia, understanding how these factors interact with extension services is crucial for promoting sustainable forest land scape restoration practices [14]. Farmers' investments in forest landscape restoration are increasingly critical for addressing land degradation and ensuring ecological balance [30]. However, there is a notable gap in the literature regarding a comprehensive analysis of the diverse environmental conditions influencing these investments, particularly in developing countries like Ethiopia, where rural communities rely heavily on forest resources [12].

Despite the importance of agricultural extension services in promoting sustainable practices, there is a noticeable gap in research regarding their effectiveness in the context of forest landscape restoration [24]. While some studies have examined the benefits of extension services, few have delved into how these services interact with environmental variables to shape investment decisions among farmers [31]. Additionally, the socio-economic dynamics, including issues of land tenure, access to resources, and market integration, further complicate the landscape of investment in restoration practices [34]. This study aims to explore the relationship between environmental conditions and farmers' engagement in restoration efforts, highlighting the effectiveness of agricultural extension programs. By examining local perceptions and investment behaviors, the research seeks to identify both the opportunities and challenges faced by farmers in enhancing forest landscapes. Additionally, the role of gender in these investment decisions will be investigated, providing a comprehensive view of the socio-economic dynamics at play in sustainable forest landscape restoration.

2. Material and Methods

The research was carried out in Soddo Zuriya Woreda, situated in the Wolaita Zone of the Southern Nations, Nationalities, and Peoples Region of Ethiopia. This area is approximately 390 km from Addis Ababa and spans 481 km², characterized by a moderate to cool sub-highland climate that has been significantly affected by land degradation. The average annual temperature in this region ranges from 15 ℃ to 20 ℃, accompanied by an average annual rainfall of about 1200 mm.

Soddo Zuriya predominantly falls within the woiyna dega climatic zone, with altitudes varying from 1500 to 2500 meters above sea level, and it includes some Dega zones above 2500 meters. Historically, the region was rich in natural forests; however, population growth, agricultural expansion, and dependence on wood fuel have led to substantial forest degradation, resulting in only 11% of the land still covered by scattered natural forests and state-owned plantations.

The prevailing soil types are vertisols and Nitosols, the latter known for their nutrient content but also their susceptibility to erosion and leaching. The population density in Soddo Zuriya is notably high, averaging 511 individuals per square kilometer, with approximately 163,771 rural residents, primarily from the Wolaita ethnic group. The local agricultural practices are predominantly crop-livestock mixed systems, with a strong emphasis on Enset cultivation integrated with other root and cereal crops.

1. Data Sources and Collection Methods

In this study, both primary and secondary data were utilized. Primary data were collected through structured interviews and field observations. Surveys targeted farmers' households. Secondary data were gathered from governmental documents and reports at regional, zonal, and Woreda levels, as well as from non-governmental organizations.

2. Sampling Technique

A multistage sampling approach was employed to select household respondents. Soddo Zuriya Woreda was purposively chosen for its land certification experience since 2005. Subsequently, three kebeles with over 70% certified households prior to 2007 were randomly selected. A total of 149 household heads were systematically sampled from these kebeles, with the sample size determined by factors such as research costs, time constraints, and transportation availability. Data collection involved structured questionnaires focusing on household characteristics and perceptions regarding land certification and tenure security. Pre-testing of the questionnaire was conducted with 5-6 households before the main survey.

3. Data Analysis

Both descriptive and inferential statistics methods were employed for data analysis, the study employed a probit model to assess factors influencing the adoption of soil and

land management practices. The model is defined as:

$$y1i=x1i\beta1+u1iy_{1i} = x_{1i} \beta_{1} + u_{1i}y1i =x1i β1 +u1i$$

where:

$$y^1i=1\hat{y}_{1i} = 1y^ 1i =1 \text{ if } yi>0y_{i} > 0yi >0$$

$$y^1i=0\hat{y}_{1i} = 0y^ 1i =0 \text{ if } yi\leq0y_{i} \leq 0yi \leq0$$

x1ix_{1i}x1i represents independent variables affecting participation in sustainable land management (SLM) practices.

β1\beta_{1}β1 denotes unknown parameters

u1iu_{1i}u1i are the residuals, assumed to be independently and normally distributed with a mean of 0.

Before applying the probit model, multicollinearity among continuous variables was examined. Two measures were used to test the variance Inflation Factor (VIF) and the Contingency Coefficient (CC) for discrete variables. A VIF exceeding 10 indicated high collinearity, while a CC above 0.75 suggested similar concerns.

Statistical measures such as means, percentages, frequencies, standard deviations, chi-square, and t-tests were used to summarize and categorize the data. Correlation analysis was employed to determine the degree of association between two variables. Upon completion of data collection, the data were coded and analyzed using the Statistical Package for Social Sciences (SPSS version 20), employing both descriptive and econometric methods to interpret farmers' responses effectively.

3. Results and Discussions

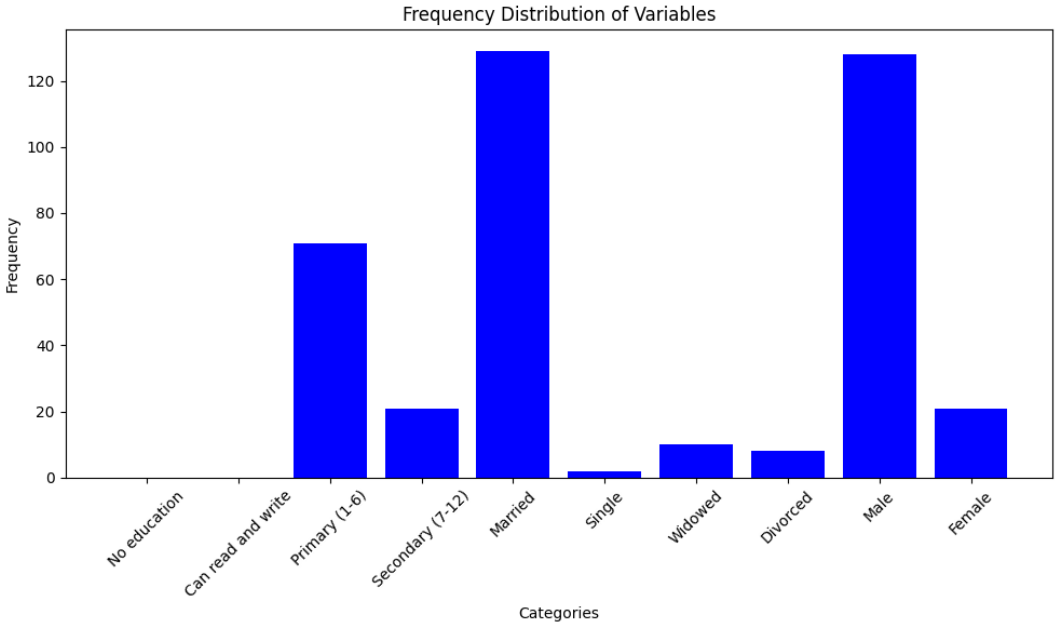

Figure 1. *Depict the demographic distribution of respondents with respect to land restoration.*

Result in Figure 1 shows the analysis of household characteristics from the study reveals significant demographic insights about the 149 respondents. The data shows that a substantial majority (85.9%) of the respondents are male-headed households, while female-headed households constitute only 14.1%. This disparity may reflect cultural norms and gender roles prevalent in the region, highlighting potential challenges women face in land management and decision-making processes. A large portion of respondents (86.6%) are married, indicating a stable family structure, which can influence agricultural productivity and labor availability.

The small percentages of single (1.3%), widowed (6.7%), and divorced (5.4%) respondents suggest that marital status does not vary significantly among the population, potentially affecting social support systems within the community. The educational attainment among respondents is notably low. Only 14.4% can read and write, and nearly half (47.7%) have no formal education. A small group (12.8%) attended secondary school. This lack of education may hinder the adoption of innovative practices tree planting and land management, as education often correlates with information access and the ability to implement new techniques.

The age distribution of the household heads indicates that nearly half (48.99%) are between 16 and 45 years old, while 46.3% fall between 46 and 64 years. Only 4.69% are above 64 years, suggesting that a significant majority of respond-

ents are within the working-age group (16-64 years), which is crucial for agricultural labor and tree planting and management activities. The mean age of respondents is 44.76 years, which indicates a mature population that may possess substantial farming experience. The average family size of 6.43 suggests a reliance on family labor in tree planting and land restoration activities. Additionally, with an average landholding of 0.54 hectares, the size is relatively small, which may impact the scale of farming operations and limit agricultural productivity. The small landholding size underscores the importance of effective land management practices to enhance productivity and sustainability.

Result in Figure 2 shows percentages of adopters and non-adopters of tree planting are fairly consistent across the different slope categories. For flat areas, 55.9% of farmers adopted tree planting, while in gently sloping areas, the adoption rate was slightly lower at 54.5%. In moderately sloping areas, there is a notable increase in adoption at 67.4%, whereas steeply sloping areas show a return to a similar rate as flat areas at 56.0%. This suggests that while slope type may influence adoption rates, the differences are not markedly pronounced. The adoption rates appear relatively consistent across all slope types, suggesting that the slope's steepness does not significantly influence the decision to adopt tree planting and land restoration practices. The chi-square statistic ($\chi^2 = 1.96$, $p = 0.581$) indicates that there is no statistically significant relationship between slope type and tree planting adoption. A p-value above 0.05 suggests that the differences observed in adoption rates across the slope categories are likely due to random chance rather than a true effect. This implies that factors other than the slope may be more critical in determining whether farmers decide to adopt tree planting.

Given the lack of significant differences in adoption rates by slope type, it may be essential to explore other influencing factors that affect farmers' decisions to engage in tree planting. These could include personal beliefs, cultural practices, and access to resources, or support from extension services. The findings suggest that while environmental factors like slope may impact agricultural practices, they may not be the primary determinant for tree planting adoption. Instead, it may be beneficial to focus on enhancing education, providing training, and fostering community engagement to encourage greater adoption of tree planting and land restoration practices.

Numerous studies have shown that socio-economic and psychological factors often outweigh environmental considerations in agricultural decision-making. For instance, research by [28] highlights how farmers' attitudes toward sustainability significantly influence their adoption of tree planting and management practices, regardless of environmental constraints. Literature from [29] confirms that extension services and community-based approaches effectively promote sustainable tree planting and management practices, making a case for resource allocation in these areas. Studies focusing on micro-level factors may reveal that in certain regions, slope could have more pronounced effects on tree planting adoption, which would argue against a one-size-fits-all approach to understanding adoption behaviors. Previous research by [7] indicates that access to financial incentives can significantly alter adoption rates of tree planting and management, suggesting a more complex interplay between environmental and socio-economic factors.

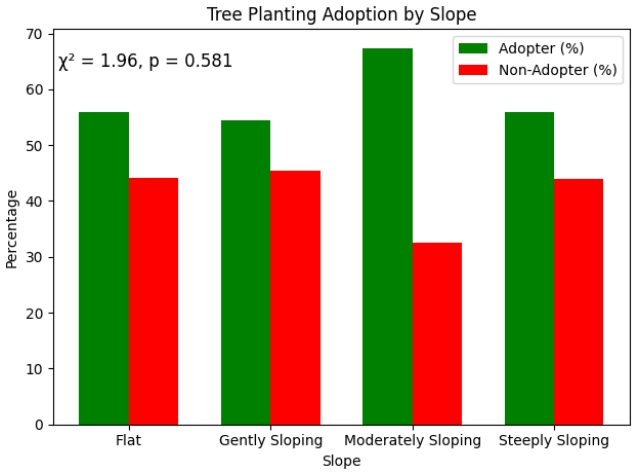

Figure 2. *Shows how tree planting and management was affected by slope gradient.*

Result in Figure 3 shows the bar chart clearly demonstrates the significant impact of extension agent contact on the adoption of tree planting. Among those without contact with extension agents, 6 (6.8%) adopted tree planting, while 12 (19.7%) did not adopt. This contrasts sharply with those who had contact, where 82 (93.2%) adopted tree planting. The data analysis shows that contact with extension agents significantly boosts adoption rates for tree planting and management. The chi-square value ($\chi^2 = 5.604$) with a p-value of 0.018 indicates a significant relationship between contact with extension agents and the adoption of tree planting.

The stark contrast in adoption rates between those who have and have not engaged with extension agents underscores the importance of these professionals in disseminating information and practices of tree planting and management. Farmers who interact with extension agents are more informed about the benefits and methods of implementing tree planting. Extension agents provide educational resources, technical assistance, and practical demonstrations, which likely enhance farmers' confidence in adopting tree planting and management practices. This support is crucial for overcoming barriers to adoption, such as lack of knowledge or perceived risks. The relationships formed between farmers and extension agents can lead to increased trust, further motivating farmers to adopt recommended practices. This trust is vital, particularly in communities where agricultural innovation is met with skepticism.

The present findings align with previous studies that emphasize the importance of extension agents in promoting agricultural practices. For instance, research has shown that extension services significantly enhance farmers' knowledge and confidence in adopting new technologies, leading to higher adoption rates [26]. The educational resources and technical assistance provided by extension agents are crucial for overcoming barriers to adoption, such as lack of knowledge or perceived risks. The relationships formed between farmers and extension agents can foster trust, which is essential for encouraging the adoption of new practices. When there are mended practices which is particularly skepticism towards agricultural innovations exists [9].

This trust is vital for effective knowledge transfer and can significantly impact farmers' decisions to engage in practices like tree planting and management. While the impact of extension agents on tree planting adoption is notable, it is also important to recognize that their influence may vary across different agricultural practices. This observation is consistent with findings from other studies that indicate varying levels of adoption based on the type of agricultural practices and tree planting and management being promoted [4].

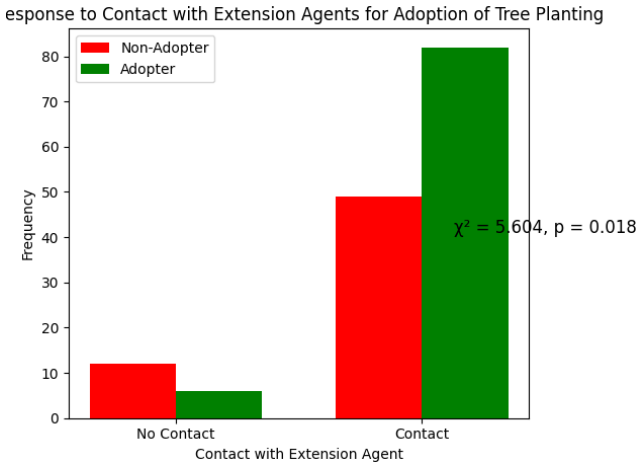

Figure 3. *Shows the extent of contact with extension agents for adopting tree planting and management.*

Result in Figure 5 shows tree planting, the numbers of adopters and non-adopters appear more similar, with adopter's still outnumbering non-adopters but not as dramatically. The chi-square statistic ($\chi^2 = 0.032$) with a p-value of 0.865 suggests no significant difference in the adoption rates related to training for tree planting practices. This indicates that training may not have a strong influence on the decision to adopt tree planting. The non-significant chi-square result for tree planting indicates that training does not significantly influence adoption levels. While the number of adopters is still higher, the lack of statistical significance suggests that other factors may be at play. The result implies that farmers might adopt tree planting for reasons unrelated to formal training, such as personal beliefs, cultural practices, or environmental awareness. Given the strong association between training and adoption, policymakers should prioritize the development and implementation of training programs focused on terrace construction. Such programs should include hands-on demonstrations, workshops, and continuous support to ensure farmers can effectively implement the techniques learned.

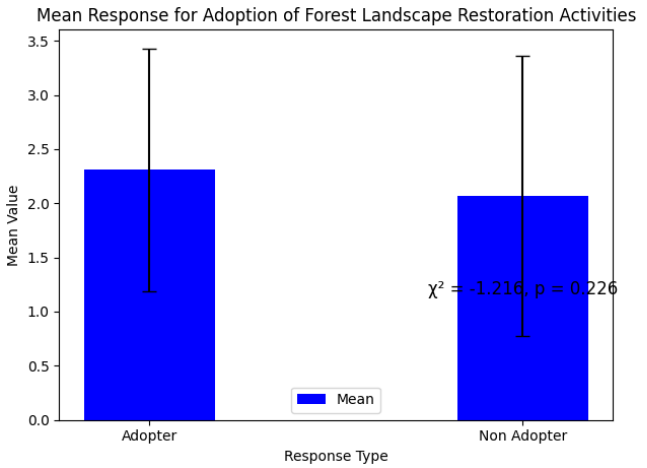

Figure 4. *Shows the extent of Training for adopting tree planting and management.*

Similar to the current findings, previous studies have shown that training alone does not significantly impact the adoption of agroforestry practices. For instance, a study in Nigeria found that while training programs were beneficial, many farmers adopted practices based on personal beliefs and cultural practices rather than formal training [3]. Research indicates that farmers often adopt tree planting for reasons unrelated to formal training, such as environmental awareness and cultural practices. A study conducted in Malawi highlighted that farmers' decisions to adopt agroforestry were influenced more by their perceptions of environmental benefits than by training received [5]. While the current results suggest limited influence of training on tree planting, other studies have shown that training can significantly enhance the adoption of different agricultural practices, such as terrace construction. For example, a study in Ethiopia demonstrated that hands-on training and continuous support led to higher adoption rates of soil conservation techniques, indicating that training can be effective when tailored to specific practices [2].

Result in Figure 5 shows bar chart presents the mean values for tree planting and management, differentiated by two groups' adopters and non-adopters. The statistical analysis is summarized with t-tests, indicating the significance of the differences observed between these groups. The mean value for adopters of tree planting is also higher than that of non-adopters; The t-test results yield a t-value of -1.216 with a p-

value of 0.226, suggesting that the difference in means are not statistically significant. This indicates that there is less distinction between the experiences or practices of adopters and non-adopters in the context of tree planting. The higher mean value suggests that adopters may be utilizing more effective techniques or experiencing better outcomes compared to non-adopters.

Figure 5. *Shows the extent of contact with extension services for adopting tree planting and management.*

Understanding the barriers faced by non-adopters is crucial. These barriers may include lack of awareness, resources, or perceived benefits. By addressing these issues, extension services can encourage more farmers to become adopters. The non-significant difference in mean values for tree planting highlights a more complex situation. While adopters have a higher mean value, the lack of statistical significance suggests that the factors influencing adoption of tree planting and management. This could indicate that various external factors such as environmental conditions, market access, or personal preferences might play a more significant role in tree planting adoption and management, making it less reliant on the influence of extension services alone. Research highlights that non-adopters often face barriers such as lack of awareness, resources, or perceived benefits, which can hinder their participation in tree planting initiatives. Addressing these barriers through targeted extension services could potentially increase adoption rates [1].

The non-significant difference in mean values for tree planting suggests that various external factors such as environmental conditions, market access, or personal preferences may play a more significant role in influencing adoption than the direct influence of extension services alone [16]. Studies on agroforestry adoption, such as those conducted under the Billion Trees Afforestation Project; show that timely adoption decisions significantly impact the success of tree planting initiatives. Factors like education and community organization positively influence adoption rates, indicating that the context of adoption matters greatly [18]. Evidence from randomized controlled trials (RCTs) suggests that programs aimed at increasing tree planting can lead to economic benefits for farmers, although the long-term impacts on income remain uncertain. This highlights the need for further research to establish a clearer link between tree planting and economic outcomes [15].

Result in Table 2 shows that there is a negligible negative correlation between the age of the household head and investment in forest restoration, but the p-value indicates that this relationship is not statistically significant. This suggests that age may not be a strong predictor of investment behavior in this context. The analysis indicates a negligible negative correlation between the age of the household head and investment in forest restoration. However, the p-value suggests that this relationship is not statistically significant, implying that age may not be a strong predictor of investment behavior in this context. This aligns with previous studies that have shown mixed results regarding age and investment decisions, often indicating that other factors may play a more critical role in influencing investment behavior [17].

The slight positive correlation suggests that larger family sizes may be associated with increased investment, but again, the high p-value shows that this relationship is not statistically significant. The slight positive correlation between family size and investment in forest restoration suggests that larger families may be associated with increased investment. However, the high p-value indicates that this relationship is not statistically significant. The present finding is consistent with literature that suggests family size can influence resource allocation but does not necessarily lead to significant differences in investment outcomes [35]. There is a moderate positive correlation between the level of education and investment in forest restoration. However, the p-value indicates that this correlation is not statistically significant at the 0.05 level, suggesting that while education may play a role, its impact is not strong enough to draw definitive conclusions. There is a moderate positive correlation between the level of education and investment in forest restoration. Yet, the p-value indicates that this correlation is not statistically significant at the 0.05 level. Previous research has similarly noted that while education can enhance awareness and understanding of sustainable practices, its direct impact on investment behavior may not be strong enough to yield definitive conclusions [32].

The positive correlation indicates that having a land certificate is associated with higher investment in forest restoration. The p-value approaches significance (0.076), suggesting that land tenure security may influence investment decisions. There is a strong positive correlation between farm size and investment in restoration efforts, with a p-value close to significance. This suggests that larger farms may have more resources or incentives to invest in sustainable practices. The positive correlation indicates some association between shorter plot distances and higher investments, with a

p-value nearing significance. This suggests that proximity may play a role in investment decisions. This strong positive correlation shows that livestock ownership is significantly associated with higher investments in forest restoration. The low p-value indicates that this finding is statistically significant, suggesting that livestock may provide both a resource base and motivation for investment in sustainable practices. There is a strong positive correlation with significant statistical support between farmers' perceptions of land tenure security and their investment in restoration efforts.

The present study shows that that perceived security in land ownership directly influences farmers' willingness to invest in long-term sustainability. The analysis reveals that certain factors, particularly livestock ownership and farmers' perceptions of land tenure security, have a significant and positive correlation with investments in forest landscape restoration. In contrast, other variables such as family size and education level show weak correlations. The findings highlight the importance of land tenure security as a key driver for investment decisions, indicating that policies aimed at securing land rights may enhance farmers' engagement in sustainable practices. Further research is needed to explore the underlying mechanisms of these relationships and to evaluate the effectiveness of extension services in promoting investment in forest restoration.

Table 1. *Pearson Correlation Coefficients with P-Values of different factors in adopting tree planting.*

Variables	Coefficient	P-Value
Age of Household Head	-0.005508	0.643
Family Size	0.0372271	0.565
Level of Education	0.3581152	0.140
Land Certificate	0.5968514	0.076
Farm Size	0.6556831	0.065
Frequency of Extension Agent Contact	-0.061163	0.573
Training on Sustainable Forest Management	-0.112568	0.653
Plot Distance	0.085584	0.097
Livestock Ownership	0.856905	0.002
Farmers' Perception of Land Tenure Security	0.786638	0.020

Result in Table 2 shows result of chi-square test with a p-value of 0.0000 signifies that the model is statistically significant. This means that the independent variables included in the model collectively have a significant effect on the likelihood of tree planting adoption and management. In other words, the model successfully explains a noteworthy portion of the variability in the adoption behavior among the observed households. Overall, these metrics suggest that the model is a robust tool for understanding the factors influencing tree planting decisions.

Result indicates that coefficient for the age of the household head is -0.0055, which is not statistically significant. This indicates that as the age of the household head increases, there is a very slight decrease in the likelihood of adopting tree planting and management practices. However, since this finding is not statistically significant, we can conclude that age does not play a meaningful role in influencing tree planting decisions and management practices. This lack of significance indicates that older individuals may not be less inclined to engage in tree planting compared to younger ones. In many agricultural settings, older farmers might have extensive experience and knowledge, potentially making them more receptive to sustainable practices. Alternatively, age-related factors such as physical limitations or traditional mindsets may not be as influential in the context of tree planting and management, indicating that other factors might drive the adoption of this practice more effectively than age alone.

The result indicates that the coefficient for family size is 0.0372, which is also not statistically significant. This finding implies that the size of the family does not have a notable impact on the decision to adopt tree planting practices. While one might expect larger families to have more labor resources available for planting and maintaining trees, this analysis suggests that family size does not significantly influence tree planting adoption. It could be that other factors, such as individual motivation, access to resources, or external support, play a more critical role. This finding also reflects the complexity of household dynamics, where mere numbers do not translate to effective engagement in sustainable practices like tree planting.

The coefficient for level of education is 0.3581, which is similarly not statistically significant. This indicates that education level does not strongly predict the likelihood of engaging in tree planting behavior. Education is often viewed as a key factor in promoting sustainable agricultural practices. However, this result suggests that simply having a higher level of education does not automatically translate into a greater likelihood of adopting tree planting. This could indicate that educational content, rather than the level of education itself, is more crucial. For instance, if education does not specifically address environmental stewardship or sustainable farming practices, it may not significantly influence behavior. Additionally, practical experience and community norms might play a more substantial role in shaping decisions related to tree planting than formal education alone. In another studies made in Southern, Tigray and Amhara region also underlined that the importance of certification likely to reduce the amount of border disputes, due to the fact that better demarcation of plot borders and renewal of witnesses

on the location of plot borders [19].

The coefficient for holding a land certificate is 0.5969, which is significant at the 10% level. This finding indicates that having a land certificate positively influences the likelihood of adopting tree planting practices. The implication here is profound: secure land rights foster a sense of ownership and stability, which encourages households to invest in long-term agricultural practices like tree planting. When farmers feel secure about their land tenure, they are more likely to engage in sustainable practices that benefit both the environment and their livelihoods. The result reflects a broader theme in agricultural development when farmers have confidence in their land ownership, they are more willing to invest time and resources into practices that may not yield immediate returns but will benefit future generations. In line with this, a study conducted in Central Rift Valley of Ethiopia revealed that almost all the farmers have some kind of awareness about the rights and responsibilities of farmers after getting certificates [25]. Another study conducted in Amhara region indicate that respondents knowledge of basic land right and obligation are found to be highest [27].

The coefficient for farm size is 0.6557, also significant at the 10% level. This suggests that larger farm sizes are associated with a higher likelihood of adopting tree planting. Larger farms likely have more resources available, such as land, labor, and capital, which can facilitate the adoption of tree planting. Farmers with larger plots may view tree planting as a viable investment, as they can allocate sufficient space and resources for both crops and trees. This connection between farm size and adoption rates highlights the importance of resource availability in promoting sustainable practices. However, it also raises a question about smaller farms how can they be supported to engage in tree planting when they may lack the same resources Land right security can't be directly measured and to large extent it is what people perceived it to be and it attribute may change from one context to another [33]. Hence, to measure perception of household on land security the respondents were asked of their feeling about land security before and after getting land certificate.

The coefficient for frequency of extension agent contact is -0.0612, which is not significant. This indicates that interaction with extension agents does not significantly affect tree planting decisions. The lack of significance suggests that simply having contact with extension agents may not be enough to inspire action. It raises the possibility that the quality, relevance, and content of the information provided by these agents are more critical than the frequency of contact. Farmers may need tailored advice that directly addresses their specific circumstances and challenges related to tree planting. This insight points to the need for more effective agricultural extension programs that not only disseminate information but also engage farmers in meaningful dialogue about sustainable practices.

The coefficient for training on sustainable forest management is -0.1126, which is not statistically significant. This suggests that training programs in sustainable practices do not significantly influence tree planting adoption. While training is generally considered essential for promoting sustainable practices, this finding indicates that the training may not be adequately addressing the real needs of farmers or may lack practical application. It could also suggest that farmers require more hands-on, localized training that integrates sustainable practices into their existing agricultural routines. Furthermore, the effectiveness of training programs may depend on how well they resonate with the farmers' experiences and knowledge, emphasizing the importance of relevance in educational content.

The coefficient for plot distance is 0.0856, significant at the 10% level. This suggests that greater distances from home to planting plots may slightly enhance the likelihood of adopting tree planting. This finding could be interpreted as an indication that farmers may be more inclined to invest in tree planting when they have access to more land, even if it is farther from their homes. The increased land availability might present opportunities for agricultural diversification, where farmers can plant trees alongside traditional crops. However, this raises logistical considerations how will distance impact the maintenance and care of planted trees? Effective support systems may be necessary to assist farmers in managing distant plots.

The coefficient for livestock ownership is 0.2857, significant at the 1% level. This indicates that owning livestock significantly increases the likelihood of adopting tree planting. The positive relationship between livestock ownership and tree planting adoption can be attributed to the resources and income that livestock provide. Farmers with livestock may have more financial stability, enabling them to invest in tree planting as a long-term benefit. Additionally, livestock can be integrated into agroforestry systems, where trees provide shade and fodder, and livestock contribute to soil fertility through manure. This interconnectedness highlights the synergies that can exist between livestock farming and tree planting.

The coefficient for farmers' perception of land tenure security is 1.0066, significant at the 5% level. This strong correlation suggests that a positive perception of land tenure security is closely linked to tree planting adoption. This finding underscores the critical role that confidence in land ownership plays in promoting sustainable agricultural practices. When farmers believe their land is secure, they are more likely to invest in practices like tree planting that require long-term commitment. This highlights the importance of policies and frameworks that enhance land tenure security, which can, in turn, foster investment in sustainable practices that benefit both the environment and farmers' livelihoods.

Table 2. *Probit regression results for tree planting.*

Variables	Coefficient	z-value	P>|z|	Marginal effect
Age of household head	-0.005508	-0.46	0.643	-0.002094
Family size	0.0372271	0.58	0.565	0.0141538
Level of education	0.3581152	1.48	0.140	0.1340888
Land certificate	0.5968514	1.77**	0.076	0.2332993
Farm size	0.6556831	1.85**	0.065	0.2492918
Frequency of extension agent contact	-0.061163	-0.56	0.573	-0.0232543
Training on sustainable forest management	-0.112568	-0.45	0.653	-0.0429693
Plot distance	0.085584	1.66**	0.097	0.0325392
Livestock ownership	0.2856905	3.14***	0.002	0.10862
Farmers' perception of land tenure security	1.006638	2.33***	0.020	0.3830458
_cons	-2.498645	-3.08	0.002	
Number of observations = 149				
Log likelihood function= -69.857021				
$-2\ln(L_R/L_U) = 37.60$				
Prob > chi2 = 0.0000				

Source: Survey data (2012*)* ***, and ** indicate statistically significant at 1% and 5% probability levels, respectively

4. Conclusion

Findings from the study underscore the critical interplay between demographic characteristics, environmental factors, and extension services in influencing tree planting adoption and land management practices. The predominance of male-headed households highlights the necessity of incorporating gender dynamics into interventions, ensuring women's participation in decision-making processes. Furthermore, the low educational levels of farmers indicate an urgent need for targeted educational programs to empower them with the knowledge required for sustainable agriculture. Age distribution suggests a workforce rich in experience, yet potentially resistant to new practices, pointing to the importance of leveraging this experience while introducing innovative techniques. While the age distribution of the workforce reflects significant experience, it also suggests potential resistance to adopting new practices, emphasizing the importance of leveraging this experience while introducing innovative techniques.

The analysis reveals that while slope type does not significantly affect tree planting adoption, the role of extension agents is pivotal. Farmers who engage with extension services exhibit markedly higher adoption rates, which emphasize the need for effective outreach and tailored support that meets farmers' unique challenges. However, training on sustainable practices appears less impactful for tree planting, suggesting that the content and application of training must be more relevant to farmers' situational needs. The critical role of extension agents is evident, with farmers engaging with these services demonstrating significantly higher adoption rates. This underscores the necessity for effective outreach and tailored support that addresses farmers' unique challenges.

Moreover, correlations indicate that land tenure security, larger farm sizes, and livestock ownership are significant predictors of investment in forest restoration. Particularly, perceptions of land security strongly influence farmers' willingness to adopt long-term practices such as tree planting. This highlights the importance of policies that enhance land rights, as secure ownership fosters confidence and encourages sustainable investments. Significant predictors of investment in forest restoration include land tenure security, larger farm sizes, and livestock ownership. Notably, perceptions of land security are crucial in influencing farmers' willingness to adopt long-term practices like tree planting.

The study concludes for a multifaceted approach to promoting sustainable land management, emphasizing the need for educational initiatives, gender-inclusive practices, and robust support systems that enhance land tenure security. Addressing these aspects could significantly improve the effectiveness and adoption rates of tree planting and other sustainable agricultural practices within the community.

Abbreviations

P	Probability
ln	Logarithm
Chi	Chi-square
RCTs	Randomized Controlled Trials
%	Percent
SPSS	Statistical Package for Social Sciences
VFI	Variance Inflation Factor
CC	Contingency Coefficient

Author Contributions

Bisrat Hailemichael: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft

Melaku Bekele: Investigation, Supervision, Visualization

Tamirat Teshome: Conceptualization, Methodology, Resources, Supervision, Visualization, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Abebaw A, Janekarnkij P, Wangwacharakul V (2011). Analysis of factors affecting adoption of soil conservation measures among rural households of Gursum, Ethiopia. Kasetsart J Soc Sci; 32(3): 503–515.

[2] Action Aid Ethiopia (AAE). (2006). Case study on policies and practices for securing and improving access to and control over land in Ethiopia. Prepared for International Conference on Agrarian Reform and Rural Development (ICARRD).

[3] Adal Y. Problems and prospects of rural land policy in Ethiopia. AESE (2003); 49-62.

[4] Adenew B, Abdi F. A (2005). Research Report 3 on Land registration in Amhara Region Ethiopia. Securing Land Rights in Africa.

[5] Amsalu A, Graaff J. (2005). Determinants of Adoption and Continued use of Stone terraces, soil and water conservation in Ethiopian highland.

[6] Ayele ZE (2008). Tree growing by Smallholders Farmers in the high land of Ethiopa. A Dissertation Presented to the School of Graduate Studies of Oregon State University.

[7] Bekele W, Drake L (2003). Soil and Water Conservation Decision Behaviour of Subsistence Farmers in the eastern Highlands of Ethiopia: A case study of the Hunde-Lafto area. Ecol Econ; 46: 437-451.

[8] Bell, K. (2006). World Bank support for land administration and management: Responding to the challenges of the millennium development goals.

[9] Brasselle AS, Gaspart F, Platteau JP. Land Tenure Security and Investment Incentives: Puzzling evidence from Burkina Faso. J Dev Econ 2002; 67(2): 373–418.

[10] Crewett W, Bogale A, Korf B. (2008). Land Tenure in Ethiopia: Continuity and Change, Shifting Rulers, and the Quest for State Control. CAPRi Working Paper 91. Int Food Policy Res Inst.

[11] CSA.(2009). (Central Statistical Authority of Ethiopia) Statistical Abstract, Addis Ababa.

[12] Dagnew M, Hagos F, Nicck C(2009). Implications of land titling on tenure security and long-term land investment: Case of Kilte Awela'elo woreda, Tigray. Ethiopia proceedings of: Sustainable land management research and institutionalization of future collaborative research. Mekelle Univerity; 264-266.

[13] Deininger K, Jin S. (2006). Tenure Security and Land-related Investment: Evidence from Ethiopia. Eur Econ Rev; 50: 1 245-1277.

[14] EEA/EEPRI (2002). (Ethiopian Economics Association / Ethiopian Policy Research Institute).

[15] Eleni T. (2008). Continued Use of Soil and Water Conservation Practices: A Case study in Tulla District, Ethiopia. MSc Thesis, Wageningen University, the Netherlands.

[16] Ersado L, Amacher G, Alwang J. (2004). Productivity and land enhancing technologies in northern Ethiopia: Health, public investments, and sequential adoption. Am J Agric Econ; 86(2): 321-331. 11 of 12 ANALYSIS ARTICLE | OPEN ACCESS.

[17] FAO (2002). (Food and agriculture organization). FAO Land Tenure studies 3. Land tenure and Development. Food and Agricultural organization of the United Nations, Rome.

[18] Federal Democratic Republic of Ethiopia (FDRE) (2005). Rural Land Administration and Use Proclamation No. 456/2005. The Federal Negarit Gazeta, Addis Ababa.

[19] Gabreselassie S. (2006). Land, land policy and smallholder agriculture in Ethiopia: Options and scenarios. Paper prepared for the Future Agricultures Consortium meeting. Future Agric.

[20] Gebremedhin B, Swinton S. (2003). Investment in Soil Conservation in Northern Ethiopia: The role of tenure security and public programs. Forth coming in Agricultural Economics.

[21] Giri S.(2010). The Effect of Rural Land Registration and Certification Programme on Farmers' Investments in Soil Conservation and Land Management in the Central Rift Valley of Ethiopia. MSc Thesis, Wageningen University, Wageningen UR.

[22] Girma. A (2000). Participatory Approach to Agro forestry in Watershed Management: A Case study at Yanessie, Southern Ethiopia. Unpublished MA thesis. Wageningen University. Highland smallholders in Ethiopia. Agric Econ; 22: 217 232.

[23] Gobena M. (2010). Effects of Large-scale Land Acquisition in Rural Ethiopia. The Case of Bako-Tibe Woreda, Master Thesis Swedish University of Agricultural Sciences, Uppsala.

[24] Habtamu E (2006). Adoption of Physical Soil and Water Conservation Structures in Anna Watershed, Hadiya Zone, Ethiopia. An MSc Thesis Presented to the School of Graduate Studies of Addis Ababa University.

[25] Hagos F, Pender J, Gebreselassie N.(2023). Causes of and responses to land degradation. In Land degradation and strategies for sustainable land management in the Etiopian Highlands: Tigray region (Second edition). Nairobi: International Livestock Research Institute (ILRI) 2002; 14-26. Discovery 59, e82d1271.

[26] Heyi DD (2012). Determinants of farmers' land management practices: The case of Tole district, South West Shewa zone, Oromia national regional state, Ethiopia. J Sustain Dev Afr; 14(1).

[27] Holden S, Yohannes H (2002). Land Redistribution, Tenure Insecurity, and Intensity of Production: A Study of Farm Households in Southern Ethiopia. Land Econ; 78(4): 573 590.

[28] Nega B, Degefa B, Sellasie SG (2003). Current Land Policy Issues in Ethiopia. In Land Reform: Land Settlements and Cooperatives 2003/3. Special Edition. Groppo P (editor). Rome. Food Agric Organ; 103-124.

[29] Pound B, Jonfa E (2005). Soil Fertility Practice in Wolita zone, southern Ethiopia: Learning from farmers. Policy and research series. Farm Africa, Review. Addis Ababa: Forum for Social Studies; 27.

[30] Qoricho YT (2011). Women and Land Rights in Rural Ethiopia: The Case of Wolaita, MSc Thesis, University of Tromsø, Norway.

[31] Rahmato D. (2007). Development Interventions in Wollaita, 1960s 2000s: A Critical Review. Addis Ababa. Forum Soc Stud.

[32] Rodrick D (1988). Imperfection Competition, Scale Economies and Trade Policy in Developing Countries. In Baldwin RE (editor). Trade Policy Issues and Empirical Analysis. London: National Bureau of Economic Research.

[33] Taye A. A.(2006). Caring for the Land: Best Practices in Soil Water Conservation in Beressa Watershed, highlands of Ethiopia. Wageningen University, the Netherlands. Ecol Econ; 46: 437-451.

[34] Tesfaye T, Lemi A.(2004). Factors affecting entry and intensity in informal rental land markets in Southern Ethiopian highlands. Agricultural Econ; 30: 117-128.

[35] Yirga. C. (2008). Land Tenure Security and Adoption of Natural Resource Management Technologies in Ethiopia. Holetta Agricultural Research Center. Addis Ababa, Ethiopia.