

Research Article

Impact of Socio-economic and Environmental Factors on Land Restoration Initiatives by Farmers: Evidence from Soddo Zuria Woreda, Southern Ethiopia

Bisrat Hailemichael¹, Melaku Bekele^{2,*}, Teshome Tamirat³ 

¹Forest Resources Monitoring Department, Ethiopian Forestry Development, Addis Ababa, Ethiopia

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

³Bamboo Development Desk, Ethiopian Forestry Development, Addis Ababa, Ethiopia

Abstract

Land degradation is a critical issue in southern Ethiopia, contributing significantly to food insecurity and rural migration. Despite various intervention programs, the management of this vital resource remains inadequate, leading to declining productivity. This study investigates impact of socio-economic and environmental factors on land restoration initiatives for adoption of soil and water conservation practices. A total of 149 household heads were selected using probability proportional method from three villages with data collected through structured questionnaires. Descriptive and inferential statistics using a probit model were employed to analyze the data. Result showed that the role of extension agents is emphasized; as contact with these professionals significantly boosts adoption rates soil and water conservation practices. The analysis reveals significant differences in the adoption of agricultural practices among adopters and non-adopters, particularly for soil bund construction and terrace construction. For soil bund construction, adopters demonstrate a mean value of approximately 2.5 compared to 0.5 for non-adopters, with a statistically significant t-test result ($t = 3.194$, $p = 0.038$). The result indicated that those who adopt this practice are more effective and engaged, possibly due to enhanced skills from training offered. Overall, these findings underscore the importance of targeted training programs to promote effective agricultural practices and highlight the need to understand barriers faced by non-adopters. In conclusion, the analysis highlights significant differences in the adoption of soil bund construction and terrace construction practices among farmers. Adopters of soil bund construction are notably more effective, likely due to targeted training. These findings emphasize the necessity of focused training programs to enhance agricultural practices with respect to soil and water conservation and address barriers faced by non-adopters to enhance the Green Legacy initiative outcomes in more sustainable manner.

Keywords

Certification, Land, Registration, Perception, Tenure Security

*Corresponding author: bekelemelaku@yahoo.com (Melaku Bekele)

Received: 10 March 2025; **Accepted:** 31 March 2025; **Published:** 28 April 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

1. Introduction

In the Global South, tenure insecurity is prevalent, particularly in agricultural and forest landscapes of developing countries [3]. Hence, understanding the historical context of this insecurity is crucial for identifying opportunities to mitigate future risks and enhance land management practices [5]. Most of rural populations depend on natural resources for their livelihoods, agricultural productivity is threatened by land degradation [6]. Factors such as population pressure, and poverty, land tenure insecurity, and insufficient market integration complicate the scenario further [7]. Cultural and identity ties to land also play a crucial role, as land is not only a means of production but also a vital asset for wealth accumulation and intergenerational transfer [9]. Access to land is particularly critical for Ethiopian smallholders, where land policy has historically shaped socio-economic conditions [12]. Current challenges include land degradation, fragmentation, and the increasing number of landless individuals [13, 20]. Ethiopia's land tenure system has evolved from a diverse system with significant insecurity and inequality to a state-controlled regime post-1975, which has resulted in further declines in tenure security and productivity [17].

The Ethiopian government has initiated a national land certification program to address these issues, aiming to enhance property rights and promote sustainable land use [21]. While some regions have begun implementing land certification, limited research has explored its effects on farmers' investment in land management, particularly in Soddo Zuria Woreda [19]. This study seeks to analyze rural community perceptions of land registration and certification and their implications for tenure security in the region [10, 22]. Few studies capture the local community's perceptions and attitudes towards soil and water conservation practices, which are crucial for understanding the effectiveness of interventions [20]. Existing studies often overlook the specific impacts of physiographic conditions on farmers' investments in soil and water conservation, particularly in diverse topographies like those found in Soddo Zuria Woreda [15]. While some research highlights the role of agricultural extension services, there is a lack of comprehensive evaluations of how these services specifically influence farmers' decisions regarding soil and water conservation investments [11].

Many studies fail to address the gender aspects of land management and investment in conservation practices, particularly the participation and influence of women in these processes [1, 15]. There is a need for longitudinal research that examines changes over time in farmers' investment behaviors in relation to physiographic and extension service variables [14]. The objective this study is investigate how various physiographic factors, such as slope, soil type, and climate, influence farmers' investments in soil and water conservation practices. It also investigates the effectiveness of agricultural extension services in promoting soil and water

conservation investments among farmers. It identifies factors that enhance or hinder their impact and examine the participation of different genders in conservation practices and the influence of gender on investment decisions related to soil and water management in Soddo Zuria Woreda.

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 °C to 20 °C, accompanied by an average annual rainfall of about 1200 mm.

Soddo Zuriya predominantly falls within the woiyana 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.

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.

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 ques-

tionnaire was conducted with 5-6 households before the main survey.

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:

$$y_i = x_i\beta_1 + u_i \quad y_i = 1 \text{ if } y_i > 0, y_i = 0 \text{ if } y_i \leq 0$$

where:

$$y_i = 1 \text{ if } y_i > 0, y_i = 0 \text{ if } y_i \leq 0$$

$$y_i = 0 \text{ if } y_i \leq 0, y_i = 1 \text{ if } y_i > 0$$

x_i represents independent variables affecting participation in sustainable land management (SLM) practices

β_1 denotes unknown parameters

u_i 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

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 for soil and water conservation practices.

The small percentages of single (1.3%), widowed (6.7%), and divorced (5.4%) respondents indicated 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 in soil and land management, as education often correlates with information access and the ability to implement new techniques on soil and water conservation activities.

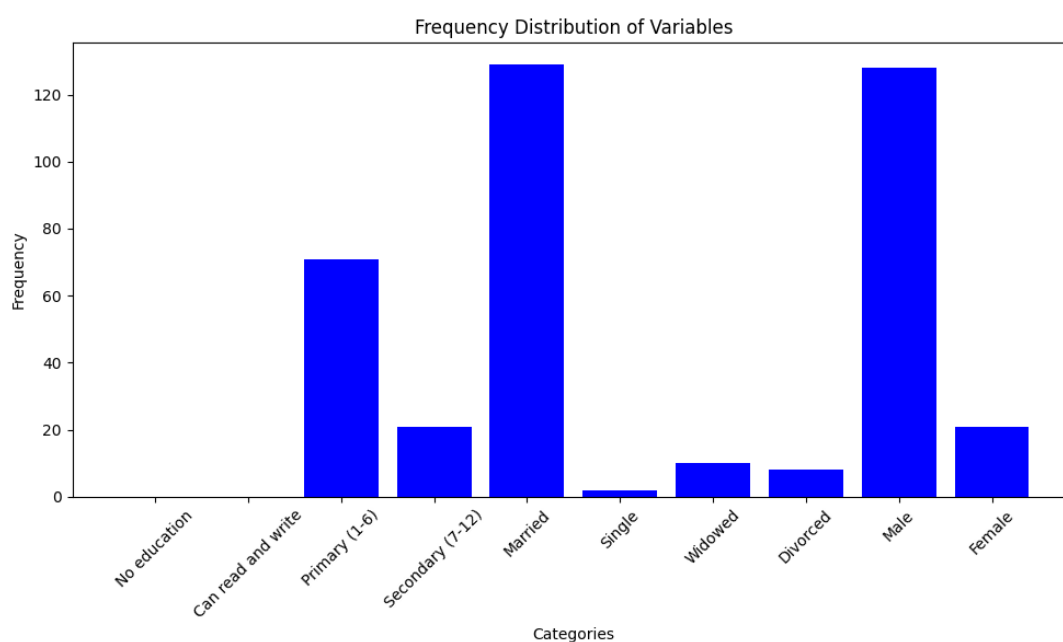


Figure 1. Depict the demographic distribution of respondents with respect soil and water conservation activities.

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, indicating that a significant majority of respondents are within the working-age group (16-64 years), which is crucial for contribution of agricultural labor for soil and water conservation practices. The mean age of respondents is 44.76 years, which indicates a mature population that may possess substantial farming experience with respect to adoption of soil and water conservation measures. The average family size of 6.43 suggests a reliance on family labor in agricultural activities. Additionally, with an average land-holding 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 the data presents the adoption rates for soil bund construction across various slope types on flat, gently sloping, moderately sloping, and steeply sloping. The results include percentages of adopters and non-adopters, along with chi-square statistics to assess significance. In flat areas, a relatively low percentage of farmers (38.2%) have adopted soil bund construction. The high rate of non-adoption (61.8%) suggests that farmers may not perceive a pressing need for soil bunds in these environments, likely due to a lower risk of soil erosion compared to sloped terrains. Adoption rates increase significantly in gently sloping areas, with 63.6% of farmers constructing soil bunds.

The reduced risk of erosion in these areas compared to steeper slopes may lead to a balanced perspective among farmers, recognizing the benefits of soil bunds without feeling an overwhelming urgency. The adoption rate escalates notably to 82.6% in moderately sloping areas. Here, the perceived necessity for soil bunds becomes more pronounced,

as farmers are likely more aware of the erosion risks associated with their terrain. This indicates a proactive approach to soil conservation. Steeply sloping areas display the highest adoption rate at 84.0%.

Farmers in these regions are likely aware of the critical need for soil bunds to combat severe erosion challenges. The low percentage of non-adopters (16.0%) may indicate that most farmers recognize the importance of this practice for sustainable land management. The data suggests that the perceived necessity for soil bunds increases with the steepness of the slope. In flat areas, the need for erosion control is minimal, leading to lower adoption rates. Conversely, in steep areas, the urgency for soil conservation drives higher adoption. The higher adoption rates in gently, moderately, and steeply sloping areas may also reflect greater awareness and education regarding the benefits of soil bunds. Farmers in these regions may have access to information about erosion risks and the advantages of implementing soil bunds. Farmers in flat areas may prioritize other agricultural practices that seem more beneficial or less costly compared to the perceived benefits of soil bund construction. In contrast, those in sloped areas may view soil bunds as a necessary investment to protect their land and ensure long-term productivity.

The findings align with result of similar studies that indicate minimal erosion concerns in flatter regions, leading to lower adoption of conservation practices [16]. They recognize the benefits of soil bunds without feeling an overwhelming urgency, which is consistent with studies showing that moderate slopes can lead to increased awareness of erosion risks [4]. The perceived necessity for soil bunds becomes more pronounced. Farmers are likely more aware of the erosion risks associated with their terrain, reflecting a proactive approach to soil conservation. This is supported by another research indicating that as the slope increases, so does the awareness and adoption of conservation practices [17].

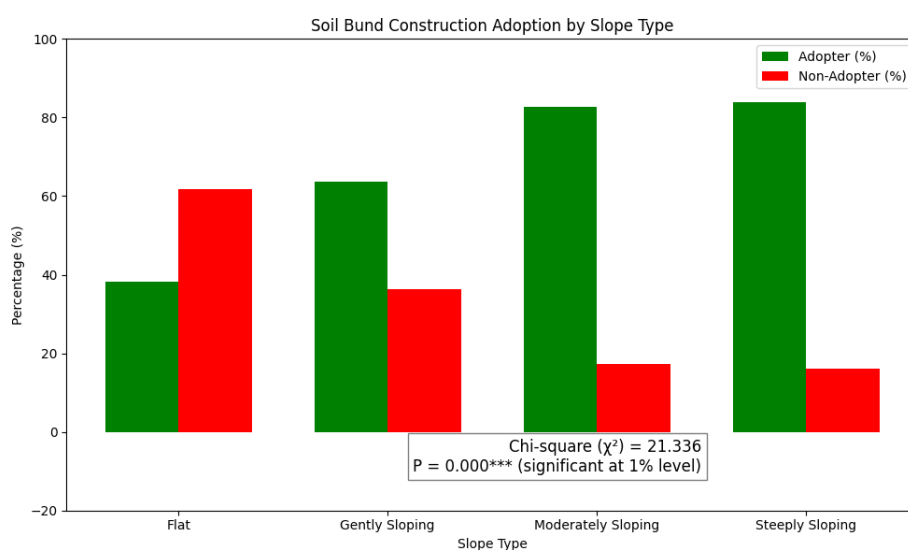


Figure 2. Shows soil bund construction adoption by slope.

Result in Figure 3 shows result that out of 149 respondents who did not have contact with extension agents, only 4 (4.0%) adopted soil bund construction, while 14 (28.6%) were non-adopters. In contrast, 96 out of 131 respondents who had contact with extension agents adopted soil bunds, resulting in a significantly higher adoption rate of 96.0%. The chi-square test ($\chi^2 = 18.694$) and the p-value (0.000) indicate a highly significant relationship between contact with extension agents and the adoption of soil bunds. This suggests that engagement with extension services is a critical factor in promoting this conservation practice with respect soil bund construction.

The bar chart clearly demonstrates the significant impact of extension agent contact on the adoption of soil bund construction. Soil bund adoption shows a strong correlation. This underscores the importance of enhancing extension services contact frequency as a means to promote sustainable agricultural practices and improve land management among farmers. By investing in these services, policymakers can

foster greater adoption, leading to improved agricultural productivity and environmental sustainability.

Findings of similar study by [18] 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. Farmers who interact with extension agents are more informed about the benefits and methods of implementing soil bunds and tree planting. Extension agents provide educational resources, technical assistance, and practical demonstrations, which likely enhance farmers' confidence in adopting these 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 [19].

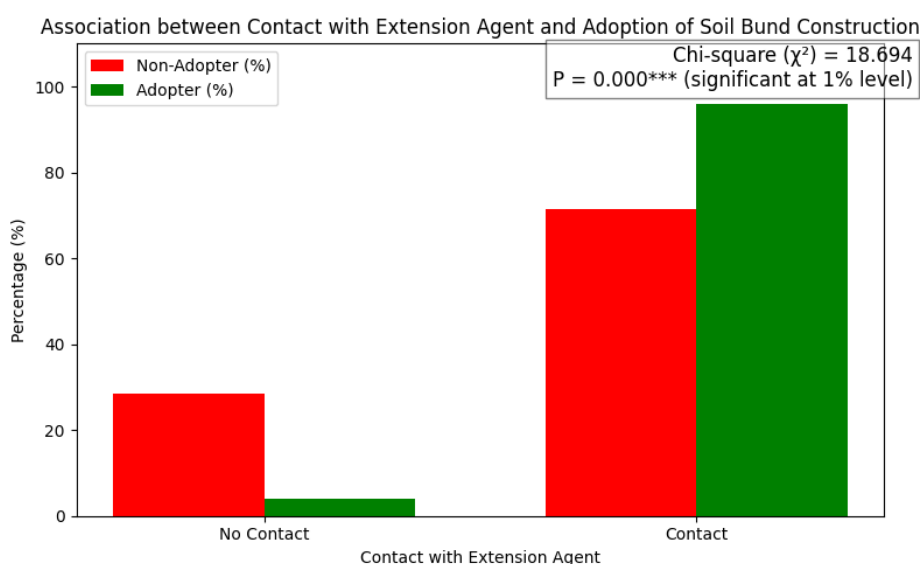


Figure 3. Shows the impact of extension agent contact on adoption of soil bund construction.

Result in Figure 4 shows the bar chart presents the mean values for adapter and non- adapter of soil bund construction differentiated by two groups. Statistical analysis is summarized with t-tests, indicating the significance of the differences observed between these groups. The mean value for adopters is significantly higher (approximately 2.5) than for non-adopters (approximately 0.5). The t-test results show a t-value of 3.194 with a p-value of 0.038, indicating a statistically significant difference between the two groups. This suggests that those who adopt soil bund construction practices engage with them more extensively or effectively compared to non-adopters.

The significant difference in mean values for soil bund

construction indicates that adopters are more likely to implement and benefit from this practice. The higher mean value suggests that adopters may be utilizing more effective techniques or experiencing better outcomes compared to non-adopters. This could be attributed to the increased knowledge and skills gained through extension services or peer influence, which enhance the effectiveness of soil bunds in combating soil erosion and improving water retention.

Given the strong positive impact of adoption on soil bund construction, policies should focus on promoting this practice. This could involve targeted training sessions, workshops, and demonstration projects to showcase the benefits and methods of soil bund construction. Understanding the

barriers faced by non-adopters is crucial. These barriers may include lack of awareness, resources, or perceived benefits [20]. By addressing these issues, extension services can encourage more farmers to become adopters. The non-significant difference in mean values for tree planting high-

lights a more complex situation. While adopters have a higher mean value, the lack of statistical significance suggests that the factors influencing adoption may not be as strong or clear-cut as those for soil bund construction [2, 14].

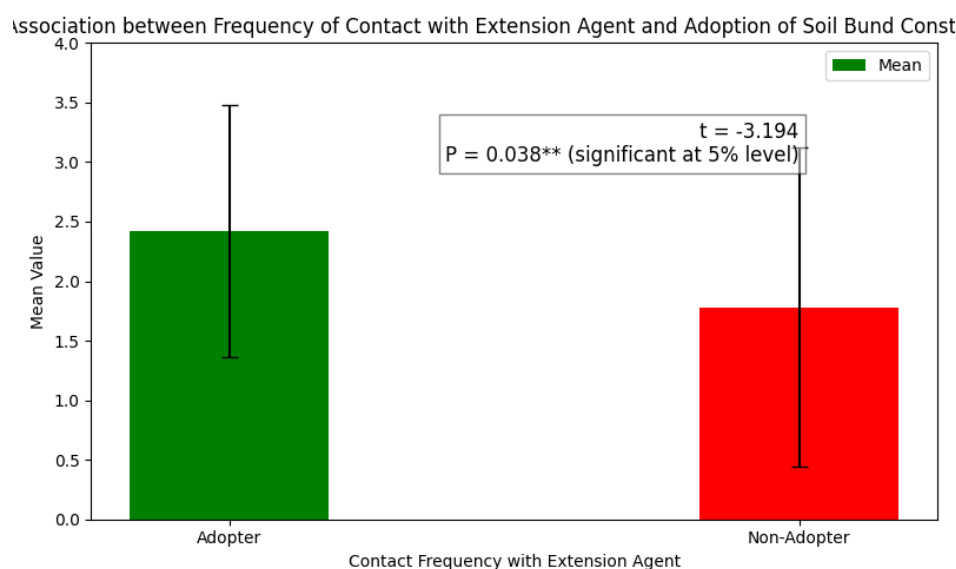


Figure 4. Shows the adaptor and non-adaptor for soil bund construction.

Result in Figure 5 shows the bar chart illustrates the number of respondents categorized as "Adopters" and "Non-Adopters" for training of farmers for terrace construction. The statistical results are summarized with chi-square (χ^2) tests, which assess the association between training received and the adoption of these practices for terrace construction. The chart shows that there are significantly more adopters (indicated by the orange bar) compared to non-adopters (indicated by the blue bar). The chi-square statistic ($\chi^2 = 4.839$) with a p-value of 0.028 indicates a statistically significant difference in the number of respondents who adopted terrace construction based on whether they received training. The significant chi-square result for terrace construction indicates that training positively affects adoption. Those who received training are more likely to adopt terrace construction as a soil conservation practice.

Identifying barriers that non-adopters face when considering terrace construction is crucial. These barriers may include financial constraints, lack of access to resources, or skepticism about the effectiveness of the practice. Addressing these barriers through tailored support can further enhance adoption rates. This suggests that the training programs are effective in educating farmers about the benefits, techniques, and importance of terrace construction, which can lead to improved soil management and erosion control [3]. This result imply that farmers might adopt terrace building for reasons unrelated to formal training, such as personal beliefs, cultural practices, or environmental awareness. Giv-

en 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 [4].

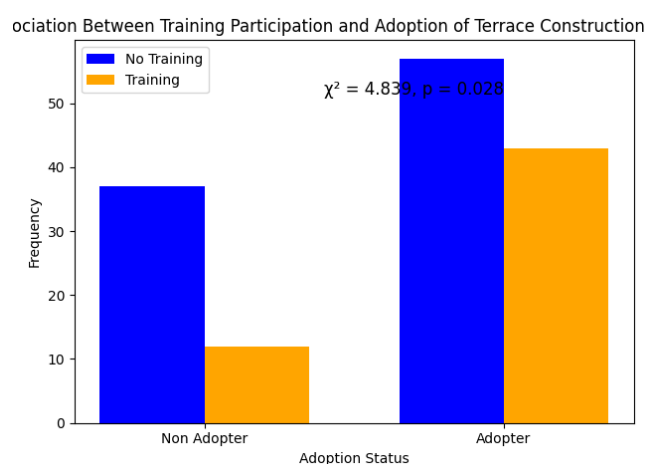


Figure 5. Shows the impact of training on adoption of terraces.

Result in Table-1 shows the positive correlation indicates that larger family sizes may somewhat correlate with in-

creased investment in sustainable practices and soil and water conservation practices. The p-value is close to significance (0.062), suggesting that family size could be a relevant factor. This positive correlation indicates that more frequent contact with extension agents is significantly associated with higher investments in sustainable practices. The p-value of 0.026 indicates statistical significance, suggesting that effective extension services could enhance investment behavior among farmers. The strong positive correlation suggests that training on soil and water conservation has a significant impact on investment in sustainable practices.

The low p-value indicates strong statistical significance, highlighting the importance of targeted training programs in promoting sustainable agricultural practices with respect to soil and water conservation activities. A strong positive correlation indicates that steeper slopes are significantly associated with increased investment in sustainable practices with respect to soil and water conservation activities. The low p-value (0.002) suggests that topography may play an important role in shaping investment behaviors. The analysis reveals that certain factors, particularly training on soil and water conservation and the frequency of extension agent contact, have significant positive correlations with investments in sustainable practices. Additionally, slope also demonstrates a significant positive relationship. In contrast, factors such as age, level of education, and livestock ownership show weak or no significant relationships [8].

These findings emphasize the importance of targeted training and effective extension services in promoting sustainable agricultural investments. The results also highlight the need for further investigation into the counterintuitive findings regarding education and land tenure perception to understand the underlying dynamics influencing farmers' decisions [17, 23].

Table 1. Shows Pearson Correlation Coefficients with P-Values of variables.

Variables	Pearson Correlation Coefficient	P-Value
Age of Household Head	-0.0256304	0.031
Family Size	0.1177786	0.062
Level of Education	-0.2217235	0.427
Land Certificate	-0.1079416	0.732
Farm Size	0.3572912	0.257
Frequency of Extension Agent Contact	0.2694438	0.026
Training on Soil and Water Conservation	0.8419626	0.004
Plot Distance	-0.0380384	0.440
Slope	0.438028	0.002

Variables	Pearson Correlation Coefficient	P-Value
Livestock Ownership	-0.1594925	0.984
Farmers' Perception of Land Tenure Security	-0.0018517	0.694

Result in Table 2 shows result on the probit regression analysis examines factors influencing the adoption of soil and water conservation practices among households, using various socio-economic and agricultural variables. The probit regression analysis is based on 149 observations, providing a sufficient sample size for the evaluation of factors influencing tree planting adoption. The log likelihood value of -69.857 reflects the fit of the model, where less negative values indicate a better fit to the observed data. The chi-square test result, which is significant at $p = 0.0001$, confirms that the model effectively explains a substantial portion of the variance in tree planting adoption. This statistical significance indicates that the independent variables included in the model have a meaningful impact on the likelihood of households engaging in tree planting.

Result in Table 2 indicates that as the age of the household head increases, the likelihood of adopting soil and water conservation practices decreases slightly, with a coefficient of -0.0085. This result is significant at the 5% level (z-value: -2.15). This negative relationship suggests that older household heads may be more resistant to adopting new soil and water conservation practices. This could stem from a combination of factors, such as a preference for traditional methods, potential physical limitations, or reluctance to change established routines [6]. As farmers age, they might prioritize short-term returns over long-term investments like soil bunds, which require ongoing maintenance and commitment. This insight highlights the need for targeted outreach and support to encourage older farmers to adopt innovative practices that can enhance soil conservation. Similar results were reported by [12].

The coefficient for family size is 0.1178, significant at the 10% level (z-value: 1.87), with a marginal effect of 0.0389. This finding indicates that larger family sizes are associated with a higher likelihood of adopting soil and water conservation practices. Larger families may have more labor available for managing the physical demands of establishing and maintaining soil bunds and terraces. This increased manpower can facilitate the implementation of soil conservation practices, making them more feasible for households with greater family resources. This underscores the importance of community and family dynamics in agricultural decision-making, suggesting that policies aimed at promoting soil bund adoption could consider family structure in their outreach strategies [20].

The coefficient for education level is -0.2217, but this result is not significant ($p = 0.427$). This indicates there is no

clear relationship between education level and the adoption of soil bunds and terraces. The lack of significance suggests that higher education alone does not necessarily lead to greater adoption of soil bunds and terraces. It may be that the content of the education received is not directly relevant to soil conservation practices. Additionally, practical experience and local knowledge could be more influential than formal education in determining adoption decisions. This finding emphasizes the need for educational programs that are tailored to the specific agricultural practices and challenges faced by local farmers [13].

The coefficient for holding a land certificate is -0.1079, which is also not significant ($p = 0.732$). This suggests that having a land certificate does not significantly influence the decision to adopt soil bunds. In this case, the lack of a significant relationship may indicate that simply having formal land rights does not translate into increased investment in soil conservation practices. Farmers may feel secure in their land tenure but still lack the resources, knowledge, or motivation to implement soil bunds. This highlights the complexity of land tenure issues, suggesting that other factors such as access to financial resources or technical support might play a more crucial role in driving adoption. 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 [25].

The coefficient for farm size is 0.3573, but this is not significant ($p = 0.257$). This indicates that larger farms do not necessarily correlate with increased adoption of soil bunds. While one might expect that larger farms would be more likely to adopt soil bunds due to greater land availability, this analysis suggests otherwise. The lack of a significant relationship may reflect a variety of factors, including differing priorities among larger landholders or the challenges associated with implementing practices across extensive areas. It may also indicate that scale alone does not determine the adoption of conservation practices, pointing to the need for holistic approaches that consider individual farmer circumstances [26].

The coefficient for frequency of extension agent contact is 0.2694, significant at the 5% level (z -value: 2.22), with a marginal effect of 0.0891. This indicates that increased contact with extension agents positively influences the likelihood of adopting soil bunds. This finding emphasizes the

critical role of agricultural support services in promoting sustainable practices. Regular contact with extension agents can provide farmers with the necessary information, resources, and motivation to adopt soil bunds. It highlights the importance of effective extension services that not only disseminate knowledge but also engage farmers in dialogue and support them in overcoming barriers to adoption. This suggests a potential area for investment in agricultural policy and practice. Similar results were reported by [7, 13].

The coefficient for training on soil and water conservation is 0.8420, significant at the 1% level (z -value: 2.86), with a marginal effect of 0.2550. This indicates that training significantly increases the likelihood of adopting soil bunds. This strong positive relationship underscores the value of targeted educational programs in enhancing farmers' understanding and implementation of soil conservation techniques. Training programs that provide practical, hands-on experiences can empower farmers to adopt soil bunds effectively, demonstrating the importance of integrating theory with practice. The substantial marginal effect suggests that even a relatively small increase in training can lead to meaningful changes in adoption rates. The result is in line with [9].

Both livestock ownership and land tenure security are noted as not significant, indicating they do not play a crucial role in the decision to adopt soil bunds. The insignificance of these variables suggests that while they may influence other aspects of agricultural practice, they are not direct drivers of soil bund adoption. This might imply that the decision to adopt soil bunds is more closely tied to immediate agricultural practices and support mechanisms than to broader issues of livestock management or land tenure security [21, 24].

The coefficient for slope is 0.4380, significant at the 1% level (z -value: 3.08), with a marginal effect of 0.1448. This indicates that steeper slopes are associated with a higher likelihood of adopting soil bunds. The positive relationship between steep slopes and soil bund adoption highlights the urgent need for soil conservation practices in areas prone to erosion and runoff. Farmers may recognize the necessity of implementing soil bunds in these regions to protect their land and ensure sustainable productivity. This finding underscores the importance of contextual factors like land topography in shaping agricultural practices, suggesting that targeted interventions in vulnerable areas could enhance the effectiveness of soil conservation efforts [22, 5].

Table 2. Probit model of regression for different variables on soil and water conservation activities.

Variables	Coefficient	z-value	P> z	Marginal effect
Age of household head	-0.0256304	-2.15***	0.031	-0.0084744
Family size	0.1177786	1.87**	0.062	.0389421
Level of education	-0.2217235	-0.79	0.427	-0.0741043

Variables	Coefficient	z-value	P> z	Marginal effect
Land certificate	-0.1079416	-0.34	0.732	-0.0348652
Farm size	0.3572912	1.13	0.257	0.1181342
Frequency of extension agent contact	0.2694438	2.22***	0.026	0.0890885
Training on soil and water conservation	0.8419626	2.86***	0.004	0.2549966
Plot distance	-0.0380384	-0.77	0.440	-0.0125769
Slop	0.438028	3.08***	0.002	0.1448289
Livestock ownership	-0.1594925	-0.02	0.984	-0.0006122
Farmers' perception of land tenure security	-0.0018517	-0.39	0.694	-0.050474
_cons	-0.6409303	-0.71	0.479	
Number of observations = 149				
Log likelihood function= -69.857021				
-2ln(L _R /L _U) = 38.56				
Prob > chi2 = 0.0001				
Pseudo R ² = 0.2598				

4. Conclusion

The findings of present study showed that adoption rates for soil bund and terrace construction significantly vary with slope type and the influence of extension services. Farmers in steeper areas exhibit higher adoption rates due to heightened awareness of erosion risks, while those in flat areas show lower adoption due to perceived minimal need. Moreover, the presence of extension agents greatly enhances the likelihood of adopting these practices, highlighting the importance of effective agricultural support systems.

The findings of our study highlight critical demographic and environmental influences on land management practices, particularly soil bund and terrace construction. The predominance of male-headed households necessitates gender-sensitive interventions to empower women in land management. Low education levels emphasize the need for targeted educational programs to enhance farmers' understanding of sustainable practices. While older farmers possess valuable experience, they may be resistant to change. Programs should leverage their knowledge while encouraging adaptation to new practice. Small landholdings suggests cooperative farming could enhance resource utilization and efficiency in land management.

Adoption rates for soil bunds and terraces significantly increase with slope steepness, indicating a greater perceived need for erosion control in steeper areas. Regular contact with extension agents significantly boosts adoption rates of both soil bunds and tree planting, underscoring the importance of effective agricultural support. Training on soil conservation significantly influences soil bund and terrace

adoption for effective soil and water conservation. The probit regression results indicate several significant factors influencing the adoption of soil bunds. Notably, training on soil and water conservation, frequency of extension contact, and the slope of the land are critical in promoting adoption. The negative coefficient for the age of the household head suggests that older farmers may be less adaptable to new practices, highlighting a generational gap in agricultural innovation.

Demographic factors are also critical; the predominance of male-headed households calls for gender-sensitive approaches to empower women in land management. Additionally, low education levels among farmers highlight a need for targeted educational initiatives to improve understanding of sustainable practices. While older farmers bring valuable experience, they tend to resist change, suggesting that programs should bridge their knowledge with encouragement for new practices. Furthermore, the prevalence of small landholdings points the potential feasibility of cooperative farming to optimize resource use and enhance land management efficiency. Overall, the study underscores the necessity for tailored training on soil conservation, focusing on factors such as slope steepness, frequency of extension contact, and deliberate educational efforts to enhance adoption rates. The findings also indicate a generational gap in flexibility towards adopting new practices, particularly among older farmers, necessitating strategies that foster innovation across age groups.

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
Prob.	Probability

Author Contributions

Bisrat Hailemichael: Data curation, Software, Writing – original draft, Writing – review & editing

Melaku Bekele: Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft

Teshome Tamirat: Funding acquisition, Methodology, Resources

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Adenew B, Abdi F. A (2005). Research Report 3 on Land registration in Amhara Region Ethiopia. Securing Land Rights in Africa.
- [2] Amsalu A, Graaff J2007. Determinants of Adoption and Continued use of Stone terraces, soil and water conservation in Ethiopian highland Watershed. *Ecological Economics*; 61: 294-302.
- [3] Ayele ZE (2023). Tree growing by Smallholders Farmers in the high land of Ethiopia. A Dissertation Presented to the School of Graduate Studies of Oregon State University.
- [4] Bekele W, Drake L2008. 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* 2003; 46: 437-451. Discovery 59, e82d1271.
- [5] Brasselle AS, Gaspart F, Platteau JP2002; Land Tenure Security and Investment Incentives: Puzzling evidence from Burkina Faso. *J Dev Econ* 67(2): 373–418.
- [6] Deininger K, Binswanger H1999. The Evolution of the World Bank's Land Policy: Principles, Experience and Future Challenges. *World Bank Res Obs*; 14(2): 247-276.
- [7] Deininger K, Zevenbergen J, Ali D2008. Assessing the Certification Process of Ethiopia's rural Lands Etablissement de la procédure de certification de terres rurales en Éthiopie. *Colloq Int*.
- [8] EEA/EEPRI 2008 (Ethiopian Economics Association / Ethiopian Policy Research Institute) 2002. 10. Eleni T. Continued Use of Soil and Water Conservation Practices: A Case study in Tulla District, Ethiopia. MSc Thesis, Wageningen University, the Netherlands.
- [9] Ersado L, Amacher G, Alwang J2004. Productivity and land enhancing technologies in northern Ethiopia: Health, public investments, and sequential adoption. *Am J Agric Econ*; 86(2): 321-331.
- [10] FAO 2002. (Food and agriculture organization). FAO Land Tenure studies Land tenure and Development. Food and Agricultural organization of the United Nations, Rome.
- [11] Giri S2023). 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 2010. Discovery 59, e81d1270.
- [12] Gomez KA, Gomez AA1984. Statistical Procedures for Agricultural Research, Wiley-interscience.
- [13] Gujarati DN2003. Basic Econometrics. 4th Edition. McGraw-Hill, New York; 563-636.
- [14] Hagos F, Pender J, Gebreselassie N. Causes of and responses to land degradation. In Land degradation and strategies for sustainable land management in the Ethiopian Highlands: Tigray region (Second edition). Nairobi: International Livestock Research Institute (ILRI) 2002; 14-26.
- [15] Heyi DD2012. 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).
- [16] Holden S, Yohannes H2002. Land Redistribution, Tenure Insecurity, and Intensity of Production: A Study of Farm Households in Southern Ethiopia. *Land Econ*; 78(4): 573-590.
- [17] Holden ST, Deininger K, Ghebru H2009. Impacts of Low-Cost Land Certification on Investment and Productivity. *Am J Agric Econ*; 91(2): 359-373.
- [18] Nega B, Adenew B, Sellasie SG2003. Current Land Policy Issues in Ethiopia. In Land Reform: Land Settlements and Cooperatives 2003/3. Special Edition. Groppo P (editor). Rome: Food Agric Organ.
- [19] Rahmato D2007. Development Interventions in Wollaita, 1960s 2000s: A Critical Review. Addis Ababa. Forum Soc Stud.
- [20] Rodrick D 2014. 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.
- [21] Tadesse Z (2000). Revisiting rural Development through a Gender Lens. Proceeding of the workshop of the FSS. Addis Ababa.
- [22] Tafesse Y2011. Women and Land Rights in Rural Ethiopia: The Case of Wolaita, MSc Thesis, University of Tromsø, Norway.
- [23] Tsegaye A, Adgo E, Selassie YG (2012). Impact of land certification on sustainable land resource management in dry land areas of Eastern Amhara Region, Ethiopia. *J Agric Sci*; 4(12).

- [24] Yirga C. (2003). Land Tenure Security and Adoption of Natural Resource Management Technologies in Ethiopia. Holetta Agricultural Research Centre. Addis Ababa, Ethiopia.
- [25] Eleni T. (2008). Continued Use of Soil and Water Conservation Practices: A Case study in Tulla District, Ethiopia. MSc Thesis, Wageningen University, the Netherlands.
- [26] 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.