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The Effect of Land Tenure Institutional Factors on Small Landholders' Sustainable Land Management Investment: Evidence from the Highlands of Ethiopia

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Abstract: Sustainable Land Management (SLM) is one of the key policy responses being implemented to curb land degradation in the highlands of Ethiopia. However, there is scant evidence to what extent Land Tenure Institutional Factors (LTIFs) influence small landholders' on-farm investment in SLM. The overall objective of this study is, therefore, to understand the extent to which LTIFs influence on-farm SLM investment in the highlands of Ethiopia through unbundling tenure security (de jure, de facto, and perceived) across a bundle of rights. Survey data were collected between April and May 2021 from 2296 smallholder households and 6692 parcels of 19 highland woredas (districts) in three regional states (Amhara, Oromia, and SNNP) in Ethiopia. A probit regression model was used to estimate the average marginal effects of LTIFs quantitatively and supported by an in-depth qualitative analysis. The results revealed that 10 out of 16 LTIF-related variables have significantly influenced households' on-farm investment in SLM with average marginal effect ranging from a minimum of 3% (tree tenure security risks) to a maximum of 14% (possession of land certificates), at 95% confidence interval, compared to a mean probability of 45%. The results also revealed that some of the households' socio-economic and demographic factors and parcel-specific variables have significantly influenced on-farm SLM investment. These imply two policy issues. Firstly, it strengthens the notion that security of tenure may be a necessary condition, but not a sufficient, factor to incentivize smallholders' on-farm SLM investment. Secondly, an in-depth analysis of the security of tenure categories across a bundle of rights is necessary to help formulate context-specific SLM policy and strategy incentivizing smallholders' on-farm SLM investment.

Keywords: land degradation; bundle of rights; security of tenure; SLM; investment; Ethiopia

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1. Introduction

Policy makers, practitioners, and researchers are becoming more conscious of the importance of clear, secure, and inclusive access to and control over land resources because of increased competition for land resources and mounting climate change uncertainties. Under the United Nations, land tenure indicators are adopted as a fundamental element of measuring the global sustainable development goals (SDGs). For instance, SDG 1.4.2 aims to measure the "proportion of the total adult population with secure tenure rights to land including (a) with legally recognized documentation, and (b) who perceive their rights to land as secure, disaggregated by sex and tenure type (%)" [1]. In addition, SDG 5.a.1 stresses women's land tenure, SDG 2, Target 2.3.1 and 2.3.2 address smallholder farmers; and Target 2.4.1 also focuses on agricultural land [2]. Land tenure also influences land use and is thus key to achieving SDG 14 (b) and SDG 15 on the sustainable use of land and natural resources. Likewise, land tenure is also vital as it is often considered a driver of

conflict if managed poorly, yet it is a source of resilience if managed properly, and hence affects SDG 16, promoting peace and inclusive societies and institutions.

Land tenure importance is also manifested by households' land use decisions at the local level, indicating the need for physical capital to spur economic growth and land governance systems [3]. Land tenure security is an important development agenda for strengthening land governance systems, thereby improving social stability, spurring economic growth, and promoting the environmental sustainability of citizens, communities, and business firms [4,5]. The assumption is that recognizing land and resource rights will benefit the rights holders by 'unlocking' capital through access to credit or by enabling full utilization of production factors, reducing uncertainty, providing opportunities and empowerment, and incentivizing the sustainable use of natural resources [6].

Tseng et al. [6] and Robinson et al. [7] also identified two dimensions of tenure issues with a strong potential to influence land-based investment decisions, including the type of rights landholders have and the security of those rights. The bundle of rights includes access, use, management, exclusion, alienation, and the rights to be compensated during compulsory expropriation [7,8]. In contrast, security is understood as a perception by right holders that rights are recognized and protected [9]. Land rights are secure when a person perceives them to be stable and predictable over a reasonable period and protected from expropriation or arbitrary change [10]. This is consistent with the SDG 1.4.2a secured tenure rights definition.

Other scholars [7,11,12] distinguished the categories of land tenure security as (1) de jure/legal, (2) de facto/contextual, and (3) perceived/socio-psychological tenure security. This category of security is associated with a given tenure system such as freehold, lease hold, or customary and the myriad social, economic, political, and environmental factors that condition the de facto performance of such an arrangement [13]. This arrangement may be formal, informal, or applied through customary institutions that can be a major hinder or enable sustainable land management or development [14]. According to Masuda et al. [5,13], Holland et al. [12], and Robinson et al. [7], as societies grow and land pressure increases, there becomes a need for clear and transparent processes that assign and enforce rights among various parties and spell out the rules for how rights can be accessed, transferred, terminated, or gained. Locke [10] even argued the primary function of government is to secure and protect such property rights. This means that sustained land tenure security most likely comes with the state-recognized backing of land rights [6]. However, such institutional genesis is a long-term process that needs to grow within the existing socio-economic and political system.

Land tenure institutions are, therefore, fundamentally important in enhancing land-based investment and promoting the efficient allocation of economic resources [15–17]. A relationship between a rights holder and a subject parcel of landholding depends on the characteristics of the bundle of rights that qualify its usefulness in economic exchange and influence economic behavior on investments [15,18,19] and the financing of these investments [20]. The governance of these relationships is mainly administered by land tenure institutions. The inefficiency and ineffectiveness of those institutions affect the quality of tenure security. Uncertainty about tenure rights also creates insecurities about land tenure and frequently leads to poor uses of limited resources as these influence the practices, abilities, and choices of landholders in line with the adoption, sustainability, effectiveness, and efficiency of their investment [4,6].

Despite a notable increase in rigorous systematic reviews in recent years, much of the evidence on land tenure remains linked to tenure security achieved through land titling and its implication on environment and development outcomes. For instance, Tseng et al. [6] recently reviewed about 117 studies to understand the causal effect of land tenure security interventions such as land titling and formalization on human well-being or environmental outcomes, of which two-thirds of the studies reported positive links. Likewise, Lawry et al. [21] undertook a similar systematic review and found that land tenure recognition positively affected productivity and income gains substantially through

perceived tenure security and investment. However, these reviews show the existing body of land tenure literature focus on a single category of tenure security and its implication on socio-economic and environmental outcomes. This approach hinders an in-depth yet broader understanding of LTIF effects along categories of land tenure security and the context-specific bundle of rights on development and environment.

Considering the land tenure theory and existing evidence base, the link between LTIFs, such as the three categories of land tenure security and investment in SLM, appears inconclusive, at least in the Ethiopian context. This is because, firstly, landholders have only perpetual usufruct rights and could not be used as collateral to access formal credit until recently, or land exchange or sale was forbidden [22]. This implies that SLM investment made in the rural landscapes, specifically at the farm level by smallholder households, cannot be attributed to either greater access to credit or enhanced functions of the land market as land sales are ruled out by law. Secondly, perceived tenure security and de facto tenure security vary in a range of transferability of legally (de jure) recognized bundle of rights such as risks related to inheritance, gift, lease/rentals, conservation, tree tenure, expropriation and compensation, and land redistribution. Thirdly, most previous studies rely on a small sample size of cross-sectional data targeted to a specific watershed and biomes and looked at secure tenure without any categorization, thus limiting more rigorous and in-depth analysis of factors influencing on-farm investment in SLM among small landholders. Specifically, this hinders the full understanding of the LTIFs linked to the country's SLM policy implementation effectiveness in guiding context-specific small landholders' on-farm SLM investment.

Historically, Ethiopia's highland agriculture is dominated by small landholders' farmland tenure model and characterized by fragmentations. Land degradation is one of the major environmental and development challenges compounded by climate change risks. SLM is also considered one of the key policy responses being implemented using watershed as a unit of planning and watershed users' cooperative societies as governance structures. However, at the landscape level, the landholding types are a mosaic of communal, private, and state/public lands associated with certain socio-ecological systems and highly dominated by smallholder land tenure. The interaction and relations of these diverse tenure types affect the land use practice and on-farm SLM investment of small landholders and its sustainability in the study areas.

For instance, legally recognized rights might be represented by registering those rights and provisioning land certificates as a de facto protection of those land rights. However, the impact of land certificates on tenure security differs by how perceived tenure security is measured [23]. Where the perceived tenure security dimension is specifically measured along risks related to the bundle of rights such as inheritance, land redistribution, expropriation and compensation, land transfer through land rent/sharecropping, conservation, tree tenure security, as well as credit transactions. This bundle of rights is an important set of land rights recognized in the existing legal framework of the country. Hence, understanding these dynamics of land tenure institutional factors through the lens of categories of tenure security across the bundle of rights is vital to design pragmatic SLM policy and context-specific implementation strategy.

Therefore, the objective of this study is to understand the extent to which LTIFs influence the probability of households' on-farm SLM investment in the highlands of Ethiopia; through the lens of the three categories of security of tenure (de jure, de facto, and perceived) across the bundle of rights in the context of the existing legal framework. To this end, this study employed household and parcel-level survey data accessed from the USAID publicly available data repository and addresses the limitations and contributes to the existing body of evidence.

2. Materials and Methods

2.1. Sample Size and Data

This study was conducted in three highland regional states of Ethiopia (Amhara, Oromia, South Nation Nationalities and People (SNNP)), 19 woreda, and 183 kebeles. This study used the 2021 survey data collected for the follow-on impact evaluation (IE) study of the USAID-funded land administration programs, namely the Ethiopia Land Tenure Administration Program (ELTAP, run between 2005 and 2008) and Ethiopia Land Administration Program (ELAP, run between 2008 and 2013). This is because the 2021 follow-on survey data were found as the best publicly available recent data in the sector, with a trove of survey data that help to respond to the research objective of the current study. The impact evaluation studies of USAID examined the impact and limitations of the land certification intervention on rural land users over a 15 years' time horizon.

As part of this panel dataset, data were previously collected in three rounds, namely, 2008 as a baseline, 2015 as an end line, and 2021 as a follow-on impact evaluation study [24,25]. In all waves of data collection, the researchers collected data using a head-of-the-household survey and a wife survey that was applied to the head of the household (male or female) and their spouse or wives in the case of polygamous households. Unlike the two previous surveys, the 2021 survey excluded households from Tigray and the 12 kebeles in Amhara because of the conflict and security issues, while the ELAP targeted households were also excluded to reduce selection bias on the results since they were targeted by the land administration programs with higher potential for agricultural investment [24], Figure 1.

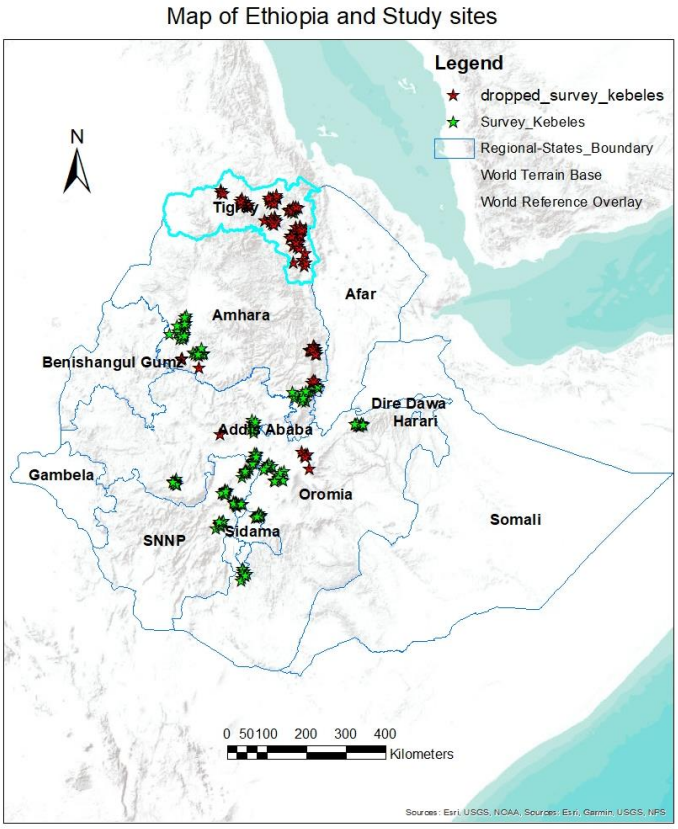

Figure 1. Map of Ethiopia and study survey sites. Compiled by the Author, 2023. Red shows the study sites excluded from the 2021 survey due to security issues in Tigray and Amhara regional states as well as ELAP-supported woredas excluded to avoid selection bias. Source: USAID [26], [Data set]. https://www.land-links.org/ accessed on 21 December 2022.

In terms of sample size, systematic stratified sampling method was employed. Firstly, six program woredas were selected from the four program participating regions. Secondly, within each woreda, a stratified systematic selection of kebeles was made based

on distance from capital/road (3 categories or clusters identified, i.e., with 5 KMs—near, 10 KMs—medium, and above 10 KMs—far). Hence, 8 treatment and 3 control groups per kebeles, and for the control group, 3 kebeles were randomly chosen per woreda. Thirdly, within selected treatment and control kebeles, the selection of households was made using stratified random sampling proportional to the number of male- and female-headed households in the kebeles, which includes 15 per treatment and 10 per control kebeles. Accordingly, the 2008 survey covered 3600 households across 284 kebeles in the four regions (Amhara, Oromia, SNNP, and Tigray). The survey yielded 2754 wives in 2643 male-headed households and 698 women in female-headed households [25]. Likewise, the 2015 survey also collected data for 3412 wives in 3412 male-headed households and 914 women in female-headed households. On the other hand, the 2021 survey collected data from the same households from April to May 2021 who had been interviewed in 2008 and 2015. However, 3 percent household attrition is observed for several reasons, including household change of place, death, separation or dissolution of household, and illness, among others. The survey in 2021 includes 2306 households, of which ten households were dropped from the sample because their information on land certification status was incomplete, meaning the final sample size was only 2296 [24].

While the original plan was to use the three waves of the panel data, after a thorough review of the panel datasets, the authors decided to use the 2021 survey data only because of several important limitations to the design and instruments among the three waves. Firstly, despite the same household survey module employed, baseline data were not collected at the parcel level, which reduces the study's ability to assess parcel-level SLM activities under the current study rigorously. Secondly, the 2021 follow-on survey contains detail data both at the household and parcel level, including (a) the socio-economic and demographic issues, (b) land tenure and land certification status, (c) engagement of households in land transactions such as land rentals/sharecropping, inheritance, gift, and credit, (d) land dispute incidents, (e) level of awareness on land rights, (f) perception in land tenure security and related risks, (g) land use quality, (h) soil and water conservation investment and productive assets building, among others.

Thirdly, over the past decade and a half, the difference between the treatment and control groups in terms of land tenure security improving interventions have been closed, such as land registration and certification. Meaning, most households in the control groups received treatment overtime. Fourthly, the discrepancies in the resolution or presence of certain variables across the baseline, end line, and follow-on datasets mean direct implications on the sample size and the ability to fully utilize certain finer resolutions between baseline and end line datasets compared to the follow-on under the current study. Finally, in terms of methodology, both the baseline and end line impact evaluation studies used a Difference in Difference (DiD) econometrics model and analysis, while the follow-on evaluation also included Continuous Treatment (CT) analysis additionally and compared the results of the two. Hence, the current study, while employing the follow-on survey data only, departs in methodology as well to better understand the role of LTIFs and their average marginal effect on the dependent variable. To perform the statistical analysis, the authors employed STAT version 14 software and ArcMap for mapping and visualizing survey kebeles spatial distribution in the country, Figure 1.

2.2. Empirical Model Specification

This study employed a probit regression model to test the hypothesis that the three categories of tenure security may have different effects on the probability of households' on-farm SLM investment across the bundle of rights. This approach also helps us to understand better the average marginal effect of the LTIFs influencing the probability of households' any on-farm SWC practice as proven SLM investment. The model looked at the fitted probability of the dependent variable due to the influence of the set of explanatory variables presented in Equation (7) below, meaning the outcome variable is determined or predicted as a non-linear model that forces the probability function to fall between 0 and 1

based on communitive density functions of independent variables derived from the robust standard errors distribution.

Using this model, the authors are able to estimate the probability of households' on-farm SLM investment, accounting for the households' demographic and socio-economic variables, quality or characteristics of the parcel of land, and the three categories of land tenure security variables across the bundle of rights. Hence, the authors estimate four models and compare the results of the regression analysis, i.e., Model 1 includes household and parcel variables only, Model 2 includes household, parcel, and de jure variables only, Model 3 includes household, parcel, de jure, and de facto variables only, and the final or Model 4 includes household, parcel, de jure, de facto, and perceived tenure risk variables. The probit regression equation is specified as:

$$P(Y = 1|X) = G(X\beta) = \int (2\pi)^{-5} \exp\left(-\frac{X\beta^2}{2}\right) \quad (1)$$

$$the\ G\ function\ of\ X\beta = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \quad (2)$$

That means:

$$fitted\ probability = \hat{p}(Y = 1|X) = G\left(X\hat{\beta}\right) \quad (3)$$

where:

$$lim_{X\beta \to \infty}\, G\left(X\hat{\beta}\right) = 1$$

$$lim_{X\beta \to \infty}\, G\left(X\hat{\beta}\right) = 0$$

To estimate the $\hat{\beta}$ coefficient, we use the maximum likelihood estimation that maximizes the joint probability of the outcome variable and constructed based on the product of each observation probability of observing what we see, which can be written as follows:

$$L = \prod_{i=1}^{N} P_i^{Y_i} \ln(1 - P_i)^{(1-Y_i)} \quad (4)$$

Taking logs, we can attain the "log likelihood" as follows:

$$lnL = \sum_{i=1}^{N} Y_i \ln(P_i) + (1 - Y_i) \ln(1 - P_i) \quad (5)$$

The marginal effects depend on X, where the average marginal effect calculates each individual observation's marginal effect and then takes the mean, which is the derivative of G with respect to $X\beta$ constructed as:

$$\frac{\partial P(Y = 1|X)}{\partial X_1} = \beta_1 G'(X\beta) \quad (6)$$

where $G'(X\beta)$ will change as X changes, which allows for diminishing returns or a non-linear relationship; therefore, the final probit empirical model is constructed as:

$$Y_{ih} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots \beta_{24} X_{24} + \varepsilon_{ih} \quad (7)$$

where Y is a dummy outcome or dependent variable which represents a small landholder's investment in any SWC practice by a household h, and X is the set of explanatory variables related to households, parcels, and categories of the three secure tenure rights across the bundle of rights as recognized in the existing legal framework. More specifically, Y = dependent variable (investment in any SWC); β_0 = constant term; X_1 is age; X_2 is sex; X_3 is highest school grade; X_4 is marital status; X_5 is land area; X_6 represents time to

walk to parcel; X_7 is walking distance to parcel; X_8 is water erosion risk, X_9 is usufruct rights-de jure; X_{10} is transfer rights (rent/sharecropping)-de jure, X_{11} is bequest-de jure; X_{12} is collateral rights-de jure; X_{13} is decision on what to grow/invest-de facto; X_{13} represents decision on the use of the produce-de facto; X_{14} represents decision on transfer, i.e., who decides on the transfer (rent/sharecropping-OUT) to others-de facto; X_{15} represents credit obtained-de facto; X_{16} represents possession of First Level Landholding Certificate-de facto; X_{17} is possession of Second Level Landholding Certificate-de facto; X_{18} represents bequest-perceived; X_{19} is transfer to others (rent-out/sharecropping)-perceived; X_{20} represents credit transaction-perceived; X_{21} is perceived conservation risk-perceived risk, X_{22} is tree tenure risk-perceived risk; X_{23} represents land redistribution risk-perceived risk; X_{24} represents enter in to any business transaction risk-perceived risk; ε_{ih} is the error term of explanatory variables.

This study also employed qualitative data collected from focus group discussions among kebele administrative officials of the study sites and legal and administrative document reviews which complement and substantiate the quantitative analysis.

3. Results

3.1. Characteristics of this Study's Kebeles (Villages)

To better understand the overall characteristics of this study's kebeles, focus group discussions were conducted that covered the estimated number of populations, mean livelihood of residents, land use, land scarcity, migration (in and out), and services, including road, market, mobile phone network coverage, financial institutions, transportation, and religious institutions.

The surveyed kebeles are spatially distributed in the three highland regions with 1500 m above mean sea level and are characterized by high population density. The mean number of households in the study kebeles was 1072, with a standard deviation of 885 households and 5.8 average persons per household. There is migration in and out of kebeles, with slightly more than half of kebeles reporting net out-migration. This net out-migration may likely increase household labor productivity and improve land use efficiency by freeing some land for the land rental market. Agriculture is the predominant land use system on small private landholdings and livelihood sources, while 14 percent of kebeles have no remaining bush or forest land. About 83 percent have fewer than 25 percent of kebele land area left as bush/forest land. In addition to agriculture, pity trade, and casual labor are the primary means of livelihood for kebele residents. About 72 percent of kebele main roads are all-weather roads, meaning they are accessible year-round, while 77 percent of kebeles have a large weekly market that exchanges goods and services locally.

About 92 percent of the kebeles had access to mobile phone network coverage, which facilitated information flow, thereby reducing the cost of information and, by extension, services. However, only 4% of kebeles had access to a bank service within their vicinity, but 39% had access to a microfinance institution's financial service. This shows kebeles have limited access to formal financial services. Thus, about 80 percent of the total credit service is provided to rural households by financial cooperatives and Microfinance Institutions (MFIs). Moreover, only 10 percent of the kebele authorities reported that there was a project-based SWC intervention between 2016 and 2021. This also shows that this study's kebeles receive limited project-based extension services related to SLM that may hinder on-farm investment among smallholder households. On average, survey kebeles were about 23 km by road to the nearest major urban center, which implied that kebele residents face some barriers to accessing services outside their kebele. For instance, one-fourth of kebeles do not have passable roads year-round and face substantial costs for public transportation, estimated to be 10 percent of the daily household per capita expenditures, meaning landholders who reside in remote areas have limited time and resources to travel to woreda offices to access land tenure related services and may sometimes involve opportunity costs for leaving their on-farm investments during their travel.

On the other hand, despite being a place of worship, churches and mosques are used as important avenues to disseminate information about administrative and community development extension services. According to the FGD, there were an average of 4.36 churches and 2.56 mosques in the survey kebeles. Those community-based religious institutions facilitate various awareness-raising meetings and serve as information disseminating points, including SWC campaigns and programs.

3.2. Descriptive Statistics of Surveyed Households

Table 1 summarizes detailed demographic and socio-economic characteristics of the survey respondents, parcel characteristics, land tenure institutional factors (LTIFs), description of the variables, means, frequencies, and standard deviations. As explained earlier in Section 2.1, the datasets also collected a range of land tenure-related information. The authors grouped the LTIFs into three categories of security of tenure: de jure/legal security, de facto/contextual security, and perceived security, as also used by Asaaga et al. [11].

Table 1. Descriptive and summary statistics of variables.

Variables	Description of Variables	Expected Sign	Mean/Ferq.	Std. Dev.
	Dependent Variable			
Invested in any soil and water conservation practices	Households invested in any SWC in their landholding, dummy (1 = yes, 0 = otherwise)	±	0.45	0.50
Stone bund	Length of constructed stone bunds (in meters), continuous	±	10.93	46.62
Soil bund	Length of constructed soil bund (in meters), continuous	±	27.75	75.16
Water retention structure	Number of on-farm water retention structures (ponds, retention ditches) constructed, continuous	±	0.087	0.004
Trees planted per hectare	Number of trees planted, continuous	±	105.54	819.75
Perennials planted per hectare	Number of perennials crops planted, continuous	±	162.49	734.79
	Independent variables			
	Household demographic and socio-economic variables			
Age	Age of the household head, continuous	±	55.17	14.26
Gender	Gender of the household head, dummy (1 = man, 2 = woman)	±	1.22	0.41
Education	Highest level of education completed, categorical Illiterate Read-only Read & write Grade 4 complete Grade 8 complete Grades 10–12 complete Above grade 12	±	 51.14 2.55 11.77 19.42 8.24 4.94 1.95	
Marital status	Marital status of the household head, categorical: 1 = Unmarried/Never married, 2 = Married, 3 = Divorced, 4 Widowed, 5 = cohabiting, 6 = preferred not to respond	±	 0.02 0.77 0.03 0.18 0.00 0.00	

Table 1. *Cont.*

Variables	Description of Variables	Expected Sign	Mean/Ferq.	Std. Dev.
Means of land originally acquired	How was land originally acquired? categorical Inherited Official land redistribution Gift Others	±	 39.24 37.51 8.64 14.61	
Holding Size	Area of land possessed in hectares, continuous	±	1.68	1.78
	Parcel variables			
Time travel to parcel	Time to walk to parcel one way (in minutes), continuous	±	15.3	24.79
Parcel distance	Walking distance to parcel one way (in meters), continuous	±	1460.26	2314.94
Water erosion risk	Parcels located on sloping lands with soil erosion risk, dummy (1 = yes, 0 = otherwise)	±	0.389	0.488
	Legal tenure security			
Usufruct rights	land laws allow to use of the parcel, dummy (1 = yes, 0 = otherwise)	±	0.976	0.154
Transfer rights (rent/sharecropping)	land laws allow making a contract (rent/sharecropping) dummy (1 = yes, 0 = otherwise)	±	0.965	0.185
Bequeath or inherit rights	land laws allow to bequest it to hires, dummy (1 = yes, 0 = otherwise)	±	0.946	0.226
Collateral rights	land laws allow to use of land as collateral, dummy (1 = yes, 0 = otherwise)	±	0.801	0.398
	De facto/contextual security of tenure			
What to grow?	Who decides on what crop (s) to grow, Continuous (1 = Husband, 2 = Wife, 3 = Husband and Wife, 4 = Children, 5 = Family, 6 = Single Household Head, 8 = Household Head and children, 97 = Other)	±	15.17 0.51 59.80 2.22 5.52 13.90 2.61 0.26	
on the use of produce	Who decides on the use of produce from the land? Continuous (1 = Husband, 2 = Wife, 3 = Husband and Wife, 4 = Children, 5 = Family, 6 = Single Household Head, 8 = Household Head and children, 97 = Other)	±	11.14 0.85 63.83 1.84 6.01 15.37 0.86 0.12	
on the transfer	Who decides on the transfer of land use rights (rent/sharecropping-out) to others? Continuous (1 = Husband, 2 = Wife, 3 = Husband and Wife, 4 = Children, 5 = the whole family, 6 = Single Household Head, 8 = Household Head and children, 97 = Other)	±	11.23 0.63 63.90 1.78 5.42 16.42 0.34 0.29	
Credit obtained	HH obtained credit (formal or informal) during the last 2 years, dummy (1 = yes, 0 = otherwise)	±	0.058	0.233

Table 1. *Cont.*

Variables	Description of Variables	Expected Sign	Mean/Ferq.	Std. Dev.
	Perceived tenure security risks			
Conservation risk	HH head fully convinced to benefit from SWC measures they may undertake., categorical (1 = Strongly Agree, 2 = Agree, 3 Disagree, 4 Strongly Disagree)	±	52.69 42.53 3.44 1.34	
Tree tenure risk	HH head fully convinced not to benefit from trees planted, categorical (1 = Strongly Agree, 2 = Agree, 3 Disagree, 4 Strongly Disagree)	±	9.59 11.73 35.06 43.62	
Land redistribution risk	HH believes that redistribution of land is likely to take place in their kebele in 5 years, categorical (1 = Strongly believe, 2 = Believe, 3 = Don't believe, 4 Strongly don't believe)	±	3.48 6.98 34.13 55.45	
Rent out risk	HH feels that renting out is a risky business, categorical (1 = Strongly Agree, 2 = Agree, 3 Disagree, 4 Strongly Disagree)	±	30.19 39.72 23.62 6.46	
Business transaction risk	HH will feel more secure entering any sort of business transaction involving credit with a farmer who has a Land Certificate than who does not have, categorical (1 = Strongly Agree, 2 = Agree, 3 Disagree, 4 Strongly Disagree)	±	53.98 39.01 6.47 0.53	

Based on the survey result, 78 percent of the respondents were male-headed households, while the remaining 22 percent were female-headed households with an average household size of 5.3. In addition, 76 and 18 percent of household heads were married and widower/ed, respectively, while 3 percent of household heads were divorced. For the entire sample, the average age of the household heads in the study area was 55, indicating that most of the household heads were active and productive. Moreover, the survey result shows that the majority (51 percent) of the respondents were illiterate, while about 47 percent of the respondents can read and write information about their land use rights, restrictions, and responsibilities.

The survey also collected data on the land parcel's biophysical characteristics or quality. Most households in the study areas were characterized as smallholders, with an average of 1.59 hectares and 3.1 parcels per landholding, which indicates a slightly higher than the national average landholding size, i.e., 1.22 hectares but with lower fragmentation [26]. This may have implications on households' on-farm SLM investment. It is also noteworthy that a land holding may consist of one or more parcels within a kebele, which is the lowest administrative and land registration unit. In terms of land use type and proportion, households reported that about 80, 7, 10, and 3 percent of their landholding area was used for annual crops, perennial crops, grazing land, and woodlots, respectively. This indicates that most land uses were dedicated to food crop production and little for conservation.

The average walking distance from home to the farm/parcel of land was 1.5 KMs which takes 15 min. This may have an implication on small landholders' on-farm SLM investment that saves time and increases labor efficiency. The survey also collected data on whether households are in areas where land use policy mandates soil and water conservation (SWC) investment due to the topographic nature (slope gradient) and soil erosion prevalence of their parcels of landholdings. Accordingly, about 39 percent of the households reported that they had at least one or more parcels located on sloping lands with high exposure to soil erosion. As a result, the survey also revealed that two-thirds of the small landholder households had been required by the woreda/kebele administration to implement SWC measures that the land use regulation mandated investment in SWC.

Regarding investment in SLM, such as practicing any SWC, about 45 percent of the households constructed and/or maintained any SWC such as stone bund, soil bund, water retention structures, planted trees, and perennials crops on their parcels of landholdings. For instance, the average length of stone bund constructed per parcel of landholding using the household's own resources was 11 m, with a maximum of 600 m on average per parcel area of 0.38 hectares in the past year. Likewise, the average length of soil bund constructed by the household's own resources on the same parcel was 28 m with a maximum of 800 m, showing households employed at least two or more complementary physical SWC practices on their farm. The survey results also revealed that one in ten parcels of landholding had on-farm water retention structures, such as ponds, that were constructed using the household's own resources. Moreover, the average number of trees and perennials crops planted by households (using their own resources) was about 106 and 163, respectively. This also shows households were practicing/complementing the physical SWC with long-term biological measures.

Regarding legal security or de jure tenure security, the survey measured whether households know what type of land rights are recognized under the existing land laws, including usufruct, transfer (rent/sharecropping), bequest/inheritance, and collateral. According to the survey results, households reported that they know their land rights are recognized in the land law, including 98 percent to usufruct, 97 percent to transfer, including rent and sharecropping, 95 to bequest, and 80 to collateralize their rights. This indicates respondents were aware of what type of tenure rights are recognized and secured in the land laws, meaning their rights are legally recognized and protected by the land laws.

Regarding de facto tenure security, the survey collected data on the decision-making power of the households on the crops to grow, the use of the produce, the transfer of their land parcels, actual credit obtained between 2019 and 2021, and whether they received land certificates (either FLLC or SLLC). Accordingly, about 60, 64, and 64 percent of decisions on the crop to grow, the use of the produce, and the transfer rights were made by both husband and wife jointly, respectively. Whereas 15, 11, and 11 percent of decisions were made by husband only, respectively. Whereas less than 1 percent of the decisions were accounted for or made by the wife only on the mentioned variables, meaning women have less decision-making power on their land rights matters within their household or joint holding. On the other hand, only six percent of household heads responded that they obtained credit over the past two years, meaning small landholders are still credit constrained, which may limit their on-farm SLM investment capacities. Moreover, in the 2021 survey, about 32 and 58 percent of respondents received FLLC and SLLC, respectively. About 90 percent of the respondent household heads are categorized as having "any certificate" in the study areas.

Perceived tenure security was also measured in terms of the right to bequeath, anticipated land redistribution within 5 years, and participation in credit transactions. The risk dimensions of perceived tenure security were also measured in terms of conservation security risks, tree tenure security risks, land redistribution risks, land rental risks, and participation in any sort of transaction involving credit if it were with a farmer who has a land certificate of possession over their land than that a farmer who does not have a land certificate. Accordingly, about 39 percent of households perceived that the inheritance right was secured after land certification, while one-fourth of the households expected land redistribution within five years. This means about 61 percent of respondent household heads feel their inheritance rights are insecure, while about 76 percent feel that they are secured from further land redistribution in the coming five years, meaning more needs to be conducted in terms of removing such perceptions. Moreover, the survey revealed that 83 percent of households feel more secure in credit transactions with land certificate holders, meaning they can lend or borrow money from anyone with a land certificate. This shows the issuance of landholding certificates strengthens the legacy informal credit market and leverages the creditworthiness of small landholders among their communities.

Regarding the risks of perceived tenure security-related variables, about 96 percent of respondents either strongly agree or agree that they are fully convinced that they will

stand to benefit in the future from whatever SWC measures they may undertake on their land at present. This indicates that respondent household heads perceive no risk of losing the benefits of their present investment in the future as their land tenure is secured. On the other hand, about 79 percent of respondents either strongly disagree or disagree that they are fully convinced that they will not stand to benefit in the future from trees that they may plant on their land at present. This means one-fifth of respondent households perceive tree tenure insecurity that likely disincentives on-farm investment such as agroforestry which is one of the proven on-farm SLM practices.

The survey results also revealed that about 70 percent of respondent households either strongly agree or agree that they feel renting out their land for money or on a sharecropping basis, even for one cropping season, is a risky business that they should avoid unless they have no other options of overcoming their difficulties. Small landholder households perceive land rental as risky, even for one cropping season. This may hinder the emergence of the land rental market in the study areas, even for short-term contracting, which may lead to land use inefficiency. Contrary to this, the survey results showed that about 93 percent of respondent household heads would either strongly agree or agree on they would feel more secure entering any sort of business transaction involving credit if it were with a farmer who has a landholding certificate of possession over their land than that a farmer who does not have a land certificate. This implied that landholding certificates facilitate credit markets among landholders who possessed landholding certificates. However, in the past two years, only six percent of respondent household heads borrowed money using their landholding certificates as collateral from financial institutions or informal lenders.

3.3. Estimates of the Parameters of the Probit Regression Model

As explained in the methods section, the authors estimate four models for the outcome variable. Summary estimates of the probit regression models results of the probability of households' on-farm SLM investment and the average marginal effects of the explanatory variables are presented in Table 2. The probit regression model 4, the best out-fitted model among the four estimated models, results indicated that among the 25 hypothesized explanatory variables, 16 variables were found to influence the small landholder households' on-farm investment significantly in SLM. Out of the total 25 hypothesized explanatory variables, 16 variables (two-thirds of the variables) are related to LTIFs. The results of regression Model 4 revealed that 10 out of 16 LTIF-related variables have significantly influenced the small landholder households' on-farm investment in SLM but in different directions. From the results, this study's regression model, i.e., Model 4, has outperformed by 14.06 percent compared with the baseline model. The likelihood ratio Chi-square of 713.56 with a *p*-value of 0.000 indicates that the research model is statistically significant.

Those variables with positive average marginal effects include marital status, FLLC, SLLC, perceived land rental risks, tree tenure security risk, water erosion risk, and decision on land rental. Whereas gender, age, education, means of original land acquisition, land area, credit obtained, perceived conservation security risks, the decision on the use of the produce, and the laws recognize bequest, have negative average marginal effects on the small landholder households' on-farm investment in SLM in the study areas. The average marginal effects of each parameter and their implications are presented and analyzed as follows.

Gender—the results revealed that the gender of the household head significantly and negatively influenced the on-farm investment in SLM. The survey result revealed that a household headed by a woman has a 10 percent reduced probability of investing in any SWC, compared to a mean probability of 45 percent with a 95 percent confidence interval. There is a significant and negative gender differential effect on investing in the on-farm SLM between a man and a female-headed household.

Table 2. Estimates of the probit regression model summary of average marginal effects on the probability of on-farm SLM investment of households. Source: calculated by the author based on the survey data obtained from the USAID data repository, 2022.

Categories of Variables	Independent Variables	Model 1		Model 2		Model 3		Model 4	
		Coefficient (Robust Std. Errors)	dy/dx	Coefficient (Robust Std. Errors)	dy/dx	Coefficient (Robust Std. Errors)	dy/dx	Coefficient (Robust Std. Errors)	dy/dx
HH demographic and socio-economic variables	Sex	−0.4311 (0.1036)	−0.0937 **	−0.5118 (0.1087)	−0.1106 **	−0.5371 (0.1115)	−0.1159 **	−0.4539 (0.1128)	−0.0958 **
	Age	−0.0054 (0.0015)	−0.0011 **	−0.0059 (0.0016)	−0.0013 **	−0.0082 (0.0017)	−0.0017 **	−0.0081 (0.0017)	−0.0017 **
	Education	−0.1115 (0.0132)	−0.0242 **	−0.1088 (0.0136)	−0.0238 **	−0.1036 (0.0145)	−0.0223 **	−0.1068 (0.0145)	−0.0225 **
	Marital status	0.1347 (0.0552)	0.0293	0.1803 (0.0587)	0.0405 **	0.2249 (0.0615)	0.0485 **	0.1965 (0.0620)	0.0415 **
	Acquisition	−0.0267 (0.0091)	−0.0058 **	−0.0308 (0.0098)	−0.0068 **	−0.0329 (0.0106)	−0.0071 **	−0.0320 (0.0106)	−0.0067 **
	Land area	−0.0574 (0.0124)	−0.0124 **	−0.0619 (0.0130)	−0.0132 **	−0.0645 (0.0138)	−0.0139 **	−0.0605 (0.0135)	−0.0127 **
Parcel specific characteristics	Time	0.0048 (0.0016)	0.0010 **	0.0055 (0.0018)	0.0012 **	0.0075 (0.0028)	0.0016	0.0066 (0.0027)	0.0014
	distance	−0.0000 (0.0000)	−0.0000	−0.0000 0.0000	−0.0000	−0.0000 (0.0000)	−0.0000	−0.0000 (0.0000)	−0.0000
	Water erosion	0.6969 (0.0364)	0.1516 **	0.7009 (0.0377)	0.1525 **	0.7214 (0.0396)	0.1557 **	0.7478 (0.0403)	0.1579 **
De jure/legal tenure security	usufruct			−0.4372 (0.1209)	−0.0957 **	−0.2480 (0.1392)	−0.0535	−0.3023 (0.1476)	−0.0638
	Rent			0.2338 (0.1234)	0.0511	0.1396 (0.1318)	0.0301	0.1300 (0.1374)	0.0274
	bequest			−0.2532 (0.0931)	−0.0554	−0.3715 (0.0969)	−0.0802 **	−0.3947 (0.0989)	−0.0833 **
	collateral			0.1008 (0.0524)	0.0220	0.0129 (0.0560)	0.0027	−0.0094 (0.0581)	−0.0019
De facto/actual tenure security	Decision on crop					−0.0736 (0.0419)	−0.0158	−0.07324 (0.0427)	−0.0154
	Decision on use					−0.2593 (0.0636)	−0.0559 **	−0.2545 (0.0640)	−0.0537 **
	Decision on rent					0.2816 (0.0563)	0.0607 **	0.2674 (0.0560)	0.0564 **
	FLLC					0.6298 (0.0767)	0.1359 **	0.6803 (0.0794)	0.1437 **
	SLLC					0.3526 (0.0460)	0.0761 **	0.3588 (0.0466)	0.0758 **
	Credit					−0.4178 0.0963	−0.0901 **	−0.3849 (0.0966)	−0.0813 **
Perceived tenure security risks	redistribution							0.0223 (0.0266)	0.0047
	Inheritance							0.0458 (0.0296)	0.0096
	Rent out							0.0880 (0.0265)	0.0185 **
	collateral							0.0593 (0.0357)	0.0125
	conservation							−0.2653 (0.0348)	−0.0560 **
	Tree tenure							0.1403 (0.0207)	0.0296 **
Constant		−0.4657	0.1437 **	−0.0657	0.1972	−0.0507	0.1990	−1.0748	0.2967 **

Note: n = 6692 Wald $Chi^2(25)$ = 713.56, Prob > Chi^2 = 0.0000; Pseudo R^2 = 0.1406; $p < 0.05$ **; Robust standard errors are given in parentheses. The average marginal effect (dy/dx) is calculated at the mean for continuous and discrete change from 0 to 1 for dummy variables.

Age—the age of a household head negatively and significantly influenced investment in the on-farm SLM with an average marginal effect of 0.2 percent with a 95 confidence interval compared to a mean age of 55. Meaning every one-year increase in the age of the household head leads to a 0.2 percent decrease in the probability of on-farm investment in SLM. This may relate to the decrease in household labor within the household and inability of a household to conduct farm management as households aging.

Education—the results revealed that educational attainment negatively and significantly affected the small landholder households' on-farm investment in SLM in the study areas with an average marginal effect of 2.3 percent with a 95 confidence interval. This shows that when the educational attainment of the household head increases by one grade level, the probability of investment in the on-farm SLM decreases by 2.3 percent.

Marital Status—the results of the current study revealed that the marital status of the head of the household positively and significantly affected the small landholders' on-farm investment in SLM with an average marginal effect of 5 percent with a 95 confidence interval. This shows that households headed by married couples have a 5 percent higher on-farm SLM investment probability than households headed by unmarried individuals or widowers.

Means of land acquisition—access to land through administrative allocation is becoming impossible due to a shortage of land caused by the increasing population. Access to land determines the on-farm investment of households. In this regard, the results unfolded that means of original land acquisition negatively and significantly influenced the probability of households' on-farm SLM investment with an average marginal effect of 0.7 percent with a 95 percent confidence interval, compared to a mean of 45 percent. This shows small landholder households who originally acquired their landholdings currently under their possession other than administrative land redistribution or allocations have a 0.7 percent reduced probability of on-farm SLM investment incentives. Given that the last administrative land redistribution was conducted 30 years ago and about 40 percent of the land was acquired through inheritances in the study areas, SLM policy and strategy need to consider this factor.

Land area—the survey results revealed that land area is also found to influence the probability of households' on-farm investment negatively and significantly in SLM in the study areas with an average marginal effect of 1.4 percent with a 95 confidence interval. Meaning every one-unit increase in the land held by the household head leads to a 1.4 percent decrease in the probability of investment in the on-farm SLM.

Time taken and distance from homestead to parcel—the survey result revealed that both time taken and distance to parcel are also found to effect the probability of households' on-farm investment in SLM positively and negatively, respectively, but insignificantly, with an average marginal effect of 0.14 and 0.00 percent, respectively. Meaning every one-minute increase in the travel time from home to the parcel leads to a 0.14 percent increase in the probability of investment in on-farm SLM. In contrast, every 100 m increase in distance from home to the parcels leads to a 0.01 percent decrease in the probability of households' on-farm SLM investment, compared to a mean distance of 1.5 KMs. This may have an insignificant effect since most of the parcels possessed by the landholders are found reachable in 15 min, with an average walking distance of 1.5 KMs.

Water erosion risk– the results also revealed that water erosion risk is found to affect the probability of households' on-farm SLM investment positively and significantly. The results revealed that households who held a parcel of landholding located on sloping lands with soil erosion risk from water had a 16 percent increased incentive to invest in SLM technologies with a 95 percent confidence interval, compared to a mean probability of 45 percent. This implies the higher the water erosion risk, the better probability of incentives to invest in on-farm SLM practices.

Possession of landholding certificates—land registration and certification is one of the mechanisms sought for improving tenure security in Ethiopia to incentivize long-term land-based investment such as on-farm SLM and climate-smart agriculture. Under the

current study, the survey result revealed that possessions of either FLLC or SLLC were found to influence the probability of households' on-farm SLM investment positively and significantly in the study areas. The results indicated that landholding certification increases the probability of investing in on-farm SLM with an average marginal effect of 14 and 8 percent for FLLC and SLLC, respectively, at a 95 percent confidence interval and compared to a mean probability of 45 percent. This shows that small landholders who possessed either FLLC or SLLC for their parcels have a 14 and 8 percent increased probability of on-farm SLM investment than those households without either FLLC or SLLC for their parcels, respectively. However, from these data, it is less clear why SLLC has a lower impact than FLLC on incentivizing households' on-farm SLM investment.

Credit—the survey results also revealed that credit access significantly but negatively affected the probability of households' on-farm investment in SLM with an average marginal effect of 8 percent at a 97 confidence interval, compared to a mean probability of 45 percent. Meaning households without credit have an 8 percent reduced probability of investing in on-farm SLM.

Conservation security risk—perceived conservation risk is found to negatively influence the probability of households' on-farm investment in SLM significantly. The results revealed that those households who are fully convinced or believe in the future benefit from an SLM investment have a 6 percent increased probability of investment incentives in SLM at a 95 confidence interval, compared to a mean probability of 45 percent.

Tree tenure security risk—in another measure of tree tenure security risk, the results revealed that those households who are fully convinced that they will not stand to benefit in the future from trees have a 3 percent reduced investment probability of on-farm SLM. Meaning households who foresee a tree tenure insecurity risk will likely be disincentivized to invest in on-farm tree planting at a 95 confidence interval, compared to a mean probability of 45 percent.

Regarding de jure tenure security, household heads who know their bequest land rights are recognized and protected by the land laws have an 8 percent increased probability of on-farm SLM investment at a 95 confidence interval, compared to a mean probability of 45 percent. Meaning those households who were aware of their bequest rights recognized before the laws were better off investing in on-farm SLM.

4. Discussion

This section discusses the results of the current study by comparing them with previous studies on factors that influence smallholder households' SLM investment. The role of land tenure institutions, be it formal, customary, or informal, in sustainable land use and resource management has paramount importance. This is because the way land tenure institutions are organized and enforced can greatly influence how communities and landholders use land resources and whether durable sustainability on-farm SLM investments are being made. Regardless of the forms of tenure rights, their recognition and protection are also critical factors for sustainable land use and resource management. For instance, secure private land use rights, without enforced land use planning which regulates land use zoning and other environmental management measures, may result in adverse environmental outcomes. Based on the findings of the current study, this section particularly discusses the effect of LTIFs represented by the three categories of land tenure security and their corresponding bundles of land tenure rights on the probability of households' on-farm investment in SLM in the study areas.

4.1. Whether De Jure Land Tenure Security Influences Households' On-Farm Investment in SLM

The current study revealed that legal recognition of land use rights of households in the study areas provides de jure tenure security, such as the right to bequest one's landholding to heirs, significantly affecting the probability of households' on-farm investment in SLM. This is consistent with Boone [27], who found legal empowerment of the poor through property rights reform in Sub-Saharan Africa incentivizes land-based investment.

In their recent systematic review, Tseng et al. [6] also found similar and strong support for strengthening land tenure security largely led to positive human well-being and environmental outcomes, particularly through formalization, land use planning, and land policy reform. Aggarwal et al. [28] conducted an assessment in 23 countries and found that governments are increasingly giving legal recognition to community forest rights but fewer legal protection and more barrier to using those rights.

Accordingly, in rural Ethiopia, individual land rights are generally recognized under the federal and regional land administration and use proclamations. The 1995 Constitution of the country enshrined the ownership of land to the state. The state body is almost always implicated as a duty holder as the entity with the power to arrest and adjudicate. Ethiopian nationals can have individual usufruct rights in that peasants and pastoralists can obtain land for cultivation and grazing purposes free of charge for an indefinite time. Proclamation 456/2005 of the federal democratic republic of Ethiopia also recognizes acquiring of individual landholding rights through allocation, redistribution, settlement programs, donation, and/or inheritance free of charge. However, neither collateralization of landholding rights to access credit nor acquiring land through sales or any other exchange are ruled out by the existing legal framework. Those recognized rights by law are exclusive but not absolute because landholders' tenure rights are generally bounded by limits on externalities, such as preventing soil and water pollution. This indicates that the existing legal framework recognizes and provides protection of small landholders' rights clearly and implies there is a de jure tenure security except for collateral and land sale. However, local conditions determine which of these bundles of rights are protected in practice. For instance, forest tenure rights held by individuals are recognized in the existing legal framework, e.g., Proc. No. 456/2005 Art 2/11 and Proc. No 1065/2018, Art 2/6 of the forest proclamation. In addition, communal forest tenure rights are recognized in the same proclamations, Art 2/12 and Art 2/7, with adequate duration and scope, respectively.

The econometric results revealed that those households who were aware of their usufruct rights, transfer rights through rent/sharecropping, and bequeath/inheritance rights recognized by the existing laws have a 5 to 8 percent better probability of investing in on-farm SLM. This implies that legal literacy or awareness of what bundles of tenure rights are recognized and protected by the existing land and forest laws makes a significant difference in on-farm SLM investment among small landholders in the study areas. This is consistent with what Vu H. and Goto D. [29] found in Vietnam that awareness about land tenure security towards agricultural land tenure rights increases sustainable land-based investment. However, the results also revealed that landholders knew that the land laws did not recognize collateralization of land rights, hence insignificantly influencing small landholders' on-farm SLM investment. Meaning collateralization of land rights was not an option for small landholders to access credit and finance on-farm SLM investment until recently. However, since 2019/20, there has been a policy change in land use rights as collateral to borrow mainly from financial institutions. Hence, de jure tenure security significantly influences the probability of households' investment in the on-farm SLM in the context of inheritance than usufruct, rental, and collateral bundles of tenure rights. Therefore, the provisions of succession in the land law need to be clear and strengthened.

4.2. Whether De Facto Land Tenure Security Influences Landholders' On-Farm Investment in SLM

De facto tenure security is also measured across the bundles of tenure rights as recognized in the existing legal framework, practiced by the smallholder households, and protected by the state or local governments in the study areas. Overall, the econometric model findings show that the de facto tenure security set was found to influence the smallholder households' on-farm investment in SLM significantly. In their systematic review, Tseng et al. [6] found that changes from de jure to de facto tenure security demonstrated by the formalization of land rights lead to better environmental outcomes. Regardless of countries' specific legal systems, legal documentation of rights refers to the recording and publication of information on the nature and location of land, rights, and rights holders [30].

In a formal system or statutory context, land titling is sought as one of the mechanisms that provide rights holders with a secure tenure right and incentivizes them to use land efficiently by investing in land conservation and improvement [5,18]. Since early 2000, the government of Ethiopia has launched one of the biggest two-stage land registration and certification programs in Africa with the aim to improve land tenure security in the highlands of Ethiopia and incentivize long-term land-based investment such as SLM practices and curb land degradation [31].

As well documented in the existing literature, land degradation is one of the major environmental and development challenges in the highlands of Ethiopia that reduces agricultural production, increases food insecurity, and disrupts sustainable ecosystem functions [32–34]. Guided by Ethiopia's Sustainable Investment Framework (ESIF) for SLM, the government of Ethiopia embarked on a national SLM flagship program in 2010. ESIF presumed that the removal of the key barrier of insecure land tenure is believed to be one of the way-outs to greater adoption of SLM practices and reduces further land degradation [35]. Component two of the ESIF recommends the improvement of the land administration and certification system. Under ESIF, the combination of participatory and integrated watershed management and secure land tenure rights is expected to lead to increased adoption of SLM practices, reducing land degradation, increasing carbon sequestration, and delivering more resilient and sustainable livelihoods.

The econometric model of the current study revealed that possession of either FLLC or SLLC was found to positively influence the probability of households' on-farm investment in SLM significantly. This is consistent with Adere et al. [34] findings in southern Ethiopia that land certification has a positive but heterogeneous impact on different SWC techniques among farmers with different risk preferences in that the effect is stronger for more risk-averse farmers in Ethiopia. Deininger et al. [36] also found consistent evidence of the impact of land certification on tenure security, investment, and land market participation in Ethiopia. Gebremedhin et al. [37] also found that land tenure security contributes to land conservation by influencing SWC actions in watersheds and enhancing household willingness to invest in high-cost and long-term conservation practices in Ethiopia's Tigray regional state. Likewise, Frank [38] also found, in some Sub-Sharan Africa countries, the clarity and recognition of land tenure rights through land registration and certification of small landholders and communities incentivized land managers to engage in higher value and more productive land use practices. Mugagga [39] also found predominantly land tenure secure communities through communal land certification invested in longer-term soil conservation measures in Uganda.

However, it is worth noting that having a certificate does not necessarily fully secure or causes a person to believe that there is an absolute guarantee. Meaning the impact of land certification on tenure security differs by how perceived tenure security is measured. In addition, the type of tenure security risks matters the intensity and adoption of SLM practices. This leads us to the discussion on the third category of land tenure security, i.e., perceived tenure security risks related to the bundle of rights recognized in the existing land laws. Before turning into the perceived tenure security discussion, it is important to highlight another de facto tenure security bundle of rights, i.e., collateralization of land use rights and its effect on the smallholder households' on-farm investment in SLM.

The econometric analysis revealed that credit access significantly but negatively affected smallholder households' investment in SLM. This result is in line with the work of Mulwa et al. [40], who found that access to credit allowed households to adopt SWC activities that helped them to invest more in agricultural inputs in Malawi. Abeje et al. [33] also found access to credit has a positive effect on adopting a higher number of SLM practices in Ethiopia. Similarly, Asaaga et al. [11] found that access to credit plays a critical mediating role in the relationship between tenure security and SLM investment in Ghana. This implied that in the absence of access to credit, small landholders may still find it difficult to invest in on-farm resource-intensive SLM investments such as SWC measures.

Contrarily, the econometric analysis shows that decision-making on the crop to grow was found to influence negatively but insignificantly the probability of households' investment in on-farm SLM. Contrarily, the decision on the use of the produce was found to negatively influence the probability of households' on-farm SLM investment significantly. This shows that although landholders have legally secured joint tenure rights under the current legal framework and documented joint title, there is a de facto tenure insecurity within intra-household. This is consistent with the results found by Feyertag et al. [41] in that women are more likely to feel threatened by internal sources of insecurity within the family or community. Chigbu et al. [42] raised the alarm concerning the failure to understand female differentials in land tenure access and security could lead to engendering policies that benefit only a section of communities rather than all women within the community. Meaning context specific inter and intra-household de facto tenure security, such as decisions on what to grow on-farm and the use of the produce, must be considered in SLM policy.

On the other hand, the decision on the transfer of rights through rent and/or sharecropping was found to positively influence the probability of households' on-farm investment in SLM significantly. This indicates that smallholder households with joint landholding rights recognized through joint land certificates should decide on the transfer of their joint landholding rights in the form of land rent/sharecropping. This is consistent with the legally recognized requirements in that the parties need to agree and provide their consent jointly to enter a land rental/sharecropping contract arrangement. This implies that joint landholding rights holders in the study areas have secured de facto tenure security that facilitates on-farm investment in SLM. This is consistence with what Ghebru and Girmachew [23] found in Ethiopia that the value-added direct and spillover effects of SLLC favor the supply side of the land rental market, the likelihood of renting/sharecropping in land is significantly enhanced even for non-beneficiary households who reside in or around land certification treated program woredas. Hence, it can be inferred that households relate their on-farm SLM investment with de facto tenure security significantly but specific to bundles of rights and contexts. Therefore, this is another strong evidence of the need to make SLM policy context specific.

4.3. Whether Perceived Land Tenure Security Risks Influence Housholds' On-Farm Investment in SLM

Coming to the perceived tenure security of small landholder households, the econometric analysis of the current study shows that this category of tenure security was found to influence the probability of households' on-farm investment in SLM significantly but in different directions. For instance, regarding perceived conservation security risk, the econometric analysis shows that perceived conservation security risk is found to negatively influence the probability of households' on-farm investment in SLM significantly. This is in line with Gebremedhin et al. [37], who found that investment in stone terraces was positively influenced by factors associated with long-term investment perspectives, such as the capacity to invest and land tenure security in the Tigray region of Ethiopia. On the other hand, Ghebru and Girmachew [23] found that while SLLC has a positive effect in reducing private land tenure risks, this intervention negatively affects men's perceived risk of private tenure security. The fact that the SLLC is predominantly implemented by issuing joint landholding certificates to heads and spouses could explain the extra sense of security married women perceive while men perceive the contrary [23].

Likewise, perceived tree tenure security risk is found to positively influence the probability of households' on-farm investment in SLM significantly. This shows that there should be clarity on the security of tree and land tenure nexus. As per the existing legal framework, in Ethiopia, land tenure rights and tree tenure rights are exclusively independent bundles of rights. As mentioned earlier, landholders have perpetual land use rights, while the forest law proclaimed individual forest ownership rights, including tree planting and use of forest and non-forest timber products. However, this might not

be well understood among smallholder households, which likely negatively influences on-farm SLM investment, such as agroforestry which is one of the proven on-farm SLM technologies promoted under the ESIF. However, other previous studies in Ethiopia also found that improvement in perceived tenure security has been witnessed after the land certification program [23,24,43,44].

The econometric analysis further shows that perceived tenure security risk to enter any sort of business transaction involving credit was found to have an insignificant influence. Since this right was not legally recognized/secured before the survey data collection period, households feel there will be a credit transaction security risk, which hinders on-farm SLM investment. This is consistent with Adere et al. [34], who found in southern Ethiopia, risk preferences influence the SWC investment of households. Contrarily, Byamugisha [38] found that landholders having secure tenure rights and secure access to credit spur long-term productive investment in some sub-Saharan Africa countries [19]. Based on these findings, households relate their on-farm SLM investment with perceived tenure security.

4.4. Households' Socio-Economic and Demographics and On-Farm Investment in SLM

Regarding the demographic variables of the households, the current study found that gender, age, and education negatively influence households' on-farm investment in SLM significantly. For instance, the econometric analysis shows that the gender and age of the household head are found to influence the households' on-farm investment in SLM significantly negatively. This is consistent with earlier studies, such as by Ghebru and Girmachew [23], who found that female-headed households with SLLC are less likely to engage in investment and/or maintenance of sustainable land management practices compared to households without SLLC in Ethiopia.

Likewise, the educational level of the household head is found to negatively influence the probability of households' on-farm SLM investment significantly. Contrary to our expectation and with others on the effect of education [40,45,46] on the adoption of sustainable agricultural practices and climate adaptation measures, the current study finds that small landholder household heads with more years of schooling are less likely to invest in on-farm SLM. This may indicate that well-educated household heads tended to look for non-land-based livelihood options such as off-farm activities or prefer out-migration. More specifically, insufficient availability and productivity of land may also be among the disincentives of investment in the on-farm SLM among household heads with more school years attainment. This implies that households' educational attainment and on-farm investment in SLM should be seen carefully, with increasing pressure on land and decreasing productivity due to land degradation compounded by climate change risks.

The economic analysis further shows that the socio-economic factors such as marital status, means of original land acquisition, and area of landholding of smallholder households were found to influence significantly but in different directions. For instance, the econometric analysis reveals that land area negatively influences the on-farm investment in SLM significantly in the study areas. This is in line with Etsay et al. [47], who found a negative relationship between farm size and the adoption of indigenous conservation practices in the Tigray region of Ethiopia. However, the current result disagrees with the findings of Wondimu et al. [32] that land area has a significant positive effect on crop rotation in the Abay basin of the Oromia region of Ethiopia.

4.5. Parcel-Specific Factors and On-Farm Investment in SLM

The econometric analysis shows that distance and walking time to parcels were found to insignificantly influence SLM investment, while the exposure of the land parcels to water erosion risks was found to influence smallholder households' on-farm investment in SLM positively. This is consistent with Adimassu et al. [35,48], who found that farmers vulnerable to erosion hazards are more likely to invest in different land management practices, but investments were highly variable across their production domain. Wondimu et al. [32] also found that the perception of erosion hazard has a positive and significant effect on

the adoption of soil bund SLM practice in the Abay basin of the Oromia regional state in Ethiopia. As land is household heads' ultimate resource for their livelihood, parcels which were exposed to water erosion were more likely to receive on-farm investment in SLM, thereby reducing land degradation and improving their productivity. Similarly, Abeje et al. [33] found that the parcel level factors influence the SLM investment, including slope gradient, fertility status, area, and distance to and from home.

5. Conclusions

This study assessed factors affecting households' on-farm SLM investment in 19 highland woredas of three regions (Amhara, Oromia, SNNP) in Ethiopia, where land degradation is considered a daunting environmental and development challenge. This study considered selected household and parcel-level variables and land tenure institutional factors. This was achieved by employing a probit regression model that estimated the average marginal effect of the explanatory variables on the outcome variable quantitatively, i.e., the probability of a household head invested in any on-farm SLM practices. While much of the existing land tenure literature recognizes the need to ensure the security of tenure in broader terms, this may hinder an in-depth yet broader perspective of understanding the effect of LTIFs along categories of land tenure security across bundles of rights and hence limits context specific SLM policy and implementation strategy. Hence, the current study empirically tested this approach and demonstrated that the approach might be replicated in other countries and contribute to the broader body of evidence.

The findings of this study revealed that households' on-farm investment in SLM is affected by several demographic and socio-economic factors, parcel-specific variables, and LTIFs. Particularly, the LTIFs were also found to jointly influence the probability of households' on-farm investment in SLM significantly but differently across the different categories of tenure security and bundles of rights. These results demonstrated that unbundling the categories of land tenure security across the bundles of rights and understanding their specific influence on households' on-farm SLM investment are important aspects of designing context-specific SLM policy and implementation strategy.

These results have three important implications. Firstly, while the household and parcel level variables are very important to consider when designing SLM investment policy at the household level, the LTIFs are equally important to consider across the bundle of rights. Meaning categories of secure tenure rights must be seen in perspective along with other influencing factors. Secondly, while securing tenure through land certification incentivizes the on-farm investment in SLM, land policies and regulatory frameworks should also consider the issues of access to credit to small landholders that create the capacity to invest in durable and intensive on-farm SLM investment. In the absence of access to credit, small landholders with secure tenure rights may still find it difficult to invest in an on-farm resource-intensive SLM investment. Hence, the SLM policy needs to strengthen access to credit for smallholder households across the country. Finally, regardless of the forms of tenure rights, their recognition (de jure) and enforcement (de facto) tenure security combined with the regulatory functions of land tenure institutions, such as the enforcement of land use regulations, are also critical factors for sustainable land use and resource management. Secure private land use rights, without enforced local level land use planning which regulates land use zoning and other environmental management measures, may bear little on-farm investment in SLM that could not balance the exploitation of land resources and may result in adverse environmental outcomes. This will likely affect the sustainability of SLM investment at the landscape level, including communal landholdings.

However, this study did not undertake an in-depth assessment of local-level land use plan implementation where available and its implication on households' on-farm SLM investment. Future research should focus on the impact of local-level land use plan implementation compliance by smallholder households and its implication on their on-farm investment endeavors in SLM.

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