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Impact of Land Tenure Security Perception on Tree Planting Investment in Vietnam

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Abstract: With over 14 million hectares allocated, Vietnam's forest and forestland allocation has been one of the largest natural resource decentralization programs in the developing world over the last three decades. Given this remarkable achievement, critics are concerned about the low rates of household tree planting investment and question the roles and effects of land institutions on investment. Using nested logit and ordered probit models, this study examined the effects of household perceptions of forestland tenure security on tree investment and the causal effects among 239 households in 11 communes in the Central Highlands. The findings suggested that, given the land titling in hand, household perceptions of potential land expropriation in the next five years did not thwart investments in both short-term acacia and long-term cashew horizons. The number of laborers, cost of plantations, off-farm and agricultural incomes, migrant status, soil condition, plot location, government subsidies, and a positive market outlook all played a significant role in this investment. Interestingly, we found that short-term tree planting had the reverse impact on decreasing land users' perceptions of land tenure security, possibly because each tree rotation shortens the 50-year land use period recorded in the Land Use Right Certificate. However, market prospects and government subsidies may significantly counteract the negative perception of LTS and encourage households to plant trees. The policy implication is that, in addition to strengthening LTS to ensure households' current and future land use rights, tree investment-incentivized policies should be implemented.

Keywords: nested logit; 2SCML; land tenure security; investment; forestland allocation; tree planting; Vietnam

JEL Classification: *Q12*; *Q15*; *Q57*

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1. Introduction

Land tenure security (LTS) is one of the most fundamental elements for optimizing the land use of rural households [1]. It refers to the certainty that a person's or group's rights to land, whether freehold, leasehold, concessional, collective, or communal, will be recognized and protected in the case of specific challenges [2,3]. The significance of LTS, particularly the duration of land use, is more relevant for forestry investment due to the long production cycles, high sunk costs, greater risks of climate change, and potential incidence of land expropriation [4–6]. This influences household investments in farmland at different spatial and temporal scales for economic purposes, as well as other social and environmental investment considerations. On the basis of this premise, there is a great interest in clarifying what constitutes land tenure security and how it influences agro-forestry investment.

Recently, there has been an increasing body of literature addressing the perceived LTS-investment nexus in the context of the fact that roughly 70% of land in developing countries is unregistered or perceived to be insecure [1]. The perceived LTS (or land tenure security perception) is conceptualized as the farmers' belief in their tenure rights and fear of losing land control in the future [2]. Broegaard (2005) [7] proposes a tripartite view of LTS, including de jure (legal) and de facto (actual) land rights, and perceived LTS. In this framework, the de jure view is based on the neo-classical concept of property rights, the de facto view places greater emphasis on actual control of property regardless of its legal status, and the perceived view refers to the sense of security that owners have in their tenure situation. Similar to the tripartite framework, Ho (2014) [8] develops the credibility framework, which includes formal (i.e., officially accorded rights), actual (i.e., rights enjoyed in practice), and targeted (i.e., rights perceived as essential) security. Qian et al. (2020) [9] extend this concept by incorporating personal traits and discover that the internal locus of control [3] is important in explaining smallholder land use behavior [10]. This individual's psychological attributes and economic preferences are key components for analyzing the impact of perceived LTS [10]. Most recent studies admit that LTS perception is ambiguous and difficult to measure, and it reflects not only current but also future incidences of conflict, eviction, and expropriation over land tenure rights. In fact, household perceptions of LTS exist in many developing countries, where formal, customary, religious, and other legitimate bases for claiming property rights are in place but the state's capacity for policy implementation is often limited [11,12]. Therefore, the perceived LTS serves as a more direct proxy for tenure security than the de jure and de facto rights of land use for household investment decisions in forest and perennial crop plantations [11,13,14].

The effect of LTS perception on investment, albeit not new, is intuitively attractive in several countries, including China and Vietnam, where households only possess land use rights rather than land ownership [1,15,16]. In Vietnam, the rights of landowners, including forestland owners, are limited to land use rights under the land titling system. According to the 2013 Land Law, individual households only have a 50-year use right with a Land Use Right Certificate (LURC) that can be exchanged, leased, inherited, sold, or mortgaged (see Section 2 for details). Under the national forestland allocation (FLA) program, 14.3 million hectares of forest and forestland have been allocated to various entities, including 4.5 million hectares of degraded and barren forestland allocated to households for the purpose of tree planting, the subject of this study. Recent critics, however, have raised concerns about low rates of household investment in tree planting, and questioned the roles of land institutions and incentivized policies designed to promote long-term investments in tree planting [4]. This highlights the need for revitalizing the concept of LTS, including household perceptions as described in Refs. [7,10], and prompts investigating the potential impacts on household forestland use behavior in Vietnam. Unlike in China, and many other developing countries, there is little empirical evidence of the impact of forestland tenure perception on capital investment in tree planting by smallholders in Vietnam. Using the case of the forestland tenure system in the Central Highlands of Vietnam, this study aims to investigate the relationship between a household's perceived LTS and their investment in tree planting.

Most studies on the relationship between LTS perception and investment in tree planting produce mixed results in several ways (see Table A1 in Appendix A for the list of reviewed studies). First, the LTS of small landholders, represented by ownership rights, is acknowledged as a crucial element for promoting investment [6,17–22]. The underlying reason for the positive impact is that the LTS provides access to capital and allows for the transfer of land rights. Secondly, tenure insecurity incentivizes tree planting by establishing solid evidence of land rights, legitimacy, and labor resource access [23–27]. Third, tenure security is not necessary for accessing the capital market for investment in forestland [28,29]. Surprisingly, several studies have found no impact of LTS on forestry investment [25,30,31], or remain inconclusive [28,32]. Empirical evidence also reports two contrasting arguments on the causal impact of capital investment on perceived LTS. Several studies prove a positive effect of capital investment on improving LTS [6,12,19,22]. The fixed capital investments, e.g., on planting trees or constructing soil bunds, may strengthen the tenant's right to the land in the event of weak or informal systems of property rights. In developing countries, the impact of capital investment in tree plantations is more evident on enhancing the LTS, e.g., in Ethiopia [6], Uganda [33] and Burkina Faso [25]. However, in China, Yi et al. (2014) report no significant effect of tree planting on improving LTS [19]. The causal impact of capital investment on enhancing LTS perception also varies across empirical contexts.

In Vietnam, several studies have investigated the relationship between LTS and agricultural crop investment [34], but only a few of them have examined the case of tree plantings. Markussen and Tarp (2014) report that land grabbing and unequal land distribution have increased the farmers' perception of insecure forestland tenure in Vietnam [35]. According to Neef et al. (2000), long-term investments can increase farmers' perceived LTS in the event of insecure tenure regimes [36]. From the perspective of national land governance, the inclusion of gender in the land formalization process (e.g., registering a land certificate with both spouses under the 2013 Land Law [5]) is expected to enhance the confidence of smallholders and increase capital investment in strengthening LTS. However, we have recently observed a declining trend of trust in formal land institutions, leading to lower levels of investment in tree planting.

Several economic models are used in the literature to empirically explain the effect of LTS perception on tree plantations [20,28,30,37], including standard discrete choice models, such as Logit, Probit and Tobit. In contrast to agricultural crops, acacia and cashew species share certain characteristics, such as medium- to long-term plantations, which violate the independence of irrelevant alternatives (IIA). We therefore apply a two-level estimation approach to examine the capital investment decisions of smallholder farmers in response to the adoption of an agro-forestry practice, including acacia and cashew plantations. In the first stage, we consider a choice between tree planting (i.e., afforestation) and conventional practices (e.g., fallow or crop production). The choice of afforestation leads to the second-stage selection of acacia and cashew for plantations. Additionally, recent studies have also been concerned about the endogenous reverse-causality between investment and tenure security [11,12,17,19,22,25]. To address this, we applied the two-stage conditional maximum likelihood (2SCML) approach proposed by Rivers and Vuong (1988) [38].

This study contributes to the literature in several ways. First, we examine the capital investment decisions of smallholder farmers using an empirically consistent two-level estimation approach. Secondly, we examine the reverse-cause effect of capital investment on strengthening LTS. To unravel the empirical evidence, we consider a comprehensive set of confounding variables, representing socioeconomic characteristics, biophysical properties, resource endowment, and the variables explaining risks and uncertainties. Positive market outlooks (product prices over the next five years) and government support may be attractive catalysts that can overcome negative LTS perceptions. Thus, the inclusion of these variables, which was rare in previous studies, would better explain household investment decisions. Finally, unlike previous studies that used a dichotomous definition of perceived LTS, we use a Likert scale to account for greater variability in the perceived LTS variable. The remainder of the paper is organized as follows: Section 2 describes the forestland policy and land tenure in Vietnam; Section 3 introduces the research area, data collection, and econometric model specifications and estimation methods; Model results are presented and discussed in Section 4; and the main conclusions and policy implications are summarized in Section 5.

2. Forestland Tenure Reforms and Tenure Security in Vietnam

Vietnam introduced a historical shift from a centrally planned economy to a "socialist-oriented market economy" in 1986 under the reform policy. After the first de-collectivization policy [6] in the late 1980s (known as Contract 100), the National Assembly passed the first Land Law in 1987, which allowed for the allocation of land to individuals and households for fixed terms of twenty years for annual crops and forty years for perennials [39]. Farmers were provided with LURC. Before the 1993 Land Law, forestland was managed by a system of over 400 State Forest Enterprises, which managed around 6.3 million hectares of forestland [40]. Although the government controlled the land (as in China's case), the people of Vietnam received ownership of the land with rights to exchange, transfer, lease, inherit, and mortgage it. This brought the status of LURCs closer to that of land with a secure land title. The 1993 Land Law [7] significantly improved ownership security as the forestland allocation period was increased to fifty years for perennial crops (versus forty years in the 1987 Land Law). This land tenure reform enhanced tenure security through transferable LURCs [41] and paved the way for the subsequent FLA policy.

The FLA policy represents the most fundamental policy intervention in the natural resource governance of Vietnam in the 1990s. By issuing stable and long-term land use rights, this policy aimed to improve local livelihoods via forestry activities and protecting the environment in the upland regions. Forestland recipient households are obligated to plant trees, but there are currently no provisions for regulated sanctions or land confiscation for abandoning land on the ground. This policy appears successful at first glance. Nonetheless, national success does not translate into local success, nor does it inspire idealistic attitudes toward land tenure among local forestland recipients [42]. In 2013, the government echoed this concern, claiming that up to 70% of the allotted land had been unused or improperly used. Studies report that more than a third of Vietnam's forestland is not covered by forest but is used for agriculture and other purposes, including leasing [34,43–45]. This may be due to several reasons. First, in many cases, locally distorted implementation has resulted in an unequal distribution of land, as seen in an inherent contradiction in many developing countries [43,46]. Second, public land expropriation and land grabbing are the two largest sources of land tenure insecurity in Vietnam. Land expropriation occurs when the public sector uses land for development purposes (e.g., national defense, roads, dams, electricity networks, mining), whereas land grabbing occurs when local politicians abuse their position by allocating land to relatives and friends or to large corporations [35,47]. Markussen & Tarp (2014) acknowledge the burgeoning phenomenon of land grabbing by private companies under the so-called "public-private partnership" or "four stakeholder linkage" [8] across the country since 2012 [35]. Third, land encroachment is also quite common in the Central Highlands, particularly on unfenced forestland plots or newly cleared areas such as shifting cultivation plots, which are the source of land disputes. Finally, despite compensation provisions in the most recent land law of 2013, there is clear evidence that rural households lose out because of much lower compensation for land expropriation and associated assets [48].

A LURC is insufficient to secure forestland tenure, which ultimately shapes the investment behavior of land users. The survey showed that many smallholder households have used the land for tree plantations in response to market prices and government supports, while other respondents abandoned or were reluctant to invest in tree planting. Household perception of LTS may have a significant impact on land investment in this case. Having said that, no policy actions have been taken by the government since the 2013 land law amendment to strengthen LTS, possibly due to a lack of specific evidence. However, there have been no quantitative or qualitative studies on the impact of forestland tenure security on household tree investment. Thus, it is crucial to investigate how forest land users perceive their land use rights and how such perceptions affect investment in tree planting.

3. Materials and Methods

3.1. Research Site and Data

We collected data from eleven communes in three districts, namely, Bao Lam, Cat Tien, and Da The in Lam Dong province in the Central Highlands of Vietnam (see Figure 1). The survey was conducted in 2012 in collaboration with Nong Lam University, Vietnam, in the selected districts for the following reasons: (i) they have a large allocation of forestland for afforestation; (ii) there is a wide variation in population ethnicity [49] and rural household economy [50]; (iii) they were the focus areas of the migration program after the Vietnam War [42] and (iv) smallholder households in these regions have different land-use strategies.

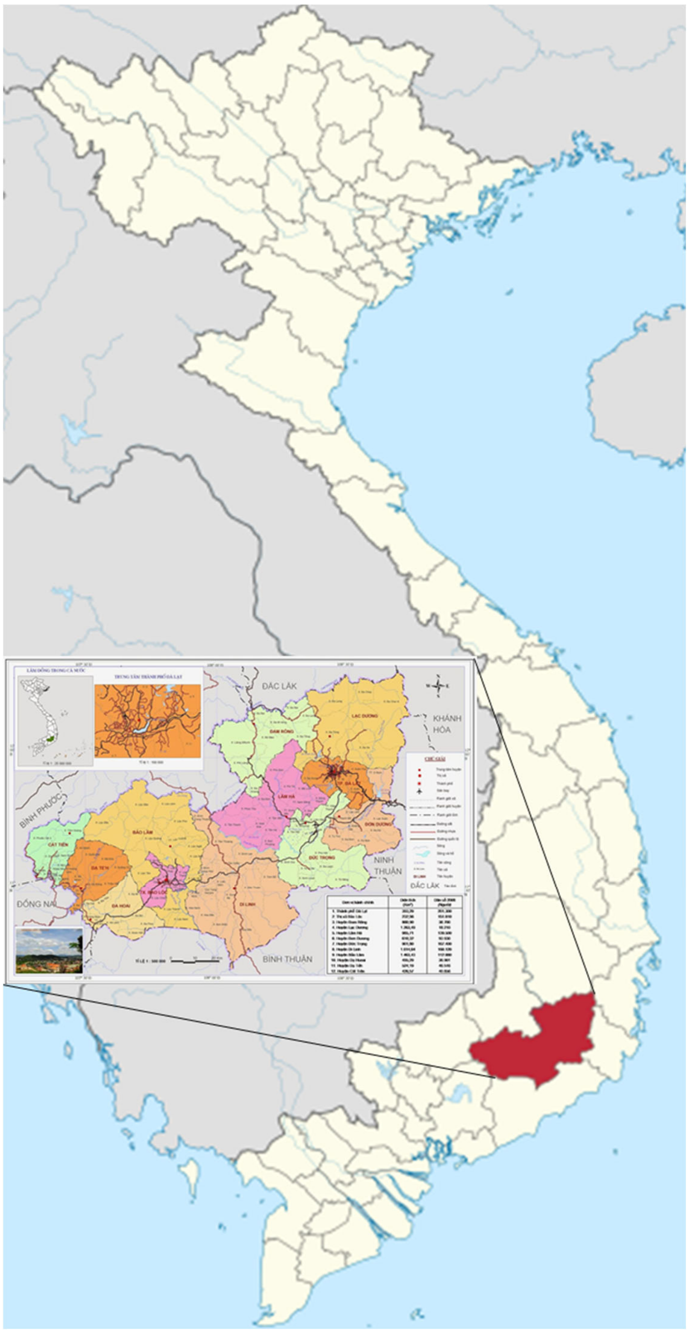

Figure 1. Map of research area.

For the farm household survey, we first randomly selected 11 from a list of 37 communes in the three districts involving the FLA program. The selected communes had a total of 937 households [9]. Most of them planted either acacia or cashew trees (hereafter referred to as the "planting group"), while a few did not practice tree plantations (referred to as the "non-planting group"). Second, we randomly selected 30% of the total households from each group (planting and non-planting groups). In this process, we excluded a few households with both acacia and cashew tree plantations, as they use a large share of land for other tree and/or crop activities. A total of 240 households, including 172 planting and 68 non-planting households, were selected (see Table 1). The selected households were interviewed using a structured questionnaire, which was designed to survey the costs and benefits of tree planting activities, and the related variables (see the list of variables in Table A2 in Appendix A). The monetary values correspond to the survey year. Out of

240, one interviewee declined to respond to the questionnaire, thus we have a sample of 239 households for econometric analysis (Table 1).

Table 1. Afforestation decision of the surveyed households.

Land Use Option	Frequency	Percent	LURC Status (%)	
			Received	Not Received
Inaction	68	28.5	28.5	0.0
Afforested with acacia species	44	18.4	11.2	6.7
Afforested with cashew species	127	53.1	52.8	0.8
Total	239	100	92.5	7.5

Source: surveyed data.

At the time of the survey, 18 households in the sample were awaiting their LURCs. A total of 172 households, or 71.9 percent, received a LURC 14 years ago, whereas 49 households (20.5 percent) received them between 8 and 13 years ago. Although most households were given LURCs, 68 households (i.e., 28.5% of sampled households) left the land fallow.

Acacia (*Acacia* sp.) and Cashew [10] (*Anacardium occidentale*) are two tree species that are frequently planted in individual forestland. The former is a fast-growing timber species with an average rotation of 5 to 7 years. This species is characterized by low tending and investing levels and provides timber materials for the paper pulp and wood chip industries. Cashew is a labor- and input-intensive crop that can last up to 35 years. Cashew provides an early harvest of nuts in the third year. People in the study area frequently apply sequential agroforestry models by intercropping with annual crops to take advantage of space in the first few years before the cashew canopy is covered. This is a preferable choice for poor households that require immediate income.

3.2. Empirical Model of Land Use Choice

Farmers in the present study are expected to use land in a way that maximizes the net benefit of tree planting on their allocated land. We analyzed the two-level nested structure of forest land use, in which farmers decide whether to plant trees in the first stage and select acacia and cashew tree species in the second stage (see Figure 2). As a result, the two-level decision process provides a nest of acacia and cashew plantations. Unlike agricultural cultivation, acacia and cashew species share some characteristics, such as medium- to long-term plantations and requiring less labor and material input than annual crops. As a result, the independence of irrelevant alternatives (IIA) of acacia and cashew plantations is violated.

To estimate the economic impact of perceived LTS on capital investment, we used perceived LTS as a treatment variable and examined its impact on household choices on tree species for planting (outcome variable) using a nested logit model (NLM). We computed the choice probability of a particular tree species as a function of relative utility among the available alternatives—no afforestation and afforestation of acacia and cashew species. In this respect, we assumed that the nth farmer will choose an ith land-use action of planting or not planting jth tree species (acacia or cashew), if the relative utility $U_{nij} > U_{nkl}\ \forall i \neq k$ and $j \neq l$ (k is other land use action, and l is other tree species). In estimating the utility of n^{th} farmer in planting of jth tree species, that is, U_{nij}, we considered the observed characteristics of individual farmers and the attributes of the tree species. However, the preferences of the farmers were unobserved. We, therefore, decomposed the farmer's utility into an observed component V_{nij} and an unobserved component ε_{nij}, as,

$$U_{nij} = V_{nij} + \varepsilon_{nij} \quad (1)$$

We assumed that the unobserved random errors ε_{nij} follow the extreme value distribution, with possible clustering of tree species (acacia and cashew) with similar characteristics. This implies that, as seen in Figure 2, the odds of choosing acacia planting would be affected by the availability of cashew species. For empirical estimation, we therefore applied the NLM, as this model relaxes the assumption of IIA by creating a nested group of similar alternatives (acacia and cashew).

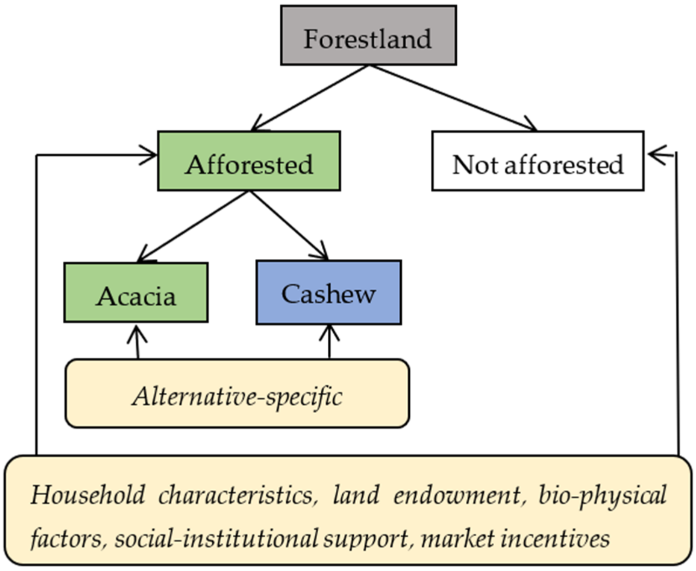

Figure 2. Logit tree of land use action-species choice.

In the NLM, we estimated the probability of adopting jth alternative to ith for nest as,

$$P_{ij} = \frac{e^{V_{ij}}}{\sum\limits_{i \in T} \sum\limits_{j \in C_i} e^{V_{ij}}} \tag{2}$$

where, P_{ij} is the joint probability of choosing $j = 1, \ldots, C$ tree species of $i = 1, \ldots, T$ land-use actions, and C_i is the set of tree species for each land-use action $i = 1, \ldots, T$.

To empirically estimate the joint probability specified in Equation (2), we defined the observed component of the farmers' utility function V_{nij} as,

$$V_{ij} = \alpha_{ij}{'}Z + \beta' X_{ij} + \eta_i{'}W + \gamma' Y_i \tag{3}$$

where Z represents observed characteristics of the individual farmer, X_{ij} is a vector of attributes of the tree species j, W is a vector of individual characteristics effecting tree choice (if any), and Y_i is a vector of attributes affecting land-use action i.

We can rewrite the joint probability of adopting a tree species j given in Equation (2) as,

$$P_{ij} = P_{j|i} P_i \tag{4}$$

where

$$P_{j|i} = \frac{e^{\alpha'_{j|i} Z + \beta' X_{j|i}}}{\sum\limits_{j \in C_i} e^{\alpha'_{j|i} Z + \beta' X_{j|i}}} \tag{5}$$

The marginal probability of each land-use action i is explained as,

$$P_i = \frac{e^{\eta_i{}'W+\gamma'Y} \sum\limits_{j\in C_i} e^{\alpha_{j|i}{}'Z+\beta' X_{j|i}}}{\sum\limits_{i\in T} e^{\eta_i{}'W+\gamma'Y} \sum\limits_{j\in C_i} e^{\alpha_{j|i}{}'Z+\beta' X_{j|i}}} \tag{6}$$

The inclusive value that links the land-use action in the first level and tree choice in the second level, is defined as,

$$I_i = ln\left(\sum_{j\in C_i} e^{\alpha_{j|i}{}'Z+\beta' X_{j|i}}\right) \tag{7}$$

Given Equation (7), we can re-write Equation (6) as,

$$P_i = \frac{e^{\eta_i{}'W+\gamma'Y_i+\tau I_i}}{\sum\limits_{i\in T} e^{\eta_i{}'W+\gamma'Y_i+\tau I_i}} \tag{8}$$

The inclusive value I_i in Equation (7) measures the expected maximum utility of planting tree species closest to the nest for the ith land-use action. The coefficient τ is a measure of independence among the choices in the nest $i = 1, \ldots, T$. When τ = 1, there is complete independence among choices in the ith nest, i.e., no correlation among alternatives within the nests. In this case, the NLM collapses to a multinomial logit. A test of the hypothesis that τ = 1 shows whether the NLM is appropriate in our empirical model set-up.

3.3. Variables and Summary Statistics

The present study considered a set of variables, accounting for perceived LTS and the associated variables, in explaining the effects of perceived LTS on investment decisions. Table 2 describes the dependent and explanatory variables, including household characteristics, farm endowment, bio-physical factors, social and institutional support, and market uncertainty.

Land use action-species decisions: Following Figure 2, the dummy variables representing land-use investment decisions equal 1 if a household chooses an alternative to planting trees on FLA land; otherwise, they are assigned a 0 (leaving the land untouched) in the first stage of the decision level. In the second stage, the selection variable is assigned a 1 if a household chooses between the acacia and cashew plant species and a 0 otherwise. Other explanatory variables explaining investment in tree planting were selected based on the economic theories and empirical literature reviewed, as shown in Table A2 of the Appendix A.

Perceived LTS: Following Deininger and Jin (2006), Holden et al. (2009) and Yi et al. (2014), we defined the perceived LTS to capture household perceptions toward future land policy change [19,20,22]. This variable was measured on a Likert scale, ranging from 1 to 5, where 1 refers to the expectation of the most secure (lowest risk) land tenure and 5 denotes the highest risk of land expropriation in the next five years. For econometric analysis, we merged categories 1 and 2, due to the small number of observations. The details of the variables are presented in Table A1.

Table 2. Variable description in the Nested Logit and Ordered Probit models.

Group	Variable	Description	Expected Sign	
			Investment	Perceived LTS
	Dependent variables			
Land use action-species (nested logit)	First-level: land use action	dummy of investment action = 1 if afforested on FLA land, 0 otherwise (inaction)		
	Second-level: species choice	dummies of tree species choice = 1 if afforested with cashew or acacia, 0 otherwise		
Causal relationship	Land tenure	Ordinal variable of perceived LTS = 1–4, 4 if household expect highest level of tenure insecurity in the next 5 years		
	Independent variables			
Household characteristics	Age of household head (number of years)		+/−	−
	Education of household head (years of schooling)		+/−	+
	At least one member working for the government (yes = 1)		−	+
	Share of laborers over total family members (%)		+	
	Off-farm labor (number of person working off-farm)			+
	Share of off-farm income (%)		+/−	
	Share of agricultural income (%)		−	
	Migrant status (dummy = 1 if yes)		+/−	
	Ethnic household (dummy = 1 if the ethnic minority)		−	−
Farm endowments	Total FLA land (ha)		+	−
	House size (m^2)		+/−	
	Value of livestock (million VND)		−	
	Value of agricultural land (million VND)			−
	Forestland use certificate (=1 if with LURC, 0 otherwise)			−
	Residential land use certificate (=1 if with LURC, 0 otherwise)			−
	Forestry experience (number of years)		+	
Bio-physical factors	Basaltic soil dummy (yes = 1)		−	+
	Grayish soil dummy (yes = 1)		+/−	+/−
	Sandy soil dummy (yes = 1)		−	−
	Average distance from home to allocated forestland (km)		−	−
	Average distance to the main roads to allocated forestland (km)		+	+
	Number of FLA plots		−	+/−
	Availability of forestry road (yes = 1)		+	
Social-institutional support	Receive at least one type of governmental support (land clearance, seedlings, fertilizer and other agricultural inputs)		+	
Market uncertainty	Dummy = 1 if household expect output prices increase more than 5% in the next 5 years		+	
District dummies	District dummy (=1 if from Cat Tien)		+/−	−
	District dummy (=1 if from Da Teh)		+/−	−
Alternative-specific variables	Total cost per hectare (million VND)		−	
	Income from tree planting per hectare (million VND)		+	

3.4. Estimation Strategy

3.4.1. The Effect of Perceived LTS on Investment in Tree Planting

Literature often points to the reverse causality of the perceived LTS variable and other missing variables in the model specification as a source of endogeneity when estimating the investment function [12,25]. To address this, we adopted a two-stage conditional maximum likelihood (2 SCML) approach proposed by Rivers and Vuong (1988) [38] and applied it to recent studies (see Table A1 in the appendix for a detailed survey of the literature). In this approach, we first estimated a linear regression equation of the perceived LTS variable on the set of exogenous variables, including instrumental variables, as below:

$$T_{per} = \beta_0 + \beta_1 M + \beta_2 I_{per} + \varepsilon_1 \quad (9)$$

where, T_{per} denotes the perceived LTS, M refers to a set of explanatory variables and I_{per} represents the instrumental variables that correlate with the perceived LTS but not with the land investment decision variable. The β_0, β_1 and β_2 are the parameters of the regression equations, and ε_1 is an iid error term.

In the second stage, we estimated the land investment equation given a set of explanatory variables that explain the investment choice on land use, including the endogenous variable and its residuals as:

$$L_{invest} = \varnothing_0 + \varnothing_1 N + \varnothing_2 T_{per} + \varnothing_3 \hat{T_{per}} + \varepsilon_2 \quad (10)$$

where, L_{invest} denotes the investment decision on land use, N indicates a set of explanatory variables, T_{per} is the endogenous variable for perceived LTS, and $\hat{T_{per}}$ is the instrumental variable proxied by the predicted residuals of Equation (9). The notations $\varnothing_0$, $\varnothing_1$ and $\varnothing_2$ are parameter coefficients to be estimated and ε_2 is *iid* error term.

Previous studies suggested that the selection of crop or tree species is mainly determined by the investment costs and the expected returns from the harvest [5,51]. In addition, the expected output price of the next five years of available alternatives for tree species is also important for farmers to make a decision on planting a crop or tree species. These alternative-specific variables were considered in the regression equations to explain the farmers' choice of a particular crop or tree species.

To address the endogeneity of perceived LTS, we employed four instrumental variables as suggested in previous studies [1,6,25]. The variable representing the longevity of forestland use was considered as a proxy for ensuring the security of forestland tenure over time and forestland use titling (with a LURC). We considered two additional instruments: prices for agricultural land and ownership of residential land. Dinh et al. (2017), however, are concerned about the relevance of using these variables as instruments in a similar empirical set-up, as these variables may directly influence farmers' perceptions of LTS without affecting investment decisions on land [45]. To ensure the eligibility of these variables as instruments, we tested the correlation between these instrumental variables and the endogenous variables.

To estimate the NLM, as in Basnet et al. (2018), we generated the counterfactual information to model the farmers' decisions on observed choices [52]. The counterfactual information was generated based on market information at the lowest administrative level with access to a common market. We estimated this model in Stata 15 using the *nlogit* command available from SSC. We performed the necessary econometric tests, such as the multicollinearity test, and estimated the heteroscedasticity robust standard errors to ensure the robustness of the model estimates. For a robust check of the NLM, an alternative-specific conditional logit (ASCL) model was estimated. Similar to the NLM, the independent variables in the ASCL model explain the choices of land use for afforestation, while the alternative-specific variables determine the acacia and cashew alternatives for tree plantations.

3.4.2. The Causal Effects of Investments on Perceived LTS

Our second objective is to examine the causal effects of different tree planting investments on perceived LTS. We split the dependent variable into two dummies—one contains the value of 1 if households invested in an acacia plantation, while in the other dummy, it is equal to 1 if the cashew plantation was selected, and zero otherwise. Using the 2SCML approach as stated above, we first regressed two linear Equations (11) and (12) of cashew L_{cashew} and acacia investments, L_{acacia} on two sets of exogenous variables N_1 and N_2, and instrumental variables I_{cashew} and I_{acacia} as follows:

$$L_{cashew} = \partial_0 + \partial_1 N_1 + \partial_2 I_{cashew} + u_1 \quad (11)$$

$$L_{acacia} = \theta_0 + \theta_1 N_2 + \theta_2 I_{acacia} + u_2 \quad (12)$$

where ∂_0, ∂_1, ∂_2 and θ_0, θ_1, θ_2 are coefficients to be estimated and, u_1, u_2 are error terms.

In the second stage, we included the residuals obtained from Equations (11) and (12), as well as two endogenous variables L_{cashew} and L_{acacia} into Equation (9). Because the perceived LTS is ordinal, we employed an ordered probit model to estimate Equation (9) and analyzed the reverse causality of different tree investment choices on the perceived LTS. In addition, we estimated an ordered logit model for a robust check. These models were estimated in Stata 15 using the oprobit and ologit commands. The investment residuals are estimated using a number of instrumental variables, including the cost and income of forestry, the amount of cashews sold, and the number of rotations that households have already practiced for acacia. These instruments have a clear influence on cashew and acacia investments, but they are unrelated to LTS perception.

4. Results and Discussions

4.1. Effect of Perceived LTS and Other Factors on Land Investments

The impact of perceived LTS on investment is presented in Figure 3. Estimating Equation (10), the likelihood ratio (LR) tests for IIA in NLM and alternative-specific conditional logit (ASCL) models (for robust check) are statistically significant, indicating the presence of nested alternatives of acacia and cashew plantations (see Appendix A Table A3). This implies that these two alternatives are similar in their characteristics and do not hold the property of IIA. The fitness of NLM is statistically significant, nearly at the 5% level (p = 0.05), but the ASCL model is significant at the 1% level (p = 0.01). In both the NLM and ASCL models, the impact directions and significant levels of the included variables are almost similar, although the impact magnitudes are larger in the ASCL model. The residuals are strongly significant in both the acacia and cashew choices in the NLM, justifying the endogeneity of the perceived LTS variable and the appropriate selection of instrumental variables.

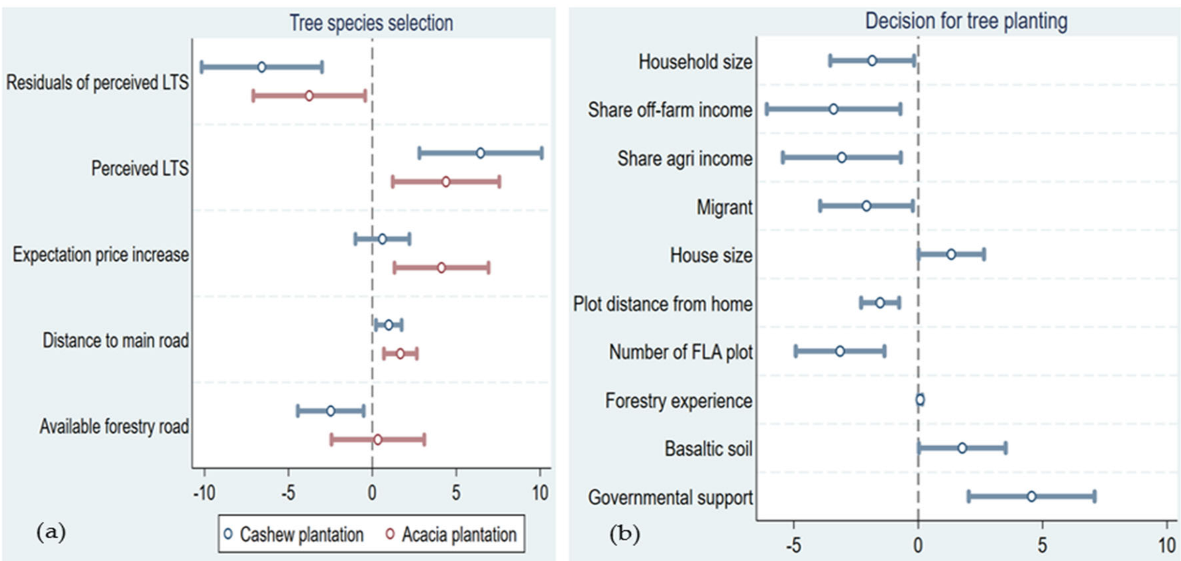

Figure 3. Impact of perceived LTS on land-use investment (**a**) Effects of LTS perceptions and other factors on species choices; (**b**) Effects of other factors on tree planting (Bar length indicates parameter confidence interval).

As an alternative-specific variable, planting cost is statistically significant, suggesting that it influences household tree planting decisions. This result is further supported by the finding of Fenske (2011) that the LTS is more robust in terms of investment in tree planting [53]. Nonetheless, the income from forestry is surprisingly low, indicating that households may still be in the early stages of planting and have not yet received income from harvesting.

The impact of perceived LTS on investment, which is the main objective of this study, is shown on the right-hand side of Figure 3. The outcome variable of perceived LTS is positively significant at 1% for both acacia and cashew choices, indicating that households are likely to invest in acacia for the short term and cashew for the long term, even if land expropriation is expected within the next five years. This finding confirms that households with negative perceptions of LTS may not only inhibit but also promote tree planting. Evidently, households can make such investment decisions because of the positive market signals (as discussed further below) and by taking advantage of government support. This finding is consistent with that of Otsuka et al. (2001), who reported the positive impact of LTS insecurity in Indonesia on early tree planting [27]. This is plausible because, like the cashew in this study, coffee is a perennial crop shown in previous studies to last for decades. In addition to other economic incentives, as discussed in the introduction, households may plant trees to strengthen LTS. This finding, however, contradicts a few studies, including Pichon (1997) and Zhang and Owiredu (2007) [21,54], which claim that insecure land tenure does not result in investment in tree planting and are skeptical of the role of investment in strengthening LTS, as claimed by Holden and Yohannes (2002) [29] with evidence from Ethiopia.

Interestingly, the study found that while the variable of government support in the first level is a determinant of tree plantations in general, the expectation of an increase in output price over the next five years in the second level positively influences the acacia choice (as expected) but not the cashew choice. This demonstrates how household confidence in the market outlook, combined with generous government subsidies, can overcome land tenure insecurity and encourage tree planting, particularly in short-term acacia plantations [11]. In some cases, households even cut down acacia trees in the fourth year to sell them for woodchips if they are in desperate need of cash or if the price of woodchips rises, by as much as 150% in 2022. This result is consistent with Shively (1998) [51], Hardie and Parks (1996), Conway et al. (2003) and Kakuru et al. (2014) [55–57]. This has important implications for enacting additional incentivized policies to promote tree plantations. The distance to field plots from the main road is positively significant for both tree choices, implying that the farther field plots are from the main road, the more likely the farmers' choice tree plantations are. This could also indicate that the farmers would prefer to cultivate agricultural crops rather than have trees in their nearby plots. Surprisingly, despite the availability of a forestry road, farmers are unlikely to invest in tree plantations, corroborating the findings of Otsuka et al. (2001), Gregory et al. (2003) [27,58]. This appears counterintuitive, but it could be due to a lack of resources among households for tree planting.

According to the first-level regression results, various explanatory variables influence the investment decisions of small farmers for tree plantations, including acacia and cashew species. Surprisingly, the age and education of the household's head do not influence the investment decision for tree plantations, as reported by Zhang and Owiredu (2007), Mekonnen (2009) and Bambio and Agha (2018) [21,59,60]. Interestingly, households with at least one family member in government services are less likely to invest in tree planting. This may be consistent with the finding of Dinh et al. (2017) that government employees gain access to better soil quality for profitable crops, hence diverting capital investment away from tree plantations [45].

Similarly, labor availability is a crucial factor when deciding on a capital investment in tree plantations. We found that households with adult members are more inclined to grow trees. This finding is also in line with the previous findings, notably Holden et al. (2009) and Abdulai et al. 2011) [20,37]. The positive impact of household size on tree investment corroborated this finding since the government considers the number of adult members and other land resources in a household when allocating forestland to them. This condition is also similar in the case of Chinese forestland allocation [19]. In contrast, Holden and Yohannes (2002) found that households with more adult members engaged in non-agriculture activities were more likely to invest in field crop farming [29]. We also observe, from the estimation of the first-level nested equation, that households with a higher share of off-farm income are less likely to invest in tree plantations. These households may have a stable income to withstand unanticipated fluctuations in farm income, caused by yield variability and market uncertainty. The negative effect of the migrant variable implies that the newcomers are less likely to plant trees. It is assumed that the migrant households may prioritize food production for the first few years of the settlement.

With respect to land fragmentation, farmers are reluctant to invest in tree planting due to multiple scattered plots [19]. Farmers are also less likely to invest in trees if farm plots are located far from their homes, as travel expenses may be higher. As indicated by the survey data, this conclusion is further supported by the fact that the average distance between households and acacia plots is 5.9 km (S.E. −7.4), almost double the distance between households and cashew plots, which is 3.01 km (S.E. = 4.8). This is understandable given the fact that cashew trees require extensive tending. Finally, it is not surprising that the longer the prior experience in forest activities, the more likely the household will plant trees, which is also confirmed by Yi et al. (2014) [19].

In general, farmers still invest in tree planting despite their concerns about the security of their future land tenure. Such investments may result from a desperate need for livelihood or from seizing the economic opportunities of the allocated land. Interestingly, positive market signals and government subsidies may counteract the negative perception of LTS and encourage households to plant trees. However, care should be taken when considering this impact for the entire forestland allocation program because, as previously mentioned, this region is an ecologically and economically dynamic region, in which land users' perceptions and their economic behavior may differ.

4.2. Reverse Causality of Investment on Perceived LTS

The empirically estimated causality effects of capital investment on LTS are consistent with the outcomes of the ordered probit models (see Figure 4). However, the standard errors of the parameter estimates differ from those of the ordered logit model (see Appendix A Table A4 for details). The results from the ordered probit model indicate that, unlike the case of acacia, the variable for residuals of cashew investment derived from the first-stage equations is statistically significant. This confirms the causal endogeneity of the capital investment in the perceived LTS equation. However, investing in a cashew plantation is unlikely to have any effect on land tenure insecurity in the next five years. One could expect a statistically significant outcome in different socioeconomic settings [53,60]. The acacia investment is positively significant, reflecting its impact on decreasing the perceived LTS. This finding surprisingly contradicts most previous empirical conclusions, including those of, (e.g., Brasselle et al. (2002), Knudsen and Mertz (2016), Degnet et al. (2020) [6,13,24,25,61,62]. The studies found that household investment in tree planting can strengthen tenure security as a prelude to future reinvestment. Given that land in Vietnam is typically allocated for 50 years, households with acacia plantations may notice a gradual decrease in the LTS period after each acacia planting cycle (7 years). Nevertheless, this finding is consistent with Bambio and Agha (2018) [60], who claim that the investment variable has a negative effect on Burkina Faso's weak land tenure rights. The low significance level of the variable land titling (=1 if hh has LURCs) in the land tenure equation indicates that people do not place a high value on LURCs. This is similar to the finding of Rao et al. (2020) in China that formal land institutions do not contribute to household perceptions of tenure security on contract land [26].

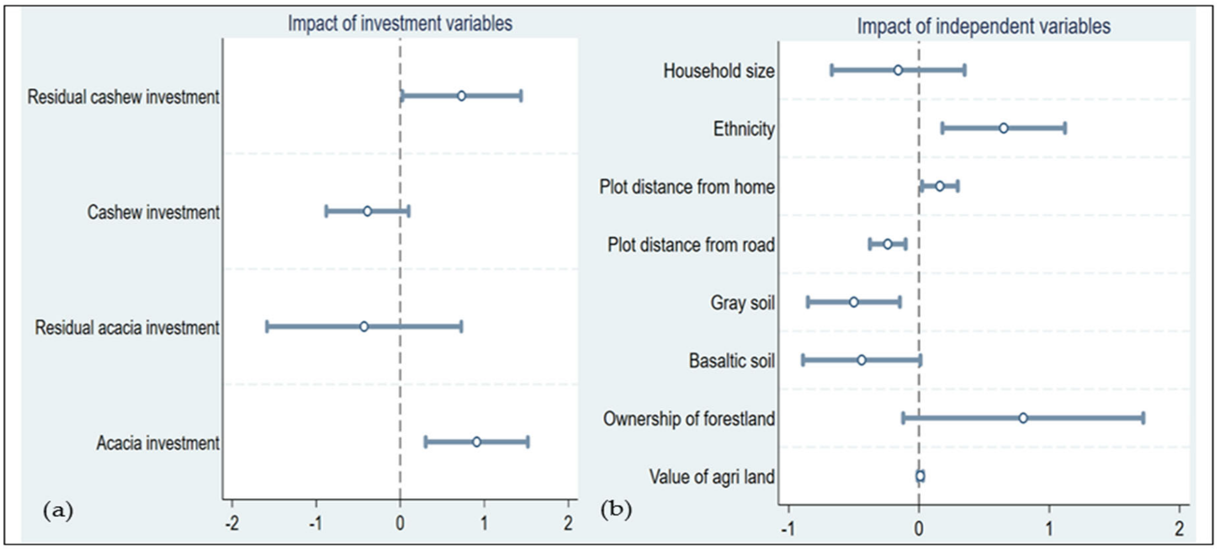

Figure 4. Causal impacts of tree investments on LTS perceptions (**a**) Effects of investment variables; (**b**) Effects of other independent variables (Bar length indicates parameter confidence interval).

Figure 4 shows that ethnic households are vulnerable to land expropriation (see Appendix A Table A4 for details). This is not surprising as the government has policies in place to protect ethnic minorities from outsiders seizing their land. Our finding also corroborates Clement and Amezaga (2009), who contend that the process of land use planning and forestland allocation disrupts the existing land use system by redistributing existing cultivated land owned by ethnic minorities for tree planting [43]. With respect to distance, the positive impact of the distance from home to plots suggests that households feel insecure about their land tenure if the plots are far from their home. On the contrary, the plot is vulnerable to expropriation risk if it is closer to the main road, which conforms to the findings of Yi et al. (2014) [19]. This is relevant to the Vietnamese context, as the national government has recently approved the extension of the national highway network. In effect, the companies have been grabbing land near roads to establish agricultural product manufacturing plants.

With respect to soil properties, land expropriation is likely mitigated if households own grayish and basaltic soil, which is good for agricultural cultivation in the region. These soils are often used for cultivating high-value agricultural crops, resulting in higher profits than afforestation with acacia or cashew. Interestingly, we find that land titling does not ensure a positive perception of LTS security among the households participating in the forestland allocation program. At this point, the land use certificate does not ensure the land ownership of the households. This finding necessitates policy action to further strengthen land use rights to facilitate investment. The higher value of agricultural land, which is a proxy for agricultural land tenure insecurity, holds true for forestland. Finally, the two districts, namely, Cat Tien and Da Teh, show a positive correlation with land tenure insecurity, indicating that land expropriation is more visible in these newly established districts [12].

Our evidence supports the notion that household investment in a 7-year acacia plantation has a positive causal effect on the perception of land tenure insecurity (or a decrease in LTS). Put another way, the investment in a 7-year acacia plantation reduces future household perceptions of LTS. This is an intriguing case, but it may reflect the land users' anxiety about gradually losing land use rights after each tree investment cycle when 50-year fixed term usage is written into the LURC. Furthermore, these concerns are well-founded, as the issue of land redistribution has previously been discussed in the public media [13]. In the case of long-term cashew investment, the results demonstrate that investment has no causal effect on the fear of future land expropriation. Smallholders with LURCs may not be assured of secure land tenure in the near future.

5. Conclusions

This study examines the effect of smallholder households' perceptions of tenure security under the forestland allocation program on their tree planting investment behavior in Vietnam. We also investigate whether such investments have a causal effect on the perception of tenure security among land users. In contrast to previous studies, we find that land tenure insecurity has a positive effect on investment, for both short-term and long-term investments in acacia and cashew plantations. This finding appears paradoxical and may reflect a different direction than in other localities, where land can only be afforested and people do not have many options. It does, however, support the influential conclusion of several scholars, who pioneered the study of land tenure security perception, claiming that land titling frequently fails to improve the tenure security of poor and small-scale farmers. In addition, the number of laborers, costs of plantations, off-farm and agricultural incomes, migrant status, soil condition, plot location, government subsidies, and a positive market outlook also contributed significantly to this investment. Interestingly, short-term tree planting (7-year acacia) has a causal effect on improving LTS. This indicates that the investment in short-term acacia plantations could decrease land tenure security, according to land users' perceptions. This is plausible because (i) the land use term stated in the forest land use certificate is 50 years, but people fear that their land use rights may be shortened after each 7-year afforestation cycle; and (ii) the distance to the main road and market are considered potentially risky for capital investment in tree plantations. With respect to long-term investment (35-year cashew), we found no statistically significant impact of investment in cashew plantations on improving land tenure security. We observed in the study area that the households may find tree planting a means of sustaining their livelihood while preserving their property rights, rather than a response to the LURC. This would deter households from relying on formal institutions in charge of redistributing land tenure rights. We conclude that, aside from being an ecologically and economically dynamic region with diverse crop patterns, taking advantage of the fast national economic growth, market prospects, and government subsidies is more important in driving land use behavior in the study area than the threat of land expropriation. Furthermore, no policy action has been taken to enhance forestland tenure security for smallholders since the 2013 land law amendment. Thus, the policy implication is that the government should take further steps toward strengthening land use rights and prioritize incentive-based policies, as this will encourage smallholder farmers to invest in or plant more trees.

To the best of our knowledge, this study is the first to investigate the relationship between users' perceptions of forestland tenure and capital investment in tree planting in Vietnam. However, it has some limitations, including (i) a small sample size and (ii) a lack of proxies for past land expropriation to reflect household perceptions toward future LTS. We also expect that this study will provide a crucial foundation for understanding investment behavior in the context of compensationless regulations prior to the 2013 Land Law, which comprehensively addresses this reimbursement. Later studies will be able to compare people's behavior before and after the 2013 Land Law revision. In addition, we focused on the effect of LTS perception on household tree planting investments, which is the primary objective of this policy. As a result, the data collection and analysis did not encompass the analysis of land rights other than LTS.

We may further disentangle the complexities that arise due to interlinkages between investment and LTS perceptions of smallholder households in multiple dimensions. The follow-up survey in the study area could provide additional insights to unravel land use dynamics and farmer perceptions and behavior before and after the 2013 Land Law revision. Extending the current study into spatial-temporal dimensions could help to define proxies for past expropriation risk and explain the evolution of recent LTS and capital investment in tree planting trends.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. List of studies relating to LTS and investment in tree planting.

Author(s)	Study Area	Number of Obs. and Method Applied	Key Finding(s)
Abdulai et al., 2011 [37]	Ghana	Sample: 246 Method: 2SCML, Multivariate Probit	LTS facilitates investment in trees and other conservation meamures, LTS increases productivity.
Asaaga et al., 2020 [32]	Ghana	Sample: 380 Method: Logit, Multivariate	Inconclusive (not significant) Perceived LTS via socio-political status and previous land dispute enhance investment in trees.
Bambio and Agha, 2018 [60]	Burkina Faso	Sample: 3500 Method: GSEM, 2SCML	Land right has positive impact on land-related investment. But reverse impact of tree investment on land right is negative.
Besley, 1995 [6]	Ghana	Sample: 1074/494, Method: Instrumental regression	LTS facilitates investment. Tree planting strengthens claims over land, rather than enhancing tenure security.
Brasselle et al., 2002 [25]	Burkina Faso	Sample: 205 Method: 2SCML, Probit	LTS is influenced by investment
Castaneda et al., 2021 [30]	Peru	Sample: >1million obs Method: 2SCML-Multivariate Probit	LTS (tittling) has zero impact on tree planting, but increases productivity.
Fenske, 2011 [53]	West Africa	Different datasets from different countries	Greater security encourages tree planting (rights are only secure conditional on use, Land left fallow may be lost). Tree planting may enhance land right.
Holden and Yohannes, 2002 [29]	Ethiopia	Sample: 505 Method: Probit, Heckman two-steps	LTS has little/no impact on short-term investment, LTS has no effect on perennial tree planting decisions; and perennial tree planting having an effect on strengthening LTS for rich households.
Holden et al., 2009 [20]	Ethiopia	Sample: 2380 plots Method: Logit, Probit, Ordered Logit	LTS increases investment in trees, no investigation on causal impact of investment on LTS

Table A1. *Cont.*

Author(s)	Study Area	Number of Obs. and Method Applied	Key Finding(s)
Lin et al., 2020 [28]	China	Sample: 960 Method: Heckman, Propensity Score Matching (PSM)	The effect of LTS on tree planting investment is not significant.
Mekonnen, 2009 [59]	Ethiopia	Sample: 1520 Method: Logit	Land tenure insecurity promotes tree planting decision, but not intensity.
Otsuka et al., 2001 [27]	Ghana	Sample: 281 Method: Tobit, Logit	Tree planting enhances LTS.
Place and Hazell, 1993 [61]	Rwanda, Ghana, Kenya	Sample: 1622 (Rwanda), 1158 (Ghana), 215 (Kenya) Method: OLS, Logit	Inconclusive
Place and Otsuka, 2001 [63]	Malawi	Sample 243 Method. Tobit, Probit	Insecure LT causes fewer tree (dispersed) plantation. Tree planting has reverse impact on LTS
Place and Otsuka, 2002 [64]	Uganda	Sample: 203 Method. OLS	LTS of any type does not inhibit investment in tree planting. Tree planting (coffee) enhance LTS
Schürmann et al., 2020 [31]	Kenya	Sample: 334 Method: Non-parametric, GIS	Land rights (ownership) have no significant impact on tree planting intensity.
Yi et al., 2014 [19]	China	Sample: 3180 Method: Ordered Probit	Land contraction augmented by certification enhances LTS, investment does not reversely enhance LTS, free-hold land does not engage in tree planting
Zhang and Owiredu, 2007 [21]	Ghana	Sample: 130 Method: Probit, two-stage selectivity	Land ownwed outright enhances tree investment, particular in silviculture.

Table A2. Descriptive statistics of dependent and independent variables (n = 239).

Variable	All Households (n = 239)		Non-Planting Households (n = 68)		Planting Households (n = 171)		Statistical Test	
	Mean	SD	Mean	SD	Mean	SD		
Dependent variable								
Dummy of investment action	0.7	0.4						
Perceived land tenure (= 1–4)	2.9	1.0	2.8	1.0	3.0	1.0	0.3	c
Cashew species choice (yes = 1)	0.5	0.5	-	-	0.7	0.4	109.6	*** c
Acacia species choice (yes = 1)	0.2	0.4	-	-	0.3	0.4	20.9	*** c
Independent variable								
Household characteristics								
Age of household head (years)	49.5	11.2	48.4	10.9	49.9	11.4	−0.8	b
Education of household head (years)	6.3	3.3	6.3	2.9	6.4	3.4	−0.2	a
Household with ≤1 government employee (yes = 1)	0.2	0.4	0.2	0.3	0.2	0.4	0.2	c
Share of laborers over total family members (%)	67.9	25.9	63.4	24.9	69.8	26.2	−1.7	* a
Share off-farm income (%)	25.7	31.9	25.9	34.8	25.6	30.8	−0.6	b
Share of persons working off-farm (%)	0.5	0.8	0.3	0.6	0.5	0.8	−1.9	* b
Ethnicity (yes = 1)	0.83	0.37	0.88	0.33	0.81	0.39	1.7	c
Migrant (yes = 1)	0.85	0.36	0.88	0.33	0.84	0.37	0.8	c

Table A2. *Cont.*

Variable	All Households (n = 239)		Non-Planting Households (n = 68)		Planting Households (n = 171)		Statistical Test	
	Mean	SD	Mean	SD	Mean	SD		
Farm endowment								
Share of agricultural income (%)	54.5	33.6	66.1	36.9	49.9	31.2	3.5	*** b
Total FLA land (ha)	5.2	4.8	5.7	4.9	5.0	4.8	1.7	* b
Number of FLA plot	1.2	0.5	1.1	0.5	1.2	0.4	−1.8	* b
House size (m^2)	61.6	47.2	51.2	23.5	65.7	53.3	−2.4	** b
Total asset value (million VND)	9.0	65.4	8.4	49.2	9.3	70.9	−2.6	** b
Livestock value (million VND)	13.0	19.3	16.8	23.0	11.5	17.4	1.78	b
Number of trainings (yes = 1)	28.4	45.2	23.5	42.7	30.4	46.1	1.1	c
Ownership status of forestland (=1 if HH has LURC)	0.9	0.3	0.9	0.3	0.9	0.2	7.7	*** c
Value of agricultural land per hectare (million VND)	122.5	181.1	101.0	118.9	139.9	199.9	−0.9	b
Number of year using forestland (years)	8.6	1.8	9.5	2.4	8.4	1.7	−16.0	*** a
Bio-physical factors								
Basaltic soil (yes = 1)	0.16	0.37	0.16	0.37	0.16	0.37	0.00	c
Sandy soil (yes = 1)	0.21	0.14	0.20	0.12	0.2	0.15	0.2	c
Gray soil (yes = 1)	0.31	0.47	0.38	0.49	0.27	0.45	2.1	c
Soilslope (%)	3.5	0.8	0.36	0.08	0.40	0.00	0.4	b
Average distance to plots (km)	5.8	7.5	0.99	0.90	0.43	0.61	5.4	*** b
Average distance to the main road (km)	3.0	4.6	6.1	6.6	1.8	2.7	5.0	*** b
Paved village road (yes = 1)	0.31	0.46	0.19	0.39	0.35	0.48	−2.3	** b
Forestry road availability (yes = 1)	0.29	0.45	0.17	0.38	0.33	0.47	5.8	** c
Social-institutional support								
Receive at least 1 type of governmental support	0.45	0.8	0.01	0.1	0.6	0.9	−9.3	*** a
Market uncertainty								
Expectation of output price increase >= 5% (yes = 1)	0.3	0.4	0.2	0.4	0.3	0.4	2.9	* c
Alternative-specific variables								
Forestry income (million VND)	13.6	29.67						
Total cost (million VND)	33.36	30.837						

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; SD standard deviation, [a] t-test, [b] Wilcoxon rank sum test, [c] χ^2-test.

Table A2 summarizes the key statistics of the variables included in our investment model. With regards to household characteristics, the planting households have a higher labor share in household size and a higher number of household laborers working in off-farm sectors than the non-planting households. There are no statistically significant differences between the two groups in terms of age, education level, immigration status, or ethnicity of household heads. Regarding the farm endowment, the planting household has a lower share of income from agriculture, a higher number of years participating in tree planting activities, and a smaller forest land area than the non-planting household. The former is also better off in terms of house area and total asset value than the latter. In terms of biophysical factors, non-planting households have a higher share of grayish soil and a higher distance from home to allocated forestland. The villages and forestlands of the planting households appear to be better physically accessible. In terms of socio-institutional support, planting households receive significantly more seedling supplies and extension services from the government. There is no statistically significant difference between the two groups of households regarding the perceived LTS.

Table A3. Impact of perceived LTS on investment in tree planting using Nested logit and Conditional logit models.

Variables	**Nested Logit**						**Conditional Logit**					
Alternative-specific variables				Coefft.		S.E.R.				Coefft.		S.E.R.
Total cost (ln)				−4.21	***	1.16				−2.62	***	(0.66)
Forestry income (ln)				−2.20		0.88				−1.12		(1.05)
Case-specific variables for tree species selection	Acacia plantation			Cashew plantation			Acacia plantation			Cashew plantation		
	Coefft.		S.E.R.	Coefft.		S.E.R.	Coefft.		S.E.R.	Coefft.		S.E.R.
Residuals of perceived LTS	−3.76	**	1.70	−6.59	***	1.83	−5.15	**	2.37	−5.73	***	1.80
Perceived LTS	4.39	***	1.62	6.45	***	1.86	5.72	**	2.36	5.66	***	1.84
Expected output price increase >= 5% (yes = 1)	4.12	***	1.43	0.60		0.82	3.53	***	0.95	0.91		0.69
Distance from plots to the main road (km, ln)	1.67	***	0.50	0.98	**	0.39	1.49	***	0.57	1.04	***	0.38
Available forestry road (yes = 1)	0.33		1.41	−2.48	**	1.00	−5.42	**	2.17	−0.90		0.82
Land use decision variables for tree planting				Tree plantations (acacia and cashew)			Acacia plantation			Cashew plantation		
Age of household head (years)				−0.04		0.03	−0.03		0.04	−0.04		0.03
Education of household head (years)				0.06		0.11	0.01		0.16	0.06		0.10
Household with ≤1 person in government service (yes = 1)				−1.85	**	0.86	−2.80	**	1.36	−1.39		0.85
Share off-farm income (%)				−3.40	**	1.37	4.91	***	1.64	2.33	**	1.07
Share agricultural income (%)				−3.07	**	1.21	−0.14		2.01	−3.40	**	1.36
Ethnicity (yes = 1)				−0.97		1.16	−2.08		1.86	−0.72		1.17
Migrant (yes = 1)				−2.08	**	0.95	−2.93	**	1.33	−1.90	*	0.98
House size (m2, ln)				1.33	**	0.67	2.52	**	1.01	0.78		0.70
Livestock value (million VND, ln)				−0.08		0.07	−0.003		0.11	−0.10		0.07
Distance from home to plots (km)				−1.53	***	0.39	−1.85	***	0.57	−1.47	***	0.39
Total FLA land (ha, ln)				0.28		0.46	0.65		0.67	0.37		0.48
Number of FLA plot				−3.14	***	0.91	−3.50	***	1.30	−2.19	**	0.86
Forest experience (years)				0.08	**	0.04	0.12	**	0.06	0.05		0.04
Basaltic soil (yes = 1)				1.77	**	0.89	2.47	*	1.29	1.69	*	0.92
Gray soil (yes = 1)				0.77		0.82	0.87		1.17	1.002		0.84
Sandy soil (yes = 1)				3.23		3.32	0.53		3.99	4.05		2.88
Governmental support				4.56	***	1.29	3.29	**	1.29	4.15	***	1.20
Cat Tien district (yes = 1)				−9.36	***	2.36	−17.08	***	4.17	−3.22		3.47
Da Teh district (yes = 1)				−9.86	***	2.60	−17.85	***	4.42	−3.68		3.65
Log likelihood				−132.94						−91.94		
χ^2 (Degree of freedom)				45.77 (32) #						79.08 (52) **		
Prob > χ^2				0.05						0.01		
Number of cases				239						239		
Number of observations				717						717		
LR test for IIA (tau = 1) χ^2 (2)				5.18						-		
Prob > χ^2				0.003						-		
VIF for multicollinearity ##				3.27						3.27		

Note: # Wald χ^2-test. ## VIF is the abbreviation for Variance Inflation Factor. Coefft. refers to the coefficients of parameters. S.E.R indicates robust standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A4. Causal impact of investments of different tree choices on LTS perceptions.

Variables	Ordered Probit			Ordered Logit		
	Coefft.		S.E	Coefft.		S.E
Investment variables						
Residuals cashew investment	0.73	**	0.36	1.07	*	0.61
Cashew investment	−0.39		0.25	−0.59		0.44
Residuals acacia investment	−0.43		0.59	−0.62		0.97
Acacia investment	0.91	***	0.31	1.28	**	0.55
Other independent variables						
Age of household head (years)	0.01		0.01	0.01		0.01
Education of household head (years)	−0.02		0.03	−0.04		0.05
Household with ≤1 person government employee (yes = 1)	−0.16		0.26	−0.15		0.46
Ethnicity (yes = 0)	0.65	***	0.24	1.06	**	0.43
Off-farm labor (Number of off-farm laborers)	0.16		0.12	0.23		0.21
Total FLA land (ha, ln)	−0.21		0.13	−0.35		0.23
Average distance from home to plots (km, ln)	0.16	**	0.07	0.29	**	0.12
Distance from plots to the main road (km, ln)	−0.24	***	0.07	−0.39	***	0.13
Number of FLA plots	0.30		0.22	0.60		0.46
Gray soil (yes = 1)	−0.50	***	0.18	−0.89	***	0.31
Basaltic soil (yes = 1)	−0.44	*	0.23	−0.77	*	0.39
Sandy soil (yes = 1)	−0.18		0.47	−0.36		0.91
Ownership of residential land (=1 if household received LURC)	−0.52		0.39	−0.87		0.72
Ownership of forestland (=1 if household received LURC)	0.80	*	0.47	1.35		0.94
Value of agricultural land (million VND/ha)	0.01	***	0.00	0.01	***	0.00
Cat Tien (yes = 1)	1.66	***	0.58	2.52	**	1.16
Da The (yes = 1)	1.76	***	0.58	2.80	**	1.14
Cut 1	0.18		0.67	0.05		1.20
Cut 2	1.67	**	0.67	2.71	**	1.20
Cut 3	2.26	***	0.67	3.69	***	1.21
Observations	239			239		
Log-pseudolikelihoods	−260.79			−260.61		
Wald χ^2 (21)	81.18			71.38		
Wald test of exogeneity (Prob > χ^2)	0.00			0.00		
Variance Inflation Factor (VIF)	1.74			1.74		

Note: Coefft refers to the coefficients of parameters. S.E. indicates standard errors; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Notes

1. Available online: https://www.usaid.gov/land-tenure (accessed on 29 January 2023).
2. See Qian et al. (2022) for the details on the evolution of the concept of LTS perception [10].
3. A generalized belief regarding the extent to which people attribute control over their situations to themselves versus the environment.
4. Report of the Ministry of Agricultural and Rural Development dated on 2 October 2017.
5. Section 4, Article 98, 2013 Land Law of Vietnam.
6. Cooperatives lost control of their capital stock, working capital, and other means of production following decollectivization. Rather than selling these elements, they retained ownership but were required to rent them to peasant households.
7. The Land Law was amended in 2003 and 2013 to include the right to use land as a capital asset.
8. As defined in the legal documents, the term “four-stakeholder linkage” refers to the involvement of farmers, businesses, scientists, and the government in a mutually binding agreement.
9. We worked with the district authorities to obtain the list of households that had participated in the FLA program.

[10] Several households plant additional species with distinct investment cycles (hybrid pine trees, eucalyptus, etc.). However, we exclude these observations to ensure that the species being analyzed are homogeneous.

[11] In the alternative model specification without the variable—expected increase in output prices—the residuals of LTS perception are also estimated to be statistically non-significant. This demonstrates that omitting this critical variable, which is often seen in previous studies, results in a biased estimate.

[12] Bao Lam district is located 15 kilometers from Bao Loc City and was established in the 1920s, while Cat Tien and Da Teh districts were founded in 1987 and are located 86 and 45 kilometers from Bao Loc City, respectively.

[13] This Is a Politically Delicate Topic, However, it Appeared on the Laborer E-news on March 7, 2011 with the Title "Will Land Be Redistributed in 2013?". Available in Vietnamese. Available online: https://nld.com.vn/thoi-su-trong-nuoc/co-chia-lai-ruong-dat-vao-nam-2013-20110307093625603.htm (accessed on 1 December 2022).

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