Abstract

Although gender gap in rural development has received attention from researchers and practitioners, there is a lack of discourse on the intersection among women's managerial rights, farm investment, and household welfare. This paper analyzes in Zambia. To this end, we take advantage of a newly nationally representative panel survey and two distinct societies in Zambia. Our study finds that land tenure has a more significant impact on tree planting for women decision makers. Moreover, we show that households led by women benefit over-proportionally from land tenure security and soil and land management in male-dominant societies. These results provide insights into the underpinnings of policies empowering women and increasing their bargaining power within households are necessary in developing countries through land reforms.

Keywords: Women empowerment, Land rights, Bargaining power, Matrilineal and patrilineal societies, Food security, Sub-Saharan Africa

Highlights

- We investigate land tenure security, farm investment, and household welfare in Zambia.
- Increased land tenure security accelerates soil and land management.
- Women decision makers are more likely to invest in tree planting with land tenure.
- Tree planting increases farm income and reduces food insecurity.
- Women in patriarchal societies benefit more from land tenure and farm investment.

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1. Introduction

Agriculture has long been a critical component of Sub-Saharan Africa's (SSA) economies in terms of economic value and labour structures. The share of employment in Agriculture in Zambia is still over 50% in 2019 as showed in Figure 1 and the share of agriculture, forestry, and fishing value added in GDP remains 2.7% in 2020 (Mulenga et al., 2021). In an agrarian sector, women play a crucial role from an equity perspective. Therefore, governments and stakeholders should work on achieving gender equality and empowering all women and girls as sustainable development goal (SDG) number 5 states.

[Figure 1 here]

Despite the consensus on the role of women in agriculture, studies consistently find the gender gap in agricultural productivity in SSA. United Nations Women (2019) identifies drivers of gender gaps in agricultural productivity. These include the fact that women have less access to male family labour and land, they have lower use of contemporary farm technologies, plant less high-value crops, and they have high burdens of unpaid household care and domestic work (Ali et al., 2016). One significant cause of gender inequality is women's lack of access to land rights, which has received increasing attention from development practitioners and activists (Doss C. , 2018). As such, many women in rural economies struggle with disparities because of poor access to land rights. Reducing the gender gap of access to land rights is inevitably necessary for sustainable rural development.

Women's land rights (WLR) have several definitions; 1) land ownership; 2) right to make planting decisions; and 3) right to make decisions on outputs (Kang et al., 2020). Ownership, for example, is found to be linked to farmer investment in soil quality improvement, terracing, bunding, creating irrigation channels, purchasing irrigation equipment, fallowing, and so on (Agarwal & Mahesh, 2023). However, empirical work on the right to make planting decisions and farm investment is sparse. Taking advantage of the trait of our dataset, we identify gender of planting decision makers on plots and if households have a sole- or joint-decision making process, which is a more reliable variable than gender of household head and plot holders (Campos, Covarrubias, & Patron, 2016).

In this paper, we have three research questions; First, we investigate whether land tenure security increases farm investment. Second, we examine whether there are any gender differences in associations between land tenure and farm investment. Eventually, we look at whether there are any heterogeneous associations among land tenure, farm investment, farm income and food insecurity across kinship systems. To these ends, we use a new panel survey designed to obtain a comprehensive picture of Zambia's small- and medium-scale farming sector using 2010 Census sampling frame followed by 2022 Census (Indaba Agricultural Policy Research Institute, 2016). Furthermore, we exploit the facts that Zambia has both patrilineal and matrilineal societies to examine if the gender inequality in agricultural decision making stems from a difference of the societies.

There is substantial literature looking at the relationship between land tenure and investment when it comes to land in rural areas of developing economies (Bellemare et al., 2020). Land is a necessary natural capital for agriculture; nevertheless Place (2009) argues continuing debates if land tenure security is constraint of agricultural production. Moreover, Meinzen-Dick et al. (2019) state that there is less agreement and insufficient evidence on the association between WLR and livelihoods including household food (in)security as opposed to bargaining power and decision making on consumption and human capital investment. A systematic review by Doss (2018) shows that distinguishing between male- and female-headed households ignores the contributions that women make to farms in households headed by men (and conversely the contributions that men make to farm households headed by women). Past studies find that incraese in women bargaining power in farming is accosiated with increased household food consumption in SSA (Doss, 2006; Muchomba, 2017). In addition, Kang et al., (2020) that females supply more of their own labor to plots they control, the pattern of own-gender bias in labor allocation varies with each structure-domain combination. However, little is known if observed agricultural gender gaps are innate or derived from environmental differneces.

The main contribution of this paper is threefold. First, we provide novel evidence about a linkage among land tenure, farm investment decision and household welfare in Zambia where matrilineal societies exist. To the best of our knowledge, there are few empirical studies looking at whether sole decision-making and joint decision-making matter in the association between farm investment and WLR (Meinzen-Dick et al., 2019). This is because the linkage depends on local context and the overarching macro and sectoral conditions (Place, 2009). Second, we examine the association farm investment and not only farm income but also household food insecurity across gender in decision making. Finally, we provide a insight into the underpinnings of the observed gendered differences in agricultural decision making across men and women, comparing patrilineal with matrilineal households.

Our results reveal that land tenure security increases farm investment in soil and land management. Land tenure security increases more investment in tree planting if decision makers on farm plots are women. Moreover, tree planting increases farm income as well as improves food insecurity. We also find that land tenure security and farm investment with only women decision makers enhances households only in patrilineal societies. Such insights might also have relevance in the policy community where the gender gap in agriculture is poorly understood.

The remainder of our study is proceeds as follows. In Section 2, we provide some background on Zambian agriculture. Section 3 shows the data and presents some descriptive statistics. In Section 4, we present the conceptual and empirical framework we use to answer our research questions. Section 5 presents and discusses our estimation results. We conclude in Section 6 by giving the research and policy implications of our findings.

2. Land tenure systems and matrilineal society in Zambia

2.1. Land tenure systems

In Zambia two land tenure systems exist: the customary system and the statutory system. Under the customary system, traditional authorities such as the chief and/or the village headman allocate vacant land to families and individuals, on recommendation of village headmen or headwomen, as first persons of contact at village level. However, such customary land does not have legal security of tenure according to Zambia's land laws. This situation renders usufruct land users vulnerable to displacements by more powerful individuals and corporations (Chu, Young, and Phiri, 2015). Customary land has its own advantages to many farmers at village level. One advantage of the customary system is that land is easy to acquire because the process is short and affordable by many usufructs.

In 1995, Zambia government implemented the Lands Act to allow for individual ownership rights and other formal land rights transfer. Once land is converted to statutory tenure, it cannot return to customary tenure (Hall et al., 2017). Under the statutory system, individual landowners have title deeds to their land and can sell, rent, mortgage, or transfer that land (Chapoto et al., 2011). According to statutory law, women in Zambia can apply for any land in any part of the country, just like their male counterparts. In rural areas, married women usually have access to land for farming through their husbands. In the event of divorce or widowhood, if the husband dies without leaving a will and if he held state land, the Intestate Succession Act regulates that the surviving spouse inherits 20% of the deceased's estates, including land, and together with the children, the house (Kapihya, 2017) . However, this Act is not applied generally on customary land. If the deceased husband held customary land, the widow may be permitted to continue to use the land. But the widow may also be evicted from the land by the relatives of the deceased (Kapihya, 2017). Thanks to data availability, we consider land title to be tenured by the customary system or the statutory system. However, in Zambia, as in almost all SSA, women rarely own or have control over land (UNECA Southern Africa Office, 2003). Therefore, understanding how the interaction between gender of plot decision maker and land tenure security is related to both investment and household welfare would encourage policy makers to plan interventions empowering women in rural economies.

2.2. Matrilineal systems

Because Zambia is one of the most ethnically diverse and highly fractionalized countries in SSA (Posner, 2004), social norms in societies can vary across the regions of Zambia. In a matrilineal society, an individual traces descent through a female line (Mizinga, 2000) and inheritance of property, including land, passes through the female line (Hall et al., 2017). Women entering the family through marriage acquire rights to land through their husbands. Under the statutory system, women have the right to own land, but titles tend to be passed through male relatives in both matrilineal and patrilineal systems (Republic of Zambia, (2005), as cited in Chapoto et al., (2011)). Though women in matrilineal systems have the legal right to make decisions about land, men still control most of the decisions as clan leaders. For instance, when it comes to land sales, although women own the land, they must consult their maternal uncles who have the final say in decisions. Hence, considering gender roles in the patrilineal (matrilineal) systems provides further understanding women empowerment and rural development in SSA.

3. Data

We use Rural Agricultural Livelihood Survey (RALS) is a two-wave household panel survey that was carried out in mid-2012 and 2015 by the Indaba Agricultural Policy Research Institute (IAPRI) in conjunction with the Central Statistical Office (CSO) and the Ministry of Agriculture in Zambia (Fung et al., 2020). The RALS covers the 2010/2011 and 2013/2014 agricultural years and the corresponding maize marketing years (2011/2012 and 2014/2015). A total of 8571 household in the first wave, and 7579 households in the second wave were surveyed in 442 Standard Enumeration Areas[i] (SEAs) in all districts of the country, after getting rid of observations with missing values. The sample was designed to be representative of the rural farm households cultivating less than 20 ha of land for farming and/or livestock production (Sitko et al., 2014). This survey enables us to explore a wide range of questions about the characteristics of smallholder households that have title to their land and the effects of titling on farm management and investment strategies (Sitko, et al., 2014). Title possession in this survey is observed at the plot level. To take advantage of the availability of plot-level characteristics, we conduct both household-level analysis and plot-level analysis. In our household-level analysis, the key indicator of title is a variable equal to one if one or more of a farm household's plots are titled. The description of variables used in this study are provided in Table 1. Because we explore both plot-level relationships and household (HH)-level relationships, plot and household characteristics are shown in Table 1. Regarding plot-level characteristics, differences in all the variables between 2012 and 2015 are statistically significant. Regarding, farm investment variables, in terms of household-level characteristics, there is no statistical difference in farm income but food insecurity. Moreover, the share of matrilineal households is around 32 to 36%. While the number of plots decreases, the number of h

[Table 1 here]

3.1. Measurement of key variables

The variables we are mainly interested in are land tenure, soil and land management, tree planting, irrigation, total household income, farm income, and agricultural productivity. The plot-level land tenure security measures 1 if the plot has legal tenure, 0 otherwise. The HH-level tenure security measures 1 if the household owns at least one plot secured by the government, 0 otherwise. Regarding the gender of decision makers, it captures 1 if the decision makers are women, 0 otherwise in the plot-level. In the HH-level, joint decision making means that households have both men and women decision makers, while women decision making means that only women participate in decision making in land management. Moreover, three farm investments are included in the analysis, soil and land management, tree planting, and irrigation. They are also measured by application areas of plot-level and HH-level. Lastly, three outcome measures are included in the analysis. The first outcome variable is farm income which captures the income from farm products such as maize, cassava, other crops, vegetables, and fruits. The unit of values is Zambia Kwacha (ZKW). The values are deflated to real 2017 terms.[ii] Another outcome variable is the food insecurity measuring the months when a household is without enough food to meet its needs in.

3.2. Descriptive statistics

Table 2 represents that women decision makers are more likely to own secured land, regardless of gender of household heads. The result is opposite to our intuition that females have less access to land. The plausible explanation is that women than can decide how to use a plot should be relatively central to the networks of social and political power that permeate a community (Goldstein and Udry, 2008). Table 3 reports a relationship among kinship, mean plot size, and gender of decision makers. Women are more likely to make a decision in the matrilineal system than the patrilineal system. However, men tend to use larger land than women. Table 4 shows that the ratio of land title possessed by smallholder farmers is slightly less than the ratio of medium farmers. Figure 2 presents the geographical distribution of farmers with land title, household income, farm investment management, based on the RALS 2012, and 2015. Panel A shows the geographical distribution of farmers with land tenure (%). Moreover, Panel B presents the geographical distribution of average farm income (ZMW). The Copperbelt province, Central province, and the Southern Province have the highest farm income where they are the pivot of the Zambian rural economy (Zambia Statistics Agency, 2015). Furthermore, Panel C, D, and E show the geographical distributions of farm investment areas (ha) in our samples. From the graphical analysis, we are not able to distinguish linkages among land tenure security, farm investment, and household welfare. Therefore, we empirically examine the nexus in the following section.

[Table 2 here]
[Table 3 here]
[Table 4 here]
[Figure 2 here]

4. Methodology

To address our research questions, we construct a conceptual framework and employ empirical approaches. The conceptual framework presents a concise and potential mechanism for the link between land tenure security, farm investment, income, and agricultural productivity through graphical and mathematical representations. The empirical approaches outline the method for estimating the model specified in the conceptual framework using the dataset.

4.1. Conceptual framework

The aim of the analysis is to provide insights in the nexus among land tenure security, farm investment, and household welfare. Within many African households, agricultural production is simultaneously carried out on many plots controlled by different members of households. Studies of gender and agricultural labour typically utilize household level information, which neglects within-household plot-level ownership variation (Doss, 2018), and plot ownership by women does not guarantee managerial rights to women (Doss et al., 2015). Therefore, it is worth noting that we conduct plot-level analysis for farm investment decisions, not assuming a unitary household. Figure 3 shows the conceptual framework about links among land tenure security, farm investment, and household welfare. Land tenure security is believed to improve household welfare through increasing farm investment (Goldstein and Udry, 2008; Bellemare et al., 2020; Issahaku and Abdulai, 2020). Moreover, Babatunde and Qaim (2010) show that increase in farm income which is supposed to be associated with farm investment is positively correlated with household food security. Although Deininger et al. (2021) find that women's rights affect investment, the relationship between land ownership and productivity has been investigated relatively little from a gender perspective in most regions (Agarwal and Mahesh, 2023). In Africa, customary systems such as patrilineal succession limit or even exclude women's access to ownership and control over land (Najjar et al., 2020). It relates to fewer female labour supply in farming without ownership for land (Palacios-Lopez et al., 2017). Therefore, it would induce less farm output since adult male labour is found to contribute more to farm output at the margin than adult female labour (Jacoby, 1991). Furthermore, as theory predicts that women prefer to devote resources to improving nutritional status (Thomas, 1990), households with land-use certificates that are solely held by a woman, compared to those without land-use certificates, allocate more of their family budget to food (Menon et al., 2014). Our study connects to literature on land tenure security and farm investment from gender perspectives. Based on the discussion from past studies above, we propose two hypotheses to test by our empirical approach.

Hypothesis I. Land tenure security enhances farm investment. Particularly, women are more likely to invest than men when a plot has tenure security.

Hypothesis II. Farm investment improves household welfare, farm income and food security in our study. The effect of farm investment is more sizable for farmers with women decision making because women get empowered within a household in this case.

[Figure 3 here]

4.2. Empirical model

We use plot-level variables in the analysis about the nexus between land tenure security and farm investment. However, land tenure security may be related to plot and household characteristics which affect farm investment behavior. Therefore, we consider an estimation strategy to explicitly control the selection on observables and match farmers with similar characteristics. Earlier studies on decision making in agriculture have used such estimation methods, including propensity score matching (PSM), inverse probability weighting (IPW), and the doubly robust (DR) method, when no other plausible instruments are available (Bellemare and Novak (2017); Lawin and Tamini (2019); Issahaku and Abdulai (2020)). We apply the DR method, or more precisely, an inverse-probability weighted regression adjustment, that combines the regression and propensity score weighting[iii]. It is more robust than the PSM estimator and the IPW estimator (Mano et al., 2022). It can provide a consistent estimator if either the propensity score for land tenure security or the outcome regression in terms of tenure characteristics is correctly specified. To estimate the propensity of owning land tenure, we first estimate the binary model as follows:

$$T^*_{pi} = \alpha_1 x_{pi} + \alpha_2 X_i + \rho_t + v_g + e_{pi}, \qquad with\, T_{pi} = \begin{cases} 1\ if\ T^*_{pi}\ > 0 \\ 0\ if\ T^*_{pi}\ \leq 0 \end{cases} \tag{3}$$

where T^*_{pi} is the latent variable of tenure security of plot p of household i, x_{pi} is the vector of plot p's characteristics of household i in year t, X_i is the vector of household i's characteristics, ρ_t is the year dummy to control time trend, v_g is province dummy to account for geographical characteristics, and e_{pi} is the error term. From Equation (3), we calculate the propensity of plots with tenure using Probit model. The probability of titled plots conditional on plot and household characteristics can be expressed as:

$$P\left(T_{pi} = 1 \middle| x_{pi}, X_i\right) \equiv p\left(x_{pi}, X_i\right)$$

where, $p(x_{pit}, X_{it})$ is the propensity score of titled plots. Using the estimated propensity $\hat{p}(x_{pit}X_{it})$, we estimate the average treatment effect on the treated (ATT) of the land tenure security on farm investment I_{pit} as the average of the difference in predicted values of farm investment:

$$\widehat{E(I_1)} = \frac{1}{n}\sum_{\{i=1\}}^{n}\left[\frac{T_i}{\hat{p}(x_{pit}X_{it})}I_{1pi} + \left(1 - \frac{T_i}{\hat{p}(x_{pit}X_{it})}\right)\hat{I}_{1pi}\right]$$

$$\widehat{E(I_0)} = \frac{1}{n}\sum_{\{i=1\}}^{n}\left[\frac{1-T_i}{1-\hat{p}(x_{pit}X_{it})}I_{0pi} + \left(1 - \frac{1-T_i}{1-\hat{p}(x_{pit}X_{it})}\right)\hat{I}_{0pi}\right] \tag{4}$$

$$\hat{\tau}_{ATT.DR} = \widehat{E(I_1)} - \widehat{E(I_0)}$$

where $\hat{I}_{1pi}$ and $\hat{I}_{0pi}$ are the predicted farm investment from of what will happen under $T_{pi} = 1, T_{pi} = 0$ conditioned on x_{pi}, X_i, and n is the number of sample plots. $\hat{\tau}_{ATT.DR}$ is the doubly robust estimator of ATT which is an unbiased estimate of the statistical association between the land tenure and farm investment. The outcome variables are farm investment I_{pi}, soil and land management, tree planting, and irrigation. In addition to the DR methods, we utilize PSM and fixed effect to investigate the heterogeneous association between land tenure security and farm investment over gender and crop type by incorporating the interaction term. The reason to employ PSM and fixed effect is that we can address the endogeneity bias due to observed characteristics and time-invariant unobserved characteristics. Thus, the specified econometric models can be written as follows

$$I_{pit} = \beta_1 T_{pit} + \beta_2 T_{pit} * gender_{pit} + \beta_3 x_{pit} + \beta_4 X_{it} + \beta_5 P_{pit} + a_i + \sigma_t + v_g + u_{pit} \tag{4}$$

where I_{pi} is farm investment of plot-level p of household i, T_{pit} is the dummy variable of land tenure status of plot *p* of household *i* in year *t*, P_{pi} is the vector of plot p's characteristics of household *i*, $a_i$is the household fixed effect, σ_t is the time fixed effect, and u_{pit} is the error term.

Beyond the relationship between land tenure security and farm investment, we also examine factors affecting household welfare using HH-level data. We estimate the fixed effect model to account for the time-invariant unobservable using the following model:

$$Y_{it} = \gamma_1 + \gamma_2 T_{it} + \gamma_3 I_{it} + \gamma_4 X_{it} + a_i + \sigma_t + v_g + \epsilon_{it} \tag{5}$$

where, Y_{it} is the outcome variable farm income and months of food insecurity, T_{it} is the land tenure which indicates a dummy variable that if household i has at least one cultivated plot with tenure, I_{it} is the cultivated areas with farm investments, a_i is the household fixed effect, and ϵ_{it} is the error term.

5. Results and discussions

5.1. Determinants of land tenure security

Although our primary interest is on the causal effect of tenure security on farm investment behavior, we first examine determinants of land tenure security. Table 5 shows the results of Equation (3), estimated by Probit model and Linear Probability Model (LPM)[4]. Regarding the plot-characteristics, the purchased land is more likely to be secured in both Column (1) and (2). In addition, the coefficient of decision maker is positively significant. It indicates that if the decision maker of a plot is a woman, the plot is more likely to be secured. One potential explanation is that women who possess land rights are likely to have bargaining power within households, and bargaining power is correlated with decision making (Meinzen-Dick et al., 2019). Moreover, if the household head has higher education experience, the plot is more likely to be secured. It is also consistent with the study in the setting of Zambia by Sitko et al., (2014). Age of household head and asset index are significantly correlated with land tenure security. It is reasonable that older or wealthier households are more likely to have tenured plots because they may hold powerful positions in a local political hierarchy and such people are likely to have more secure tenure rights (Goldstein and Udry, 2008).

[Table 5 here]

5.2. Effect of land tenure on farm investment

Table 6 summarizes the result from the DR estimation for the whole sample and subsamples. The result in Column (1) shows that land tenure security is significantly associated with soil and land management to prevent soil erosion and flash flooding. It indicates that land tenure security induces farm investment, especially soil and land management. When we divide the whole sample into the two sub-sample groups which are women decision makers and male decision makers. The coefficient of land tenure is positively significant for soil and land management. If a plot is registered with de jure tenure security, the areas invested in soil and land management increase around 0.6 ha. It indicates that the land tenure encourages both males and women to invest in improvement of land fertility. The result is consistent with Goldstein & Udry, (2008); Abdulai et al., (2011); Ali et al., (2014); Lovo, (2016); and Lawin & Tamini (2019). Column (2) shows that the only coefficient of land tenure of plots operated by women is significant. The result indicates that land tenure security increases tree planting by women decision makers. As insecure rights for women can undercut growth and productivity (Dillon & Voena, 2018), the results highlight the importance that women involves decision making in agriculture for sustainable agricultural development.

[Table 6 here]

Moreover, Table 7 shows the heterogeneous effect of land tenure on farm investment over gender of decision makers and crop types. In Column (2), the coefficient of the interaction term is positively significant, indicating that women decision makers of plots with land tenure are more likely to invest in planting trees to protect yield than male decision makers with land tenure. The result corroborates our findings in Table 5, and it is the consistent with Otsuka et al. (2003); Dillon & Voena (2018). The result shows that our Hypothesis I is correct and emphasizes that land tenure security encourages women decision makers to invest in agricultural practices enhancing output, especially for tree planting. Furthermore, all the coefficients in Columns (4), (5), and (6) are insignificant. The results indicate that whether cash crop or subsistence crop are planted does not matter in farm investment decision.

[Table 7 here]

5.3. Potential mechanism among land tenure, farm investment, and household welfare

As we discussed in Section 4, our main research objective is to examine the empirical linkage among land tenure, farm investment and household welfare. Table 8 presents the factors related to household welfare including farm income and food insecurity. Coefficient estimates for factors relating to the farm income are presented in columns (1), (3), and (5). The results derived by OLS-FE with control variables indicate that soil and land management has a positive and significant association with farm income. It indicates that an additional hectare invested in soil and land management leads to 10.5% increase in farm income on average. Moreover, the tree planting is significantly associated with farm income, indicating that an additional hectare invested in tree planting provides the households with increase in 17.6% of farm income on average. Land tenure and irrigation have significant associations with the farm income in column (1), but the coefficients of them are insignificant in column (5).

In terms of food insecurity (columns (2), (4), and (6)), the benefit of tree planting is negative and significant. It indicates that an additional hectare of tree planting reduces 0.03 months of food insecurity. Although the estimates of land tenure security, soil and land management and irrigation are significant, the coefficients turn into insignificant after controlling covariates and fixed effects.

In column (7), farm income is treated as independent variables so that we can investigate the mechanism that it is improving food insecurity as depicted in Figure 3. The coefficient of farm income is statistically significant. The results indicate that 1% increase in farm income reduces 0.09 months of household food insecurity. The results are reasonable because the farm investment in agricultural practice increase farm income and efficiency, showing an indirect effect of the farm investment on the food security through farm income. In all columns, the estimation results by OLS work as a sort of robustness checks, respectively. Overall, the welfare benefits from tree planting in Zambia are generally consistent with those of past studies by Abdulai & Huffman (2014); Nkomoki et al. (2018); and Issahaku & Abdulai (2020). Our findings contribute to the vast literature about farm investment and household welfare, from the viewpoint of not only income but also food security.

[Table 8 here]

5.4. Does gender matter in farm investment and household welfare?

Many voices in development communities take it as given that causal links between agricultural intervention and women's productivity are valid, and donors increasingly require that gender issues be addressed in development projects and proposals. Other voices continue to express skepticism about a women-focused strategy in agriculture—or at least suggest that there may be trade-offs associated with targeting interventions at women (Doss, 2018). To assess women's agricultural productivity, one approach that has been widely used is to consider the 'household farm enterprise' as the production unit and to compare the productivity of different households, distinguishing between male- and female-headed households. While this approach is relatively simple, it ignores the contributions that women make to farms in households headed by men (and conversely the contributions that men make to farms in households headed by women) (Doss, 2018). To address this gap, we utilize the data about who make a decision in a plot so that we can even consider the women's contribution to a farm in households headed by men. This section investigates if farm households benefit more from farm investment when women involve in decision making in households.

Table 9 summarizes the estimation results for the heterogeneous association between farm investment and household welfare among households with decision making by women, joint decision making, decision making by men. Column (1) and (2) show the estimation results for matrilineal households while column (3) and (4) present the ones for matrilineal households. After controlling for confounding factors, soil and land management significantly increases farm income for households with only women decision makers in column (1). However, the significant relationship disappears for matrilineal societies in column (3). The result plausibly explains that the investment in soil and land may make up for the less labour input from household members and fertilizer for women's plots, especially in the patrilineal societies where the women bargaining power is relatively lower than the matrilineal societies (Udry, 1996; Fenske, 2011). Moreover, acquisition of land tenure security alleviates food insecurity for households with decision making by women in column (2). Same as column (2), the significant association is not found in column (4). It indicates that the households that women solely involve in decision making benefit from land title for food insecurity. We find that land tenure security for women itself increase bargaining power of women within households taking care of more food consumption and nutrition, as our Hypothesis II states. Throughout our analysis, irrigation is not significantly correlated with household welfare. Since there are few application areas of irrigation in our observations as showed in Table 1, we may be not able to capture the variations of irrigation adoption.

Overall, it is important to note that the land tenure security and farm investments provide benefit for the farm income and household food security, especially when women participate in decision making in male dominant societies. From the perspective of women empowerment, these are encouraging results because they imply that policy makers should promote farm investments through strengthening land tenure security for women decision makers in Zambia.

[Table 9 here]

5.5. Robustness checks

In this section, we carry a robustness check to see whether the results change when we use a different measurement method. The effect of land tenure security on the farm investments may vary with different measures of the farm investment. Therefore, in this section, we replace application areas of the farm investments with dummy variables of the investment. The estimated results are in Table A2. Similar to those reported in Table 6, the result presents that the effect of land tenure security on soil and land management is robust, indicating that land tenure security increases the farm investment. Regardless of gender of decision makers, the significant relationships are uniformly observed in Table A2. Moreover, Table A3 shows the heterogeneous association between land tenure security and farm investment. The results confirm that the significant difference in gender of decision makers regarding the relationship between land tenure security and tree planting, as shown in Table 7. It indicates that plots with women decision makers are more likely to be invested in tree planting.

6. Summary and concluding remarks

This paper makes two main contributions. First, it assesses the impact of land tenure security on farm investment decisions and how the effect differs in gender of decision makers. To this end, we take advantage of the informative RALS datasets including the gender of decision makers of plots to avoid ignoring the contributions that women make to farms in households headed by men. Although there have been mixed empirical findings about the relationship between land tenure security and farm investments, we find that women decision makers tend to invest in more tree planting when plots have land tenure. Empirical analysis of Zambian farmers provides robust evidence in support of the hypothesis, given the conceptual framework stating the positive association between greater tenurial security and further farm investment. Second, we investigate a mechanism about how household welfare is improved through farm investment with land tenure security. Our findings corroborate the past evidence that farm investment increases farm income, then improves food insecurity, ultimately household welfare. Moreover, we provide further understanding about associations among land tenure security, farm investment, and household welfare from gender perspectives. The heterogeneous analysis shows that land tenure security improves food security as well as soil and land management increases farm income in patrilineal societies when decision makers are women. Since there are few studies looking at the mechanism using nationally representative surveys in Zambia and addressing descent systems, the results and implications would help policy makers considering sustainable agricultural development and land policies and avoid mistargeting.

Although our econometric estimations remain endogeneity problems stemmed from the unobservable time-varying factors due to characteristics of the dataset, the lessons learned in our study are valuable for future directions in rural development and women empowerment in Zambia. This is the first study to examine how different in gender of decision makers the relationship among land tenure, farm investment and household welfare among patrilineal and matrilineal households. We suggest that households that women have the final say in household decisions increase the household welfare through the farm investments and land tenure security. Furthermore, the robustness checks accounting for alternative measurement support our main findings.

This study highlights the significance of land tenure security and suggests that it can promote gender equality in agricultural production. Although our study has limited data in Zambia and do not have other plot-level farm investment variables such as fallow, manure, and stress-tolerant varieties and managerial right on agricultural output, we can draw policy recommendations for countries near Zambia such as Malawi, Mozambique, and Angola which have similar environmental settings, and both patrilineal and matrilineal societies co-exist. Land policies securing women's rights could potentially improve household welfare through enhancing farm investment especially by women in male-dominant societies.

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1. SEAs are the lowest geographical sampling units used by CSO and were the primary sampling units in the RALS. An SEA typically contains 100-200 households.
2. 2017 exchange rate: 9.5 ZMW/US$
3. We used *teffects ipwra* in STATA to run the DR method.
4. Our main interpretation is from the estimation by Probit model, but we use LPM to account for the unobservable heterogeneity of households.

Table 1 Description of plot and household variables

Variable	Description	N	Mean	SD	N	Mean	SD	Dif
Plot characteristics			2012			2015		
Land tenure	1 if a plot has secured tenure, 0 otherwise	26,022	0.0867	0.281	21,517	0.0564	0.231	-0.003***
Soil and land management	Areas of preventing soil erosion and/or flash flooding (ha)	26,022	0.157	0.578	21,517	0.169	0.690	-0.007***
Tree planting	Areas of planting trees to protect yield (ha)	26,022	0.024	0.238	21,517	0.764	1.104	0.078***
Irrigation	Irrigated areas (ha)	26,022	0.004	0.074	21,517	0.007	0.126	-0.078***
Purchased	1 if the plot is acquired by purchasing, 0 otherwise	26,022	0.060	0.237	21,517	0.067	0.249	0.0460***
Inherited	1 if the plot is acquired by inheritance, 0 otherwise	26,022	0.115	0.319	21,517	0.193	0.395	-0.0170***
Allocated	1 if the plot is acquired by allocation, 0 otherwise	26,022	0.730	0.444	21,517	0.652	0.476	0.175***
Possibility to change the tenure status	1 if the plot’s status is possibly changed, 0 otherwise	25,763	0.328	0.470	21,517	0.282	0.450	0.016***
Decision maker	1 if the decision maker of the plot is woman, 0 otherwise	25,973	0.248	0.432	21,517	0.265	0.441	-0.003***
Cash crop	1 if a cash crop is planted, 0 otherwise	25,821	0.108	0.310	21,460	0.092	0.288	-0.007***
Hectare	Hectare of plot	26,021	0.819	1.194	21,517	0.851	1.904	-0.032**
Household characteristics								
Farm income	Total Farm income (ZMW)	8,566	4,869	12,771	7,579	4,908	18,379	-38.948
Food insecurity	Number of months of food insecurity	8,571	1.335	1.915	7579	1.515	2.118	-0.180***
Educational level of HH	Educational year of household head	8,571	6.222	3.940	7,579	5.805	4.015	0.417***
Matrilineal household	1 if the household is matrilineal, 0 otherwise	8,553	0.364	0.481	7,579	0.313	0.464	0.051***
Local household	1 if the household head is local,	8,566	0.888	0.315	7,579	0.895	0.307	-0.007

head	0 otherwise							
Number of plots	Number of plots	8,571	3.019	1.592	7,579	2.896	1.391	0.124***
Cash crop	1 if the household plant a cash crop, 0 otherwise	8,571	0.126	0.332	7,579	0.195	0.397	-0.068***
Credit	1 if the household can obtain credit, 0 otherwise	8,571	0.166	0.372	7,579	0.192	0.394	-0.027***
Age of HH	Age of household head	8,568	45.64	14.97	7,416	49.16	14.97	-3.525***
Adult equivalent	Number of adult equivalents	8,571	3.688	1.903	7,579	4.692	2.458	-1.003***
Asset index	Asset index based on principal component analysis	8,571	-0.000	2.209	7,578	0.008	2.318	-0.008
Tropical Livestock Unit	Tropical livestock unit based on	8,571	2.515	7.955	7,579	2.692	8.779	-0.177
Time to the nearest paved road	Time from homestead to the nearest paved road (minutes)	8,366	117.9	256.7	7,578	106.2	178.3	11.755***

Source: RALS2012, 2015.

Note: Zambian Kwacha (ZMW) values are in real 2017 terms. 2017 exchange rate: 9.5 ZMW/US$. The calculation of Tropical livestock Unit is based: cattle = 0.7, sheep = 0.1, goats = 0.1, pigs = 0.2, chicken = 0.01. We excluded households who earn less than 0 ZMW as outliers. It is important to note that costs of production are partially observed. Thus, net crop income accounts for fertilizer costs and the costs of transportation, but not for labor, transaction, seed, or other input expenditures. ***, **, * denote level of significance at 1%, 5% and 10% respectively.

Table 2 Gender of decision maker and tenure security (plot-level)

	Land title		
Decision maker	No	Yes	
Men	32,854	2,505	35,359
	92.92%	7.08%	100%
Women	11,167	964	12,131
	92.05%	7.95%	100%
Total	44,021	3,469	47,490
	92.7%	7.3%	100%

Note: The difference in gender is significant at 5% level.
Source: Authors' calculation using the RALS2012 and 2015 data.

Table 3 kinship system, plot size, and gender of decision maker

	Gender of decision makers		
	Men	Women	Total
Patrilineal	8,429	2,222	10,651
	79.14%	20.86%	100%
Matrilineal	4,065	1,416	5,481
	74.17%	25.83%	100%
Total	12,494	3,638	16,132
	77.45%	22.55%	100%
			Diff
Mean plot size (ha)	1.24	0.79	0.45***
SD	(0.02)	(0.03)	(0.04)

The difference in gender is significant at 5% level. ***, **, * denote level of significance at 1%, 5% and 10% respectively.
Source: Authors' calculation using the RALS2012 and 2015 data.

Table 4 Cultivated land size and land titled (household-level)

	Land title		
	No	Yes	Total
5 to 19.99 ha	3,391	392	3,783
	89.64%	10.36%	100%
0 to 4.99 ha	11,369	992	12,361
	91.97%	8.03%	100%
Total	14,760	1,384	16,144
	91.43%	8.57%	100%

The difference in land title is statistically significant at 5% level.
Source: Authors' calculation using the RALS2012 and 2015 data.

Table 5 Determinants of land tenure security (plot-level)

	(1) Probit	(2) LPM
Purchased	1.240***	0.300***
	(0.072)	(0.011)
Allocated	-0.108*	-0.004
	(0.060)	(0.005)
Inherited	-0.051	-0.013**
	(0.075)	(0.006)
Possibility to change the tenure status	0.227***	0.026***
	(0.042)	(0.004)
Women decision maker	0.126***	0.013***
	(0.041)	(0.003)
Educational level of HH	0.038***	0.006***
	(0.005)	(0.001)
Cash crop planted	0.002	-0.001
	(0.036)	(0.003)
Matrilineal household	-0.016	0.005
	(0.043)	(0.003)
Local household head	-0.127**	-0.012**
	(0.060)	(0.006)
Hectare	-0.000	-0.001
	(0.008)	(0.001)
Age of HH	0.005***	0.001***
	(0.001)	(0.000)
Adult equivalent	-0.006	-0.001
	(0.010)	(0.001)
Asset index	0.061***	0.010***
	(0.009)	(0.001)
Tropical Livestock Unit	0.002	0.000
	(0.002)	(0.000)
Time to the nearest paved road	-0.000	-0.000
	(0.000)	(0.000)
Household FE	No	Yes
Province FE	Yes	Yes
Year FE	Yes	Yes
Observations	45,868	45,868

Note: Robust standard errors clustered by households in parentheses. ***, **, * denote level of significance at 1%, 5% and 10% respectively. Only the plots where crops are planted are used for the estimation. Garden, natural fallow, rented/borrowed out, orchard, and virgin plots are removed because the crops planted in these plots are not identified. Full regression table is available upon request. Source: Authors' calculation using the RALS2012 and 2015 data.

Table 6 Effect of land tenure security (Plot-level, Doubly Robust)

	(1) Soil and land management	(2) Tree planting	(3) Irrigation
ATT	0.068***	0.005	-0.008
N=45,878	(0.021)	(0.021)	(0.007)
Women decision makers' ATT	0.052**	0.040*	-0.002
N=11,771	(0.022)	(0.023)	(0.001)
Men decision makers' ATT	0.063**	-0.031	-0.012
N=34,107	(0.028)	(0.027)	(0.010)

Note: ATT is the average treatment effect on treated. Robust standard errors clustered by households in parentheses. Land tenure security is a dummy variable. The unit of the outcome variables is hectare. ***, **, * denote level of significance at 1%, 5% and 10% respectively. Full regression table is available upon requests. Source: Authors' calculation using the RALS2012 and 2015 data.

Table 7 Heterogeneous association between land tenure and farm investment (Plot-level, PSM-FE)

	(1) Soil and land management	(2) Tree planting	(3) Irrigation
Land tenure	-0.024	-0.144	0.017
	(0.090)	(0.153)	(0.026)
Land tenure *women decision maker	0.098	0.219**	-0.014
	(0.063)	(0.099)	(0.012)
Control variables	Yes	Yes	Yes
Household FE	Yes	Yes	Yes
Province dummy	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes
Observations	33,947	33,947	33,947

Note: Bootstrap robust standard errors in parenthesis. Full regression table is available upon requests. Land tenure security is a dummy variable. The unit of the outcome variables is hectare. ***, **, * denote level of significance at 1%, 5% and 10% respectively. Full regression table is available upon requests. Source: Authors' calculation using the RALS2012 and 2015 data.

Table 8 Determinants of household welfare (Household-level)

	(1) Farm income OLS	(2) Months of food insecurity OLS	(3) Farm income OLS	(4) Months of food insecurity OLS	(5) Farm income OLS-FE	(6) Months of food insecurity OLS-FE	(7) Months of food insecurity OLS-FE
Land tenure	0.641***	-0.373***	0.010	0.009	-0.094	-0.106	-0.116
	(0.100)	(0.051)	(0.100)	(0.054)	(0.146)	(0.088)	(0.087)
Soil and land management	0.344***	-0.107***	0.132***	-0.007	0.105***	-0.010	-0.000
	(0.041)	(0.013)	(0.023)	(0.009)	(0.036)	(0.015)	(0.015)
Tree planting	0.337***	-0.059***	0.146***	-0.027***	0.176***	-0.037***	-0.021*
	(0.024)	(0.008)	(0.021)	(0.009)	(0.025)	(0.013)	(0.013)
Irrigation	0.236***	-0.060***	0.056	0.009	0.101	-0.003	0.005
	(0.044)	(0.017)	(0.044)	(0.018)	(0.073)	(0.034)	(0.033)
Women decision making			-0.559***	0.198***	-0.512***	0.205***	0.156**
			(0.067)	(0.041)	(0.103)	(0.062)	(0.062)
Joint decision making			0.192**	0.102**	0.348***	0.067	0.097
			(0.076)	(0.049)	(0.127)	(0.077)	(0.076)
Farm income							-0.092***
							(0.008)
Control variables	No	No	Yes	Yes	Yes	Yes	Yes
Household FE	No	No	No	No	Yes	Yes	Yes
Province FE	No	No	No	No	Yes	Yes	Yes
Year FE	No	No	No	No	Yes	Yes	Yes
Observations	16,116	16,150	15,603	15,631	15,603	15,631	15,603

Note: Robust standard errors clustered by households in parenthesis. Outcome variables are log farm income and number of months of food insecurity. ***, **, * denote level of significance at 1%, 5% and 10% respectively. Full regression table is available in Table A1. Source: Authors' calculation using the RALS2012 and 2015 data.

Table 9 Heterogeneous association on different decision making processes (Household-level OLS FE)

	(1)	(2)	(3)	(4)
	Patrilineal		Matrilineal	
	Farm income (log)	Months of food insecurity	Farm income (log)	Months of food insecurity
Land tenure	-0.536	-0.012	-0.055	-0.647
	(0.333)	(0.200)	(0.876)	(0.525)
Soil and land management	0.090	0.009	0.142	-0.015
	(0.056)	(0.033)	(0.183)	(0.107)
Tree planting	0.173***	0.006	0.374***	-0.045
	(0.049)	(0.029)	(0.126)	(0.079)
Irrigation	0.179	-0.042	-0.070	-0.128
	(0.160)	(0.067)	(0.325)	(0.244)
Women decision making	-0.727***	0.367***	-0.639	0.399
	(0.249)	(0.142)	(0.552)	(0.331)
Joint decision making	0.481*	0.068	0.910	0.315
	(0.291)	(0.181)	(0.691)	(0.484)
Land tenure*Decision making by women	0.301	-0.741*	0.124	-0.281
	(0.685)	(0.397)	(1.944)	(1.052)
Land tenure*Joint decision making	-0.405	0.173	0.088	0.508
	(0.749)	(0.482)	(1.986)	(1.221)
Soil and land management * Decision making by women	0.346**	-0.018	0.371	0.052
	(0.171)	(0.089)	(0.515)	(0.296)
Soil and land management * Joint decision making	-0.059	0.013	-0.044	-0.110
	(0.141)	(0.083)	(0.406)	(0.332)
Tree planting * Decision making by women	0.003	-0.019	0.012	-0.027
	(0.135)	(0.057)	(0.379)	(0.166)
Tree planting * Joint decision making	-0.070	-0.040	-0.370*	0.012
	(0.078)	(0.045)	(0.200)	(0.122)
Irrigation* Decision making by women	0.236	0.335	0.135	0.009
	(0.614)	(0.276)	(0.836)	(0.479)
Irrigation * Joint decision making	-0.178	-0.030	0.151	0.249
	(0.226)	(0.123)	(0.516)	(0.378)
Control variables	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observation	10,288	10,305	5,366	5,377

Note: Robust standard errors clustered by households in parenthesis. Outcome variables are log farm income and number of months of food insecurity. ***, **, * denote level of significance at 1%, 5% and 10% respectively. Full regression table is available upon requests. Source: Authors' calculation using the RALS2012 and 2015.

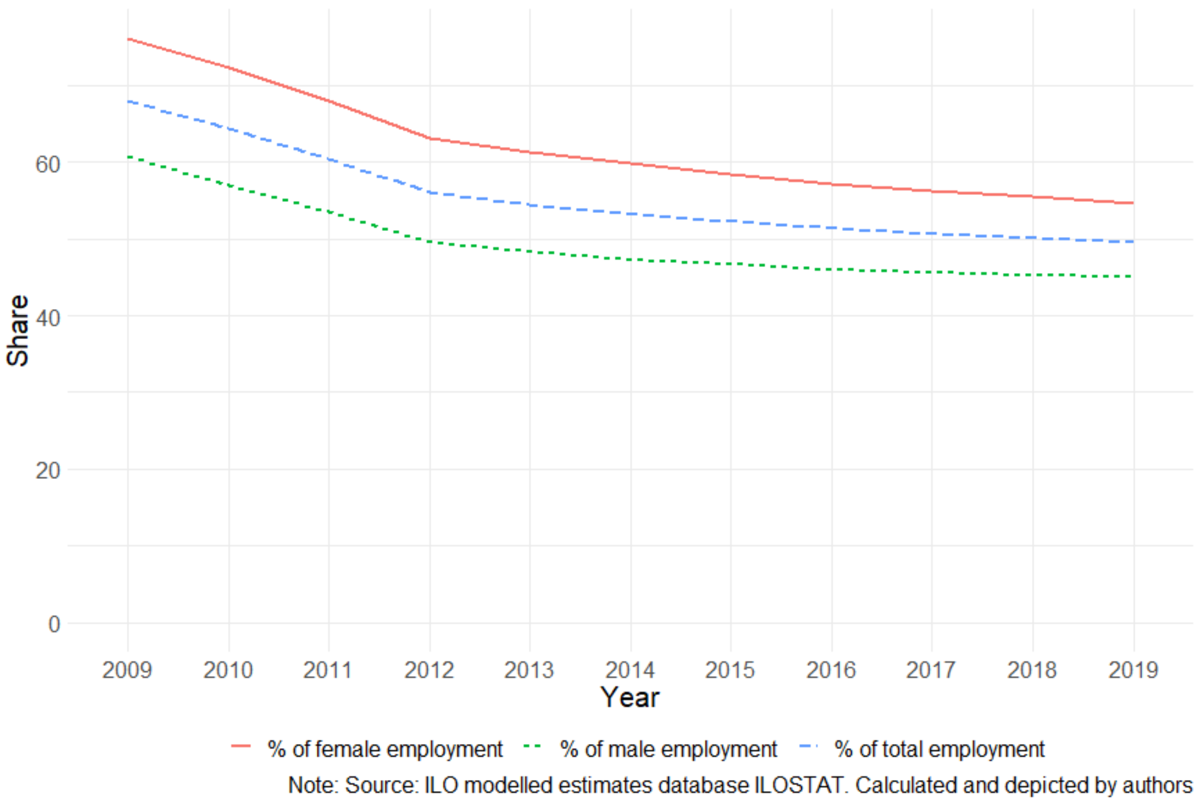

Figure 1 Employment in agriculture in Zambia

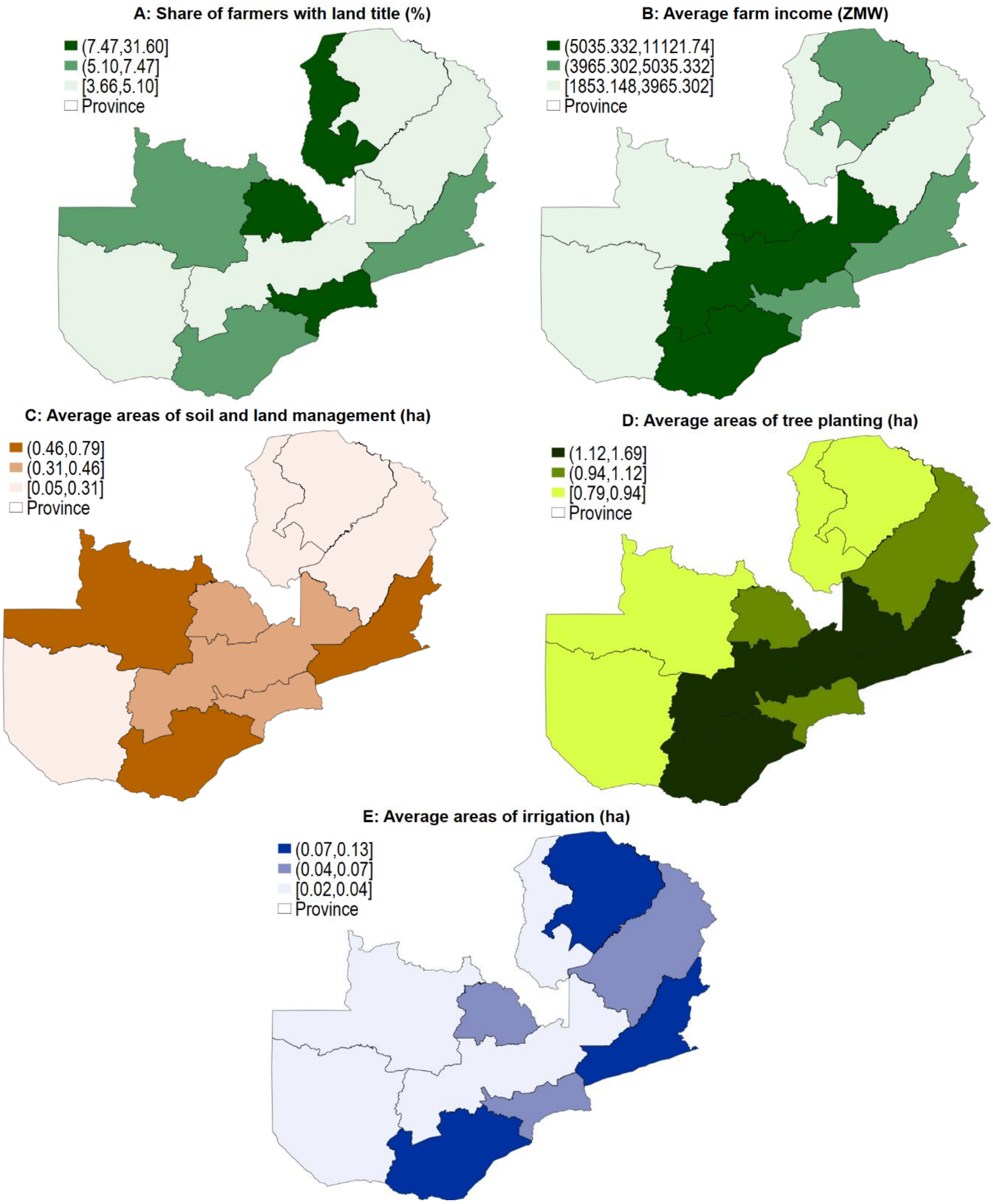

Figure 2 Land tenure, farm income, and farm investment in Zambia

Panel A shows the proportion of households with land title by province. Panel B shows the average farm income by province. Panel C shows the average areas of soil and land management per household by provinces. Panel D shows the average areas of tree planting per household by province. Panel E shows the average areas of irrigation per household by province. Source: Authors' compilations using the RALS2012 and 2015 data

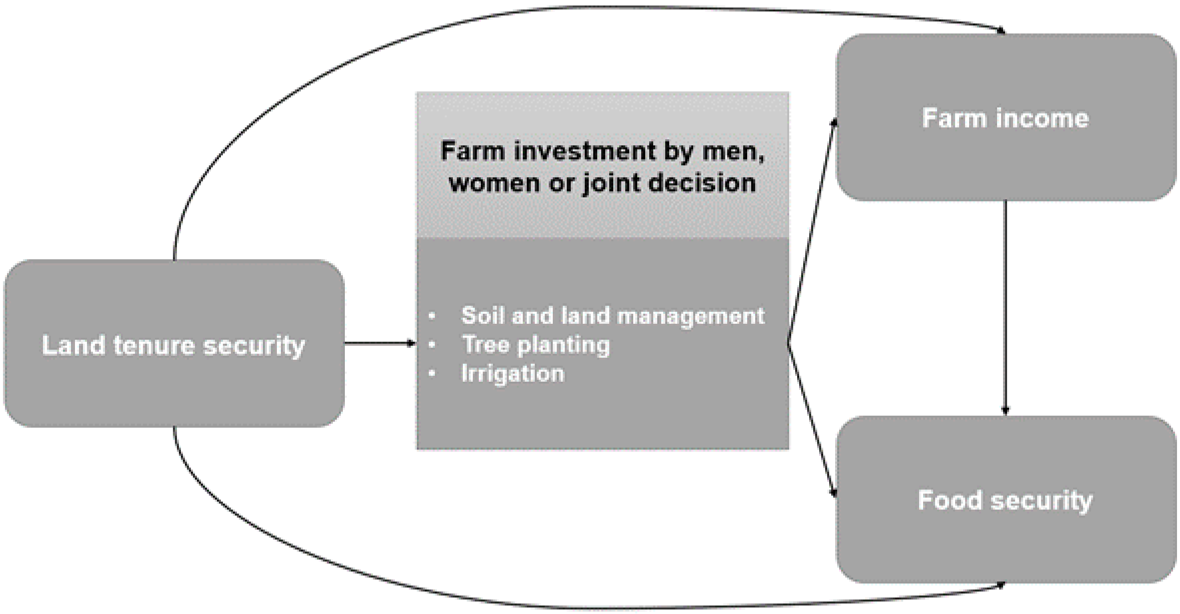

Figure 3 Conceptual framework about nexus among land tenure, farm investment, and household welfare

[i] SEAs are the lowest geographical sampling units used by CSO and were the primary sampling units in the RALS. An SEA typically contains 100-200 households.
[ii] 2017 exchange rate: 9.5 ZMW/US$

[iii] We used *teffects ipwra* in STATA to run the DR method.