Gender matters in farm investment in rural Zambia:

Implications for tenure security and household welfare.

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Abstract

The gender gap in rural development has received attention from researchers and practitioners. However, there is a lack of discourse on the intersection among women's managerial rights and farm investment, and household welfare. Using a nationally representative survey in Zambia and doubly robust estimator, we show that land tenure has a more significant impact on tree planting for women decision makers and that households led by women are more likely to benefit from soil and land management. In conclusion, policies aimed at empowering women and increasing their bargaining power within households are necessary in developing countries to address gender inequality.

Keywords: Women empowerment, Land rights, Rural development, Investment, Developing countries

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1. Introduction

Agriculture is critical to economies in Sub-Sharan Africa (SSA), in terms of economic value and labor structures. The share of employment in Agriculture in Zambia is still 50% in 2019 and the share of agriculture, forestry, and fishing value added in GDP remains 2.7% in 2021 (Mulenga et al., 2021). In an agrarian sector, land is a significant natural capital and an input, and women play an important role in, both from equity and because they are associated with positive outcomes for women and households. Despites the consensus, a gender gap in land rights has remained and has received attention from development practitioners and activists. Therefore, reducing the gender gap plays a vital role in 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 farmers investing in improving soil quality, terracing, bunding, creating irrigation channels, purchasing irrigation equipment, fallowing, and so on (Agarwal and Mahesh, 2023). However, empirical work on the right to make planting decisions and farm investment are sparse. Taking advantage of the trait of our dataset, we focus on who makes a decision on a plot for planting.

In this paper, we look at how gender differences in decision making affect farm investment and household welfare. To this end, using a nationally representative panel data set on Zambian households, we examine the impact of land tenure security on farm investment behavior among the gender of decision makers. Moreover, we investigate whether decision making by women improves household welfare compared to households with decision making by men or joint decision making, focusing on patrilineal and matrilineal societies in Zambia.

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). Regardless of the substantial literature, Meinzen-Dick et al. (2019) point out that there is less agreement and insufficient evidence on the association between WLR and livelihoods rather than 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 farms in households headed by women). Moreover, Meinzen-Dick et al. (2019) mentions weaker evidence between WLR and food security while WLR and bargaining power and decision-making on consumption, human capital investment, and intergenerational transfers. In Ghana, the share of family farmland that is owned by women is associated with the proportion of the family budget that is spent on food (Doss, 2006). Moreover, joint land certification to spouses was accompanied by increased household consumption of homegrown food in Ethiopia (Muchomba, 2017). However, there is a lack of research focusing on the linkage among farm investment, gender of decision maker, and household welfare including food security.

The main contribution of this paper is twofold. First, we provide novel evidence about the effects of gender on the 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 women land rights (Meinzen-Dick et al., 2019). We use a recent nationally representative panel dataset and econometric methods to account for endogeneity and unobserved heterogeneity. Thus, we find that land tenure security increases investment in soil and land management. Furthremore, tree planting is more invested if decision makers of plots are women. Second, we examine the association farm investment and not only farm income but also a household food security indicator over gender roles in decision making. Our analysis reveals that tree planting increases farm income as well as improves food insecurity. Moreover, soil and land management with only women decision makers enhances farm income even in patrilineal societies.

The remainder of this paper is organ 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

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. 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). Once land is converted to statutory tenure, it cannot return to customary tenure (Hall et al., 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.

Because Zambia is one of the most ethnically diverse and highly fractionalized countries in sub-Saharan Africa (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). 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. Inheritance of property, including land, passes through the female line (Hall et al., 2017). Hence, considering gender roles in the patrilineal (matrilineal) systems provides further understanding for 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[1] (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

[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.

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 households planting cash crops and obtaining credit increases over time.

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.[2] Another outcome variable is the food insecurity measuring the months when a household is without enough food to meet its needs in.

[2] 2017 exchange rate: 9.5 ZMW/US$

3.2. Descriptive statistics

Table 2 is the cross table between planted crop type and gender of decision makers. It shows that cash crops such as tobacco, coffee, and cashew nuts are more likely to be planted by male decision makers. Table 3 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 4 shows that the ratio of land title possessed by smallholder farmers is slightly less than the ratio of medium farmers. Figure 1 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.

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 labor 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 2 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). 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 labor supply in farming without ownership for land (Palacios-Lopez et al., 2017). It would induce less farm output since adult male labor is found to contribute more to farm output at the margin than adult female labor (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.

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[4]. It is more robust than the PSM estimator and the IPW estimator (Mano et al., 2022). It can provide a consistent

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

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:

$$\begin{gathered} \widehat{E(I_1)} = \frac{1}{n} \sum_{\{i=1\}}^{n} \left[\frac{T_i}{\hat{p}(x_{pit} X_{it})} I_{1pi} + \left(1 - \frac{T_i}{\hat{p}(x_{pit} X_{it})}\right) \hat{I}_{1pi} \right] \\ \widehat{E(I_0)} = \frac{1}{n} \sum_{\{i=1\}}^{n} \left[\frac{1 - T_i}{1 - \hat{p}(x_{pit} X_{it})} I_{0pi} + \left(1 - \frac{1 - T_i}{1 - \hat{p}(x_{pit} X_{it})}\right) \hat{I}_{0pi} \right] \\ \hat{\tau}_{ATT.DR} = \widehat{E(I_1)} - \widehat{E(I_0)} \end{gathered} \tag{4}$$

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

$$\begin{gathered} I_{pit} = \beta_1 T_{pit} + \beta_2 T_{pit} * gender_{pit} + \beta_3 x_{pit} + \beta_4 X_{it} + \beta_5 P_{pit} + a_i + \sigma_t + v_g + u_{pit} \\ I_{pit} = \beta_1 T_{pit} + \beta_2 T_{pit} * cash\ crop_{pit} + \beta_3 x_{pit} + \beta_4 X_{it} + \beta_5 P_{pit} + a_i + \sigma_t + v_g + u_{pit} \end{gathered} \quad (4)$$

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:

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

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)[5]. 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).

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 and Udry, (2008); Abdulai et al., (2011); Ali et al., (2014); Lovo, (2016); and Lawin

[5] Our main interpretation is from the estimation by Probit model, but we use LPM to account for the unobservable heterogeneity of households.

and 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 and Voena, 2018), the results highlight the importance that women involves decision making in agriculture for sustainable agricultural development.

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 and 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.

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 **エラー! 参照元が見つかりません。**. The coefficient of farm income is statistically significant. The results indicate that 1% increase in farm income resuces 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 and Huffman (2014); Nkomoki et al. (2018); and Issahaku and 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.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. After controlling for confounding factors, soil and land management significantly increases farm income for households with only women decision makers. Furthermore, the relationship exist for patrilineal societies. The result plausibly explains that the investment in soil and land may make up for the less labor input from household members and fertilizer for women's plots (Udry, 1996; Fenske, 2011). Moreover, acquisition of land tenure security alleviates food insecurity for households with decision making by women. It indicates that the households that women solely involve in decision making benefit from land title for food insecurity. It means 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. Same as the association of farm income, the significant relationship exist for even patrilineal societies. Throughout our analysis, irrigation is not significantly correlated with household welfare. Since there are few application areas of irrigation in our observations, we may be not able to capture the variations of irrigation adoption.

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

5.4. Robustness checks

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 A1. 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 A1. Moreover, Table A2 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 dataset including the gender of decision makers to plots to avoid ignoring the contributions that women make to farms in households headed by men., Although there are mixed empirical findings about the relationship between land tenure security and farm investments, we find that women decision makers tend to invest more when plots have land tenure. Empirical analysis of Zambian farmers provides robust evidence in support of the hypothesis, given the conceptual framework stating the effects of greater tenurial security on investment. Second, we investigate a mechanism about enhancing household welfare through farm investment with land tenure security. Our findings corroborate the past evidence that farm investment increase farm income, then improve food insecurity, ultimately household welfare. Moreover, our findings provide further understanding about associations among land tenure security, farm investment, and household welfare because we show how different the associations from gender perspectives vary for food insecurity as well as farm income. Since there are few studies looking at the mechanism with nationally representative surveys in Zambia, the results and implications would help policy makers considering sustainable agricultural development and land policies.

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. Our finding corroborates that land tenure security increases farm investment, especially soil and land management. Moreover, we find that women decision makers are more likely to invest in tree planting when a plot is tenured. Regarding the association between farm investment and household welfare, the results indicate households where women involve in decision making benefit more from soil and land management, tree planting, and irrigation for farm income. Although the causal mechanism of the relationship needs to be studied in future research, this is the first study to examine how different in gender of decision makers the relationship among land tenure, farm investment and household welfare in patrilineal 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, our results of 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, we can draw policy recommendations for countries near Zambia like Malawi, Mozambique, and Angola which have similar environmental settings and patrilineal and matrilineal societies co-exist. Land policies securing women's rights could potentially improve household welfare through enhancing farm investment especially by women.

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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 Crop type and gender of decision makers (plot-level)

	Decision maker		
	Men	Women	Total
Subsistence crop	31,340	11,153	42,493
	73.75	26.25	100
Cash crop	3,830	913	4,743
	80.75	19.25	100
Total	35,170	12,066	47,236
	74.46	25.54	100

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

Table 3 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

The difference in gender is significant at 5% level.
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	(4) Soil and land management	(5) Tree planting	(6) Irrigation
Land tenure	-0.024	-0.144	0.017	-0.001	-0.089	0.013
	(0.090)	(0.153)	(0.026)	(0.075)	(0.136)	(0.022)
Land tenure *women decision maker	0.098	0.219**	-0.014			
	(0.063)	(0.099)	(0.012)			
Land tenure *Cash crop				0.082	0.099	0.003
				(0.091)	(0.072)	(0.007)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Province dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	33,947	33,947	33,947	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 upon requests. Source: Authors' calculation using the RALS2012 and 2015 data.

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

	(1)	(2)	(3)	(4)
	Whole sample		Patrilineal	
	Farm income (log)	Months of food insecurity	Farm income (log)	Months of food insecurity
Land tenure	-0.240	-0.003	-0.536	-0.012
	(0.175)	(0.104)	(0.333)	(0.200)
Soil and land management	0.095**	-0.021	0.090	0.009
	(0.042)	(0.017)	(0.056)	(0.033)
Tree planting	0.181***	-0.025*	0.173***	0.006
	(0.029)	(0.015)	(0.049)	(0.029)
Irrigation	0.156*	-0.023	0.179	-0.042
	(0.094)	(0.042)	(0.160)	(0.067)
Women decision making	-0.715***	0.276***	-0.727***	0.367***
	(0.142)	(0.078)	(0.249)	(0.142)
Joint decision making	0.507***	0.064	0.481*	0.068
	(0.158)	(0.095)	(0.291)	(0.181)
Land tenure*Decision making by women	0.417	-0.573***	0.301	-0.741*
	(0.354)	(0.208)	(0.685)	(0.397)
Land tenure*Joint decision making	0.434	0.146	-0.405	0.173
	(0.430)	(0.250)	(0.749)	(0.482)
Soil and land management * Decision making by women	0.211**	0.036	0.346**	-0.018
	(0.104)	(0.051)	(0.171)	(0.089)
Soil and land management * Joint decision making	-0.034	0.031	-0.059	0.013
	(0.076)	(0.040)	(0.141)	(0.083)
Tree planting * Decision making by women	0.117	-0.042	0.003	-0.019
	(0.114)	(0.048)	(0.135)	(0.057)
Tree planting * Joint decision making	-0.071*	-0.020	-0.070	-0.040
	(0.040)	(0.024)	(0.078)	(0.045)
Irrigation* Decision making by women	0.060	0.223	0.236	0.335
	(0.360)	(0.152)	(0.614)	(0.276)
Irrigation * Joint decision making	-0.216	0.015	-0.178	-0.030
	(0.135)	(0.072)	(0.226)	(0.123)
Control variables	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Control variables	15,603	15,631	10,288	10,305

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 data.

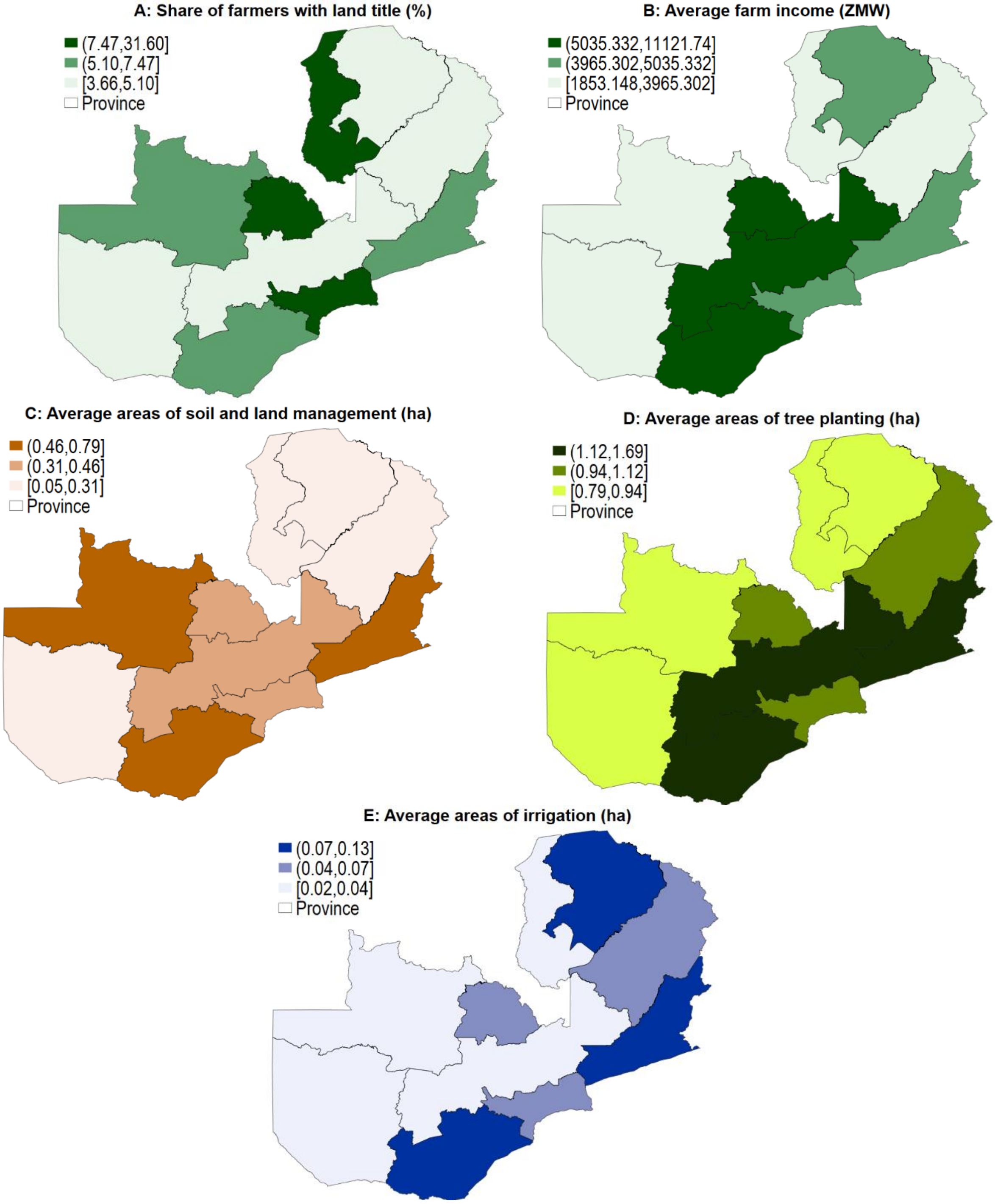

Figure 1Land tenure, farm income, and farm investment

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

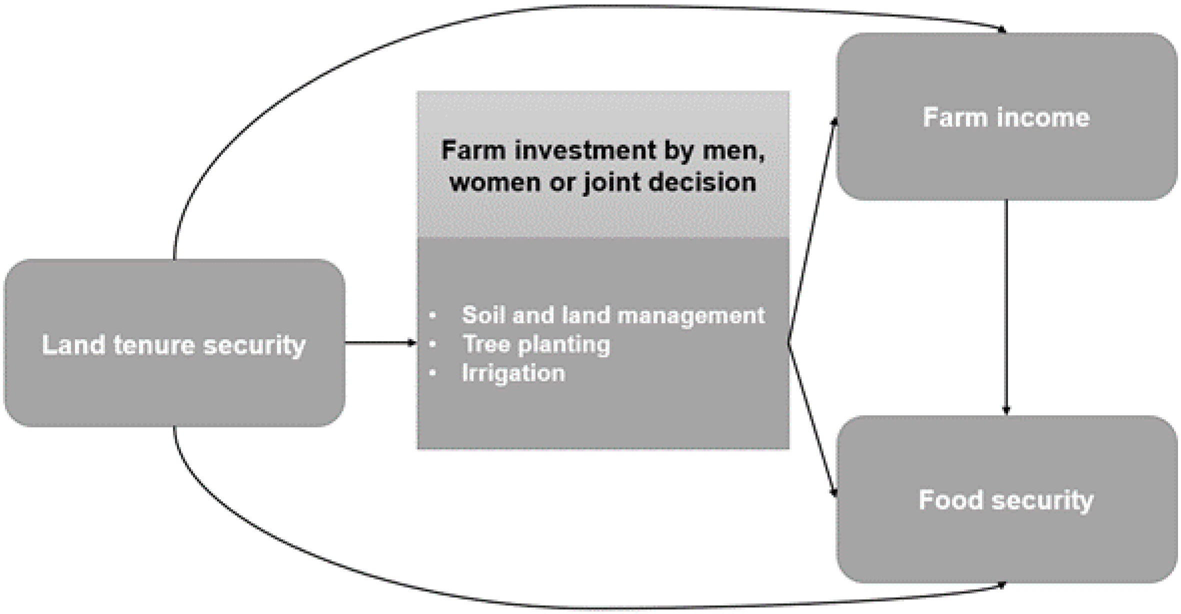

Figure 2 Conceptual framework about nexus among land tenure, farm investment, and household welfare

Appendix.A. Tables

Table A 1 Effect of land tenure security on farm investment (Doubly robust)

	(1) Soil and land management	(2) Tree planting	(3) Irrigation
ATT	0.055***	0.003	0.001
N=45,878	(0.009)	(0.006)	(0.003)
Women decision makers' ATT	0.045***	0.015	0.002
N=11,771	(0.017)	(0.011)	(0.003)
Men decision makers' ATT	0.053***	-0.007	0.001
N=34,107	(0.011)	(0.006)	(0.004)

Note: ATT is the average treatment effect on treated. Robust standard errors clustered by households in parenthesis. ***, **, * 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 A 2 Heterogeneous associations on decision maker and cash crop (Probit-PSM)

	(1) Soil and land management	(2) Tree planting	(3) Irrigation	(4) Soil and land management	(5) Tree planting	(6) Irrigation
Land tenure security	0.167***	-0.099*	0.105	0.159***	-0.048	0.055
	(0.033)	(0.057)	(0.078)	(0.035)	(0.060)	(0.092)
Land titled* women decision maker	0.024	0.242**	-0.255			
	(0.066)	(0.110)	(0.178)			
Land titled*Cash crop				0.121	0.128	0.019
				(0.094)	(0.231)	(0.229)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Province dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	45,458	45,458	45,458	45,458	45,458	45,458

Note: Bootstrap robust standard errors clustered by households in parenthesis. ***, **, * 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.