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## **Gendered-impacts of smallholder land titling: a plot-level analysis in rural Zambia**

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*We explore the determinants of land titling by smallholder farmers in Zambia, and evaluate the impacts of titling on land productivity investments. We examine plot-level outcomes, and test for gendered differences in titling impacts. We find generally positive impacts of titling on investments, including strong gender-specific pathways of impact. Although female-headed households are less likely to make investments than male-headed households, female title holders are significantly more likely to make investments than male title holders (at least for labor intensive investments). We posit that these results are related to the systematically weaker rights of women in customary tenure systems, under which the security-enhancement of formal land title plays a relatively greater role in incentivizing long-term farm investments. Our results suggest the importance of facilitating access to titling mechanisms (and other tenure security mechanisms) by female farmers.*



## 1. INTRODUCTION

Theoretically, acquisition of title should encourage investments in land productivity and enhance incomes from farm enterprises. However, in Sub-Saharan Africa (SSA) empirical evidence of the effects of land titling on land productivity and investment has been mixed (Deininger and Binswanger 1999; Deininger and Feder 2009; Place & Otsuka, 2001; Smith 2004; Gavian & Fafchamps, 1996). Recent studies in Zambia highlight the ambiguity of land titling affects in smallholder production systems. In his 2004 study, Smith found that land titling yielded positive results in terms of fixed investments in land and the profitability of farm enterprises for smallholders operating in a handful of “settlement schemes” in Southern Province. Yet the geographic scope of this study was limited, making it difficult to make broader inferences at the national level. Responding to this gap Sitko et al. (2014) used nationally representative smallholder household survey data to estimate the determinants of land title acquisition and its effects on investments in land improvements. They found that the policies and procedures for awarding land titles appeared to systematically favor non-local investors, such as formal wage earners and individuals with connections to the state, over local farmers. As a consequence of this structural bias in institutional access, farm land title was very weakly associated with long-term productive investments in land (ibid).

The analysis by Sitko et al. (2014) suggests the need for further investigation. By aggregating their analysis to the smallholder household-level, important differences between households and between fields controlled by different household members may be obscured. This paper, therefore, seeks to extend Sitko et al.’s analysis in two important ways. First, we examine plot-level, rather than household-level, outcomes. Our contention is that, even where most titled farmers have title to all their plots (a fact which justified Sitko et al.’s household-level study), plot-level analysis enables the inclusion of important controls that help clarify analytical results. Secondly, we explicitly test for gendered differences in titling impacts, through the incorporation of interaction terms in our econometric work. This approach is motivated by the fact that females in customary systems in Zambia have land rights which are structurally more insecure and

limited than those of males (Sitko 2010; Moore and Vaughn 1994; Davision 1988; Shipton 1988).

We find that plot-level analysis substantially clarifies impacts, indicating generally positive impacts of titling on investments, although such impacts are highly variable across investment types. Furthermore, we find strong gender-specific pathways of impact. Although female-headed households are less likely to make investments than male-headed households, and female title holders are significantly *more* likely to make investments than male title holders (at least for some kinds of investments). These results suggest that usurpation of formal titling institutions by non-local elites is a gendered phenomenon.

The rest of this paper is structured as follows. Section 2 reviews the literature on land titling effects on women's land rights and investments. Sections 3 and 4 describe the data and methods used in this study, respectively. Results are presented in Section 5 and conclusions are offered in Section 6.

## **2. LAND TITLES AND WOMENS' LAND RIGHTS**

Analyses of the effects of land titling and other types of land tenure formalization in Africa have tended to pursue two primary lines of inquiry. In the agricultural economics and development economics the effect of land titling schemes have been explored through the use of household level survey data. In general, these studies have sought to assess the effects of land titling schemes against the theoretical arguments of their proponents. Proponents of land titling schemes in Africa argue that the underdevelopment of formal property rights increases land insecurity and thus hinders agricultural development by limiting farmers' willingness to make long-term investments in their land and undermining the capacity of land and credit markets to develop in rural areas (de Soto 2000; Feder 1988).

When assessed in these terms, the effects of land titling on household-level outcomes have been mixed. While some studies have found that land titling is associated with an increased likelihood of farmers making long-term beneficial investments in land, such as tree planting and manuring, the magnitude of these effects has often small and highly localized (Place & Otsuka, 2001; Smith

2004; Gavian and Fafchamps, 1996; Deininger et al. 2008). Indeed, a large literature on land titling and other forms of land formalization in Africa suggests that in many cases these programs have had little or no impact on smallholder productivity or fixed investment (See Place 2009 for a recent review of the literature. Also see Carter and Olinto 2003; Place and Migot-Adholla 1998; Deininger and Feder 2009).

The second line of inquiry into the effects of land titling in Africa has approached the question from a different angle. Rather than approach the questions about the effects of titling schemes through the lens of household survey data, social scientist have examined the implications of titling schemes on marginalized populations. These studies have tended to examines these effects at both the community-level (Meinzen-Dick and Mwangi 2009) and at the intra-household level (Carney and Watts 1991; Dei 1994; Fleuret 1988; Davision 1988; Shipton 1988). These studies have emphasized the social and economic consequences of titling schemes, including the role of information and power asymmetries in enabling a process of elite capture of land, often at the expense of usufruct rights holders (World Bank 2003; Leuprecht 2004; Government of Kenya 2004; Jansen and Roquas 1998; Benjaminsen and Sjaastad 2002; Peters 2004).

It is within this second line of inquiry that the gender dimensions of land titling schemes are most frequently examined. This literature has tended to examine the ways in which women's rights to land have changed, often negatively, as a result of land titling systems. The literature on women's right to land is large and diverse, reflecting both the complexity of African social institutions and the importance of women to agriculture on the continent. Thus, to summarize the literature on women's land rights is fraught with challenges. Yet, in a stylized sense the critique of land titling schemes on women's rights to land revolves around "regularities" in the gendered ways in which land is accessed and controlled.

A large body of literature suggests that, relative to men, women are limited in their capacity to be "owners of land," in the sense that their ability to exercise transfers rights to land are often limited by the multiplicity of competing claims to the land under their control (Shipton and Goheen 1992; Bruce and Migot-Adholla 1994; Berry 1988). Instead, women are often "owners of crops," in the sense that they exercise use right to land that are frequently accessed through

their ties to kin, mostly men, and husbands (Gray and Kevane 2008; Shipton and Goheen 1992; Bruce and Migot-Adholla 1994). Through the process codifying land ownership, land titling or registration schemes have frequently ended up codifying women's rights land as subordinate to the "owner" of the land, the male head of household (Shipton 1988; Plateau 1996; Toulmin and Quan 2000). Davison (1988) summarizes this process in Kenya, stating that registration policies gave "precedence to individual ownership invested in male heads of households and in turn marginalized the usufruct rights of women formerly guaranteed under lineage tenure"(165). While there are accounts of women using land titling and registration schemes to enhance their control over land in the literature (Weiss 1993; Dei 1994), these are the minority.

In Zambia there are several channels by which land titles can be acquired. Like much of SSA, land in Zambia is administered through a dual tenure system. On the one hand, leasehold titles are awarded what are called state lands, which were originally designed during the colonial era for allocation to European settlers. These areas tend to be clustered in proximity to major transport routes and urban centers. These lands are subject to statutory law and can be bought and sold. On the other hand, usufruct land rights are granted in customary land areas, which are administered by traditional authorities, such as chiefs and headmen. Procedures for transferring customary lands to leasehold titles are codified in the 1995 Land Act, which is the current governing document on land in Zambia. Through the 1995 Land Act, and previously the 1947 Northern Rhodesia Order in Council for Native Trust Lands, individuals, corporations, and the state are able to convert customary land (formerly native trust land) to leasehold title upon consent from the local chief and the district council. Through this conversion process land is removed from customary administration and becomes subject to statutory law. Smallholders can access land titles on former customary land either as individuals or through state run settlement schemes. The processes for converting customary land to leasehold or acquiring leasehold on a settlement scheme are fraught with opaque negotiations between the land seeker and authorities and may entail substantial costs. This contributes to a structure of land title acquisition that tends to favor non-local individuals with access to wage employment, often from the public sector (Sitko et al 2014). Despite barriers to entry for more marginalized segments of Zambian society, women in Zambia can and do acquire title to their land. Nationally representative survey data

indicate that nearly one-fifth of titled smallholder households are headed by women (see table 3 below). This is equivalent to about 27,000 households nationwide, representing a non-trivial component of the rural economy.

Summarizing the literature on women and land use suggests that by in large women attain far lower yields than man and focus overwhelming on the production of food crops while men tend to focus on commercial crops (Gladwin 2002; Dercon 2006; Urdy 1996). To what extent, then, might titling affect this stylized characterization of female-headed farm households? We hypothesize that, the systematic disadvantaged land rights and tenure security that women generally have, that the impacts of titling may be correspondingly greater for females than for males. If this is true, we would expect that the productivity-incentivizing effects of title would be greater for female-headed households than for male-headed households.

### **3. DATA**

This study uses nationally representative household survey data from the Rural Agricultural Livelihoods Survey (RALS), carried out in 2012 by the Indaba Agricultural Policy Research Institute (IAPRI) in collaboration with the Central Statistical Office (CSO) and the Ministry of Agriculture and Livestock (MAL) in Zambia. A total of 8,839 households were surveyed in 442 Standard Enumeration Areas (SEAs) in all districts of the country. 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. The survey asked the respondent to recall events primarily for the 2010/2011 production and marketing seasons (May 2011 to April 2012).

### **4. METHODS**

At the core of our conceptual model are two central assumptions. First, that title-possession confers incentives for medium- and long-term investments in land productivity, primarily through enhancing security of tenure rights (Feder 1988). Thus, *ceteris paribus*, we assume that

$\frac{\partial \Pr(\text{investment})}{\partial \text{title}} > 0$ . Second, we assume that these impacts are larger for those households with systematically weaker rights under customary (non-titled) tenure. Thus, for female-headed households, we expect that the impact of title on investment outcomes is larger than for male-headed households, i.e.  $\frac{\partial \Pr(\text{investment})}{\partial \text{title} * \text{female}} > \frac{\partial \Pr(\text{investment})}{\partial \text{title} * \text{male}}$ , although we acknowledge *a priori* that this may be particularly true of labor-intensive investments. In other words, we allow for the possibility that capital-intensive investments may be less available to female-headed households, which tend to have fewer capital assets available for such investments.

Since most of the investments we observe are measured as binary outcomes, we use a probit modeling framework to estimate the impacts of title on investments, where title possession is observed at the plot-level. To differentiate impacts across male and female-headed households we interact the titling dummy with a female-head dummy. Furthermore, we evaluate the robustness of this gendered approach by also evaluating an alternative specification which uses a plot-level gender indicator of the principal decision maker, in place of the gender-of-head indicator

A key estimation challenge lies in the possible endogeneity of title possession with investment outcomes, whereby bias arises from unobserved factors which are correlated with both title acquisition and investment outcomes (i.e. some kind of unobserved ability and/or human capital endowments, or similar characteristics). We respond to this possibility by using proxy variables to control for unobserved heterogeneity of this nature.<sup>1</sup> We further evaluate the robustness of our models by evaluating the sensitivity of coefficient estimates to the inclusion of progressively larger sets of observed plot-, household- and village-level characteristics. The argument underlying this approach is that the degree of sensitivity to conditioning on unobservables is indicated by the degree of sensitivity to conditioning on observables (Acemoglu et al. 2001; Altonji et al. 2005; Kilic et al. 2014). In other words, if coefficient estimates are stable across model specifications which differ in the number of observable characteristics used as regressors,

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<sup>1</sup> To proxy for unobserved ability, human capital and non-local social capital we use several observed proxies, measured as binary outcomes: blood kinship with chief, status as local vs immigrant household, and wage income from civil service employment.



then they are likely also robust to (unimplementable) specifications that include unobserved characteristics.

## 5. RESULTS

The two primary channels of investment incentives are title-as-collateral and title-as-security. Table 1 shows that title to rural agricultural land does not seem to be used as collateral in any formal sense. Only 16% of the sample obtained formal credit for agricultural purposes; of this group, only 29% reported using collateral to secure these loans. Of those who did use collateral as security, only 4% indicated that they used land title as collateral. Of this group of 15, only 1 household reported having titled agricultural plots, suggesting that the titled land used as collateral was in another (probably urban) area.

[TABLE 1 ABOUT HERE]

This leaves us with title-as-security as the primary focus. Our conceptual model posits that women face systematically higher levels of insecurity in customary systems. Although descriptive evidence to support this is widely available elsewhere, we contribute to this literature by showing that at least some perceptions about land access are gender-differentiated. Table 2 shows responses, by sex of household head, to a number of perception questions. Female-headed households are less likely to report that it is possible to convert tenure status from customary to titled land. Female-headed households are also less likely to report that land can be bought and sold without having tenure. Females are also more likely to report that there is no more unallocated land available locally, but this difference is not statistically significant. These responses support the notion that women have weaker rights to land in customary systems, and, furthermore, that accessing leasehold systems (via titling) are more difficult for women not only because of greater capital constraints, but also because of systematically different perceptions about the availability of conversion mechanisms.

[TABLE 2 ABOUT HERE]

Table 3 shows descriptive statistics for the nationally representative survey households. Although women<sup>2</sup> are less likely than men to obtain title, this difference is very small: slightly more than 10% of each household type are title-holders. Women are more likely, however, to obtain title in areas of former customary tenure, rather than in State lands (in which most land is under title). Presumably these are land titles that have been acquired through a direct conversion process or through state sponsored settlement schemes.

Both the farm size and number of plots are smaller for title-holders than non-title-holders, and also smaller for women than for men. About 10% of plots in male-headed households are controlled by women, compared to nearly 100% in female-headed households. More than 90% of the plots held by title-holders of either gender are titled.

Female-headed households are slightly more likely to be local, rather than immigrants from other areas. Their income, in per-capita terms, are about on par with those of male households, given their smaller average household size. For all households, about half of total income is from non-farm sources, on average.

In terms of plot acquisition, titled land is much more likely to come from government or private sellers than from chief or family, which are the dominant acquisition sources in customary areas. (About 60% of titled land was acquired directly from government or private sellers, as compared to about 10% in the full sample.) The channel of acquisition in the full sample does not vary significantly between females and males. However, for title-holders, there is a gendered pattern: female title-holders are less likely than males to have land obtained from the chief, and more likely to have acquired their land from private actors. (The relative shares of land from family and government are about the same.)

Titled households are more likely to report making land-productivity investments than the sample average. However, the share of households making such investments varies widely by investment type. Less than a quarter of households report investments in irrigation or erosion

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<sup>2</sup> For convenience of exposition, we will refer to female-headed households as “women” and male-headed households as “men.”

control structures (which include bunds, terracing, drainage ditches, grass barriers and contour planting).

[TABLE 3 ABOUT HERE]

We examined the determinants of title acquisition with a probit model. Estimation results are shown in Table 4. Title-holders are better educated and have more productive assets than non-holders. Title-holders are less likely to have blood kinship with the chief and more likely to be immigrants than non-holders.

In terms of place-specific controls, a number of things stand out. Surprisingly, the mean village response to the question “is conversion allowed” is not a significant determinant of acquisition. However, in areas where the mean village response to the question “is there unallocated land remaining here?” is negative (indicating perceptions of land scarcity), the probability of titling is greater. The probability of titling increases with population density and proximity to urban centers, suggesting that demand for conversion is greater in areas with better access and, possibly, as a response to relative land scarcity.<sup>3</sup>

[TABLE 4 ABOUT HERE]

Probit estimates of the determinants of land productivity investment decisions are shown in table 5 (coefficient estimates). The probability of making irrigation investments is marginally lower for females but significantly higher for title-holders. The interaction term (female \* titled) is not significant, indicating that there is no discernable gendered-component to the titling incentives for irrigation. Possession of title has a significantly positive impact on the probability of making erosion control investments. Furthermore, female-headed households with title are significantly more likely to make such investments. The probability of making agroforestry investments is not discernably impacted by titling or by gender. The probability of using inorganic fertilizer is higher for title holders but lower for female heads.

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<sup>3</sup> In alternative specifications, we also included marital status indicators to see if female-heads were more likely to acquire title if they were divorced or widowed, which would suggest that they obtained title via their husbands rather than directly. The coefficient estimates for these indicators were not significant, indicating that this was not the primary channel of acquisition.

[TABLE 5 ABOUT HERE]

Tables 6 and 7 show Average Partial Effects (APEs) from these models. Table 6 shows the APEs for changes in each of the model covariates. In the case of gender and title, the APEs account for covariates entering the model separately as well as via the interaction term. In general, after controlling for title possession, female-heads are less likely to make such investments than male-heads (by 0.8% and 2.3% respectively for irrigation and fertilizer; insignificantly different from zero for the other outcomes). Title possession, in turn, is positively associated with most outcomes, with titled plots associated with 2.1%, 4.9% and 7.5% greater probability of investments for irrigation, erosion control and fertilizer, respectively (and insignificant impacts on agroforestry investments).

However to clarify the gendered impacts of titling, table 7 shows changes in the predicted probabilities of investments with respect to changes in tenure status by female- and male-headed households respectively. Here we observe gendered impacts for most investments. The impact of titling for male-headed households is greater for irrigation investment probability. However, titling has a much larger impact on erosion control and fertilizer investments for female-headed households: the impact of title possession is associated with 5.1% greater likelihood of erosion control investments on female-headed farms, compared with 4.9% on male-headed farms, and with 10.1% greater likelihood of fertilizer investments on female-headed farms, compared with 6.8% on male-headed farms.

[TABLE 6 ABOUT HERE]

[TABLE 7 ABOUT HERE]

To test the robustness of these gendered results, we used a plot-level indicator of the gender of the principal decision maker, in place of the gender of household head dummy. Results, shown in table 8, are very consistent with those shown earlier in table 5. This lends support to our findings.

[TABLE 8 ABOUT HERE]

## 6. DISCUSSION AND CONCLUSIONS

To the extent that Zambia's system for converting land from customary to formal tenure is meant to encourage productive, rather than speculative land uses, the participation of female-headed households appears to be important. Female-headed households currently constitute a minority of title-holders, a proportion which is slightly smaller than their share in the agricultural population as a whole. Finding ways to lower the transaction costs and bureaucratic complexity of acquiring title to land, particularly by female-headed households, should be a policy objective.

The analysis presented in this paper has shown that the impacts of titling on investments, while limited, are generally positive, although such impacts are highly variable across investment types. The types of investments most affected are, in order: erosion control, inorganic fertilizer application and irrigation.

Furthermore, we find strong evidence of gender-specific impacts of titling. Although female-headed households are less likely to make investments than male-headed households, and female title holders are significantly *more* likely to make investments than male title holders for erosion control structures and fertilizer application. These results suggest that usurpation of formal titling institutions by non-local elites is a gendered phenomenon.

Finally, our study has shown that plot-level analysis substantially clarifies the impacts of land titling in smallholder systems. Our findings indicates that tenure security is a localized phenomenon, which is best measured at plot-level -- despite the fact that most titled farmers have title to all their plots (a fact which guided Sitko et al.'s 2014 analysis of titling impacts in Zambia).

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## TABLES

**Table 1: Credit and collateral**

	Total # of households	Households with agricultural loans		Households with loans who used collateral		Households using collateral who used land title deeds	
	n	n	%	n	%	n	%
Households without title	7780	1305	17%	362	28%	14	4%
Households with title	935	121	13%	47	39%	1	2%
total	8715	1426	16%	409	29%	15	4%

**Table 2: Perceptions about land availability, access and institutions**

	% of households indicating "yes"			difference (male- female)	p- value	
	all	male- headed	female- headed			
"Is it possible to change the tenure status of customary land in this village (i.e. to convert customary land into titled property)?"	31.3%	32.0%	28.9%	3.1%	0.042	**
"Is it possible to buy or sell customary land in this village, without first changing it to titled land?"	24.0%	24.6%	22.1%	2.5%	0.055	*
"In your perception, do village headmen/authorities still have unallocated arable land that could be given to households in this area?"	45.9%	46.3%	44.6%	1.7%	1.080	

**Table 3: Descriptive statistics for male- and female-headed households**

	total		title-holders	
	male	female	male	female
% households	80.8%	19.2%	81.6%	18.4%
% with title	10.8%	10.3%	--	--
% with title - State land	6.4%	5.1%	59.2%	50.0%
% with title - former customary land	4.4%	5.1%	40.8%	50.0%
Avg. age of head	44.4	50.5	47.1	49.1
Avg. education of head	6.6	4.3	8.4	6.3
Avg. adult equivalents	5.0	3.7	5.1	4.3
Avg. farm size	3.0	1.9	2.9	2.0
Avg. # of plots	4.0	3.3	3.7	3.2
Avg. % of plots controlled by females	8%	98%	11%	98%
Avg. % of plots with title	--	--	92%	93%
% of HHs which are local	88%	91%	82%	84%
farm income per capita ('000s ZMW)	1,231	1,209	1,155	1,148
off-farm income per capita ('000s ZMW)	857	774	1,360	1,556
total income per capita ('000s ZMW)	2,075	1,956	2,564	2,606
% of plots acquired from chief	44%	45%	19%	14%
% of plots acquired from family	38%	38%	19%	20%
% of plots acquired from gov't	4%	4%	32%	31%
% of plots acquired from pvt actors	7%	7%	25%	31%
% of plots acquired as "self-given"	6%	5%	5%	4%
% with irrigation	19%	13%	26%	19%
% with erosion control structures	23%	20%	23%	32%
% with agroforestry	4%	3%	4%	6%
% using inorganic fertilizer	59%	44%	77%	70%

**Table 4: Determinants of title acquisition (household-level model)**

(1)	
	APE/p-value
Female head (=1)	0.0036 (0.702)
Age of head	-0.0001 (0.746)
Education (years)	0.0085*** (0.000)
Farm size (ha)	0.0009 (0.562)
Adult equivalents	0.0009 (0.623)
Assets (ZMK)	0.0000*** (0.000)
Chief kin (=1)	-0.0318*** (0.001)
Immigrant (=1)	0.0246** (0.035)
Civil service (=1)	0.0142 (0.476)
Number of plots	0.0052*** (0.010)
Polygamous (=1)	0.0015 (0.912)
Conversion ok	0.0033 (0.858)
Unallocated	-0.1450*** (0.000)
Resettlement area (=1)	0.6399*** (0.000)
Pop. density	0.0008*** (0.000)
Hours to town	-0.0047*** (0.000)
N	8362

Note: P-values are based on cluster robust standard errors. Significance levels are denoted as \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. Provincial dummies included but not reported. The variables “Conversion ok” and “Unallocated” are the village-mean responses to the perception questions described in Table 1.

**Table 5: Determinants of land-productivity investment decisions (coefficient estimates from probit models)**

	(1) Irrigated coef./p-value	(2) Erosion control coef./p-value	(3) Agroforestry coef./p-value	(4) Fertilizer coef./p-value
Female head (=1)	-0.0894* (0.084)	-0.0402 (0.237)	-0.0923 (0.195)	-0.1025*** (0.001)
Has title (=1)	0.2207*** (0.001)	0.1654*** (0.001)	0.0347 (0.635)	0.2214*** (0.000)
Female * titled	-0.0270 (0.864)	0.2457** (0.024)	0.2234 (0.222)	0.1133 (0.319)
Plot size	-1.3824*** (0.000)	-0.0637*** (0.000)	-0.0163* (0.070)	-0.0072* (0.065)
Age of head	-0.0072*** (0.000)	-0.0031*** (0.000)	-0.0010 (0.512)	-0.0035*** (0.000)
Education (years)	0.0045 (0.499)	-0.0054 (0.201)	0.0075 (0.278)	0.0865*** (0.000)
Farm size (ha)	0.0448*** (0.000)	0.0131*** (0.001)	0.0025 (0.676)	0.0274*** (0.000)
Adult equivalents	0.0052 (0.541)	0.0308*** (0.000)	0.0157 (0.158)	0.0204*** (0.000)
Log assets	0.0327** (0.012)	0.0362*** (0.000)	0.0367** (0.012)	0.1837*** (0.000)
Number of plots	0.0229*** (0.005)	-0.0253*** (0.000)	0.0524*** (0.000)	0.0628*** (0.000)
Chief kin (=1)	0.0144 (0.778)	0.1056*** (0.002)	0.1083* (0.077)	-0.0550* (0.074)
Immigrant (=1)	-0.1205** (0.035)	-0.0979*** (0.009)	-0.1995*** (0.009)	-0.0419 (0.226)
Civil servant (=1)	0.0002 (0.998)	0.3080*** (0.000)	-0.0889 (0.627)	0.4492*** (0.000)
Resettl. area (=1)	0.1735 (0.440)	-0.9438*** (0.000)	-0.9125** (0.012)	0.3791* (0.063)
Slope	0.0516*** (0.000)	0.0537*** (0.000)	-0.0140 (0.546)	0.0438*** (0.000)

Pop. density	0.0025** (0.017)	0.0067*** (0.000)	0.0057*** (0.000)	0.0112*** (0.000)
Hours to town	-0.0186*** (0.000)	-0.0014 (0.491)	0.0055 (0.186)	-0.0225*** (0.000)
N	32303	32303	32303	32303

Note: P-values are based on cluster robust standard errors. Significance levels are denoted as \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. Provincial dummies included but not reported.

**Table 6: Determinants of land-productivity investment decisions (APEs from probit models)**

	(1) Irrigated coef./p-value	(2) Erosion control coef./p-value	(3) Agroforestry coef./p-value	(4) Fertilizer coef./p-value
Female head (=1)	-0.0078** (0.048)	-0.0035 (0.609)	-0.0026 (0.267)	-0.0297*** (0.001)
Has title (=1)	0.0214*** (0.002)	0.0490*** (0.000)	0.0031 (0.320)	0.0745*** (0.000)
Plot size	-0.1213*** (0.000)	-0.0134*** (0.000)	-0.0006* (0.071)	-0.0022* (0.065)
Age of head	-0.0006*** (0.000)	-0.0007*** (0.000)	-0.0000 (0.512)	-0.0011*** (0.000)
Education (years)	0.0004 (0.499)	-0.0011 (0.201)	0.0003 (0.278)	0.0266*** (0.000)
Farm size (ha)	0.0039*** (0.000)	0.0028*** (0.001)	0.0001 (0.675)	0.0084*** (0.000)
Adult equivalents	0.0005 (0.541)	0.0065*** (0.000)	0.0006 (0.160)	0.0063*** (0.000)
Log assets	0.0029** (0.011)	0.0076*** (0.000)	0.0014** (0.011)	0.0566*** (0.000)
Number of plots	0.0020*** (0.005)	-0.0053*** (0.000)	0.0020*** (0.000)	0.0193*** (0.000)
Chief kin (=1)	0.0013 (0.779)	0.0230*** (0.003)	0.0046 (0.101)	-0.0170* (0.075)
Immigrant (=1)	-0.0099** (0.024)	-0.0199*** (0.006)	-0.0067*** (0.002)	-0.0129 (0.226)
Civil servant (=1)	0.0000 (0.998)	0.0737*** (0.001)	-0.0032 (0.595)	0.1335*** (0.000)
Resettl.area (=1)	0.0171 (0.489)	-0.1212*** (0.000)	-0.0152*** (0.000)	0.1131* (0.052)
Slope	0.0045*** (0.000)	0.0113*** (0.000)	-0.0005 (0.546)	0.0135*** (0.000)
Pop. density	0.0002** (0.017)	0.0014*** (0.000)	0.0002*** (0.000)	0.0034*** (0.000)
Hours to town	-0.0016***	-0.0003	0.0002	-0.0069***

	(0.000)	(0.491)	(0.187)	(0.000)
N	32303	32303	32303	32303

Note: P-values are based on cluster robust standard errors. Significance levels are denoted as \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. Provincial dummies included but not reported.



**Table 7: Change in predicted probability of investments with respect to change in tenure status, by household type**

	<u>Irrigation</u>			<u>Erosion structures</u>			<u>Agroforestry</u>		<u>Fertilizer</u>		
	dy/dx	p-value		dy/dx	p-value		dy/dx	p-value	dy/dx	p-value	
male-headed	0.022	0.00	**	0.048		**	0.001	0.64	0.067		**
female-headed	5	2	*	7	0.000	*	5	4	9	0.000	*
	0.017	0.24		0.051		**	0.009	0.22	0.100		**
	2	5		4	0.000	*	7	6	9	0.001	*

**Table 8: Determinants of land-productivity investment decisions, using controls for gendered plot-level decision-making (coefficient estimates from probit models)**

	(1) Irrigated coef./p-value	(2) Erosion control coef./p-value	(3) Agroforestry coef./p-value	(4) Fertilizer coef./p-value
Female control (=1)	-0.0410 (0.339)	-0.0169 (0.572)	-0.0535 (0.393)	-0.0562** (0.033)
Has title (=1)	0.2269*** (0.001)	0.1435*** (0.004)	0.0618 (0.412)	0.2382*** (0.000)
Fem. control * titled	-0.0389 (0.768)	0.2470*** (0.009)	0.0536 (0.745)	0.0255 (0.796)
Plot size	-1.3867*** (0.000)	-0.0636*** (0.000)	-0.0168* (0.063)	-0.0073* (0.061)
Age of head	-0.0076*** (0.000)	-0.0033*** (0.000)	-0.0012 (0.431)	-0.0038*** (0.000)
Education (years)	0.0045 (0.493)	-0.0057 (0.178)	0.0075 (0.277)	0.0864*** (0.000)
Farm size (ha)	0.0453*** (0.000)	0.0134*** (0.001)	0.0026 (0.658)	0.0278*** (0.000)
Adult equivalents	0.0072 (0.396)	0.0315*** (0.000)	0.0163 (0.136)	0.0224*** (0.000)
Log assets	0.0343*** (0.008)	0.0371*** (0.000)	0.0379*** (0.009)	0.1855*** (0.000)
Number of plots	0.0235*** (0.004)	-0.0252*** (0.000)	0.0527*** (0.000)	0.0633*** (0.000)
Chief kin (=1)	0.0151 (0.768)	0.1062*** (0.002)	0.1073* (0.080)	-0.0548* (0.075)
Immigrant (=1)	-0.1201** (0.036)	-0.0970*** (0.009)	-0.1964** (0.011)	-0.0405 (0.241)
Civil servant (=1)	-0.0001 (1.000)	0.3139*** (0.000)	-0.0871 (0.633)	0.4502*** (0.000)
Resett. area (=1)	0.1727 (0.442)	-0.9386*** (0.000)	-0.9031** (0.012)	0.3802* (0.063)
Slope	0.0522*** (0.000)	0.0533*** (0.000)	-0.0140 (0.547)	0.0440*** (0.000)
Pop. density	0.0025** (0.020)	0.0067*** (0.000)	0.0056*** (0.000)	0.0111*** (0.000)
Hours to town	-0.0187***	-0.0013	0.0054	-0.0226***

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	(0.000)	(0.504)	(0.190)	(0.000)
N	32303	32303	32303	32303

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\* p<0.10, \*\* p<0.05, \*\*\* p<0.01

## APPENDICES

Note: for all Appendix tables, P-values are based on cluster robust standard errors. Significance levels are denoted as \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Provincial dummies included but not reported.

**Table A1: Testing for omitted variables bias in investment models (dependent variable: irrigation)**

<i>Dependent variable:</i>	(1)	(2)	(3)	(4)
<i>Irrigated (=1)</i>	coef./p-value	coef./p-value	coef./p-value	coef./p-value
Female head (=1)	-0.0894* (0.084)	-0.0953* (0.064)	-0.0953* (0.064)	-0.0976* (0.057)
Has title (=1)	0.2207*** (0.001)	0.2215*** (0.001)	0.2146*** (0.001)	0.2168*** (0.001)
Female * titled	-0.0270 (0.864)	-0.0302 (0.847)	-0.0314 (0.840)	-0.0310 (0.842)
Plot size	-1.3824*** (0.000)	-1.3831*** (0.000)	-1.3837*** (0.000)	-1.3846*** (0.000)
Age of head	-0.0072*** (0.000)	-0.0071*** (0.000)	-0.0071*** (0.000)	-0.0071*** (0.000)
Education (years)	0.0045 (0.499)	0.0049 (0.462)	0.0051 (0.441)	0.0055 (0.409)
Farm size (ha)	0.0448*** (0.000)	0.0444*** (0.000)	0.0444*** (0.000)	0.0441*** (0.000)
Adult equivalents	0.0052 (0.541)	0.0045 (0.596)	0.0049 (0.568)	0.0047 (0.574)
Log assets	0.0327** (0.012)	0.0320** (0.014)	0.0318** (0.015)	0.0309** (0.018)
Number of plots	0.0229*** (0.005)	0.0225*** (0.005)	0.0217*** (0.007)	0.0223*** (0.006)
Chief kin (=1)	0.0144 (0.778)	0.0142 (0.781)	0.0136 (0.790)	0.0159 (0.756)
Immigrant (=1)	-0.1205** (0.035)	-0.1208** (0.034)	-0.1212** (0.035)	-0.1225** (0.033)
Civil service (=1)	0.0002 (0.998)	0.0013 (0.992)	-0.0029 (0.981)	-0.0031 (0.979)
Resettlement area (=1)	0.1735 (0.440)	0.1737 (0.439)	0.1914 (0.395)	0.1879 (0.403)
Slope	0.0516*** (0.000)	0.0515*** (0.000)	0.0505*** (0.000)	0.0491*** (0.000)
Pop. density	0.0025** (0.017)	0.0026** (0.015)	0.0027** (0.012)	0.0025** (0.019)
Hours to town	-0.0186*** (0.000)	-0.0188*** (0.000)	-0.0183*** (0.000)	-0.0183*** (0.000)
Polygamous (=1)		0.0512 (0.326)	0.0534 (0.306)	0.0529 (0.311)
Unallocated (=1)			-0.0003	0.0007

			(0.995)	(0.986)
Conversion ok (=1)			0.0239	0.0219
			(0.567)	(0.599)
Buy/sell ok (=1)			0.0719	0.0709
			(0.129)	(0.136)
Km to largest field				0.0058
				(0.733)
Km to FRA				-0.0043
				(0.329)
<hr/>				
N	32303	32303	32303	32303
<hr/>				

Note: P-values are based on cluster robust standard errors. Significance levels are denoted as \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. Provincial dummies included but not reported.

**Table A2: Testing for omitted variables bias in investment models (dep. var.: erosion control structures)**

<i>Dependent variable:</i>	(1)	(2)	(3)	(4)
<i>Erosion structures (=1)</i>	coef./p-value	coef./p-value	coef./p-value	coef./p-value
Female head (=1)	-0.0402 (0.237)	-0.0506 (0.140)	-0.0532 (0.121)	-0.0580* (0.091)
Has title (=1)	0.1654*** (0.001)	0.1665*** (0.001)	0.1672*** (0.001)	0.1707*** (0.001)
Female * titled	0.2457** (0.024)	0.2435** (0.025)	0.2344** (0.033)	0.2331** (0.032)
Plot size	-0.0637*** (0.000)	-0.0639*** (0.000)	-0.0643*** (0.000)	-0.0646*** (0.000)
Age of head	-0.0031*** (0.000)	-0.0030*** (0.001)	-0.0030*** (0.001)	-0.0029*** (0.001)
Education (years)	-0.0054 (0.201)	-0.0046 (0.281)	-0.0052 (0.221)	-0.0043 (0.312)
Farm size (ha)	0.0131*** (0.001)	0.0122*** (0.003)	0.0124*** (0.002)	0.0116*** (0.005)
Adult equivalents	0.0308*** (0.000)	0.0296*** (0.000)	0.0296*** (0.000)	0.0292*** (0.000)
Log assets	0.0362*** (0.000)	0.0342*** (0.000)	0.0311*** (0.000)	0.0287*** (0.001)
Number of plots	-0.0253*** (0.000)	-0.0258*** (0.000)	-0.0261*** (0.000)	-0.0242*** (0.000)
Chief kin (=1)	0.1056*** (0.002)	0.1046*** (0.002)	0.1103*** (0.001)	0.1155*** (0.001)
Immigrant (=1)	-0.0979*** (0.009)	-0.0962** (0.010)	-0.0971*** (0.009)	-0.0999*** (0.008)
Civil service (=1)	0.3080*** (0.000)	0.3072*** (0.000)	0.3061*** (0.000)	0.3086*** (0.000)
Resettlement area (=1)	-0.9438*** (0.000)	-0.9418*** (0.000)	-0.9480*** (0.000)	-0.9528*** (0.000)
Slope	0.0537*** (0.000)	0.0530*** (0.000)	0.0541*** (0.000)	0.0515*** (0.000)
Pop. density	0.0067*** (0.000)	0.0068*** (0.000)	0.0069*** (0.000)	0.0065*** (0.000)
Hours to town	-0.0014 (0.491)	-0.0017 (0.386)	-0.0014 (0.484)	-0.0013 (0.523)
Polygamous (=1)		0.1111*** (0.002)	0.1089*** (0.002)	0.1079*** (0.002)

Unallocated (=1)			-0.0301 (0.224)	-0.0273 (0.272)
Conversion ok (=1)			0.1255*** (0.000)	0.1221*** (0.000)
Buy/sell ok (=1)			-0.1350*** (0.000)	-0.1357*** (0.000)
Km to largest field				0.0181* (0.099)
Km to FRA				-0.0116*** (0.002)
N	32303	32303	32303	32303

Note: P-values are based on cluster robust standard errors. Significance levels are denoted as \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. Provincial dummies included but not reported.



**Table A3: Testing for omitted variables bias in investment models (dependent variable: agroforestry)**

<i>Dependent var:</i> <i>Agroforestry</i> <i>(=1)</i>	(1) coef./p-value	(2) coef./p-value	(3) coef./p-value	(4) coef./p-value
Female head (=1)	-0.0923 (0.195)	-0.0903 (0.206)	-0.1059 (0.126)	-0.1029 (0.137)
Has title (=1)	0.0347 (0.635)	0.0344 (0.638)	0.0386 (0.601)	0.0366 (0.621)
Female * titled	0.2234 (0.222)	0.2246 (0.220)	0.2228 (0.227)	0.2225 (0.230)
Plot size	-0.0163* (0.070)	-0.0163* (0.070)	-0.0173* (0.058)	-0.0172* (0.060)
Age of head	-0.0010 (0.512)	-0.0010 (0.510)	-0.0008 (0.590)	-0.0008 (0.562)
Education (years)	0.0075 (0.278)	0.0073 (0.293)	0.0059 (0.395)	0.0053 (0.445)
Farm size (ha)	0.0025 (0.676)	0.0027 (0.647)	0.0032 (0.584)	0.0037 (0.530)
Adult equivalents	0.0157 (0.158)	0.0159 (0.157)	0.0160 (0.154)	0.0164 (0.141)
Log assets	0.0367** (0.012)	0.0370** (0.011)	0.0344** (0.018)	0.0358** (0.014)
Number of plots	0.0524*** (0.000)	0.0528*** (0.000)	0.0516*** (0.000)	0.0502*** (0.000)
Chief kin (=1)	0.1083* (0.077)	0.1077* (0.078)	0.1120* (0.067)	0.1070* (0.081)
Immigrant (=1)	-0.1995*** (0.009)	-0.1995*** (0.009)	-0.2020*** (0.009)	-0.2013*** (0.009)
Civil service (=1)	-0.0889 (0.627)	-0.0889 (0.627)	-0.0868 (0.638)	-0.0834 (0.651)
Resettl. area (=1)	-0.9125** (0.012)	-0.9123** (0.012)	-0.9092** (0.012)	-0.9102** (0.012)
Slope	-0.0140 (0.546)	-0.0139 (0.551)	-0.0134 (0.566)	-0.0124 (0.599)
Pop. density	0.0057*** (0.000)	0.0057*** (0.000)	0.0061*** (0.000)	0.0062*** (0.000)

Hours to town	0.0055 (0.186)	0.0055 (0.179)	0.0059 (0.153)	0.0056 (0.178)
Polygamous (=1)		-0.0258 (0.691)	-0.0222 (0.733)	-0.0230 (0.724)
Unallocated (=1)			0.0199 (0.635)	0.0168 (0.689)
Conversion ok (=1)			0.1991***	0.2017***
Buy/sell ok (=1)			(0.000) -0.1494***	(0.000) -0.1501***
Km to largest field			(0.004)	(0.004) -0.0153
Km to FRA				(0.514) 0.0061* (0.059)
N	32303	32303	32303	32303

Note: P-values are based on cluster robust standard errors. Significance levels are denoted as \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. Provincial dummies included but not reported.

**Table A4: Testing for omitted variables bias in investment models (dep. variable: inorganic fertilizer)**

<i>Dependent var:</i>	(1)	(2)	(3)	(4)
<i>Fertilizer (=1)</i>	coef./p-value	coef./p-value	coef./p-value	coef./p-value
Female head (=1)	-0.1025*** (0.001)	-0.0912*** (0.003)	-0.0945*** (0.002)	-0.0993*** (0.001)
Has title (=1)	0.2214*** (0.000)	0.2193*** (0.000)	0.2128*** (0.000)	0.2390*** (0.000)
Female * titled	0.1133 (0.319)	0.1248 (0.273)	0.1210 (0.287)	0.1440 (0.215)
Plot size	-0.0072* (0.065)	-0.0073* (0.063)	-0.0073* (0.061)	-0.0071* (0.078)
Age of head	-0.0035*** (0.000)	-0.0036*** (0.000)	-0.0036*** (0.000)	-0.0036*** (0.000)
Education (years)	0.0865*** (0.000)	0.0859*** (0.000)	0.0861*** (0.000)	0.0860*** (0.000)
Farm size (ha)	0.0274*** (0.000)	0.0284*** (0.000)	0.0288*** (0.000)	0.0288*** (0.000)
Adult equivalents	0.0204*** (0.000)	0.0220*** (0.000)	0.0223*** (0.000)	0.0251*** (0.000)
Log assets	0.1837*** (0.000)	0.1854*** (0.000)	0.1837*** (0.000)	0.1958*** (0.000)
Number of plots	0.0628*** (0.000)	0.0637*** (0.000)	0.0620*** (0.000)	0.0556*** (0.000)
Chief kin (=1)	-0.0550* (0.074)	-0.0551* (0.073)	-0.0556* (0.072)	-0.1008*** (0.001)
Immigrant (=1)	-0.0419 (0.226)	-0.0436 (0.208)	-0.0447 (0.197)	-0.0411 (0.245)
Civil service (=1)	0.4492*** (0.000)	0.4474*** (0.000)	0.4414*** (0.000)	0.4686*** (0.000)
Resettl.area (=1)	0.3791* (0.063)	0.3776* (0.065)	0.3751* (0.069)	0.2694 (0.194)
Slope	0.0438*** (0.000)	0.0447*** (0.000)	0.0445*** (0.000)	0.0527*** (0.000)
Pop. density	0.0112*** (0.000)	0.0111*** (0.000)	0.0113*** (0.000)	0.0127*** (0.000)
Hours to town	-0.0225***	-0.0222***	-0.0218***	-0.0216***

	(0.000)	(0.000)	(0.000)	(0.000)
Polygamous (=1)		-0.1244***	-0.1206***	-0.1272***
Unallocated (=1)		(0.000)	(0.000)	(0.000)
			0.0084	0.0161
Conversion ok (=1)			(0.697)	(0.457)
			0.0768***	0.0805***
Buy/sell ok (=1)			(0.001)	(0.001)
			0.0443	0.0294
Km to largest field			(0.103)	(0.280)
				-0.2104***
Km to FRA				(0.000)
				-0.0127***
				(0.000)
N	32303	32303	32303	32303

Note: P-values are based on cluster robust standard errors. Significance levels are denoted as \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. Provincial dummies included but not reported.