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Property rights and farmers' investment decisions in Burkina Faso

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Abstract

This article analyzes the relationship between land tenure arrangements and households' investment in soil improvement and conservation measures. The research is based on survey data collected from 2,160 households across Burkina Faso and uses a model that accounts for endogeneity between land rights and investment decisions as well as interdependence between investment decisions. The findings show that land tenure arrangements seem to stimulate farmers' short-term investment decisions such as buying fertilizer while significantly reducing incentives for long-term investment decisions such as tree planting. Further, education and technology do affect investment decisions, suggesting that land tenure arrangement policies should take these issues into account.

Key words: *Land tenure; Property rights; Investment; Burkina Faso.*

1. Introduction

Property rights have been shown to be a critical determinant of economic development, impacting resource allocation and economic efficiency. The institutions governing land ownership rights affect land use efficiency and the investments that are made to improve agricultural productivity. Under these conditions, the relationship between land rights and agricultural investments has attracted the attention of both researchers and policy makers (see Besley, 1995; Brasselle, Gaspart and Platteau, 2002; Place and Otsuka, 2002; Goldstein and Udry, 2008; Deininger and Ali, 2008; Abdulai, Owusu and Goetz, 2011). While the theory seems to suggest a positive relationship between land rights and agricultural investments, empirical findings appear to be inconclusive.

Theoretically, we anticipate a positive relationship between land rights and investment. It is admitted that rational individuals will not invest if the benefits of their investments are not adequately protected (Alchian and Demsetz, 1972;

Demsetz, 1967). Land tenure security encourages investment by reducing the risk that the property could be confiscated. The right of alienation encourages investment by increasing the value of land for potential buyers, and ongoing development also increases the possibility that land may be used as collateral to obtain loans from financial institutions (Fenske, 2011; Besley, 1995; Feder and Feeny, 1991).

Despite these theoretical developments predicting the positive effects of land tenure on agricultural investment, empirical results have been ambiguous in developing countries, particularly in Africa (Brasselle *et al*., 2002). While Migot-Adholla, Benneth, Place and Atsu (1994) and Pinkney and Kimuyu (1994) show that the impact of land rights on soil improvement investments and planting tree crops is quite low, Jacoby, Li and Rozelle (2002) on China and Carter and Olinto (2003) on Paraguay show that tenure security has a positive and significant impact on investments. Banerjee, Gertler and Ghata (2002) also found land reform to have had a positive impact on agricultural productivity in India. This is partly attributed to the increased investment caused by land tenure security. Brasselle *et al*. (2002) note that Burkina Faso's tenure security can be affected by agricultural investments, and when endogeneity bias is well controlled, improved land rights do not stimulate investment.

In many developing countries, particularly in sub-Saharan Africa, land ownership rights are not always well defined and a hybrid system governing property rights prevails: customary rights or common law and modern law. In these countries, particularly in Burkina Faso, the traditional land tenure systems still play an important role in the allocation and protection of land rights. However, population pressure can easily dislocate such systems and affect agricultural production. The traditional legal system therefore offers insufficient guarantees for agricultural investment although some authors argue that customary rights can stimulate agricultural investment and growth (Place, 2009). These issues are particularly pressing for Africa, in light of the relatively poor economic performance and the fact that individualistic notions of ownership are not yet fully accepted (Besley, 1995).

Burkina Faso offers an interesting setting in which to study the relationship between land tenure and agricultural investments. It is a country whose livelihood comes mainly from agriculture. Indeed, the agricultural sector employs 85% of the active population (World Bank, 2010). However, agriculture is characterized by low productivity due in part to the weakness of investment in agriculture. Burkina Faso has an average crop yield of 1,048 kg per ha, while average crop yields are 1,359 kg/ha in Ghana, 1,765 in Côte d'Ivoire, 3,300 kg/ha in India, and 5,101 kg/ha in China (World Bank, 2010). The yield level depends mostly on the level of investments. One should note that the use of inputs that enhance crop yields is relatively low in Burkina Faso. For example, the quantity of fertilizers used is estimated to be 7 kg/

ha in Burkina while China uses 395 kg/ha (World Bank, 2008). Low investment is partially due to the structure of land ownership rights. Gradually building early signs of land crisis are being seen in rural areas of Burkina Faso. Stakeholders in rural areas are in permanent conflict for the control, operation and use of land and other natural resources. The growth of rural agro-business and the low efficiency of the legal and institutional mechanisms for land and rural conflict management contribute to land insecurity in rural areas. For the purpose of providing effective and sustainable responses to the problem of land insecurity that rural stakeholders face, the Government of Burkina Faso has undertaken a series of actions: the development and adoption of a national policy on land security in rural areas, the Land Tenure Act in rural areas, a revision of the laws on agrarian and land reform, among others. Despite these efforts, land insecurity remains a major concern, especially for smallholder farmers. Although the law allows private property, in practice, agricultural lands are governed by the traditional land tenure system and rural-farmer leaders or landlords are the ones who manage land rights. Under these conditions, one can wonder whether or not such a property rights system is favorable to land-improving and land-conservation investments such as applying chemical fertilizers and organic manure, and building anti-erosion bunds,[1] quickset hedges and *zaï*.[2] Studies that have investigated this issue comprehensively taking into account the endogeneity of property rights are scarce in Burkina Faso. Only the study done by Brasselle *et al*. (2002) addresses the endogeneity issue, and it only covers the Bobo-Dioulasso area.

The present research has the advantage of covering the whole country, making it possible to take into account both the diversity of traditional systems of each region and the changes in these systems as they cohabit with the modern land tenure system. The objective of this research is to analyze the effect of land tenure rights on agricultural investments in the context of these changes at a time when agricultural policy is concerned with finding the best way to generate economic growth. The research is based on survey data collected from 2,160 households across the country and uses a model that checks for endogeneity between land rights and investment decisions as well as interdependence between investment decisions.

The remaining sections of the paper are organized as follows. Section 2 provides a summary of the literature on the relationship between land rights and agricultural investments in developing countries. Section 3 presents the model and discusses econometric issues. Section 4 presents the data used to implement the model. Section

[1] *Built on gentle slopes, anti-erosive bunds can prevent run-off and soil loss.*

[2] *Zaï is a intensive technique for manure management and water preservation. It is an ancestral practice used to regenerate the poorest parts of fields. It consists of digging holes in the ground, putting organic manure in them and finally sowing seeds in these holes. The holes are 10 to 15 cm in depth and 15 to 20 cm in diameter. The micro-environment thus created helps the plants better resist drought, and yields improve substantially.*

5 discusses the results of the estimates. Section 6 concludes the paper and discusses the main economic policy implications.

2. Review of related literature

The role of land tenure in improving agricultural investments has been the subject of debates in the literature in developing countries, particularly in sub-Saharan Africa where land is one rural households' most important assets (Abdulai *et al*., 2011). Two trends have been observed: (i) property rights and investment are positively related; and (ii) an inverse or no relationship between property rights and agricultural investment.

Feder, Oncan, Chalamwong and Hongladarom (1988) noted that tenure security is supposed to increase the incentives to undertake agricultural investments. If a farmer thinks he is entitled to enjoy the long-term benefits of his investment, the level of investment will increase compared to a situation where property rights are not well defined. Generally, secure individual property rights induce high levels of work and investment to protect the land for productivity improvement (Feder and Feeny, 1991; Carter and Olinto, 2003 and Besley, 1995).

Securing land has a positive effect on the security of property rights and the adoption of soil fertility improvement technologies and improved access to credit (Feder and Onchan, 1987). Deininger and Chamorro (2004) and Gebremedhin and Swinton (2003) found that farmers with well-defined formal rights are more willing to undertake long-term investments on their land. It is often recognized that restrictions on land rights in terms of duration or redistribution opportunities are not suitable to allowing investments that could improve agricultural productivity and trigger an economic incentive (Deininger and Jin, 2006). Poorly defined property rights can also indirectly affect production as farmers are unable to use land as collateral to access credit (Besley, 1995). Indeed, credit constraints may be reduced if farmers can use land as collateral, which can contribute to increased use of commercial inputs, therefore enhancing productivity (Twerefou, Assibey and Tettey, 2011; Carter and Olinto, 2003; Feder *et al.*, 1988). Land rights also encourage agricultural investment and contribute to increased productivity, reducing poverty and improving households' well-being (Demsetz, 1967; Ault and Rutman, 1979; De Alessi, 1980; Feder *et al*., 1988; Feder and Feeny, 1991; Binswanger, Deininger and Feder, 1995; Feder and Nishio, 1997; Finan, Sadoulet and de Janvry, 2005).

If property rights affect investment, it is also possible that investment may help establish property rights. Indeed, if property rights are uncertain or poorly defined, fixed investments can increase the rights to the land in the event of conflict (Baland, Gaspart and Place, 1999; Chimhowu and Woodhouse, 2008; Deininger and Jin, 2006). In sub-Saharan Africa, some land improvements measures such as tree planting and

building bunds are recognized methods by which farmers with temporary or weak property rights may improve their land tenure (Bruce, 1988; Sjaastad and Bromley, 1997; de Zeeuw, 1997; Quisumbing, Aidoo, Payongayong and Otsuka, 2001; Place and Otsuka, 2002; Deininger and Jin, 2006). In Ethiopia, Gebremedhin and Swinton (2003) indicated that bunding is a strategy to improve land rights. This investment strategy to secure property rights is also seen in Zambia where farmers develop good soil conservation practices and willingness to invest in order to receive titles to the land (Smith, 2004).

Agricultural investments and land rights may move in opposite directions or may have no relationship. In this case, land insecurity will tend to boost investment, while more land tenure security proves to be a disincentive for farmers to invest in their plots. Tenure insecurity may not affect the incentives to invest if the benefits of secure rights are not available. In areas where land is abundant, the need for formal rights is not necessary if informal institutions provide adequate security. This result was also established by Matchaya (2010) in Malawi. The author found no difference in the incentive to invest for farmers with property rights and for those who do not have these rights. Deniger *et al*. (2003) indicated that the effect of tenure security on investment differs depending on the specific type of investment. In their study in Ethiopia, they show that tenure insecurity encourages long-term investment and discourages short-term investments. If the producer is altruistic, his level of investment may well increase despite land insecurity since he gives more priority to the community's interest than to his own (Besley, 1995).

Land reforms aiming at providing more security for property rights may discourage farmers from investing when the guarantee that the land will not be taken back is not strong enough. In Nicaragua, for example, successive governments have implemented land reforms to secure property rights but because of the multitude of the various documents and the various levels of rights covered, the propensity to invest has tended to decrease (Bandiera, 2007; Bromley, 2008). Migot-Adholla *et al*. (1994) and Pinkney and Kimuyu (1994) found that the impact of land ownership rights on investment is quite low, while Twerefou et al. (2011) note that land tenure security does not improve agricultural investment in Ghana. This implies that agricultural investments are not induced by land tenure security. In the Philippines, Omura (2008) has shown that the formalization of property rights does not have a significant effect on investment incentives for farmers, indicating that there is no difference between formal rights and customary rights in indigenous communities.

3. Modeling and econometric issues

In this section, we employ plot-level data to examine the relationship between land tenure arrangements and investments in productivity-enhancing measures.

One of the major problems in modeling the relationship between land ownership and agricultural investment thus relates to the treatment of endogeneity. If the incentives to invest are property-right sensitive (Besley, 1995), investing can strengthen land tenure (Sjaastad and Bromley, 1997). The results of econometric estimates can differ fundamentally depending on whether endogeneity is taken into account or not (Besley, 1995; Brasselle *et al*., 2002; Abdulai *et al*., 2011). Few studies have addressed the issue of the endogeneity of land rights to estimate the effect of land tenure on agricultural investment. Besley (1995) is one of the first authors have clearly taken into account the endogeneity of property rights in estimating the relationship between property rights and agricultural investment. Brasselle *et al*. (2002) and Abdulai *et al*. (2011) also took into account the endogeneity issue in estimating the relationship between property rights and agricultural investments in Burkina Faso and Ghana respectively. Our research is based on the model developed by Abdulai *et al*. (2011).

It is assumed that farmers will invest in land-improving or conservation activities if doing so augments the expected farm net benefit aggregated over the planning horizon. However, this expected farm net benefit is not observable; what we can observe is the decision whether or not to invest in land improvements and conservation measures. The empirical analysis focuses on the factors that influence farmers' likelihood of making these investments. In line with the profit maximization hypothesis, farmers invest in soil-improving and natural resource management measures if doing so improves the farm net benefit. However, changes in the net benefit are not observable, but can be expressed as a function of observable elements. Let J_{him}* denote the latent propensity variable for investment on plot m, owned by farmer h, for soil-improving and natural resource management strategy i. The underlying propensities can therefore be related to the plot's observed characteristics and farmer-related variables (Z_{him}) as well as land tenure arrangements (R_{him})

$$J^*_{him} = Z_{him}\beta_m + R_{him}\gamma_m + \varepsilon_{him} \quad (1)$$

with ε_{him} the error term.

Equation (1) can then be transformed into a binary probit equation for the participation of each investment option under the following mapping from the latent variable to its observed realization:

$$J^{**}_{him} = \begin{cases} 1 \; si \; J^*_{him} > 0 \\ 0 \; si \; J^*_{him} \leq 0 \end{cases} \quad (2)$$

Because of the potential for substitutability or complementarity of investment options and because of the similarity among plots, it is possible that errors are correlated. Moreover, land rights may be affected by the investments made in the plots, which creates an endogeneity of the variables representing property rights in the investment

equation. Jacoby and Mansuri (2008) have shown that in many agricultural contract models, there is a correlation between contractual choices and unobservable characteristics of farmers. This reinforces the endogeneity of land rights. One possible method to solve this problem is the two-stage instrumental variables approach. The first step specifies an equation of property rights as a function of exogenous variables in the equation (1) in addition to other variables affecting land tenure arrangements:

$$R_{him} = \alpha_0 + Z_{him}\alpha_1 + V_{him}\alpha_2 + \tau_{him} \quad (3)$$

where V_{him} is a vector of instrumental variables that are correlated with land tenure but not correlated with ε_{him} and is therefore excluded from equation (1), and τ_{him} the error term. The predicted values from equation (3) are then used in the second stage estimation of equation (1). When the dependent variable is as discrete as it is in the present research, the usual two-step approach will not be able to address the endogeneity problem. Wooldridge (2002) argues that the most useful two-step approach to examine endogeneity in a probit model is the Two-Stage Conditional Maximum Likelihood (2SCML) method suggested by Rivers and Vuong (1988). Rather than using the predicted values from the first-stage linear probability regression, the 2SCLM approach involves specifying the investment equation as follows:

$$I^*_{him} = \beta_0 + \beta_1 Z_{him} + \beta_2 R_{him} + \beta_3 U_{him} + \mu_{him} \quad (4)$$

where R_{him} is the vector of observed land tenure arrangement variables, U_{him} is the vector of residuals obtained from equation (3) and μ_{him} the error term. The probit estimates of β_2 in equation (4) are consistent (Wooldridge, 2002; Abdulai et al., 2011). A significant feature of the approach is that the usual probit t-statistics on β_3 are valid tests of the null hypotheses that the variables are exogenous, i.e. $\beta_3 = 0$. However, if $\beta_3 \neq 0$, then the probit standard errors and test statistics are not strictly valid, and we would have only estimated β_1 and β_2 up to scale (Wooldridge, 2002). According to Brasselle *et al*. (2002), a joint Wald test can also be performed on the β_3 vector to examine the exogeneity of tenure arrangements as a whole.

While the specification in equation (4) controls for farmers and plot characteristics, it does not control for family-level unobservable variables that could be correlated with both tenure status and the decisions to adopt land-improving measures. To address this concern, we allowed for household fixed effects in equation (4) to yield the following specification:

$$J^*_{him} = \lambda_{hi} + \beta_1 Y_{him} + \beta_2 R_{him} + \beta_3 U_{him} + \tau_{him} \quad (5)$$

with λ_{hi} as the household specific intercept and representing the intrinsic propensity of farmer *h* for investment *i*; Y_{him} is the vector of plot level variables. By estimating the fixed effects model, all variables at household level drop out of regression.

To ensure the identification of the investment equation in the estimation, some of the variables included in the first-stage estimation of tenure rights are excluded from the multivariate probit estimation. Jacoby and Mansuri (2008) suggested that a suitable identification strategy is to employ a variable that strongly influences

contractual choice but is orthogonal to unobserved plot characteristics. The variables that are excluded from the second-stage regression of investment decisions are the mode of acquisition of the plot and soil quality. The validity of the exclusion restrictions is tested with the approach suggested by Lee (1992). The test involves estimating an alternative version of equation (4), that includes the instruments as follows:

$$J^{*}_{him} = \beta_0 + \beta_1^{'} Z_{him} + \beta_2^{'} R_{him} + \beta_3^{'} U_{him} + \beta_4^{'} I + \mu^{'}_{him} \quad (6)$$

The significance of β_4' then provides direct evidence that the instrument can be excluded from equation (4).

4. Data and descriptive statistics

This study uses nationally-representative survey data collected in 2011 by a team of researchers from the Laboratory of Quantitative Analysis of Development in Sahel (LAQAD-S) at the University of Ouaga II Faculty of Economics for the Community-based Rural Development Project (PNGT) evaluation in Burkina Faso. The project was funded by the Burkina Faso Ministry of Agriculture, the International Fund for Agricultural Development (IFAD) and the World Bank. A multi-stage sampling strategy was used to select the sample. First, villages were chosen using cluster sampling according to the PNGT's mode of action and based on the representativeness of the population at the national and regional level in order to allow for the spatial comparison between the 13 regions and 45 provinces of Burkina Faso. Two to seven villages were selected from each province according to the PNGT's mode of action based on a complete list of villages provided by the National Institute of Statistics and Demography (INSD). Second, households in each village were chosen through two-stage stratified random sampling. In the first stage, holding animal traction was chosen as a criterion for the stratification variable and comprised three terms: (i) holding animal traction as equipment, (iii) not holding animal traction as equipment but using (renting) animal traction; and (iii) non-use of animal traction as equipment. In the second stage, a simple random selection method was used to select households within each group. The sample size was set at 90 communes with 3 villages each, forming a sample of 270 villages. In each village, 8 households were surveyed, for a total of 2,160 households. The information collected includes data on the households' demographic characteristics, agricultural investments on the plots, land ownership rights and soil types. The survey requested that each household report its land tenure arrangement on each plot cultivated. Farmers were also asked about investments they had undertaken in the past five years to improve the land they were cultivating. Property rights issues are addressed at the plot level. Three types of property rights were defined: (i) owner-operated with full rights, (ii) owner-operated without transfer rights, and (iii) user-operated without rights. The sample contained

127 owner-operated with full rights, 1,835 land owners without transfer rights, and 260 user-operated without rights. This latter category of land tenure is considered to be the reference category in the estimates of equations 4 and 5. The investments include mineral and manure fertilizer, anti-erosive bunds, quickset hedges and zaï. Land purchases are very rare in rural Burkina Faso, where they account for just 0.14% of all plot acquisitions in the sample. On the other hand, family inheritance (71%) and gifts (18%) are more common (Table A1 in the Appendix). Information on household characteristics such as education, age, gender and household size were included. Differences across plots in terms of quality and location also affected the suitability of the plots for various investments. Information on plot characteristics includes plot size, plot location, plot status and crop(s) grown on the plot. The descriptive statistics on the variables used in the analysis are summarized in Table 1.

Table 1: Descriptive Statistics of Variables Used in the Regression Models

Variable	Definition	Average	Standard Deviation
Dependent Variables			
Fertilizer	1 if the farmer uses chemical fertilizers, 0 otherwise	0.52	0.49
Manure	1 if the farmer uses organic manure, 0 otherwise	0.64	0.47
Bunds	1 if the farmer builds bunds, 0 otherwise	0.11	0.31
Zaï	1 if the farmer practices zaï, 0 otherwise	0.13	0.33
Quickset Hedges	1 if the farmer plants quickset hedges, 0 otherwise	0.07	0.26
Tenure Variables			
Rights	1 if the farm is owner-operated with full rights	0.06	0.23
No Rights	1 if the farmer is owner-operated without transfer rights	0.82	0,37
User	1 if the farmer uses the plot of land but has no rights	0.12	0.33
Households' Demographic Characteristics			
Educ	1 if the farmer has received formal education, 0 otherwise	0.22	0.41
Age	age of farmer in years	45.09	12.74
Size	household size	10.10	7.16
Sex	1 if the farmer is a man, 0 otherwise	0.97	0.15
Occupation	1 if the farmer's main occupation is farming, 0 otherwise	0.95	0.23
Animal Traction	1 if the farmer uses animal traction, 0 otherwise	0.58	0.51
Plot Characteristics			
Topo	1 if the plot is on a slope, 0 otherwise	0.39	0.48
Area	surface area of the plot in ha	2.3	2.97
Soil	1 if the plot is located on a fertile soil, 0 otherwise	0.25	0.69
Status	1 if the plot is operated as an individual field, 0 otherwise	0.09	0.27
Crops			
Typecrop	1 if the crop on the plot is a grain, 0 otherwise	0.86	0.33
Growing Area	1 if the growing area is humid, 0 otherwise	0.43	0.49

Source: Survey Data

5. Discussion of the results

The determinants of land tenure are first estimated to account for the potential endogeneity between land tenure arrangements and agricultural investment. The results indicate the role of the instruments used in the allocation of property rights. These results are given in Table A2 in the Appendix.

The results of the investment equations are presented in Table 2. Most of the correlation coefficients are significant, indicating that unobservable variables in each investment option are interconnected; this confirms that it is more efficient to estimate investment decisions jointly rather than separately. This result is confirmed by the likelihood ratio test, which indicates that the assumption of uncorrelated errors cannot be accepted. A combined estimation is more appropriate than a separate one. The variables representing the residuals derived from the regressions of the determinants of property rights are not statistically significant, indicating a lack of simultaneity bias, which confirms that the coefficients have been consistently estimated. In general, the statistical results indicate that the estimates are not biased.

The variable representing "owner-operated with full rights" is positive and significantly different from zero for the investment in chemical fertilizers and negative for investment in quickset hedges. For other investment options, the effect is not significant. These results suggest that compared to the owner-operated without rights group, the farmers in the owner-operated with full rights group are more likely to invest in chemical fertilizers and less inclined to invest in quickset hedges. Compared to the owner-operated without rights group, the farmers in the owner-operated with full rights group are more likely to access commercial inputs compared to those who have no rights on the land. This result is consistent with the theoretical predictions of Besley (1995), and indicates that in Burkina Faso, secure property rights enhance fertilizer usage. Abdulai *et al*. (2011) found in the case of Ghana that property rights positively affect farmers' use of fertilizers. However, the results differ for tree planting. The effect of property rights on investment in quickset hedges supports the results of Brasselle *et al*. (2002) who found that when the endogeneity bias is controlled, property rights do not influence agricultural investment in Burkina Faso.

The variable representing "owner-operated without transfer rights" has a negative effect on all investment options but this effect is significant only for bunds. This means that compared to the owner-operated without rights group, farmers in the owner-operated without transfer rights group tend to invest less in bunds. Insecurity of tenure thus negatively affects soil protection investments such as building bunds. Farmers in the owner-operated without transfer rights group are less incited to undertake long-term investments. Agricultural investments do not seem to be undertaken with a view to consolidating property rights in Burkina Faso. This result

is similar to those found by Goldstein and Udry (2008) in Ghana and Jacoby and Mansuri (2008) in Pakistan.

Plot status has an impact on agricultural investments. The results indicate that households tend to invest less on individual plots than they do on collective plots. This may be explained by the way that production is organized in rural areas in Burkina Faso. In general, collective plots under the responsibility of the head of the household are the ones used to feed household members whereas individual plots are managed for the particular needs of the individual. In this sense, it is likely that households would concentrate their resources to improve the productivity of collective plots by investing more on them, especially in the context of subsistence farming as is the case in Burkina Faso.

Agricultural investments are more likely to be undertaken by producers who have a high level of education and use animal traction. In particular, the level of education has a positive and significant effect on all five investment options. This supports the human capital theory. Such a result was found by Abdulai *et al*. (2011) in Ghana. It suggests that land policies should also focus on household education. Animal traction has a positive and significant effect on investments in chemical fertilizers, organic manure, zaï and quickset hedges. Households that use animal traction are more likely to undertake these types of investment. Grain producers' households tend to use less chemical fertilizers and organic manure, but are more likely to invest in anti-erosion bund construction. In general, grain farmers tend to use some inputs to improve productivity but focus more on soil erosion control methods.

Table 2: Multivariate Probit Regressions of Investment in Land Improvement Measures

Variable	Fertilizer	Manure	Zaï	Bunds	Quickset Hedges
Constant	-1.676***	0.103	-2.372***	-3.514***	-6.781
	(0.413)	(0.347)	(0.871)	(0.528)	(11.577)
Right	0.545***	-0.116	0.149	-0.187	-0.503*
	(0.154)	(0.146)	(0.292)	(0.216)	(0.292)
No Right	-0.046	-0.094	-0.229	-0.225*	-0.154
	(0.097)	(0.090)	(0.194)	(0.126)	(0.149)
Topo	0.033	0.061	-0.143	0.022	-0.016
	(0.062)	(0.058)	(0.115)	(0.086)	(0.102)
Growing Area	0.548***	-0.261***	-0.055	0.323***	0.592***
	(0.047)	(0.044)	(0.084)	(0.071)	(0.097)
Area	-0.2.97e-05	-0.207e-05	1.68e-05	0.005	-0.016
	(1.742e-04)	(1.438e-04)	(1.563e-04)	(0.017)	(0.020)
Status	-0.203*	-0.275***	0.286	-0.298*	-0.361*
	(0.113)	(0.103)	(0.206)	(0.170)	(0.213)
Educ	0.151**	0.263***	3.241***	1.475***	1.712***
	(0.073)	(0.071)	(0.184)	(0.085)	(0.105)
Sex	1.077***	0.404**	-0.609	0.129	2.473
	(0.287)	(0.191)	(0.693)	(0.337)	(11.576)
Age	-0.010***	0.003	0.003	0.005	0.001
	(0.002)	(0.002)	(0.004)	(0.003)	(0.004)
Size	-0.007	0.011*	0.006	-0.009	0.009
	0.007	(0.006)	(0.010)	(0.007)	(0.008)
Type of Crops	-0.419***	-0.236**	0.015	0.533***	0.221
	(0.094)	(0.092)	(0.169)	(0.149)	(0.154)
Animal Traction	0.233***	0.495***	0.596***	0.131	0.234**
	(0.065)	(0.062)	(0.119)	(0.087)	(0.108)
Soil	-0.043*	-0.026	-0.119***	-0.009	-0214
	(0.023)	(0.022)	(0.044)	(0.033)	(0.039)
Occup	0.011	0.341**	0.074	0.325	0.337
	(0.157)	(0.137)	(0.229)	(0.208)	(0.273)
Resid	-2.339	-5.603	-3.499	2.330	3.205
	(2.144)	(4.257)	(5.812)	(2.908)	(3.527)
Correlation Coefficient between Equations					
	ρ^{FE} 0.328***	ρ^{HE} -0.042	ρ^{DF} -0.208***	ρ^{ZF} -0.094	ρ^{ZD} 0.663***
	ρ^{DE} -0.086*	ρ^{ZE} 0.021	ρ^{HF} -187***	ρ^{HD} 0.790***	ρ^{ZH} 0.762***
Likelihood Test Ratio Chi2(10)=502.596 Prob>Chi2=0.000					

*Source: Survey Data. Standard deviations are given in parentheses. ***,** and * Significant at1% 5% and 10% respectively.*

To control household characteristics, the model was re-estimated by excluding these variables (Equation 5). The results of the estimation of this equation are shown in Table 3. They are essentially the same as those in Table 2. In particular, both the positive and negative effects of property rights on investment remain, except for investments in zaï by farmers who have no rights, even though the magnitudes of the coefficients appear to be lower in the fixed-effects model compared to the model without fixed effects. This suggests that unobservable factors at household level are not responsible for the positive effect of secure property rights on investment decisions in land improvement measures.

Table 3: Multivariate Probit Regression of Investment in Land Improvement Measures with Fixed Effects

Variable	Fertilizers	Manure	Zaï	Bunds	Quickset Hedges
Constant	-0.914***	1.306***	-1.226***	-2.196	-2.653***
	(0.178)	(0.177)	(0.215)	(0.255)	(0.297)
Right	0.541***	-0.146	0.009	-0211	-0.421*
	(0.152)	(0.145)	(0.179)	(0.192)	(0.237)
No Right	-0.042	-0.109	0.217**	-0.013	0.094
	(0.095)	(0.088)	(0.110)	(0.111)	(0.126)
Topo	0.063	0.087	0.041	0.079	0.093
	(0.061)	(0.057)	(0.068)	(0.074)	(0.081)
Growing Area	0.591***	-0.148***	0.011	0.267***	0.440***
	(0.045)	(0.042)	(0.049)	(0.059)	(0.0739)
Area	-1.51e-05	-3.33e-06	-1.21e-05	-0.009	-0.025
	(1.749e-04)	(1.141e-04)	(2.105e-04)	0.014)	(0.017)
Status	-0.188*	-0.265***	-0.043	-0.335**	-0.374**
	(0.111)	(0.101)	(0.124)	(0.147)	(0.169)
Type of Crops	-0.477***	-0.367***	-0.006	0.391***	0.127
	(0.092)	(0.089)	(0.100)	(0.128)	(0.126)
Soil	-0.29	-0.019	-0.060**	-0.016	-0.020
	(0.023)	(0.021)	(0.026)	(0.029)	(0.032)
Resid	-1.881	-2.169	-0.356	1.641	1.468
	(5.374)	(9.757)	(2.608)	(2.408)	(2.859)
Correlation Coefficient between Equations					
	ρ^{FE} 0.332***	ρ^{HE} 0.055	ρ^{DF} -0.047	ρ^{ZF} 0.087***	ρ^{ZD} 0.748***
	ρ^{DE} 0.009	ρ^{ZE} 0.096**	ρ^{HF}-0.018	ρ^{HD} 0.870***	ρ^{ZH} 0.795***
Likelihood Test Ratio Chi2(10)=1130.88 Prob>Chi2=0.000					

*Source: Survey Data. Standard deviations are given in parentheses. ***,** and * Significant at1% 5% and 10% respectively.*

6. Conclusions and policy implications

In this article, we used a framework developed by Abdulai *et al*. (2011) to examine the relation between different land tenure arrangements and farm households' investments in land-improving and conservation measures in Burkina Faso. Three land tenure arrangements were considered: (i) owner-operated with full rights, (ii) owner-operated without transfer rights, and (iii) user-operated. We employed variations in tenure arrangements between different plots to estimate plot-level regressions relating tenure arrangements to investment in quickset hedges, bunds, zaï, and manure and mineral fertilizer application.

The analysis revealed that farmers in the owner-operated with full rights group are more likely to use chemical fertilizers on their plots but invest less in quickset hedges. The positive effect on fertilizers is explained by the fact that the land can be used as collateral to obtain credit to invest in commercial inputs. However, the negative effect on investment in quickset hedges suggests that when farmers have defined rights, they tend not to undertake such investments. Farmers that do not have rights tend to reduce the construction of anti-erosion bunds. Land tenure insecurity reduces the building of bunds. Such a result suggests that these investments in Burkina Faso are not undertaken with a view to consolidating property rights as has been suggested by authors such as Baland *et al*. (1999); Sjaastad and Bromley (1997) and Deininger and Jin (2006).

The analysis also showed that level of education is a fundamental determinant of agricultural investment decisions in Burkina Faso. This implies that policies that increase the level of education can improve agricultural investments. The current land tenure security policies in the country should consider these aspects.

In addition, animal traction has been seen as a decisive factor in investment decisions. This suggests that policies that improve production technologies have the indirect effect of improving agricultural investments. In this sense, agricultural policies aimed at improving agricultural investment should consider measures to provide farmers with better farming equipment. Contrary to what one might think, households are more likely to make investments on collective plots than on individual plots. This is due to the fact that the system of social organization still gives significant weight to the community organization of life in rural areas of Burkina Faso. Current land tenure security policies should take into account these social aspects.

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Appendix

Table A1: Land Acquisition Modes

Variable	Percent
Purchase	0.14
Borrowing	0.41
Crop Sharing	9.93
Gift	18.47
Inheritance	71.05
Total	100

Source: Survey Data.

Table A2: First-Stage Estimations of Determinants of Land Rights

Variable	Rights	No Rights
Constant	-0.159 (0.104)	0.753*** (0.164)
Topo	0.028*** (0.010)	-0.061*** (0.016)
Soil	0.051** (0.021)	-0.099*** (0.033)
Status	0.0312* (0.017)	0.005 (0.027)
Grain	0.077 (0.086)	-0.112 (0.136)
Tubercule	0.011 (0.243)	-0.011 (0.384)
Cash Crop	0.039 (0.087)	-0.1000 (0.137)
Gift	0.009 (0.224)	0.234*** (0.035)
Purchase	0.982*** (0.133)	-0.492** (0.209)
Crop Sharing	-0.019 (0.031)	0.432*** (0.049
Inheritance	0.050** (0.020)	0.394*** (0.032)
Borrowing	-0.032 (0.078)	-0.010 (0.124)
Area	-5.08-e07 (2.56e-06)	-8.26e-06** (4.04e-06)
Sex	0.040 (0.031)	-0.047 0.048
Age	9.840e-05 (3.832e-04)	-0.001* (0.0006)
Animal Traction	0.022*** (0.007)	-0.024** (0.011)
Occupation	-0.072*** (0.023)	0.083** (0.036)
F	7.06	17.57
Prob > F	0.000	0.000

Source: Survey Data.