Land Tenure Security, Land-Related Investments and Agricultural Performance in Sub-Saharan Africa: Efficiency or Equity? A Microeconomic Analysis Applied to the Case of Burkina Faso

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Land tenure security, Land-Related Investments and Agricultural Productivity in Subsaharan Africa: Efficiency or Equity? A Microeconomic Analysis Applied to the Case of Burkina Faso.

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Abstract

In this article, we study the impact of both secure individual and mixed allocation of plots of land on the farming household propensity to invest in land as well as to improve the productivity of the soil. For that purpose, we resort to the World Bank LSMS-ISA database established in 2014 from a representative sample at the national level of 10,800 farming households in Burkina Faso. The empirical application favors the estimation of a multivariate Probit with random effects and of a translog model with household fixed effects. The results show that households which have got an individual land management on the one hand, and mixed management on the other have on average a greater tenure security effect on the performance of agricultural activities than the peasants who manage their land collectively. Consequently, it would be advisable to stress, strengthen and increasingly promote the protection of individual exploitations specifically.

Keywords: Economics of Land Tenure, Tenure Security, Land-Related Investment, Agricultural Performance, Sustainable Agricultural Development, Burkina Faso.

JEL classification : D1, K0, Q1

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1. Introduction

In the course of world recognition of the multifunctionality in agriculture in the process of development (Myrdal in Hayami and Ruttan, 1998 ; World Bank, 2008 ; IFAD, 2016 ; ADB, 2017), the theory of induced institutional change argues that when transaction costs start becoming high in agricultural land management and exploitation, a better formal or informal security of land rights would lead the farm households to invest based on their own assets in devices for soil improvement and proctection.

A number of studies were conducted to assess the facts with respect to hypotheses developed within the framework of this theory. The limits of the top-down approach of tenure securing in terms of incentive to the productivity-based behaviours, particularly for the Subsaharan Africa (SSA) nations (Bruce and Migot-Adholla, 1994; Deininger et Biswanger, 1999; Lawry et al., 2014), have created the need to deeply analyse the african experience concerning land rights insurance. In this process, for the studies which have centered their interests on the economic importance of the social norms and practices through land rights securing, the scope is as theoretical as empirical. Theoretically the concept of land tenure security has evolved from an orthodox perception towards a more flexible conceptualization (Bruce and Migot-Adholla, 1994; Sjaastad and Bromley, 1997; Toulmin, 2009; Gelder, 2010; Arnot, 2011) which have taken into account the African reality. In the early 1990s, several empirical works tried to shed light on the security of land rights provided by the local institutions in most part of African countries. However, as empirical literature review studies realized by Place (2009), Fenske (2011), Lawry et al. (2014) have revealed, the results are still mixed for this group of countries and the explanations put forward are both conceptual and methodological.

Some authors have used specific rights (Place and Hazell, 1993; Besley, 1995; Place and Otsuka, 2002) as proxies of tenure security, while others on the contrary, resort to generic variables taking into account the concept of the bundle of rights (Pender et al., 2003; Deininger and Jin, 2006 ; Deininger and Ali, 2006 ; Deininger et al., 2008). Otherwise, most of the empirical studies are limited in terms of statistical inference. In fact, as observed by Deininger and Jin (2006) « […] many of the conclusions in the literature are derived from small samples originating in limited geographical domains ». For instance, this is the case for the study realized by Place and Otsuka (2001) based on a sample of 97 households compared to studies by Deininger et al. (2006) and Deininger and Ali (2008) concerning all of Uganda. These latter works have used samples of 970 and 7,500 households respectively. Contrary to the first study, the latter authors have managed to highlight the effect of tenure security on the incentives for farmers to adopt the technologies for the soil improvement and protection. The same result, in terms of the expected effect of the land tenure security on the agricultural performance, can

be obtained from the studies carried out by Amsalu and De Graaf (2007) and Deininger and Jin (2006) concerning Ethiopia, which concerned samples of 147 and 8,540 farming households respectively.

Another criticism is the econometric approach to the behaviour of investment of farm households and the limited functional forms used in the specification of the agricultural productivity functions. This criticism is in particular about the strong hypothesis of individual random effects at the expense of household fixed effects in estimation and the appeal to productivity functions of the kind of limited Cobb-Douglas functional form; this restrained form concerns the basic hypotheses about the constancy and the unitarian character of substitution elasticity, covering up more flexible forms.

With regard to these various reports associated with the growing degree of land insecurity, there is emerging a reactive need to develop a more adapted tenure system, particularly the harmonization of the De Jure and De Facto rules. It is most probably the sense of the elaboration of a new theoretical conception to the land tenure security by Simbizi et al. (2014), which allies the top-down and bottom-up approach of the security of tenure. Regarding this process, one of the subjects which constantly arises in the scientific debates concerning the way of strengthening the economic effects of land tenure security, is the manner agricultural plots are managed (De Soto, 2000, p. 187-252; Lavigne-Delville, 2006). Yet it seems that very few empirical studies have been interested in this issue, which nevertheless appears to be very important in the context of the SSA's countries, and this is probably due to unavailability of appropriate microeconomic data. Thus, for optimal interventions of development entities (if necessary) concerning the improvement of the results of productive agricultural activites, it is a question of considering whether the land reform policy should empirically favor more the efficiency target rather than the equity one in the exploitation of farmlands.

The present study answers this interrogation by examining the context of Burkina Faso. Burkina Faso is a country where the question of land security occupies an important rank in the debates on the socioeconomic levers of development, because the insecurity of land rights is admitted to be a real bottleneck in the activities of agricultural production. To do this study, we resort to the World Bank LSMS-ISA database derived from a representative sample at the national level of 10,800 households. This databank presents a certain number of specificities.

The survey LSMS-ISA / Burkina Faso contains information on the modalities of land security in Burkina Faso, according to the theoretical development. It is specifically focused on modes of current land security in this country and the different ways of management of farms. It also contains information on the location of cropland with regard to the housing environment and the status of households from the point of view of their membership in social and interdependent organizations. From a methodological point of view, a recursive system of simultaneous equations concerning decisions of investment and agricultural productivity is estimated. In general, it appears that the more households are protected in their rights, the more they are incited to invest, and this tends to improve

the agricultural productivity. Specifically, the plots of land managed in an individual way are empirically more efficient than those held in a collective manner.

The remainder of this paper is presented in the following way. In sections two and three, we approach respectively the conceptual framework and the diachronic evolution of land tenure systems in Burkina Faso. Then in the fourth section, we present a description of the statistical data used in our empirical analyses. The strategies of estimation and the econometric results follow this section in sections five and six respectively. Finally, we end this article with a conclusion in section seven.

2. Land tenure security and agricultural productivity: conceptual framework and measurement issues.

The conceptual framework of the study is developed within the limits of the evolutionary theory of land rights (Platteau, 2000). This theory is fundamentally based on transaction cost theory. It also rests on the hypothesis according to which, the evolution of land rights depends on the configuration of the ecological, socioeconomic and demographic configuration of the environment. According to this theory, when transaction costs start becoming high because of the paucity of the soil, due to the population growing, amplified by the agro-climatic, economic and demographic changes, the insurance of the agricultural producers' rights has a major incentive power on their investment and production behavior according to two channels. On one hand, it is admitted that the access to a formal plan to strengthen the security of their land claims tends to incite the agricultural producers to invest more in basic equipment for improvement of the soil quality. The effect of this equipment is strengthened by the spending in complementary investments. This channel finally ends in an increase of the profits from the agricultural production.

Another channel contained in the framework of this theory with the aim of agricultural productivity improvement uses the financial market. Indeed, greater realized land security, either by the delivery of a land-related document symbolizing the access to a protection guaranteed by the State, or by the indisputable insurance of the privileges provided by the local authorities, tends to favor the emergence of a land market. The process of rights securing creates an improvement of the market value of the land, which can be used then as a mortgage-related security in loan-based operations both with the formal institutions of agricultural credit and the informal ones. It is admitted that the emergence of a land market and the granting of agricultural credit mutually strengthen each other. The capital stemming from this loan is then used in the long, average and/or short-term investment expenditure, which in turn tend to strengthen the performance of the agricultural activities of production. However, it is advisable to note that the relinquishment of the dichotomous approach to land safety has given rise to a sophisticated diachronic development of this concept.

Land tenure security is now considered as a multidimensional notion, with the attribution of land title as a sign of « maximum safety » (Brasselle and al., 2002, p. 379). Indeed, many components enter into the conceptualisation made by Simbizi and al. (2014), with both the works of North (1990) and De Soto (2000) having been ostensibly the premises to that. It is a question of knowing whether the households have an individual or collective access to the plots of land (Lavigne-Delville, 2006, p. 13-14) they exploit, or do they have overlapping rights: both Individual and collective? This has two possible implications for our study.

It is implicitly admitted that the farming households which have an individual access to the lands they exploit are more productive than those having access to lands collectively. Indeed, the guarantee of the profit from their work in an exclusive way urges the households to invest more in the activities of production, particularly in a context of land safety. On the other hand, for the peasants who exercise a mixed management of the exploited lands, the results are not predetermined. As Deininger and Ali (2008) have shown, this overlapping of land rights can be harmful to the households from the point of view of their participation in the global outcome of production realized by the whole peasant population, compared with the households having a collective access to their agricultural plots. It is admitted this inefficiency of the group can result from members of a peasant family who have an individual access to portions of land which were granted to them, but which can be removed from them at any time.

This clarification concerning the approach of tenure security is little investigated in the empirical literature from the point of view of its impact on the productivity-related behaviour of the farming households and hence, the interest of paying a particular attention there. In this sense, as De Soto (2000) has mentioned, it is advisable to grasp the psychological and social processes acting in a society and specifically the "bottom", if we strongly desire to develop a harmonious institutional environment (p. 191) capable of spurring the performance of the activities of agricultural production.

3. The economic evolution of the land tenure system in Burkina Faso

The history of the land-related institutions in Burkina Faso can be globally divided into three sub-periods beginning from the time of the independence to nowadays: 1960-1983, 1984-1990, 1991 - today. However, only the part of this evolution having its starting point in 1984 matters; it is from this moment that the accent actually began to be put on the tenure system as one of the factors susceptible to significantly affect the pace with which agricultural yields evolve (BM and al., 2014) in a context of growing and diversified land tenure insecurity.

The main characteristics of the land system in Burkina Faso are its law pluralism with a customary tenure system and that concerning statutory law which originally owes its existence to the French colonial government. The first characteristic coordinates relationships between people from

the point of view of the use of arable lands according to measures of the customary law. The second characteristic insures the land governance by focusing on rules established by the laws, decrees and/or orders and thus aiming, according to BM et al. (2014), at economic, financial or monetary targets.

However, markedly affected by the famines of the 1970s and the beginning of the 1980s, the new government of Burkina Faso decided in 1984 to completely invalidate the authority of the customary institutions in the management of the land-related relationships, putting forward the *De Facto* productive ineffectiveness of these (BM and al., on 2014, p. 29). Therefore, this emerging system of rights had a productivity perspective. It is however advisable to specify that under this political system, the private, individual and collective ownership of lands had been cancelled for the benefit of the State which became the unique legitimate and legal owner. Only the usufruct was given to the workers of farmlands through the delivery of titles of enjoyment. This configuration of the juridico-economic landscape lasted only a few years, because new agrarian and land reforms (RAF) were put into place from 1991 with the advent of the fourth republic and the expansion all over the world of the liberal capitalist ideology.

Still in this productivity-related perspective, the amendment of the RAF which intervened in 1991, restored the concepts of individual and collective private ownership thanks to the rise of neo-liberalism. It is however necessary to note that the lands of the national land domain remained the property of the State, but with a possibility for third parties to solely possess the land-based resources with regard to a set of constraints. The private, physical or moral persons who were concerned by this question had from then on the possibility of acquiring relative titles of enjoyment and private property sanctioned by the RAF of 1996, both documents having the same legal value.

This configuration of the institutional and juridico-economic environment is the one which prevails nowadays with few exceptions. Indeed, after making a report stating that the legal and institutional frameworks were ineffective and inefficient (MAHRH, on 2005, p. 3), the parliament, after the government proposal, passed a new law n°034 / 2009 concerning rural tenure system. This law has the unusual feature that has institutionalized the customary land law (Art. 8) as a source of the statutory law, the idea being a conciliation of legality and legitimacy. Moreover, it argues in its article 5 that the lands of the rural land domain (DFR) are a legacy of the nation, and not only a property of the State. Therefore, the lands of the DFR can be divided into three main categories (Art. 5): the rural land domain of the State, the rural land domain of local authorities with a measure of autonomy and the rural land holdings of the private individuals. This law recognizes in its article 34 that the private property of lands can be individual or collective, thus representing the reality which prevails over the land. As a result, the feeling of safety of the land-related claims of individuals can have diversified and/or interdependent sources, contrary to statutory provisions n° 014/96/ADP which stipulates that «the State is the only source of the rights held by the private individuals» (CNSFMR, 2005, p. 41).

Another reform enacted in 2012, law n°034/2012 concerning agrarian and land reorganization in Burkina Faso, aims to be complementary to the law n°034/2009, and so testifies to the important productive function of a legal and institutional guarantee of the land-based privileges of the farmers. The last two laws dealing with agrarian matter, although not completely applied in practice (BM and al., 2014, p. 32), have succeeded in carrying out a bottom-up strategy (World Bank, 2001) of land governance which Burkina Faso's government intends to employ from now on. This new legal and institutional configuration eventually aims at a strategic legitimization and legalization of land-based relationships and acts. And as Holmes argues (in De Soto, 2000, p. 187), «the life of the law is not made of logic, it is made of experience», implicitly evoking the importance of *ex-ante* analyses prior to development policies, and hence the increasing need to obtain a microeconomic examination of the existing agro-juridico-institutional landscape.

This study is all the more necessary as, according to our investigations, the applied scientific works are more a matter of economic sociology and anthropology. Furthermore, it would seem that no dissertation in Economics deals with the subject in the context of Burkina Faso. Moreover, some studies of empirical applications conducted within the framework of this country (Malton, in Bruce and Migot-Adholla, 1994; Ouédraogo and al., 1996; Brasselle and al., 2002; Linkow, 2016) with samples of relatively low size, did not generally end in the results predicted by economic theory.

With regard to these reviews and the new development in theoretical framework, it is desirable that the empirical estimations are repeated, particularly as the legal and institutional order were changed by the adoption and promulgation of the laws n°034/2009 and n°034/2012. It is a question of putting a particular emphasis on the way of land management, especially the individual, collective and mixed characters of farms, which appear as factors in the variation of the degree of land security.

4. Data and statistical description

4.1. LSMS-ISA survey in the case of Burkina Faso

Our analysis is related to a database built by the ''Institut National de la Statistique et de Démographie du Burkina Faso" (INSD) in collaboration with the World Bank. This databank is composed from a sample survey realized in 2014 with a representative sample at the national level of 10,800 households in the beginning, from which 7,410 are active farming households.

The data were collected within the framework of the program LSMS-ISA, the final goal of which is the support, elaboration and implementation of development policy based on reliable and thorough statistics. The households were randomly chosen and are based on the results of the general census of the population and housing environment in 2006, in all the forty-five provinces that make up Burkina

Faso. Consequently, 900 zones of enumeration (ZD) were considered. In every ZD, 12 households were selected and hence the above-mentioned total size. After the processing of the base, we conclude in a secondary sample of 5,339 farming households and 17,580 plots of land.

The statistics, considered in two dimensions, which are the plot of land and household levels, concern information about the characteristics of the households, croplands, and in particular the modes of land rights insurance, the modalities of land management and location of the plots of land, as well as the topography of the piece of land, the typology of soils, and quantities of the farming goods produced.

4.2. The characteristics of households and the plots of land

From the point of view of the description of the characteristics of the agricultural households, three types of farmers can be distinguished. 10.3 %, 71.8 % and 18.1 % of the households have respectively an individual, collective and mixed access to the lands they exploit. Table 2 presents a description of the characteristics of the households, their material and cultural assets, and the production of the agricultural goods according to each group. One must accept the fact that the households having an exclusive collective management of plots present characteristics on average quite close to those of the three groups altogether. As to the question of knowing whether there are enough variations between these groups, we show (not presented here) that the three types of peasants are generally statistically different from the point of view of their characteristics.

Excluding the incomes from the activities of production, the off-farm employment is the largest secondary source of household income, to which is added transfers and received non-monetary advantages, totalling respectively roughly 79.9 %, 22.9 % and 3 %. Moreover, the categories of households do not statistically distinguish themselves on average from the point of view of the performance of the activities of production, except for the groups with individual and mixed management. This report may suggest that the effect of these groups on the general agricultural efficiency is not significantly differentiated statistically. So there appears in general a potential heterogeneousness of the farming households to be considered in the econometric estimations downstream.

With regard to the characteristics of the plots, table 3 highlights the attributes according to the modes of land management and of the insurance of farmlands. The guarantee of the plots is mainly insured by the local institutions and contains two modalities which are the ownership of land with the agreement of the land authorities and onwership without their specific support. These two modalities, in addition to the method of land management and the geographical location of the plots, determine the executive characterization of the concept of land security in the case of Burkina Faso. This is all the

more useful because it gets closer to the theoretical conceptualization elaborated by Simbizi and al. (2014), and to the insurance strategy of the land laws that the government of Burkina Faso intends to set up. The characteristics of the croplands are particularly informative on the state of the practices concerning plowing, the used systems of cultivation, the mode of land acquisition and the quality of the soil. The relief of the plots as well as the nature of the land-related investments undertaken by the farmers, are also evoked.

For each of the three categories of peasants, it is possible to observe that the plots benefiting from an approval for exploitation and control are greater in absolute value than those which do not possess it: 71.1 % ; 73.5 % ; 68.9 % and 66.5 %, respectively (see table 3). This implicitly expresses not only a gradually increasing will of the households to resort to any protection (either legal, traditional, or coming from household members themselves) of their land privileges, but also a land tenure insecurity which is growing because of the pressure exercised on farmlands coming from various rural land-based actors. Moreover, table 3 partially indicates the proportions of the plots in terms of their attributes according to the various characteristic components of the tenure security. Whether the plots associated with an ownership with agreement are generally more numerous than those where the access and exploitation received no approval, it is important to note that this direction is sometimes reversed when we consider the statistics in terms of proportion for each land characteristic of land (Results not presented here).

On the other hand, it is advisable to observe that in the case of compost or organic fertilizers, the proportion of the plots of land which receive it is greater for the "Ownership With Agreement" than for the "Ownership Without Agreement", and it is true whatever the methods of land management and the location of land. This result may express the fact that the farmers are more inclined to invest in the farmlands on which they have a larger room for maneuver. But this finding does not appear for the two other types of investment which in practice appear as supplementary to the action of compost. This description remains even if we take into account the location of the plots of land which presents two modalities worth knowing. There are lands not far from dwellings and other lands which are far away from there situated in the bush. A difference in the proportions according to both the two modalities of objective tenure security shows that there is enough variation in the data. This result can be even highlighted through the distribution of the investments according to the ‘’Socio-Land Zones’’.

As indicated in graph 1, the differences in the proportions of investors, can be explained by many factors among which are particularly the agroecological conditions and the level of insecurity of land rights. If we consider both the extreme groups of graph 1, those are the provinces of Ziro and Sissili both situated in the West Central region of the country, it is possible to observe that the proportion of farmers having used some compost is greater in Sissili (14.6 %) than in Ziro (12.5 %). This

difference of frequency is noteworthy in the sense that, a priori, there should not exist such a gap there. These two zones indeed represent respectively the provinces where soil is mainly of sandy and clayey type (respectively 57 % and 15 %, and 60 % and 25 %). Yet these kinds of soils, markedly rich in minerals for the second but difficult to cultivate, need organic fertilizers to improve the physico-chemical and biological properties of the soil. Thus, there is a possibility that this difference is attributable to the difference in the degree of the land risks which the farming households are confronted underlining the importance of the insurance of land rights.

Interestingly, another way of highlighting the variations in the data is to look at the distribution of the plots in terms of the types of cultivation and the intensity of the labour force according to the components of land security. This is also another way to calculate to what degree farmers are concerned by the question of the insurance of land privileges. As one can observe in table 4, there are more plots which receive local recognition on behalf of the land authorities whatever the type of considered household. A priori, all the proportions seem to appear in favor of the category of the plots of land not having received approval in the case of ‘’Principal Cash Crop’’ but for the other characteristics, such as "Principal Grain Crops" and "Days.Men" and this difference clearly appears in favor of lands associated with the approved rights. Based on this result, it may be possible to argue that the farmers would be inclined to invest and produce on the plots on which their rights seem guaranteed. This report is the same for the lands located away from dwellings (not presented here).

With regard to the findings obtained by means of the statistical description of the data of investigation, it generally emerges that the various soils from the point of view of the components of the land security present a certain statistical heterogeneousness. A complementary econometric analysis to the statistical description appears to be needed with the aim of quantifying the nexus theorized between the land tenure security and the performance of the cultural activities given the conditions of the global environment of agricultural production.

5. Specification and estimation strategy

5.1. Land-related investment decision model

At this stage, many considerations must be taken into account. One of the questions which comes up quite often in the literature concerning this issue is the nature of the security of land rights, whether it is exogenous or endogenous. This is a question of knowing if the farmers are actors in the insurance of the land rights they have received or whether this can be considered predetermined. In this respect, according to Besley (1995), the land tenure security can be considered as a function of the mode of acquisition of the plots of land, the detention of land documents, visible investments realized upstream, etc. By considering the first one of these factors, it is necessary to note that inheritance is the most frequent mode of lands or rights acquisition. In Burkina Faso, 77.1 % of the

plots were inherited (LSMS-ISA, 2014). Yet as Hayes et al. (1997) have underlined for Gambia, the land security depends more on the mode of accession to the plots or the land rights via legacy which in turn is a function of factors outside the control of the households. According to Deininger and Ali (2008, p. 9), it is even more likely that the inherited plots of land were awarded very long ago to the predecessors of the current farmers. Thus, the concerned farmers get little chance to have obtained them because of their specific behaviour. By virtue of this argumentation, the variables of land security can be considered exogenous in this study.

The second stage in the process of modeling is the specification of the functional shape of the behaviour of investment according to the explanatory variables which include the components of land rights safety. For that purpose, the cognitive framework (Phillipe-Lavigne, 2006, p. 1) frequently used in the empirical literature as a benchmark model concerns the one developed by Feder (1988, in Place, 2009, p. 1327). So with regard to our study, two types of investment can be underlined, which are the middle-term devices (compost) and the short-term ones (mineral fertilizers and phytosanitary products). In reference to the framework of Feder (1988), the middle-term investments influence the decisions of the households in their choice concerning the short-term. However, for the relationship between the short-term investments mentioned here, it emerges in the agronomic literature that the use of the phytosanitary products is impacted by mineral or chemical fertilizers (Rahman, 2015). Given the dichotomous character of these variables, the recursive specification in qualitative answers are usually used as the model of analysis for the decisions of land-related investment. This is the specification which allows us to determine the probability P_h of the agricultural households (h) to resort or not to these types of investment.

To determine this probability, we define two latent unobserved or continuous variables ${IM^*}_{hp}$ and ${IC^*}_{hp}$ which generate the matched behavior of investment observed respectively of middle and short term IM_{hp} and IC_{hp}. So the global model of decision of investment on the plots p by the household h can appear as follows:

$$\begin{cases} IM_{hp} = 1 \text{ iff } {IM^*}_{hp} > 0 \text{ ; 0 otherwise,} & (1) \\ IC_{hp} = 1 \text{ iff } {IC^*}_{hp} > 0 \text{ ; 0 otherwise.} & (2) \end{cases}$$

with:

$$\begin{cases} {IM^*}_{hp} = LS_{hp}\beta + P_{hp}\delta + HD_h\gamma + G\varphi + \alpha_h + \varepsilon_{hp} & (3) \\ {IC^*}_{hp} = IM_{hp}\beta' + P_{hp}\delta' + HD_h\gamma' + G\varphi' + {\alpha'}_h + \mu_{hp} & (4) \end{cases}$$

The explanatory variables of the behaviour of investment are contained in the matrix defined as follows : LS_{hp} the matrix of proxies of tenure security the household h feels with regard to the plot of land p ; the observed socio-demographic and economic characteristics of household h by means of the matrix HD_h ; the plot figures expressed by the matrix P_{hp} ; α_h and ${\alpha'}_h$ represent the unobserved

characteristics of the farming households respectively for the equations (3) and (4) ; the other variables (structural) are put together in the matrix G. The remaining components of the model are the parameters to be estimated: β, β', δ, δ', γ, γ', φ and φ', and the error terms of equations ε_{hp} and μ_{hp} respectively.

Thus, we have a multivariate model, the nature of which depends on the distribution of the error terms: normal or logistic. As it generally appears in the literature, we favor a normal distribution and hence a multivariate Probit model with individual random effects estimated thanks to the method of estimation with limited information (Greene, 2011) or method of sequential estimation in two dimensions (plot of land and household).

5.2. The specification of agricultural productivity

Knowing that the model of analysis of the impact of the tenure security on the agricultural performance is a structural system of inter-connected equations, the specification of the functional shape of the agricultural productivity joins in the continuity of the formalization of the behavior of investment.

Agricultural productivity is generally defined as the total monetary value of the agricultural production aggregated by hectare of cultivated land, in reference to indicators used in the literature. Concerning the conceptual framework from Feder (1988), tenure security has an impact on agricultural productivity via its effect upon the household propensity to resort to land-related investments. From the point of view of a structural model, the investment variables are then introduced as adjusted ones in the functional form of agricultural productivity. In the economic literature, the econometric models usually used in searching for the determinants of the agricultural productivity concern the Cobb-Douglas function types. But as is mentioned in the literature relative to the fundamental research, there is a functional form of productivity more flexible, which is the translogarithmic shape or the translog model of productivity (Christensen and al., 1971, 1973). This translog model, a generalized form of Cobb-Douglas production function, is an extended specification from the model made by Arrow-Chenery-Minhas-Solow, which takes into account only two factors of production (1961, in McFadden, 1963, p. 73), and appears as follows :

$$lny_{hp} = (b + \alpha_h) + \sum_{p_1=1}^{m} \delta_{P_1} lnP_{hp_1} + \sum_{k_1=1}^{v} \gamma_{k_1} lnHD_{hk_1} + \tau I_{hp} + \varphi G + \frac{1}{2}\sum_{p_1=1}^{m}\sum_{{p'}_1=1}^{m} \theta_{p_1{p'}_1}\left(lnP_{hp_1} * lnP_{hp'_1}\right) + \frac{1}{2}\sum_{k_1=1}^{v}\sum_{{k'}_1=1}^{v} \theta_{k_1{k'}_1}\left(lnHD_{hk_1} * lnHD_{hk'_1}\right) + \sum_{p_1=1}^{m}\sum_{k_1=1}^{v} \theta_{p_1k_1}\left(lnP_{hp_1} * lnHD_{hk_1}\right) + \sum_{P_2=m+1}^{r} \delta_{P_2} P_{hp_2} + \sum_{k_2=v+1}^{n} \gamma_{k_2} HD_{hk_2} + \mu_{hp}$$

y_{hp} for yield. P_{hp_1} and HD_{hk_1} represent the characteristics of the plots of land and those of households respectively, which are quantitative variables and which may be the object of a substitution (partial or

total) between them. P_{hp_2} and HD_{hk_2} , which also represent the characteristics of the plots of land and households in the order given, are either indicator values, or variables which are not substitutable between them (Zhengfei et al., 2006, p. 208; Theodoridis and Anwar, 2011, p. 97). τ, δ_{P_1}, γ_{k_1}, $\theta_{p_1p'_1}$, $\theta_{k_1k'_1}$, $\theta_{p_1k_1}$, δ_{P_2}, γ_{k_2} and φ are the coefficients to be estimated. b, α_h, and μ_{hp} represent respectively the constant, the specific individual household effects and the error term. I_{hp} represents the predicted value of the investments. The implications of this model are numerous.

The particularity of this model rests on the fact that it is about a global functional shape which, from restrictions about the parameters, may result either in a standard Cobb-Douglas or CES form. So by supposing the following symetry restrictions $\theta_{p_1k_1} = \theta_{k_1p_1}$ for $k_1 \neq p_1$, and those of inequality and equality $\delta_{P_1} > 0$, $\gamma_{k_1} > 0$, $\theta_{p_1p'_1} = \theta_{k_1k'_1} = \theta_{p_1k_1} = 0$, it is possible to result in a classical Cobb-Douglas production function. For the following conditions of homogeneity, like the elaboration developed by Christensen et al. (1973), Berndt et al. (1979), Kmenta (1967) and Kymn and Hisnamick (2001), the function of productivity corresponds to a CES form (but different from 1) :

$$\begin{cases} \sum_{p_1=1}^{m} \delta_{P_1} + \sum_{k_1=1}^{v} \gamma_{k_1} = 1 & (6) \\ \sum_{p_1=1}^{m} \theta_{p_1p'_1} = \sum_{p'_1=1}^{m} \theta_{p_1p'_1} = 0 & (7) \\ \sum_{k_1=1}^{v} \theta_{k_1k_1} = \sum_{k'_1=1}^{v} \theta_{k_1k'_1} = 0 & (8) \\ \sum_{p_1=1}^{m} \theta_{p_1k_1} = \sum_{k_1=1}^{v} \theta_{p_1k_1} = 0 & (9) \end{cases}$$

These $(3m + 3v + 1)$ restrictions, which guarantee an approximation of the functional form CES, can be subjected to tests of hypotheses within the framework of the estimation of this model. The technique of the estimation of this model lies within the global framework of the method of the estimation of a recursive system of simultaneous equations and in this particular case, the Limited Information Maximum Likelihood Method (LIM) which resembles the method of instrumental variables. Thus the idea is to apply the method of the maximum likelihood for the estimation of the parameters of the functions to qualitative responses, and the feasible generalized least squares (FGLS) or the least squares with dummy variables for the linear regression of the yields on all the explanatories.

5.3. Specification of variables proxies of the econometric model

The objective of this sub-section is to define the nature of the dependent and exogenous variables, corresponding to the matrices detailed above, and coming into play in the modelling of the relationship between land security, investment activities and agricultural productivity.

Table 1. The variables description used in the regression models.

Variables	Expected signs	Variables description
Dependent variables		
Compost	Nil	1 if compost is used and 0 otherwise
Chemical fertilizer	Nil	1 if mineral fertilizer is used and 0 otherwise
Phytosanitary products	Nil	1 if phytosanitary products are used et 0 otherwise
Farming yield	Nil	Agricultural yield (continuous FCFA/Kg)
Explanatories variables		
Tenure security proxies		
Objective Land Tenure Security (1)	+	1 for the ownership approved and 0 otherwise (Objective security)
Individual land management (2)	+	1 if it is a plot individually managed and 0 otherwise (Subjective security or De facto).
Mixed land management (3)	+/-	1 if it is a plot managed by a household having the two types of management and 0 otherwise (Subjective security or De facto).
$(1) * (2)$	+	Plots possessed and managed by households having an individual control on (Objectivo-subjective security).
$(1) * (3)$	+/-	Plots possessed and managed by households having mixed control on (Objectivo-subjective security).
Plot location	+/-	1 if plots are located around dwellings and 0 otherwise (Subjective security).
Socioeconomic organisation membership	+/-	1 if household head is a membership of a socio-economic organization (Subjective security).
Plots characteristics		
Land size	+/-	The area of plot in hectares
Clayey	+/-	1 if plot is of clay and 0 otherwise
Sandy	+/-	1 if plot is of sand and 0 otherwise
Plain	+/-	1 if relief is of plain and 0 otherwise
Plateau	+/-	1 if relief is of plateau and 0 otherwise
Households characteristics		
Age of Household head	+	Age of household head measured in year (Continuous variable)
Household adult members	+	Family labour force equivalent-adult (Continuous variable)
Days.Men for plowing	+	Number of working days by men and women for plowing (Continuous form)
Days.Men for land maintenance	+	Number of working days by men and women for plot maintaining (Continuous form)

Table 1. (Continuation)

Days.Men for harvest	+	Number of working days by men and women for harvest (Continuous variable)
HouseholdHead eduction	+	1 if household head can read and 0 otherwise
Wealthiness	+	1 if household is rich and 0 otherwise
Number of plots owned	+/-	The number of plots owned by household
Household Distant to the Nearest Market	+/-	Distance between household and the nearest market
Household Distant to the Nearest Road	+/-	Distance between household and the nearest road
Share of Non-worker taken care of	-	Proportion of non-working persons being looked after by household
Principales cultures réalisées		
Grains	+	1 if grains have been grown on the plot and 0 otherwise
Cash crop	+	1 if cash crops have been grown on the plots and 0 otherwise
Muslim	+	1 if household head is a Muslim
Zones agro-écologiques		
Kadiogo	+/-	1 if household is located in the Kadiogo and 0 otherwise
Banwa	+/-	1 if household is situated in the Banwa and 0 otherwise
Tuy	+/-	1 if household is emplaced in the Tuy and 0 otherwise
Ziro	+/-	1 if household is set in the Ziro and 0 otherwise
Sissili	+/-	1 if household is installed in the Sissili and 0 otherwise

Source : Constructed by the author using LSMS-ISA 2014 data for Burkina Faso case.

At this stage of our reasoning, the question which it is important to ask concerns the identifiable character of the structural equations of the model of analysis. For that purpose, if the condition of rank is one of the criteria of possible decisions, it turns out that the condition of order (Bourbonnais, 2015, p. 222-223) is the most used in the literature. So, the application of the latter to the system of equations of investment and of productivity has resulted in the over-identified equations by construction, thus authorizing the application of the empirical estimation methods.

6. Interpretation of econometric results

6.1. Effect of land tenure security on the investment decisions of farming households

The results in terms of marginal effects of the estimation of the recursive system of Probit models with random effects modelizing investment decisions with regard to organic and chemical fertilizers, and phytosanitary products use are highlighted in table 5.

According to column 1 of table 5, the variable ''Objective Land Tenure Secure'' representing the plots of land, the exploitation and control of which have received the traditional local authorities approval, present a positive and significant sign at the threshold of 1 %. This result implicitly expresses the fact that the peasants, whoever they may be, are all the more inclined to produce and to use some organic fertilizer (+ 11 percentage points) as they are insured to completely reap the benefits of their investment efforts. Insofar as this mode of local insurance, which is land possession, authorizes complete transfers (alienation) and limited (loans or gift) land rights, it is easy to observe that the same results, in terms of significance, were reached by a number of research projects. It is in particular those of Gavian and Fafchamps (1996) for Niger, Hayes et al. (1997) for Gambia (but of negative sign), Deininger and Ali (2008) for Uganda.

For the other sources of subjective and objectivo-subjective control power (column 2), the results are in general positive as well as significant except for the membership in a social organization. As a result, the farming households seem more inclined to spread some organic fertilizers on the plots of land over which they have an objectivo-subjective power of control and exploitation, and the plots of land on which they have an informal close surveillance. The more the plots of land are managed in a mixed way by the households, the more the households are incited to use some compost independently of the status of farmlands (+ 21 points). However, the plots of land owned by the households of mixed management are less inclined to receive some organic fertilizers (-22 points). This may either result from portions of land managed collectively by the household, or by individual lands benefiting from less security within the framework of this household. Concerning the possessed plots of land and having individualized access, the households which have access there are inclined to use more compost (+ 15 points). But the fact of being a member of an institutional social organization reduces significantly on average the investment decision of farmers to the level of 7 percentage points.

On the other hand, the fact of controlling this dimension increases the impact of "Objective Land Tenure Security" on the consent to use some compost by the households. This result is not at all surprising in the sense that the donations of inputs the farmers often receive, can actually influence their final decision to invest, these results not taking into account the sources of potential land tenure insecurity.

After having checked variables expressing the factors peculiar to the various socio-land zones, column 5 gives us an idea of the relationship between the variables of land security and the intentions of investment of farmers. If the effect of the mode of insurance increases slightly for the objective proxy of safety, it is reduced on the other hand for the variables of subjective safety. In addition, it still remains positive and statistically significant for the coefficients associated with the variables of mixed management, property managed individually and the location of the plots of land. The probability of investing associated with the objective variable increases by 2 percentage points. Whatever the level of land insecurity, the farmers who have permanent control over their lands will be always inclined, to the same degree, to invest in the application of manure on their plots of land. The fact of benefiting from a subjective and objectivo-subjective insurance increases the propensity of the household of individual and mixed management to invest at a level of 36 percentage points (the combined effects of secure individual land management and mixed land management). For this type of land investment, the results are in accordance with the predictions made within the framework of the theoretical analysis. This last remark also appears generally in the estimation of the equation expressing the decisions of the household to resort to the chemical fertilizers.

According to column 3 in table 5, the insurance of land rights guaranteed by the land authorities, as well as the De Facto or subjective land tenure security, have a considerable impact on the tendencies of households to use mineral fertilizers. This result is imputable as well to the impact of the objectivo-subjective security which is a combination of the De facto safety and that inspired by the local land authorities. Consequently, for the latter, the more households are safe having relative control on all the benefits stemming from their investment effort, the more they will be incited to use mineral fertilizers (+ 2,88 points) (Column 2). This effect of insurance is transmitted through the use of manure, which has apparently a complementary relationship with the chemical fertilizers. The characteristics of the plots of land and households present for the greater part expected results within the framework of the economic theory, with the control of the potential risks of land insecurity. The fact of adding the proxies of land insecurity (column 6) does not change significantly the results in terms of amplitude and of significance in the previous interpretation. The adjusted probability of the application of compost keeps a positive and significant value at the threshold of 1 %. These little differentiated results still call for a more thorough study of the sociogeographic zones, as this

differentiation results from adding the variables which represent them, and which also appear in the specification of the decisions of households to use phytosanitary products.

Column 4 of table 5 shows the results of the estimation of the equation expressing the propensity of the households to resort to the phytosanitary products. As it is possible to observe in columns 4, the explanatory variables " Compost Predict " and "Chemical Fertilizers Predict" present coefficients statistically different from zero. This means that the subjective and objectivo-subjective tenure security indirectly influence the propensities of the households to use the phytosanitary products through the influence of the use of the compost and mineral fertilizers (0.75 percentage points). The more the households are inclined to use some organic fertilizer, the less they have a tendency to use phytosanitary products (PPS) by 2.9 percentage points on average. These two inputs are thus substitutes. This finding can be explained by the properties of compost. Indeed, the application of the compost, according to the standards and the required practices, has the quality of strengthening the plant which gives it the means to fight against diseases and the appearance of weeds. Yet the reason for the use of the PPS is exactly to fight against these harmful pests and hence there is a reduction of the appeal for this product. But the plots of land having received some mineral fertilizers are more inclined to be covered by the PPS (+21 points). Therefore, with regard to the farming household, the PPS and the chemical fertilizers seem to be complementary.

These results do not change significantly in terms of sign after the addition of variables representing both the agro-climatic conditions and the eventualities of land insecurity, as indicated in column 7 of table 5: in general, the subjective and objectivo-subjective tenure security favor the improvement of the propensity to invest by 0.50 percentage points.

As table 5 indicates, the feeling of having a guarantee of their land privileges constitutes a determinant factor in the household decisions of land-related investment, either directly or indirectly. These data result from the application of a method of econometric estimation with information limited in the regression of a multivariate recursive Probit. As we have mentioned above, it is also possible to turn to the estimation of conditional Logit, a functional form which takes into account the household fixed effects. This specification, in addition to answering the criticism formulated in the literature with regard to the negligence of the household fixed effects on the one hand, allows us, on the other hand, to test the robustness of the results obtained. From the point of view of the signs of the coefficients associated with the variables of interest, the findings are generally identical to those obtained in the previous estimations. However, the significance of the parameters is different from those predicted by the theory (not presented here). This is probably linked to the specificity of conditional Logit, namely the deletion of a big part of the data during the estimation procedure. Therefore, we keep the results stemming from the estimation of the Probit with random effects.

6.2. Impact of tenure security on agricultural productivity

The estimation of the agricultural productivity function in a sequential way with household fixed effects leads to the results presented in table 6.

The determinants of the productivity of the soil, which is measured by the global monetary value of the production by hectare, arise from the application of the OLS method on variables centered on their intra-individual average. As it is possible to observe in the first three columns, three types of investment significantly influence the agricultural yields, though in a certain sense, contrary to the theoretical expectations. A plausible explanation of these results can be linked to failing to take into consideration important exogenous variables in each of the cases, because as it is possible to see, the estimation of the equation of yield with three investment variables taken together (column 4) produces the signs expected to a lesser extent: the coefficient associated with the mineral fertilizers proxy preserves its negative sign. However, it is possible to assert that the more the land privileges of the farmers on the agricultural plots of land are guaranteed (subjective and objectivo-subjective security), the more it leads to an increase in the agricultural yields (+30 points), through the use of compost and phytosanitary products.

The signs of the other variables, in particular the characteristics of the households and the plots of land are generally in accordance with the theoretical expectations. The family workforce represented by ‘’Days.Men’’ positively and significantly impacts the productivity of soil. An increase in 1 % of ‘’Days.Men’’ entails an increase in the productivity of ground by 0.22 %. The more soils are of clayey type, the more this factor favors the increase of the agricultural yields by 19 percentage points. The soil of a sandy type on the one hand, and the reliefs of plain and plateau on the other, entail on average a decrease in yield (- 9, - 76, and – 48 points respectively). On the other hand, the results of table 6 clearly show that the agriculture of Burkina Faso is more an extensive one. Indeed, the increase of yields is favored by a unitarian increase in the planted areas at the level of 0.06 %.

Additionally, the results show that the cash crops (usually cowpea, groundnut, sesame, cotton) unlike cereals (usually millet, sorghum, rice, maize) contribute more to the increase of the agricultural yields respectively by 38 and 31 percentage points. These results were also obtained by Deininger and al. (2006), but for other types of agricultural products. Similarly, it is possible to observe that the plots of land which are the object of both conservation techniques regarding the physical, chemical and biological properties of soil, and mechanization participate significantly in the increase of the productivity of soil. Indeed, the farmlands which have an association of different crops influence the increase of the productive efficiency of soil by 39 percentage points. Those which are subject to the use of plow animals show an increase in the productivity of soil of 16 percentage points. The discussed results above are obtained by postulating a Cobb-Douglas technology with its restrictive hypotheses of homogeneity and substitution elasticity equal to the unity. But it is possible to eliminate postulates

and to estimate a more general function of productivity, the translog form. The results from this model estimation allow us to also test the robustness of those obtained in a more restricted frame. As it is useful to observe, the regression of the translog leads to slightly superior coefficients of the variables of interest (column 5). For the variables of control, the statistics remain almost unchanged, with the exception of the variable "Land Size" which changes its sign. We can also notice that among the additional explanatory variables, only the square of ‘‘Days.Men’’ and the interaction between ‘’Days.Men’’ and ‘’Land Size’’ are connected positively and significantly to the agricultural yield. The translog function seems to be the one to be favored since its corrected coefficient of determination (R-squared adjusted) is higher than the one obtained with the specification of the classical Cobb-Douglas function (42.9% against 42.3 %).

7. Conclusion and policy implications

In a context of the relative weakness concerning agricultural performance and the growing increase of the land risks against which the farming households are confronted in Burkina Faso, few empirical economic studies have been realized in this country to guide the decision-making of economic policies in this domain. This study has mainly dealt with a microeconomic analysis of the nature of the relationship between land tenure security and the performance of agriculture in Burkina Faso. It has tried to answer the question of knowing if, in this context, it is necessary to favor the objective of efficiency or equity in the access and the control of the agricultural plots of land.

In as much as the tenure security is considered as the result of the interaction of a set of elements, this study has settled two specific objectives. The first objective concerns the question of examing the effect of the components of the insurance of the rights of farmers on their propensity to use various investments. The second objective has consisted in examining the effect of the latter on agricultural productivity through the household tendency to invest in two investments both of improvement and of maintenance and protection of soil. In general, obtained econometric results seem to correspond to the theoretical expectations. Land tenure security measured by proxies such as land possessions, the individual and mixed management of the plots of land, the location of the plots of land and the membership in a socio-economic organization, which constitutes a source of economic power for farmers, contributes to increase the productivity of soil by 30 percentage points. On average, a farmer whose rights are perfectly opposable in third parties is more incited to resort to compost, chemical fertilizers and phytosanitary products (+36, +2.8 and +0.50 points respectively). Moreover, the results have shown that a greater tenure security incites the agricultural households to adopt an environment-friendly behavior, and thus sustainable development. Indeed, it seems that the more land rights are institutionally guaranteed against any risk of contesting and violation, the more farmers show a willingness to resort to a reduced use of phytosanitary products through the use of organic

fertilizer. Consequently, to favor the efficiency objectives in the access and exploitation of farmlands would help strengthen the effects of land tenure security on the performance of the agricultural production activities.

The results obtained allow us to formulate some recommendations for economic policies and the perspectives for future research. First of all, it would be advisable to stress, to strengthen and to increasingly promote the protection of the individual farmers in particular. Secondly, it seems necessary to promote good governance in the peasant organizations, since knowing there is a diversity of structures capable of defending their interests, particularly land-related, would constitute for a farmer a kind of strengthening of his subjective power concerning his land rights, and incite him in fact to undertake the activities of productive investments. Finally, for a better understanding of the role of tenure security on agricultural performance, an empirical study should be implemented on the effect of the harmonization of the systems of land-related standards; this study should take into account the differentiation among the native, non-native agricultural producers (i.e. immigrants) and the vulnerable groups (i.e. children, women), thus bringing information economically useful for the global well-being of the population *in fine*.

Table 2. The socio-economic and demographic household characteristics by the method of management of plots.

Variables		All households	Households of collective management of land	Households of individual management of land	Households of mixed management of land
Households characteristics					
Household size	(Mean)	8.6	8.6	6.6	9.5
Members younger than 15 years	(Mean)	4.6	4.6	3.0	5.1
Members 15-60 years	(Mean)	4.0	3.8	3.6	4.02
Members older than 60 years	(Mean)	1.3	1.3	1.2	1.4
Age of household head	(Mean)	48.1	47.9	46.4	49.6
Household head can read	(%)	23.2	24.1	21.7	20.74
Socio-economic organisation membership	(%)	26.1	26.0	23.5	26.1
Female Household head	(%)	6.7	6.4	19.5	3.4
Household total income	(Mean)	165,054.6	220,202.9	22,492.5	25,356.9
Wealthiness	(%)	29.1	29.0	25.0	32.8
Sources of household income (%)					
Employment		79.7	81.1	74.5	77.0
Received privileges in nature		3.0	3.2	1.5	2.7
Transfers received in cash		22.9	22.0	26.0	25.0
Transfers made in cash		24.0	23.6	23.2	25.1
Material assets of household					
Number of plots owned by household	(Mean)	3.7	3.3	2.9	5.5
Cultural assets (%)					
Muslim		59.0	59.7	54.25	59.9
Christian		25.0	24.6	30.0	27.7
Farming goods production					
Value of production (Mean)		386,702	479,111.7	152,77	149,738.8
Value of production by hectare (Mean)		271,258.9	318,561.1	194,321.7	124,964.6
Number of observation (Household)		**5,339**	**3,836**	**553**	**950**

Source : Generated by the author using LSMS-ISA 2014 data for Burkina Faso case.

Table 3. The characteristics of plots and land-related by the kind of households and the control power on plots.

Variables	All households			Households of collective management of plots			Households of individual management of plots			Households of mixed management of plots		
	Total	Ownership with agreement	Ownership without agreement	Total	Ownership with agreement	Ownership without agreement	Total	Ownership with agreement	Ownership without agreement	Total	Ownership with agreement	Ownership without agreement
The characteristics of plots												
Land size (Mean)	1.4	1.2	1.7	1.57	1.4	2.2	1.3	1.0	1.8	0.9	1	0.9
Animal drawn (%)	58.4	54.9	67.1	58.8	55.7	67.4	34.7	37.3	29.5	64.4	58.3	76.7
Mode of farming (%)												
Pure culture	78.9	77.3	83.0	79.5	77.8	84.4	82.8	81.8	85.0	76.4	74.6	79.9
Associated culture	21.1	22.7	16.9	20.5	22.2	15.6	17.2	18.2	14.9	23.6	25.4	20.0
The mode of acquisition of land (%)												
Inheritence	77.1	79.9	70.2	80.5	82.6	74.4	64.2	65.4	61.7	73.3	77.6	65.8
Gift	12.2	11.1	14.9	12.8	11.8	15.7	15.7	17.8	10.8	9.9	7.6	14.9
Others	10.7	8.9	14.9	6.7	5.6	9.9	20.1	16.7	27.5	16.8	15.1	20.3
The quality of soils (%)												
Sandy	49.3	50.7	45.7	49.1	51.6	42.4	47.3	51.7	37.4	50.1	48.2	54.0
Clayey	29.9	27.8	35.3	28.9	25.9	38.2	26.2	27.1	24.4	33.4	33.6	33.1
Lateritic	17.9	18.5	16.4	19.1	19.8	16.9	22.1	18.5	29.9	13.9	15.1	11.7
The typography (%)												
Plain	58.6	63.9	45.3	55.3	61.4	38.5	51.8	55.6	43.6	67.8	72.9	57.8
Plateau	29.3	25.6	38.7	31.6	27.3	43.5	38.2	35.6	44.1	21.6	18.1	28.6
Low ground	9.6	8.5	11.5	9.7	8.9	11.8	8.3	7.6	9.7	8.9	7.6	11.6
Land-related investments (%)												
Compost	40.3	42.4	35	40.6	43.8	31.5	45.8	49.9	36.5	37.9	36.5	40.9
Chemical fertilizers	24.9	24.0	27.1	27.8	26.8	30.7	24.8	21.1	33	18.5	18.0	19.4
Phytosanitary products	21.3	20.4	23.6	24.0	22.8	27.5	17.2	14.9	22.2	16.4	16.1	17.1
Number of observation(Plots)	**17,580**	**12,504**	**5,076**	**11,145**	**8,187**	**2,958**	**1,463**	**1,009**	**454**	**4,972**	**3,308**	**1,664**

Source : Generated by the author using LSMS-ISA 2014 data for Burkina Faso case.

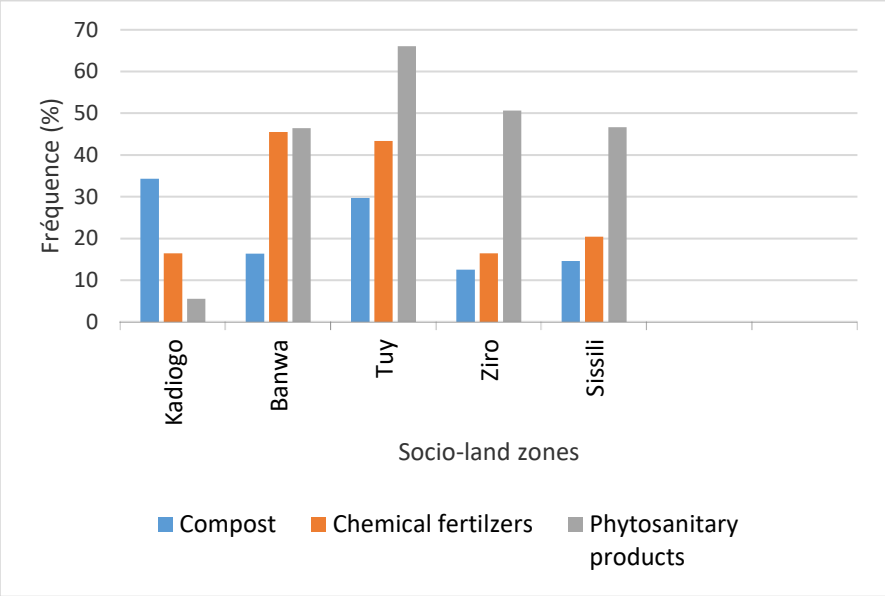
Table 4. The characteristics of plots by the modalities of tenure security and the mode of management of plots near dwellings.

Variables	All households			Households of collective management of land			Households of individual management of land			Households with mixed management of land		
	Total	Ownership with agreement	Ownership without agreement	Total	Ownership with agreement	Ownership without agreement	Total	Ownership with agreement	Ownership without agreement	Total	Ownership with agreement	Ownership without agreement
Principal farming characterictics (%)												
Principal grain crops	70.3	72.0	63.9	75.4	76.1	72.3	70.6	71.7	67.3	60.0	63.4	49.8
Principal cash crops	25.5	24.2	30.23	21.4	20.9	23.4	22.9	23.9	20.3	34.5	31.3	43.9
Intensity of laborforce (Mean)												
Days.Men by hectare for the plowing[a]	46.8	51.1	30.8	46.2	49.8	31.2	52.9	58.2	37.6	46.0	52.0	28.0
Days.Men by hectare for the maintenance	87.6	98.4	48.9	82.3	90.2	49.5	100.2	114.2	59.2	94.5	110.9	44.8
Days.Men by hectare for harvest	44.5	45.5	40.7	44.0	44.2	43.4	57.3	59.8	49.9	41.4	44.0	33.7
Number of observation (plots)	**6,543**	**5,124**	**1,419**	**3,951**	**3,181**	**770**	**601**	**448**	**153**	**1,991**	**1,495**	**496**

Source: Generated by the author using LSMS-ISA 2014 data for Burkina Faso case.

Note: [a] ``Days.Men'' is a unit of measure of work duration made by the family labour. The concept 'Men' encompasses men and women.

Graph 1. Land-related investsement by limited socio-land zones in Burkina Faso in 2014[2].



Source: Generated by the author form LSMS-ISA 2014 data for Burkina Faso case.

[2] ''Limited socio-land zones'' because we are only interested in the zones where there are land conflicts and hence land rights insecurity.

Table 5. The determinants of the household propensity to resort to the different types of investment in Burkina Faso in 2014.

	Limited security proxies and absence of risk variables	**Augmented security proxies and absence of risks of insecurity**			**All variables**		
	Compost	Compost	Chemical fertilizer	Phytosanitary product	Compost	Chemical fertilizer	Phytosanita-ry products
Chemical Fertilizer Predict[a]				0.21*** (6.40)			0.14*** (4.35)
Compost Predict[b]			0.08*** (3.16)	-0.029*** (4.76)		0.10*** (3.81)	-0.017*** (2.94)
Objective Land Tenure Security (1)	0.11*** (6.75)	0.10*** (5.28)			0.13** (5.37)		
Individual Land Management (2)		0.02 (0.44)			0.005 (0.1)		
Mixed Land Management (3)		0.21*** (4.53)			0.19*** (4.28)		
(1)*(2)		0.15** (2.04)			0.17*** (2.24)		
(1)*(3)		-0.22*** (5.86)			-0.2*** (5.29)		
Location of Plots		0.29*** (20.72)			0.28*** (20.25)		
Socioeconomic Organisation Member		-0.07*** (3.38)			-0.06** (3.10)		
Clayey	-0.04** (2.47)	-0.02 (1.37)	0.03** (2.46)	-0.006*** (3.36)	-0.02 (1.32)	0.03** (2.32)	-0.004** (2.09)
Sandy	0.08*** (4.44)	0.07*** (3.71)	-0.02 (1.62)	-0.005** (2.41)	0.07*** (3.71)	-0.02 (1.51)	-0.006*** (2.78)
Plain	0.17*** (8.93)	0.13*** (6.65)	-0.10*** (7.54)	0.013*** (4.00)	0.13*** (6.64)	-0.11*** (7.51)	0.006* (1.74)
Plateau	0.08*** (3.37)	0.03** (1.54)	---------	0.019*** (3.91)	0.046* (1.94)	----------	0.014*** (3.11)
Land size	0.04*** (10.45)	0.05*** (12.98)	0.008*** (8.4)	-0.001*** (4.04)	0.058*** (12.88)	0.008*** (7.84)	-0.0006** (1.90)
Squared Land Size	-0.00*** (9.22)	-0.000*** (11.4)	----------	----------	-0.009*** (11.35)	----------	----------
Household Head Age	0.01** (2.48)	0.01** (3.87)	-9.12e-03 (0.48)	-3.45e-04 (0.86)	0.013** (3.85)	1.14e-03 (0.6)	-0.00 (0.79)
Squared Household Head Age	-0.00** (1.98	-0.00*** (3.27)	6.36e-09 (0.00)	5. 91e-07 (0.16)	-1.12e04*** (3.85)	1.21e-06 (0.07)	9.71e-08 (0.03)
Days.Men for Plowing	0.00 (0.66)	0.00 (0.92)	----------	----------	0.00 (0.86)	----------	----------

Table 5. (Continuation)

Days.Men for Maintenance	0.00 (1.03)	-0.00 (1.26)	-1.7e04*** (4.77)		-0.00 (1.26)	-1.67e-04*** (4.51)	
Household Education Level	0.04 (0.70)	0.04 (1.69)	0.027** (2.20)	-0.004* (1.85)	0.04 (1.57)	0.024* (1.93)	-0.001 (0.53)
Number of Plots Owned	-0.05*** (5.17)	-0.02*** (4.78)	0.002 (1.03)	6.75e-04 (1.28)	-0.01*** (4.30)	0.003 (1.33)	0.0005 (1.09)
Food Insecurity	0.02 (0.47)	0.02 (0.83)	0.11*** (9.77)	-0.005* (1.72)	0.02 (1.04)	0.1*** (9.62)	0.0011 (0.34)
Wealthiness	0.21*** (3.86)	0.09*** (4.30)	0.06*** (4.98)	-0.003 (1.55)	0.09*** (4.47)	0.057*** (4.72)	-0.001 (0.39)
Muslim	0.56*** (10.92)	0.23*** (12.39)	0.04*** (3.69)	-0.01*** (3.49)	0.22*** (12.11)	0.035*** (3.17)	-0.01*** (3.13)
Share of Non-worker taken Care of	-0.015 (0.58)	-0.01 (1.01)	-8.42e-03 (1.55)	6.05e-04 (0.51)	-0.01 (1.14)	-8.25e-03 (1.52)	0.0004 (0.41)
Household Distant to the Nearest Market	0.001 (1.55)	0.000 (1.34)	-6.87e-04*** (2.81)	1.97e-04*** (3.36)	0.000 (1.03)	-7.06e-04*** (3.11)	0.0001** (2.24)
Household Distant to the Nearest Road	0.003*** (3.27)	0.001*** (2.92)	-4.05e-04** (1.81)	-7.4e-05 (1.53)	0.001*** (2.88)	-3.91e-04* (1.74)	-9.85e-05** (2.02)
Household Adult Members				-8.2e-04* (1.7)	----------	----------	-0.00 (1.34)
Kadiogo					-0.11** (2.42)	-0.7*** (4.03)	-0.009*** (6.58)
Banwa					-0.21*** (4.55)	0.19*** (3.54)	0.007 (0.46)
Tuy					-0.07 (1.03)	0.12** (2.40)	0.21*** (1.90)
Ziro					-0.31*** (10.49)	-0.05 (1.04)	0.56** (2.54)
Sissili					-0.25*** (5.44)	0.05 (0.93)	0.34** (1.91)
Number of observations	17,580	17,580	17,580	17,580	17,580	17,580	17,580
Wald Chi2	587.8***	881.8***	480.9***	502.4***	898.6***	509.6***	570.5***

Source: Generated by the author from LSMS-ISA 2014 data for Burkina Faso.

Note: Absolute value of z-statistics are in brackets. The significance levels are p<0.01 (***), p<0.05 (**) and p<0.1 (*).

[a]Predicted values from compost equation estimation; [b]Predicted value from mineral fertilizer equation estimation.

Table 6. Determinants of soil productivity in Burkina Faso in 2014.

Variables	Compost	Chemical fertilizer	Phytosanitary product	All variables	Translog form
	Coefficient	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**
Compost Predict	-0.14*			0.48***	0.49***
	(1.73)			(5.34)	(5.47)
Chemical Fertilizer Predict		-4.99**		-6.85***	-7.33***
		(16.50)		(16.03)	(17.00)
Phytosanitary Products Predict			-2.24***	2.03***	2.18***
			(7.32)	(5.02)	(5.40)
Clayey	-0.012	0.12***	-0.007	0.19***	0.21***
	(0.33)	(3.37)	(0.19)	(4.98)	(5.39)
Sandy	-0.048	-0.088**	-0.10***	-0.09***	-0.09**
	(1.27)	(2.37)	(2.74)	(2.57)	(2.46)
Plain	-0.067*	-0.57***	-0.15***	-0.76***	-0.80***
	(1.72)	(12.18)	(4.13)	(13.67)	(14.36)
Plateau	-0.13***	-0.36***	-0.12***	-0.48***	-0.51***
	(3.20)	(8.25)	(2.94)	(10.16)	(10.64)
Log Land Size	0.09***	0.048***	-0.069***	0.06***	-0.16**
	(6.90)	(3.01)	(4.88)	(3.76)	(2.45)
Squared Log Land Size	0.015***	0.07***	0.028***	0.07***	0.16***
	(2.58)	(10.61)	(4.63)	(10.89)	(15.29)
Log Days.Men for Harvest	0.32***	0.29***	0.32***	0.28***	0.22***
	(24.73)	(22.22)	(24.62)	(21.66)	(3.07)
Associated Culture	0.40***	0.37***	0.40***	0.385***	0.38***
	(16.65)	(15.75)	(16.55)	(16.03)	(16.18)
Cash Crops	0.37***	0.38***	0.38***	0.38***	0.37***
	(9.18)	(9.47)	(9.37)	(9.49)	(9.26)
Grain Crops	0.35***	0.33***	0.34***	0.31***	0.31***
	(8.49)	(8.06)	(8.42)	(7.78)	(7.77)
Animal Drawn	0.15***	0.16***	0.14***	0.159***	0.14***
	(4.01)	(4.24)	(3.95)	(4.23)	(3.88)
Squared Log Days.Men for Harvest					0.024***
					(3.30)
Log Land Size * Log Days.Men for Harvest					0.12***
					(10.51)
Log Land Size * Log HouseholdDistanToThe Nearest Market					-0.018
					(1.20)
Log Land Size * Log HouseholdDistanToThe Nearest Road					-0.017
					(1.25)
Log Days.Men for Harvest * Log HouseholdDistanToThe Nearest Road					-0.005
					(0.37)
Log Days.Men for Harvest * Log HouseholdDistanToThe Nearest Road					-0.001
					(0.08)
Constant	9.70***	10.93***	9.85***	11.07***	11.22***
	(126.06)	(103.11)	(126.19)	(101.52)	(94.13)
Number of observations	**17,580**	**17,580**	**17,580**	**17,580**	**17,580**
R-squared adjusted	**0.408**	**0.421**	**0.411**	**0.423**	**0.429**
Fisher-Statistic	**122.04*** **	**147.14*** **	**126.76*** **	**129.51*** **	**97.89*** **

Source: Generated by the author using LSMS-ISA 2014 data for Burkina Faso.

Note: t-statistics are in brackets; the significance levels are p<0.01 (***), p<0.05 (**) and p<0.1 (*).

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