African Journal of
Agricultural and Resource Economics
Volume 20, Number 4 (2025), pp 337–352

Does land tenure security matter for household income diversification in Burkina Faso? Empirical evidence from a mixed process regression

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Received: July 2025
Published: December 2025

DOI: https://doi.org/10.53936/afjare.2025.20(4).20

Abstract

Income diversification is considered an important livelihood strategy for rural households in agrarian economies, especially in contexts of erratic agricultural income. In this study, we investigate whether land tenure security is a pull factor for household income diversification. Relying on survey data collected from 1 852 rural households by the Burkina Faso Rural Development Program in 2017, and using a mixed process regression dealing with the endogeneity, we find evidence that land tenure security stimulates household income diversification. The results also point out other factors, including age, the ratio of active members in the household, access to infrastructure, farm size and location in the Sudanian zone as drivers of household income diversification. This evidence calls for the institutionalisation of land tenure security in order to improve rural households' livelihoods and suggests alternative, efficient measures for addressing land tenure insecurity challenges in rural Burkina Faso.

Key words: mixed-process regression, income diversification, land tenure security, livelihoods

1. Introduction

Agriculture is a vital economic sector for sustaining rural people's livelihoods in developing countries, especially in Sub-Saharan Africa, where it represents the main economic activity in terms of employment (Asfaw *et al*. 2019). However, agricultural income is erratic and insufficient for satisfying households' food needs due to multiple factors, including land degradation, climate change and demographic pressure. Consequently, rural households relying on the agricultural sector are generally forced to diversify their sources of income to cope with frequent agricultural income losses (Loison 2015; Nagler & Naudé 2017; Asfaw *et al*. 2019; Aikaeli *et al*. 2022).

The contribution of income diversification to households' welfare is well developed in the literature, and some factors are identified as the motives of households' engagement in multiple income-generating activities (Asfaw *et al*. 2019; Matsuura-Kannari *et al*. 2024). These factors are generally grouped into push and pull motives. Pull factors are related to earning opportunities, whereas push factors are causes of fluctuations in agricultural income, constraining households to adopt risk management or risk-coping strategies to smooth their income and consumption over time.

One of the most important push factors is the constraint on access to land. Indeed, in developing countries, land is one of the most important resources for the poor, and land ownership has been considered as a significant factor in household diversification strategies (Kidane & Zegeye 2019; Le & Le 2020). Even if larger land holdings have been linked mainly to increased participation in agricultural activities (Winters *et al.* 2009), some studies have pointed out the lack of land holding as one of the entry barriers to non-farm activities for rural households (Chang *et al*. 2018).

Despite the converging idea that land holding is crucial in a household diversification strategy, little attention is given to the security of land tenure. However, it is well established that the security of land tenure is an important factor of household productivity, agricultural income and sustainable land management (Bambio & Bouayad Agha 2018). In this way, households with limited access to land, or those with insecure land tenure, are more likely to rely on non-farm activities for their welfare, whereas those with secure access to land can rely on both farm and non-farm activities (Séogo 2024). The literature has overlooked this role of land tenure security in household livelihood strategies.

The objective of this study was to analyse the effect of land tenure security on household income diversification. It focuses specifically on the particular case of Burkina Faso, where land tenure security is at the centre of the debate on the structural transformation of the agricultural sector and the improvement of rural households' welfare. In this country, most people rely on farm activities for their livelihoods. However, land access remains a major constraint, especially for vulnerable groups such as women and immigrants (Linkow 2016; Bambio & Bouayad Agha 2018).

Exploiting the rural development programme survey data, we adopted four alternative measures of land tenure security, and use a complex mixed process regression to assess its effect on household income diversification.

The results show that land tenure security is a factor of income diversification. Unlike previous studies, which have focused on the investment and productivity-enhancing effect of land tenure security, this study goes further to shed light on how the latter is a pull factor in rural households' livelihood diversification strategy. In the context of the erratic agricultural income faced by households, this study contributes to informed decision-making aimed at improving and smoothing rural households' income. Indeed, the results call for providing land tenure security in rural development policies, especially in agrarian economies.

The rest of the paper is structured as follows. Section 2 – based on the literature – presents the conceptual framework linking land tenure security and households' income diversification. Section 3 is devoted to a methodological approach, followed by a discussion of the econometric results in Section 4. Section 5 concludes the paper with some policy implications arising from the results.

2. Land tenure security and household income diversification: the conceptual framework

In response to agricultural income variability due to multiple factors, rural households are turning to adaptive strategies, including livelihood diversification (Asfaw et *al*. 2019). One of the most important livelihood strategies adopted by rural households is income diversification. The sustainable rural livelihoods framework has been used as a basis for analysing the livelihood strategies of rural households. In this framework, households' livelihood strategies are influenced by five main types of capital: natural capital, human capital, social capital, financial capital, and physical capital. According to the literature, household income diversification is conditioned by these asset endowments (Faye *et al*. 2025). Households with substantial asset endowments are better off and are more likely to engage in activities from which they can obtain higher earnings. In contrast, poor households with limited asset endowments are pushed into low-return activities (Séogo 2024).

In countries such as Burkina Faso, rural households are poorly endowed in assets, especially physical, human and financial assets. They face several constraints, including poor road infrastructure, low human capital and limited access to credit (Bromley 2008). The only asset they can rely on is land, a natural asset ensuring their livelihood. Consequently, land holding is a fundamental asset in generating greater income from both agricultural and non-agricultural activities for rural households (Jayne et *al*. 2014; Séogo 2024). It can influence households' opportunity for well-being in terms of food security and basic income. Indeed, households with secure land tenure may sell, rent out land or use it as collateral to access credit for non-farm activities or for providing inputs for on-farm activities (Bambio & Bouayad Agha 2018). Land tenure security may be a pull factor of income diversification, and the literature shows that pull factors can be associated with market opportunities leading to an improvement in households' welfare (Asfaw *et al*. 2019).

With climate change, population growth and land degradation, there is growing competition for access to fertile plots of land in rural areas. This is proving to be a serious threat to land tenure security and access to land by vulnerable groups, including women and immigrants, who may be forced to shift their labour to non-farm activities (Jayne *et al*. 2014). Then, as highlighted in Figure 1, the rationale is that households with land tenure security are more likely to diversify, since they could use land to achieve a greater level of income needed for their engagement in multiple activities. They could rely on both farm and non-farm income sources for their livelihoods. In contrast, insecure land owners are obviously the most constrained in asset endowments, and this constitutes an impediment to their income diversification. They might focus on alternative sources of income, either from agricultural labour work or engagement in non-farm activities. Then, we hypothesised a positive relationship between land tenure security and household income diversification in agrarian economies such as Burkina Faso, where constraints to access to financial resources is a serious threat to households' livelihood strategies. The current context of Burkina Faso is characterised by the coexistence of both formal and customary land tenure systems, with the latter being dominant.

The customary land tenure system is based on unwritten rules, where indigenous people (especially men and the elderly) are the owners of land inherited from their ancestors. In this system, land must not be subject to alienation and the elderly allocate land to the members of their family according to their needs. Women, migrants and young people are excluded from land ownership in the customary system. This is why a new land law was introduced in 2009 to establish private formal ownership, allowing all individuals to access land by following formal rules – without any discrimination based on gender or age (Séogo & Zahonogo 2019). However, the customary land tenure system remains dominant and both systems may be a source of land tenure security, as discussed in the section devoted to the assessment of tenure security. The customary land tenure system can affect income diversification through land use and land investment, which would increase farm income. As advocated by neoclassical proponents (Bambio & Bouayad Agha 2018), the formal land tenure system is argued to be more efficient, since – beyond allowing land use – it stimulates land rental, land sales and land use as collateral, giving farmers the possibility of efficiently managing their farms and to obtain high returns from non-farm opportunities.

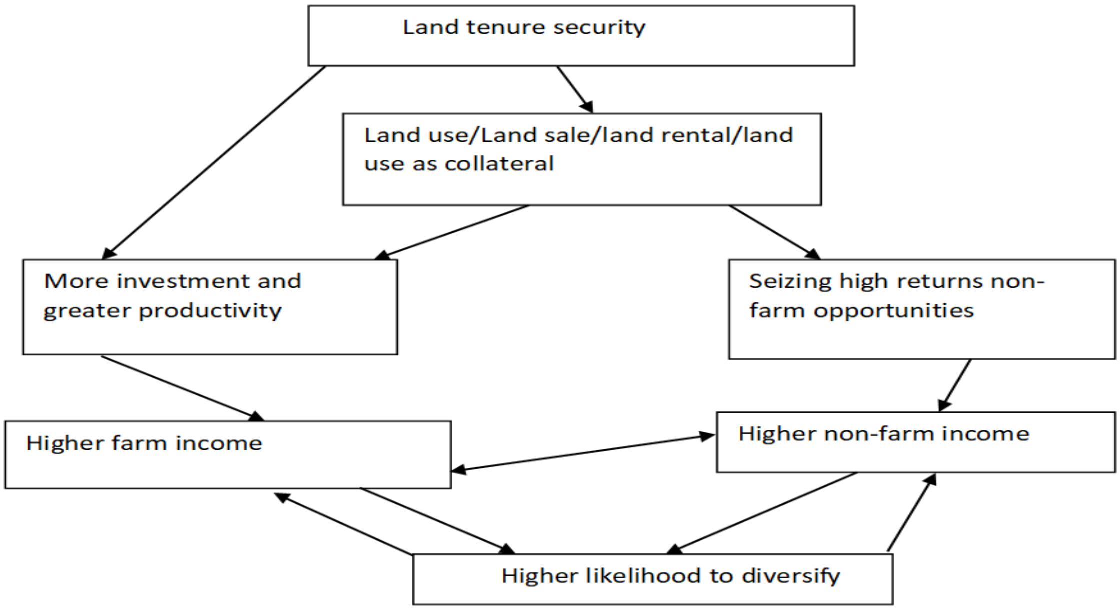

Figure 1: **Land tenure security and household income diversification**
Source: Author's construction

3. Methodological approach

3.1 The assessment of land tenure security in the study area

Land tenure security has been assessed in multiple ways in the literature. The reason for this is that land tenure security is context-specific, and its assessment must reflect the actual tenure status of rural households. Many studies refer to the neoclassic theory of land property rights advocating for individualized and formal land rights, which have the power of inciting productive investment and sustainable land management practices, since these rights allow an internalization of externalities in land transactions (Bambio & Bouayad Agha 2018). This neoclassical view has not been fully supported by the empirical evidence in Sub-Saharan Africa, where several studies have led to non-conclusive results (Lawry *et al*. 2017). Arguments against the formalisation of land rights advocate for the consideration of the social nature of land and land abundance as factors explaining the non-necessity of formalisation. Bromley (2008) argues that land tenure security should not be confused with formalised land title. Indeed, the security of land tenure means that land right holders are assured that their land rights (regardless of what they are) will not be contested, and that they will be confirmed by local or central authorities if they are challenged. Referring to Séogo (2022), the context of the Burkina Faso land tenure system may be suitable evidence regarding Bromley's view of land titling. Indeed, the last land reform in 2009, aiming at formalising land ownership, failed to realise the provisions of land legislation, and the majority of rural people still rely on the customary land tenure system. Also, Séogo and Zahonogo (2019) believe that formalisation is a failure that has led to uncontrolled transactions involving land and a shifting of land from the poor to the rich, who are accumulating land purely for the purpose of speculation. The proportion of plots held under formal land rights is negligible, and more than 90% of households stated that land is not a good that must be subject to financial exchange. Consequently, considering a legal land title holding as a measure of tenure security is not appropriate in the context of Burkina Faso.

This is why the current study relies on the perception of household land tenure security in assessing land tenure security. It should be noted that perception entails self-selection bias. For this bias to be minimised, the data collection captured the perception of tenure security at the plot level. The households were asked to identify the plots of land they fear losing because of land disputes, or private or state expropriation. Based on the responses, households were grouped into two. The first is the land tenure secure group, which includes households that fear losing none of their plots of land. The second group comprises the land tenure insecure households, who feared losing at least one of their plots of land.

Although previous studies in Burkina Faso have argued that the perception of tenure security is the best way of assessing land tenure security, this measure may be judged to be simplistic. For robustness, we used three additional measures of tenure security, referring to the literature and the context of the study: (i) the right to plant a tree, (ii) the right to transfer land to descendants or as a gift, and iii) the right to sell or rent land. In Burkina Faso, planting a tree on a given plot is evidence of tenure security, since it is found to be a way of claiming land ownership and ensuring tenure security (Bambio & Bouayad Agha 2018). Also, the customary tenure system is dominant and, in this system, only land owners have the right to transfer land to their descendants or as a gift (Séogo 2022). Finally, following the literature, we considered the right to sell or rent land, based on the view that the right to alienate land is an important feature of tenure security, as it allows access to credit and leads to an efficient allocation of land (Bambio & Bouayad Agha 2018).

3.2 Measuring household income diversification

In the literature, income diversification generally refers to on- and off-farm activities undertaken by rural households to generate additional income as a complement to their main income activity. The methods of measuring income diversification are multiple. Income diversification has been measured as a simple count of the number of income sources. The weakness of this approach is that it does not account for the relative contribution of each activity to total household income. Thus, the Simpson index (SI), which accounts for the intensity of diversification, has been widely used in the literature (Kidane & Zegeye 2019). The SI takes into account both the number of different types of income diversification and the balance of income distribution between sources. Considering five income sources, the SI is computed as follows:

$$SI_h = 1 - \sum_{i=1}^{5} \varphi_{hi}^2, \tag{1}$$

where SI_h is the Simpson index for household h, and φ_{hi} is the proportion of the ith income. We follow the five income sources established by the Burkina Faso National Institute for Statistics and Demography (INSD 2021): crop production, non-farm activities, livestock, remittances, off-farm wage, and property rent and pension. The SI lies between 0 and 1, where higher values indicate more diversification.

When incomes are inaccurately estimated in certain contexts, the Margalef index (MI) is sometimes used. The MI is the count index, adjusted by the labour force count of all managed livelihood activities of a household. The MI has the advantage of simplicity and strong intuition. Unlike the SI, the MI has no limit value and extends beyond 1. However, the MI is highly sensitive to sample size and is dominant in richness.

The MI is expressed as follows (see Mahama & Nkegbe 2021):

$$MI_h = \frac{S_h - 1}{\ln(L_h)}, \tag{2}$$

where MI_h is the Margalef index, S_h is the total number of income sources of a household h, and L_h is the total labour force count over all the income managed by the household.

This study uses SI, since it encompasses both the count and income size aspects of income diversification. Ignoring the income sizes of activities is a great weakness of MI. The MI was considered in checking the robustness of the findings.

3.3 Model of the effect of land tenure security on household income diversification

In this analysis, household tenure security variables are binary outcomes, while the Simpson index is a zero-censored one. Thus, a tobit model is suitable for estimating the effect of factors affecting household income diversification (Agyeman *et al*. 2014). However, the right-hand side variable of interest (tenure security) is not exogenous. Indeed, some factors, including individual household characteristics, institutional factors, climatic factors and social factors, may influence tenure security (Musah *et al*. 2024). In Burkina Faso specifically, being a native is a major social factor of land tenure security (Linkow 2016; Bambio & Bouayad Agha 2018). To account for this endogeneity, in a first equation this study estimates the probability (Pr) of the household to be land tenure secure, considering the four measures of tenure security in the following form:

$$Pr\left(T_{ij}\middle|X_i, I_i, S_i, G_i\right) = \Phi\left(X_i'\alpha_{1j} + I_i'\alpha_{2j} + S_i'\alpha_{3j} + G_i'\alpha_{4j}\right) \qquad j = 1,2,3,4 \tag{3}$$

T_{ij} is a dummy variable equal to one if the land tenure of a household i is secure, and zero otherwise; j stands for the four tenure security measures; X_i records household characteristics; I_i stands for institutional factors; S_i represents the social variable; and G_i is a set of household living zone variables. Φ is the cumulative function of the normal distribution. Based on the literature, X_i includes the age of the household head, their gender, marital status and education, and the ratio of active members. Among the institutional factors, we include distance to the nearest market and good road infrastructure, which eases access to the household's living zone. G_i includes the three agroclimatic zones of the country.

Si refers to being a native household, and was used to instrument the tenure security variable. Previous studies in the study area have advocated that being a native is a key determinant variable in controlling selection bias arising from tenure security (Linkow 2016; Séogo 2022). Indeed, in the customary land tenure system, which is dominant, only native people can own the land inherited from their ancestors. Non-native people generally negotiate land with these customary owners. We also used a falsification test to confirm the validity of this instrument.

In a second equation, we estimate the effect of land tenure security on household income diversification using a tobit model, as follows:

$$D_{ij}{}^{*} = \beta_0 + \ T_{ij}'\beta_{1j}\ X_i'\beta_{2j} + I_i'\beta_{3j} + S_i'\beta_{4j} + G_i'\beta_{5j} + \varepsilon_{ij}, \tag{4}$$

where $D_{ij}{}^{*}$ stands for income diversification latent variables. T_{ij} is tenure security, and X_i, I_i, S_i and G_i are control variables as defined in Equation (3).

The next equation is

$$D_{ij} = \begin{cases} D_{ij}^{*}\ if\ D_{ij}^{*} > 0 \\ 0\ if\ D_{ij}^{*} \leq 0 \end{cases}, \tag{5}$$

where D_{ij} represents the Simpson index in each equation related to the four tenure security variables. Since some factors affecting tenure security may also affect household income diversification, the error terms in equations (3) and (5) were correlated. To generate consistent results, we thus estimated both the probit and the tobit models simultaneously using a complex mixed process (CMP) regression, as follows:

$$\begin{cases} T_{ij} = \alpha_{0j} + X_i'\alpha_{1j} + I_i'\alpha_{2j} + S_i'\alpha_{3j} + G_i'\alpha_{4j} + \mu_{ij} \\ D_{ij} = \beta_{0j} + T_{ij}'\beta_{1j}\, X_i'\beta_{2j} + I_i'\beta_{3j} + S_i'\beta_{4j} + G_i'\beta_{5j} + \varepsilon_{ij} \end{cases} \tag{6}$$

The CMP regression is a full-information method of estimating structural equations. It allows us to estimate an instrumental tobit model with a discrete endogenous covariate. This regression is suitable for taking into account the correlation between tenure security and the outcome variable, leading to consistent results. The CMP modelling framework is a much broader on that that of seemingly unrelated regressions. Indeed, the individual equations need not be classical regressions with a continuous dependent variable. They may also be categorical, censored, binary, or based on interval measures (Roodman 2011). It offers more flexibility in model construction and endogeneity bias management. These features of CMP regression make it preferable to alternative methods, such as instrumental variable approaches and endogenous switching regressions (Alhassan *et al*. 2020; Thiombiano & Ouedraogo 2025).

3.4 Data source and descriptive statistics

For this study, we used the Burkina Faso National Rural Development Program (PNGT2) survey data collected in 2017. This programme implemented several rural development projects. For the data collection, a large, nationally representative initial sample of 2 160 households was selected randomly via the programme. Information regarding household- and village-level socio-economic characteristics were collected. In the empirical analysis, the final representative sample of 1 852 households in the survey was considered, on which more complete data had been collected regarding the interest and control variables used for the estimations. Moreover, this dataset is the only one in which households' land tenure security is investigated based on their perception, justifying its use instead of an alternative, recent dataset on the study area. A description of the variables used in this study is provided in Table 1.

Table 1: Description of variables used for the empirical analysis

Variable	Description	Mean	Standard deviation
Tenure security and dependent variables			
Tenure is perceived as secure	1 if the household perceives their land tenure as being secure, and 0 otherwise	0.7159	
Right to plant a tree	1 if household has the right to plant a tree on any of their plots, and 0 otherwise	0.7284	
Right to transfer	1 if household has the right to transfer any of the plot to their descendants or give it as a gift, and 0 otherwise	0.7316	
Right to sell or rent	1 if household has the right to sell or rent any of the plot, and 0 otherwise	0.1976	
Simpson	Simpson diversification index	0.4321	0.2040
Margalef	Margalef diversification index	2.355	0.9545
Control variables			
Household head age	Numbers of years	46.92	13.81
Household head gender	1 if household head is male, and 0 otherwise	0.9395	
Household head marital status	1 if the household head is married, and 0 otherwise	0.9319	
Formal education	1 if the household head has at least primary education level, and 0 otherwise	0.2176	
Native household	1 if the household head is a village native, and 0 otherwise	0.8164	
Ratio of active members	The proportion of active household members	0.4946	0.1657
Credit	Total household credit received (CFA franc)	75 883.48	25 333.36
Good road infrastructure	1 if good road infrastructure allows easy access to household living area, and 0 otherwise	0.4330	
Distance to market	Distance from household village to the nearest market (km)	15.08	2.544
Sahelian zone	1 if the village is located in the Sahelian zone, and 0 otherwise	0.1031	
Sudano-Sahelian zone	1 if the village is located in the Sudano-Sahelian zone, and 0 otherwise (reference zone variable)	0.6290	
Sudanian zone	1 if the village is located in the Sudanian zone, and 0 otherwise	0.2678	
Number of observations = 1 852			

Note: EURO 1 = CFA franc 655.957
Source: National Rural Development Program-Phase II (PNGT2) 2017 data

In Table 2, we provide incomes and their shares in the total household income. The main source of household income is crop production, representing more than 40% of the total income. Non-farm activities are the second source of household income, with a share of 32.36%. These two main important sources are followed by off-farm wages (12.81%), livestock (8.81 %), remittances (5.12%), and property rent and pension (0.71%). A similar ranking of income shares was reported by the National Institute for Statistics and Demography in 2018 (INSD 2021).

Table 2: Household income shares from different sources

Income source	Share in the total income (%)
Crop production	40.2
Non-farm activities	32.36
Off-farm wages	12.81
Livestock	8.80
Remittances	5.12
Property rent and pension	0.71
Total	100

Source: Author's calculation based on PNGT2 2017 data

In Figure 2, we highlight the intensity of household income diversification regarding the tenure security status of the household head. Regardless of the considered tenure security measure, the households with secure land tenure were found to have a more intensive income diversification compared to insecure households. Tenure security tends to have a positive effect on household income diversification. The econometric results will tell us whether this correlation is conclusive.

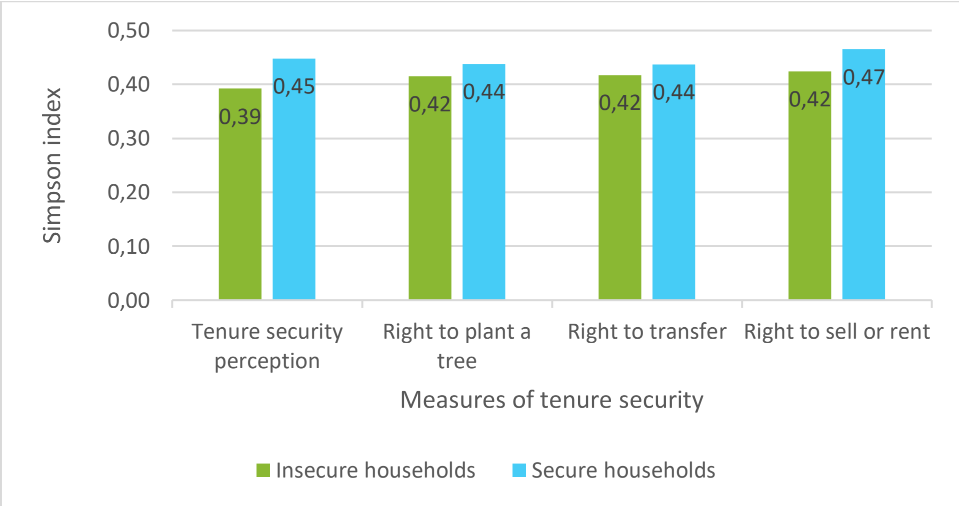

Figure 2: Tenure insecurity and intensity of household income diversification
Source: Author's conception from PNGT2 2017 data

4. Econometric results

4.1 The determinants of land tenure security

As argued in the methodology section, the native variable effect was positive, as expected. Indeed, the customary land tenure system is still dominant in rural land governance. In this system, native people are the owners of the land, and migrants are excluded from land ownership. They have the right to use land for production purposes after negotiating with the native people. Moreover, some people in this system still believe that land is a sacred good inherited from the ancestors and may not be subject to monetary exchange (Séogo & Zahonogo 2019). Thus, native people are more likely to be tenure secure compared to migrants. Other factors of discrimination in access to land in rural Burkina Faso are gender and age. In the customary system, women, just like migrants, are excluded from issues related to land governance. They cannot inherit land, and widows' lands are frequently subject to expropriation. Land issues are a matter for men and the elderly in the dominant customary system (Musah *et al*. 2024). Consequently, aged and male-headed households are found to have greater tenure security in rural areas.

Good road infrastructure, which allows better access to household living zones, is found to have a negative effect on land tenure security. In the Burkina Faso context, accessibility is fundamental in enhancing both farm and non-farm activities (Séogo 2022), implying that villages with easy access may experience more competition for land use. This is a factor of land tenure insecurity. A positive effect is observed when households are distant to a market. Indeed, proximity to the market is one of the factors of tenure insecurity, since transactions on land in Burkina Faso are multiple and uncontrolled in peri-market areas. The greater the distance of the household living zone to the market, the less its plots of land are exposed to expropriation or encroachment.

Finally, households located in the Sudanian zone are more likely to have secure land tenure compared to those in the Sudano-Sahelian zone (the reference variable). This is expected, since the Sudanian zone is land-abundant compared to the Sudano-Sahelian zone, where lands are mostly infertile, inducing competition for the rare fertile plots of land. This induces land tenure insecurity, forcing a significant number of populations to move toward the Sudanian zone. For example, in the Central Plateau and Northern regions of Burkina Faso (both located in the Sudano-Sahelian zone), land degradation has historically stimulated large-scale out-migration toward more fertile areas in the south (Ilboudo Nebie & West 2019). The negative effect of the Sudanian zone on the right to sell or rent land may be explained by the dominance of the customary land tenure system in this zone compared to the reference zone. The right to sell or rent land is perceived by some households as an abomination in the customary system (Séogo & Zahonogo 2019).

In Table 3, we present the probit estimates of the determinants of land tenure security.

Table 3: The determinants of land tenure security: CMP probit estimates

Variable	Tenure is perceived as secure	Right to plant a tree	Right to transfer land	Right to sell or rent land
Native household	0.1804*** (3.28)	0.4837*** (6.40)	0.3923*** (5.59)	1.274*** (8.20)
Age of household head	0.0019 (0.89)	0.0049** (2.15)	0.0042* (1.85)	0.0081*** (3.13)
Household head is male	0.5437*** (3.38)	0.5783*** (3.46)	0.6598*** (3.95)	1.184*** (3.86)
Household head is married	-0.1891 (-1.21)	-0.0185 (-0.11)	0.0317 (0.20)	-0.0300 (-0.13)
Formal education	-0.0619 (-0.86)	-0.0729 (-0.95)	-0.0393 (-0.51)	-0.1090 (-1.21)
Ratio of active members	0.1225 (0.69)	0.0156 (0.08)	-0.03463 (-0.18)	-0.6184*** (-2.76)
Good road infrastructure	-0.3105*** (-5.16)	-0.2214*** (-3.47)	-0.1408** (-2.30)	-0.2017*** (2.72)
Distance to market	0.0035*** (2.75)	-0.0004 (-0.35)	0.0002 (0.22)	0.0039*** (2.72)
Sudanian zone	0.4410*** (6.12)	0.2633*** (3.52)	0.2778*** (3.74)	-0.5280*** (-5.69)
Sahelian zone	-0.0673 (-0.71)	0.0423 (0.41)	-0.0273 (-0.27)	-0.1290 (-1.15)
Constant	-0.0842 (-0.44)	-0.4973*** (-2.38)	-0.5316*** (-2.56)	-3.018*** (-8.79)
	LR $chi^2(23)$ = 264.9***	LR $chi^2(23)$ = 182.63***	LR $chi^2(23)$ = 174.75***	LR $chi^2(23)$ = 273.97***
Number of observations = 1 852				

Notes: *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively; Values in parentheses are z-statistics
Source: Estimations from PNGT2 2017 data

4.2 The effect of land tenure security on household income diversification

Table 4 presents the results of the tobit model assessing the effect of land tenure security on household income diversification. In each equation related to the tenure security variable under consideration, the correlation term between the two models (Rho) is significant, suggesting that a separate estimation method for each equation would have yielded biased results. The use of the CMP regression addresses this bias and leads to consistent results. Moreover, the significance of the likelihood ratios (LR chi^2) indicates a goodness of fit of both the probit and tobit models in this regression.

Regardless of the tenure security variable used, the findings indicate a significant positive effect of land tenure security on household income diversification. In rural Burkina Faso, land is an important resource for households' livelihoods. Indeed, those with secure access to land are more likely to be more productive and may generate substantial income, allowing them to diversify their sources of income. The reason is that, in countries such as Burkina Faso, where credit constraints are binding, households generally have to rely on earnings from agriculture to invest in non-cropping activities. Moreover, in this country, land tenure security has been found to be an engine of rural households' investment, productivity and welfare (Linkow 2016; Bambio & Bouayad Agha 2018; Séogo 2022). Providing land tenure security is a significant policy tool for enhancing households' ability to obtain sufficient food and enjoy sustainable livelihoods in Burkina Faso.

Table 4: The effect of land tenure security on household income diversification: CMP Tobit estimates

	The Simpson index results from the consideration of four alternative measures of tenure security			
Variable	**Simpson index** *(Tenure security perception is the tenure security variable)*	**Simpson index** *(Right to plant a tree is the tenure security variable)*	**Simpson index** *(Right to transfer land is the tenure security variable)*	**Simpon index** *(Right to sell or rent land is the tenure security variable)*
Tenure security	0.4683*** (22.58)	0.3093*** (8.50)	0.3274*** (10.84)	0.1034** (2.29)
Age of household head	0.0066*** (3.50)	0.0060*** (2.97)	0.0060*** (2.96)	0.0062*** (3.02)
Household head age squared	-0.00005*** (-3.18)	-0.00005*** (-2.76)	-0.00005*** (-2.72)	-0.00005*** (-2.67)
Household head is male	-0.0599 (-1.60)	-0.0365 (-1.08)	-0.0505 (-1.47)	0.0067 (0.23)
Household head is married	0.0267 (0.76)	0.0083 (0.27)	-0.0004 (-0.01)	0.01152 (0.43)
Formal education	0.0249 (1.54)	0.0224 (1.57)	0.0190 (1.31)	0.0166 (1.36)
Ratio of active members	0.0495 (1.25)	0.0657* (1.89)	0.0695* (1.96)	0.0788** (2.58)
Good road infrastructure	0.0712*** (5.21)	0.0392*** (3.22)	0.0320*** (2.62)	0.0205* (1.96)
Distance to market	-0.00007 (-0.30)	0.0004* (1.78)	0.0003 (1.52)	0.0001 (0.84)
Total credit contracted	0.0010 (1.21)	0.0010 (1.12)	0.0010 (1.19)	0.0010 (1.11)
Cultivated land area	0.0033** (2.16)	0.0038** (2.47)	0.0037** (2.42)	0.0036** (2.44)
Sudanian zone	-0.1157*** (-7.44)	-0.0782*** (-5.71)	-0.0816*** (-5.86)	-0.0471*** (-3.62)
Sahelian zone	-0.0062 (-0.29)	-0.0112 (-0.58)	-0.0051 (-0.26)	0.0034 (0.21)
Constant	-0.0940 (-1.53)	0.0188 (0.30)	0.0289 (0.47)	0.1670*** (2.93)
	LR $chi^2(23)$ = 264.9*** $Rh0_{12}$ = -0.899***	$LRchi^2(23$= 182.6*** $Rh0_{12}$ = -0.721***	LR $chi^2(23)$ = 174.7*** $Rh0_{12}$ = -0.754***	LR $chi^2(23)$ = 273.9*** $Rh0_{12}$ = -0.197***
Number of observations = 1 852				

Notes: *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively; values in parentheses are z statistics
Source: Estimations from PNGT2 2017 data

Regarding the control variables, the age of the household head had a non-linear positive effect on household income diversification, implying that experience is a factor of income diversification. The negative effect of gender suggests that women-headed households were more likely to diversify. In the context of Burkina Faso, where women have less access to productive resources (Loaba *et al*. 2021), they face a greater risk of income loss, pushing them into diversification as a strategy to manage income risk. The positive effect of the ratio of active members in the households was expected, since family labour is essential for income diversification (Ky 2024). Good road infrastructure is found to have a positive effect on income diversification. It also is a factor of market integration, stimulating both farm and non-farm activities, leading to substantial income earnings. It is a key element in any rural development strategy (Bromley 2008). Households located in areas with good access consequently have greater opportunities to diversify their sources of income and sustain their livelihoods.

The results indicate an unexpected positive effect of cultivated land area on income diversification. Land area is a variable capturing the household level of engagement in farm activities. Theoretically, households with more land area devoted to agriculture are less likely to be engaged in other activities, since a considerable portion of their time is devoted to farm management (Winters *et al*. 2009). However, in Burkina Faso, the seasonality of both farm and non-farm activities can justify such a result. Besides, since households face constraints in accessing credit, farm and non-farm activities are interrelated, making households with more engagement in agricultural activities the most likely to generate greater income, thereby fuelling income diversification. The literature indicates that the reasons why larger farms do not necessarily lead to specialisation may be due to potential diseconomies of scale, as larger farms tend to require more (hired) labour and arguably higher labour productivity, and can result in higher costs of monitoring (Klasen *et al.* 2016). Similar results were found in Malawi, where livelihood diversification increases with cultivated land area (Heumesser & Kray 2019).

Finally, the results show a negative effect of location in the Sudanian zone on income diversification compared to location in the Sudano-Sahelian zone. This is expected, since the Sudanian zone is the most favourable zone for agriculture, and it records sufficient rainfall. Households in the Sudanian zone face less risk of agricultural income loss compared to those in the Sudano-Sahelian zone, where climatic variability is a frequent threat to crop production (Séogo 2024). Consequently, households in this area are expected to diversify their sources of income as a risk management strategy.

4.3 Robustness check

To check the robustness of the findings, we used the Margalef index (MI) as an alternative measure of income diversification. Table 5 presents the econometric results using the MI as the outcome variable. The findings lead to the same conclusion regarding the effect of land tenure security on income diversification. Indeed, as in the case of using SI, land tenure security was found to have a positive and significant effect on household income diversification in all four equations. Consequently, these results were found to be robust.

Table 5: The effect of land tenure security on household income diversification: CMP tobit estimates robustness check

	The Margalef index results from the consideration of four alternative measures of tenure security			
Variable	**Margalef index** *(Tenure security perception is the tenure security variable)*	**Margalef index** *(Right to plant a tree is the tenure security variable)*	**Margalef index** *(Right to transfer land is the tenure security variable)*	**Margalef index** *(Right to sell or rent land is the tenure security variable)*
Tenure security	1.242*** (10.66)	1.669*** (13.38)	1.681*** (14.79)	0.6597** (2.08)
Age of household head age	-0.0250*** (-2.68)	-0.0276*** (-2.97)	-0.0276*** (-2.94)	-0.0279 *** (-3.12)
Household head age squared	0.0002*** (2.83)	0.0002*** (2.89)	0.0002*** (2.91)	0.0002*** (3.16)
Household head is male	-0.7213*** (-4.65)	-0.8164*** (-5.51)	-0.8744*** (-5.73)	-0.6272 *** (-4.59)
Household head is married	0.0755 (0.52)	0.0276 (0.20)	-0.0179 (-0.13)	0.0409 (0.36)
Formal education	0.0489 (0.74)	0.0715 (1.13)	0.0510 (0.79)	0.0392 (0.73)
Ratio of active members	0.1681 (1.04)	0.2214 (1.44)	0.2390 (1.51)	0.2976** (2.16)
Good road infrastructure	0.0775 (1.36)	0.0563 (1.06)	0.0129 (0.24)	-0.0400 (-0.85)
Distance to market	0.0008 (0.78)	0.0027*** (2.62)	0.0023** (2.23)	0.0010 (1.19)
Total credit contracted	0.0084** (2.00)	0.0060 (1.47)	0.0063 (1.54)	0.0050 (1.50)
Cultivated land area	0.0248*** (3.45)	0.0212*** (3.06)	0.0220*** (3.14)	0.0328*** (4.99)
Sudanian zone	-0.5873*** (-9.11)	-0.5280*** (-8.76)	-0.5429*** (-8.76)	-0.3551 *** (-5.40)
Sahelian zone	-0.0354 (-0.39)	-0.0949 (-1.10)	-0.0585 (-0.66)	-0.0058 (-0.08)
Constant	2.504*** (8.88)	2.387*** (8.69)	2.475*** (8.93)	3.203*** (12.89)
	LR $chi^2(23)$ = 254.1 *** $Rh0_{12}$ = -0.7286***	LR $chi^2(23)$ = 255.3*** $Rh0_{12}$ = -0.6874***	LR chi^2 (23) = 247.7*** $Rh0_{12}$ = -0.7224***	LR $chi^2(23)$ = 321.9*** $Rh0_{12}$ = 0.1165***
Number of observations = 1 852				

Notes: *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively; values in parentheses are z-statistics
Source: Estimations from PNGT2 2017 data

5. Conclusion and policy implications

Income diversification is a risk management strategy for rural households in countries with climatic variability and constraints related to equitable access to land, such as Burkina Faso. This study investigated whether land tenure security is a key factor in households' income diversification. A complex mixed process regression, including a probit model and a tobit model, was followed to address the potential endogeneity of the land tenure security variable.

The results show that land tenure security is an incentive for households' income diversification. Indeed, in countries with constraints in access to credit, land is a primordial resource for households' livelihoods. Secure land tenure households have the opportunity to be engaged in both farm and non-farm activities, resulting in greater earnings. The literature gives substantial evidence of the positive effect of land holding on households' income diversification. This study goes further to highlight the necessity of land tenure security for households' income diversification.

As in previous studies in developing countries, the results call for ensuring land tenure security and equitable access to land. In Burkina Faso specifically, land tenure insecurity remains a major constraint to rural households' livelihoods. Although a new land law was passed in 2009 to enhance tenure security, issues related to access to land continue to prevail, since the authorities lack both human and financial resources to implement this law, resulting in uncontrolled transactions on land and a conflict between formal and customary systems in some areas (Séogo & Zahonogo 2019). The situation is worsening with the insecurity caused by terrorist attacks, forcing people to move towards peri-urban areas. Providing land tenure security is a challenge to be achieved in Burkina Faso, with alternative, less costly methods of controlling land transactions. This could be made possible by establishing new, credible land administration institutions, where corruption is addressed with enough resources to enforce the law. Thus, the country needs good land governance in which speculation in land is severely punished and discouraged – this would be key to ensuring land tenure security in Burkina Faso.

It is also important to support rural households' farm and non-farm activities, especially those of women, who are discriminated against in access to productive resources such as land. Indeed, this study shows that women face insecure land tenure and may be exposed to more risk of income loss, pushing them into diversification. Specific rural programmes targeting women by facilitating their access to credit, equipment, professional training and land are crucial for enhancing households' welfare. Due to social norms excluding young people, women and migrants from accessing land through the customary system, decision makers could increase the proportion of land area devoted to these vulnerable groups in irrigated perimeters provided by the government. Ensuring land tenure security for vulnerable groups is also a challenge in improving rural households' welfare in Burkina Faso.

Acknowledgement

The author acknowledges the Burkina Faso National Rural Development Program (PNGT2) for funding the collection of the data.

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