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Effect of agricultural modernisation on rural household food security in Burkina Faso: A multidimensional analysis using the consolidated approach for reporting food security indicators

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Abstract

This paper analyses the effects of agricultural modernisation on the food security of rural households in Burkina Faso. It uses data from the Permanent Agricultural Survey (EPA 2021). An agricultural modernisation index was constructed as a variable of interest, and the consolidated approach for reporting indicators of food security (CARI) was used to measure the prevalence of different types of food insecurity within the population. The value of this paper lies in its holistic approach, which allows for a distinct examination of the effects of agricultural modernisation on food security. By using the CARI approach, this research aligns with a dynamic of renewed approaches to food security, a multidimensional concept. The results show that agricultural modernisation improves the food security of rural households. These results suggest a need for the development of policies aimed at securing land tenure by simplifying the procedures for obtaining land titles, structuring certified seed sectors through subsidies and the establishment of local distribution networks to ensure constant availability, and promoting shared mechanisation models to enable smallholdings to reach the necessary capitalisation threshold.

Key words: agricultural modernisation, Burkina Faso, food security, rural households

1. Introduction

One of the major problems of this century is the acute global issue of food insecurity. The current definition of food security clearly demonstrates the multidimensional nature of this concept, expressed in terms of quantity and quality across four aspects: food availability, food accessibility, food stability, and food utilisation.

According to the World Bank's report on food crises, 238 million people in 48 countries faced acute food and nutrition insecurity in 2023 (World Bank 2023). Indeed, statistics from the United Nations Food and Agriculture Organization (FAO), the United Nations Economic Commission for Africa (UNECA) and the African Union Commission (AUC) show that the rates of food insecurity in Africa increased from 18.2% in 2014 to 20% in 2018, while in sub-Saharan Africa, they rose from 20.8% to 22.8% over the same period (FAO *et al*. 2020). In sub-Saharan Africa, the prevalence of undernourishment was 22% in 2022, compared to 15% in South Asia and 4% in countries in East Asia and the Pacific (World Bank 2022).

In Burkina Faso, agriculture remains the primary activity of households. It holds significant importance in food production and is considered a key sector for economic development. The agricultural sector employs over 80% of the population and contributes 30% to the GDP (FAO 2014). The observation is that these family farms are poorly modernised, despite the important role they play in the country's food supply. Indeed, agricultural modernisation includes innovation, mechanisation, research and development, along with the use of selected seeds, modern agricultural technologies and scientific knowledge. This low level of modernisation on family farms reflects the country's overall agriculture, which is poorly mechanised. In fact, the rate of mechanised ploughing (plough or tractor) varied between 62% and 72% during the period from 2008 to 2017.

The interest in agricultural modernisation for Burkina Faso stems from the fact that the country, like most countries in the region, faces food insecurity. More than two million people were considered to be in a situation of food insecurity in 2020, with 136 175 cases requiring emergency intervention (Bougma & Tou 2021).

According to modernisation theory (Rostow 1960), development is considered a linear process of economic growth that must be achieved in stages through industrialisation, urbanisation and investment. This development of technologies and infrastructure would lead to per capita income growth. Modernisation involves a massive transfer of capital, technology, know-how, ideology and socio-political culture from developed, modern Western societies to underdeveloped traditional societies in the Third World (Servaes 1995; Melkote & Steeves 2001). Furthermore, the theory (Rogers 1962) defines the diffusion of innovation as "the process by which an innovation is communicated through certain channels over time among the members of a social system". It explains how new technologies spread among farmers and points out that, if they do not adopt these techniques, the effect on food security would be limited.

As for entitlement theory (Sen 1981), food security cannot be measured solely by economic indicators, such as income, but must also take into account the entitlements individuals have to resources to satisfy their basic needs. In addition, Malthus (1798) demonstrated a link between population growth and the availability of food resources. Malthus argued that the population tends to grow exponentially, while food resources increase arithmetically. This Malthusian prediction leads to the idea that, without constraints (famine, war and disease), the population will always outstrip the means of subsistence, inevitably leading to crises and the restoration of balance through suffering and increased mortality. In contrast to Malthus, the neoclassicals (Walras, 1874; Marshall, 1890) are optimistic about the ability of the economy and technology (modernisation) to adapt and produce enough goods to meet the demand.

Empirically, studies show that agricultural modernisation policies, such as innovation, mechanisation, research and development, have a positive impact on food security. According to Douillet and Girard (2013), agricultural production depends not only on the climatic conditions to which a soil is subject, but also on existing technologies, agricultural practices and public policies, which directly or indirectly influence farmers' activities through general or specific economic orientations. Furthermore, Arslan *et al*. (2017) show that household characteristics and the low modernisation of farms are constraints to improving agricultural productivity, and when these constraints are applied to West Africa, they become food security problems (Dury *et al*. 2017).

According to Bougma and Tou (2021), almost half of households experienced in Burkina Faso have experienced at least one transition between food security and insecurity. Their study demonstrates the importance of modernisation in food security. Therefore, modernisation is a means to achieving higher agricultural productivity and better food security through an increase in the supply of cereal products (Mounier 1992). The level of agricultural modernisation in Burkina Faso is low, however, and no study has analysed the effect of agricultural modernisation on household food security from the perspective of the consolidated approach for reporting on food security indicators (CARI), leaving a gap in the literature.

This paper aims to analyse the effect of agricultural modernisation on the food security of rural households in Burkina Faso. It hypothesises that agricultural modernisation reduces food insecurity in rural households in the country.

The originality of this research lies in its holistic approach, which allows for a distinct examination of the effects of agricultural modernisation on household food security and well-being. This dimension is directly linked to national strategic priorities for modernising farms and improving household food security. As such, this research aligns with the objectives of public policies aiming to achieve inclusive development and greater resilience of agrarian systems. Furthermore, by using the consolidated approach for reporting on food security indicators (CARI) of the World Food Programme (WFP), this research participates fully in a dynamic of renewing food security approaches, which is a multidimensional concept. Finally, this research articulates a solid theoretical framework through a rigorous empirical analysis, mobilising representative data from Burkina Faso and appropriate econometric tools. It thus offers robust scientific results, as well as useful avenues for reflection that will contribute to better decision-making to improve the living conditions of households in rural areas.

The paper is structured into three sections. The first presents the methodology used. The second analyses and discusses the main results. The final section outlines the economic implications.

2. Methodology

2.1 Theoretical framework

The reduction in food insecurity can be analysed through Sen's (1981) entitlement theory, Rogers' (1962) diffusion of innovation theory, and Rostow's (1960) modernisation theory.

Entitlement theory posits that food security cannot be measured solely by economic indicators, such as income, but must also consider the entitlements individuals have to resources to meet their basic needs. Furthermore, the diffusion of innovation theory (Rogers 1962) demonstrates that new technologies spread among farmers through certain channels, and the adoption of these techniques improves food security.

Modernisation theory, moreover, teaches us that the development of technologies and infrastructure would lead to growth in per capita income. This translates into a massive transfer of capital, technology, know-how, ideology and sociopolitical culture from modern, developed Western societies to traditional, underdeveloped third world societies (Rostow 1960).

On this basis, Zou and Mishra (2024) developed an analytical framework for the relationship between agricultural modernisation and household food security. The analytical framework for the link between the two is represented in Figure 1.

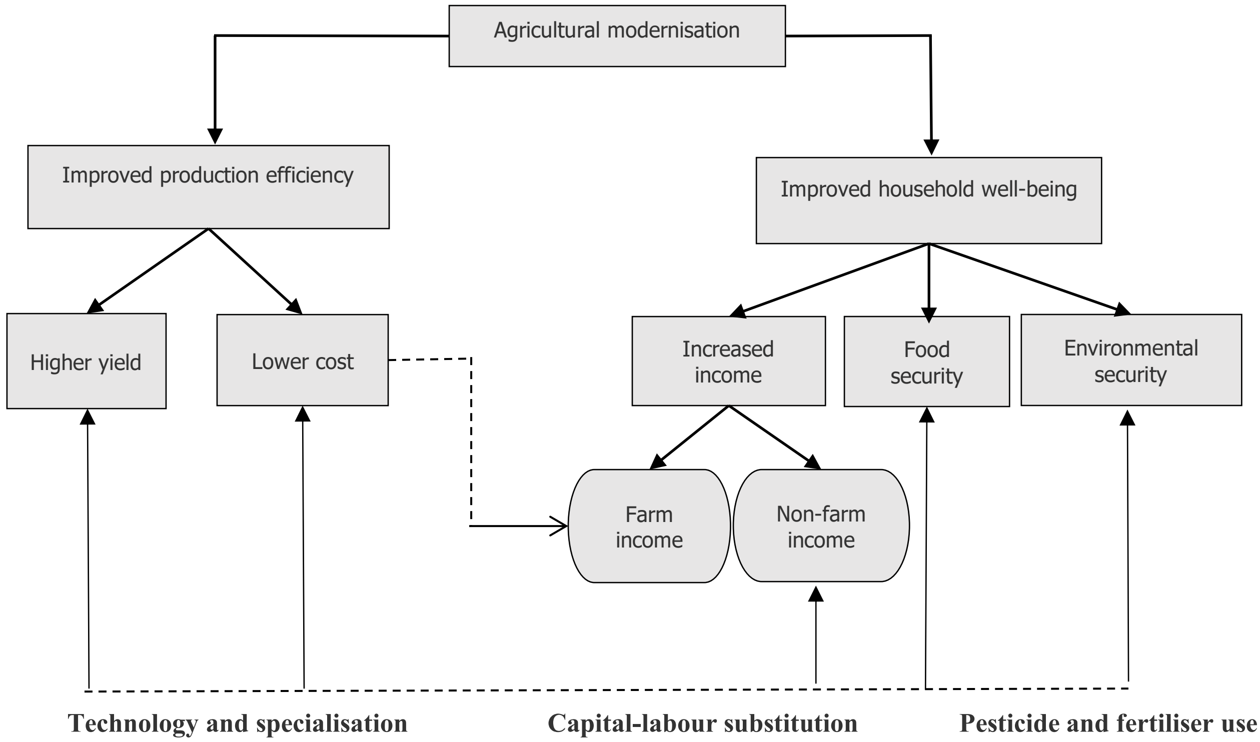

Figure 1: Analytical framework for the link between agricultural modernisation and food security
Source: Zou and Mishra (2024)

2.2 Analytical model

This paper analyses the effect of agricultural modernisation on the food security of rural households from a multidimensional perspective. Food security is a multidimensional concept, expressed in terms of quantity and quality across four aspects (food availability, food accessibility, food stability and food utilisation), and the consolidated approach for reporting indicators of food security (CARI) is suitable for its analysis.

The CARI approach comprises two domains. These are the current status domain, measured by the food consumption score and/or the food energy deficit. This can give one an idea of whether the household's current food consumption is satisfactory. The second domain is coping capacity, which uses indicators that capture economic vulnerability and household asset depletion.

Economic vulnerability is measured by the share of food expenditure or poverty status. When measuring this vulnerability, only one of these indicators should be used in the CARI methodology. Household asset depletion is associated with livelihood-based coping strategies.

Some authors have used this methodology in their studies. Mulumeoderhwa *et al*. (2020) used the CARI method to determine food security in their study titled 'Coping strategies and household food security in the Minembwe Highlands, South Kivu'. In essence, CARI is a food security reporting table. The table also shows the prevalence of different types of food insecurity within the population, which can be obtained from a single indicator called the food security index (FSI), which shows the overall household food security status (World Food Programme [WFP] 2014), which is a function of five indicators:

FSI = f (FCS, FED, SFE, PS, CSI),

with: FCS = food consumption score; FED = food energy deficit; SFE = share of food expenditure; PS = poverty status; CSI = coping strategies index.

Based on this indicator, the population is divided into four groups (food secure, marginally food secure, moderately food insecure, and severely food insecure). The CARI method assigns each household to a food security group. However, given the data required to calculate the indicators, it is advisable in practice to use only indicators that can be justified by existing data (WFP 2014). Consequently, in this paper, the food security index (FSI) is a function of three elements, as detailed below:

FSI = f (FCS, SFE, CSI)

2.2.1 Food security indicators for the CARI approach

This section defines and explains the indicators used in the CARI approach, detailing the formulas and elements required for their construction.

- **Food consumption score (FCS)**

This score reflects a household's economic capacity to consume a wide range of foods. The household food consumption score (FCS) is a key indicator that reveals the variety, frequency and nutritional value of foods consumed by a household over a specific period (number of consumption days within the last seven days). It takes into account all food groups and products that are part of a household's diet and assigns a weight to each of the eight food categories. Table 1 presents the food groups and their weight in the FCS.

Table 1: Food groups and their weight in the FCS

Food Groups	Weighting
Cereals and tubers	2
Pulses	3
Vegetables	1
Fruit	1
Meat and fish	4
Milk	4
Sugar	0.5
Oil	0.5

Source: Ndiaye (2014)

The food consumption score is a valuable tool for assessing the nutritional status of households and identifying areas where improvements are needed. It is calculated as follows:

$FCS = \sum_{i=1}^{n} F_i * W_i$ (FAO & WFP 2013),

where F_i is the frequency of consumption of each food group i (≤ 7 days), and W_i is the weight attributed to food group i.

- **Share of food expenditure (SFE)**

The share of food expenditure (SFE) indicator is a simple measure that involves dividing the total amount spent on food by the total household expenditure. However, both the numerator and the denominator of this indicator must include the value of food consumed, but not purchased (WFP 2014). To calculate this for each household, we need to sum the total food expenditure over the last 30 days and add the value of unconsumed food that was not purchased during the same period. This gives the total food expenditure for the month, denoted as MFE. Then, for each household, we also add short-term non-food expenditure (three months), denoted as NFE1, and non-food expenditure of less than six months (six months), denoted as NFE2 divided by six. The SFE is obtained from this formula:

$SFE = MFE/(MFE + NFE1 + NFE2)$ (WFP 2014).

- **Coping strategy index (CSI)**

The coping strategy index (CSI) is a proxy indicator for food access and provides insights into the degree of household vulnerability and potential threats to their survival. According to WFP (2014), strategies are based on livelihoods, insurance and consumption. In this essay, coping strategies are based on livelihoods. These strategies include selling household assets/property, reducing expenditure on health (including medicines) and education, selling productive assets or household transport, spending savings, borrowing money and/or food from a formal lender, selling a house or land, withdrawing children from school, selling the last female animals, begging, and excessive selling of animals (non-productive).

Once these indicators are calculated, they are converted into the CARI table according to the procedure described in Table 2. This table is used to calculate the prevalence of food insecurity (WFP 2014).

Table 2 : CARI approach indicators

Domain	**Indicator**	**Food security (FS) (1)**	**Borderline food security (BFS) (2)**	**Moderate food insecurity (MFS) (3)**	**Severe food insecurity (SFI) (4)**
Current status	Food consumption score (FCS)	Acceptable if FCS ≤ 21		Borderline if 21 ≤ FCS ≤ 35	Poor if FCS > 35
Coping capacity	Share of food expenditure (SFE)	SFE < 50%	50 at 60%	65 at 75%	SFE > 75%
	Livelihood coping strategy	None	Stress	Crisis	Emergency

Source: Ndiaye (2014)

2.2.2 Composite agricultural modernisation index

In line with the agricultural modernisation assessment framework, which considers the multidimensional aspect of food security, we have integrated production-related indicators to construct a composite agricultural modernisation index (AMI) (Table 3). In constructing the AMI, we selected factors such as labour, mechanisation, water resources (source of water used), chemical fertilisers, pesticides, seeds and land tenure security. Based on previous studies, the results obtained have shown that agricultural modernisation is associated with food security (Guo *et al*. 2013; Tian *et al*. 2021).

Table 3 presents the AMI, its indicators, and the weights of its indicators in the calculation of the composite index. The first column lists the modernisation factors, and the second column lists the indicators used to measure modernisation. The last column indicates the weights associated with each indicator (Shi *et al*. 2023). In calculating the AMI, each indicator records a value of '1' if the respondent's answer is appropriate, and '0' otherwise. The value representing the modernisation index of a farm is the weighted average of these indicators using their respective weights in accordance with Table 3 (Shi *et al*. 2023). The agricultural modernisation index therefore corresponds to the weighted percentage of the different indicators. Furthermore, farms are considered modernised if they have a modernisation score greater than or equal to 0.8.

Table 3: Composite agricultural modernisation index

Domain	Indicator	Weight
Work	Agricultural labour	0.1
Agricultural mechanisation	Type of tillage	0.2
Water resource	Water source used	0.1
Chemical fertiliser	Fertiliser consumption	0.1
Pesticide	Pesticide consumption	0.1
Seed	Type of seed used	0.2
Land tenure security	Level of land tenure security	0.2

Source: Constructed by the author from Shi *et al*. (2023)

2.2.3 Empirical specification of the multinomial logit model

Analysing household food security involves examining the probability of households being food insecure or not. For this purpose, food security status can be considered a categorical variable. Logit or probit models are suitable for such cases (Greene 2003). Furthermore, given the nature of the endogenous variable and the ease with which the logit model allows for the interpretation of estimated coefficients (Hosmer & Lemeshow 2000; Cameron & Trivedi 2005), the ordered multinomial logit model is used in the econometric section of this paper. Thus, the model that explains food security is given by the following equation:

$$y_i^{*} = x\beta + \varepsilon_i, \quad (1)$$

where x represents household characteristics and ε is the random term. The empirical specification of the model is:

$$y_i^{*} = f(Age, Sex, Edu, Tail\_Menag, Modern\_Agri, Acc\_Credi, Activ\_Conex, Sup\_Emblav, Rev, Adh\_OP) + \varepsilon_i \quad (2)$$

Food security constitutes the dependent variable, which has four (4) modalities (Table 2). Marginal effects are obtained by differentiating the probabilities with respect to the explanatory variables (Table 4). Such a model is also used by Ouoba and Sawadogo (2022) in their study on household food security, poverty and resilience to COVID-19 in Burkina Faso, using two categorisable food security indicators: the food consumption score and the dietary diversity score. Following the aforementioned authors, this document uses the food consumption score, along with the share of food expenditure and the coping strategy index, as indicators of household food security. Indeed, the food security function for a household is explained by the ten (10) variables in Table 4. This function is represented by Equation (2).

The variables Age, Sex, Edu and Tail_Menag represent, respectively, the age of the household head, their gender, their education level, and the size of their household in adult equivalents. As for the variables Acc_Credi, Activ_Conex, Sup_Emblav, Rev, Modern_Agri and Adh_OP, they denote, respectively, access to agricultural credit, the household's engagement in related activities, the cultivated area, income, agricultural modernisation, and the household head's membership of a farmers' organisation.

2.3 Data sources and collection method

This paper uses data from the permanent agricultural survey (MARAH/EPA 2021), which was conducted by the ministry in charge of agriculture through the Directorate General of Sectoral Studies and Statistics (DGESS). The permanent agricultural survey (EPA) consists of 4 824 households distributed across 1 668 enumeration areas (EPs) (i.e. 884 villages), with a maximum of three households per EP (six households per village).

2.4 Selection and description of model variables

2.4.1 Dependent variable

The dependent variable represents food security. Based on the ordered multinomial logit model, food security levels can be determined between modernised and non-modernised farms (Deressa *et al*. 2009). Indeed, the model can be used to compare the expected food security status of modernised farms with that of non-modernised farms.

2.4.2 Explanatory variables

The literature review identified a number of variables likely to influence food security.

2.4.2.1 Variable of interest

Agricultural modernisation, a continuous variable, represents the variable of interest in this study and ranges between 0 and 1. It is argued that agricultural modernisation decreases the likelihood of households being food insecure. Factors such as labour, mechanisation, water resources, chemical fertilisers, pesticides, selected seeds and land tenure contribute to improving agricultural productivity and reduce the likelihood of households being food insecure (Shi *et al*. 2023). We hypothesise a negative and statistically significant sign for the coefficient of the 'agricultural modernisation' variable.

2.4.2.2 Control variables

According to the literature, variables likely to explain household food security include:

Age of the household head: This is a quantitative variable measured in years. The effect of the age of the household head on food status has been a subject of debate in the literature. According to Babatundé *et al*. (2007), younger household heads have more physical strength to cultivate more land than older household heads, greater ease in engaging in non-agricultural activities, and a higher chance of achieving food security. Sigue *et al*. (2019) add that younger household heads have the physical capacity to diversify their crops, especially in a context where the agricultural production tools used are not very efficient. The expected effect of this variable is indeterminate.

Gender of the household head: This is a binary variable taking 1 if the head is male and 0 otherwise, and its influence on food security remains indeterminate. Indeed, female-headed households are more likely to be exposed to food insecurity than male-headed households due to their limited physical capacities and economic opportunities (Yabile 2013).

Educational level of the household head: This is a categorical variable and, according to Ahmadi and Melgar-Quiñonez (2019), higher educational levels are associated with higher levels of food security. Educated household heads are better able to apply and disseminate advice from extension services, which improves agricultural productivity and decreases the likelihood of households being food insecure (Ndjadi *et al*. 2019). We hypothesise a negative and statistically significant sign for the coefficient of the 'educational level of the household head' variable.

Size of the farming household: This variable measures the number of individuals in a farming household. According to the Ministry of Agriculture, Animal and Fisheries Resources (MARAH 2021), there are on average between 10 and 11 members in each farming household in Burkina Faso. Household size provides family labour and contributes to an increase in agricultural productivity when the household has a significant number of agricultural assets, thereby decreasing the likelihood of households being food insecure (Folefack *et al*. 2012). We hypothesise a negative and significant sign for the coefficient of the 'household size' variable.

Access to credit: This is a binary variable taking the value 1 if the household has access to credit and 0 otherwise. Credit strengthens the productive capacities of households and increases production levels through the adoption of agricultural innovations, thereby decreasing the likelihood of households being food insecure (Mensah *et al*. 2013; Guodaar *et al*. 2016). A negative effect is expected from this variable.

Engagement in related activities such as fishing, trade, and crafts: This is a binary variable taking the value 1 if the household engages in at least one of these activities and 0 otherwise. Indeed, these activities are sources of additional income for households, allowing them to obtain supplementary products that decrease the likelihood of the household being food insecure (Yabile 2013). A negative effect is expected from this variable.

Cultivated area: This is a quantitative variable measured in hectares. The hypothesis is that a larger cultivated area signifies the adoption of innovations leading to higher agricultural productivity, which in turn decreases the likelihood of the household being food insecure (Mbétid-Bessane 2014). A negative effect is expected from this variable.

Income is a quantitative variable. Average income levels are a frequently used indicator to assess the overall well-being of agricultural households. The assumption is that sufficiently high and stable incomes are a prerequisite for improving household living conditions and significantly reducing the level of food insecurity (Sunding & Zilberman 2001; Hill 2019).

Membership in farmer organisations is a binary variable. The assumption is that producers who are members of a farmer organisation can benefit from advice and support regarding production, which leads to higher agricultural productivity and in turn decreases the household's probability of being food insecure. A negative effect is expected from this variable.

Table 4: Summary of model variables

Definition of the variable	Variable type	Expected sign
CARI: 1 = Food security; 2 = Borderline food security; 3 = Moderate food insecurity; 4 = Severe food insecurity	Categorical	Dependent
Age of the household head	Continuous	+/-
Gender of the household head: 1 = Man; 0 = Woman	Binary	+/-
Educational level of the household head: 0 = Illiterate; 1 = Literate; 2 = Primary level; 3 = Secondary level; 4 = Higher level; 5 = Arabic school	Categorical	-
Household size per adult equivalent	Quantitative	-
Access to credit: 1 = if the household has access to credit; 0 = otherwise	Binary	-
Related activities: 1 = if the household engages in a related activity; 0 = otherwise	Binary	-
Agricultural modernisation	Continuous	-
Cultivated area	Quantitative	-
Income	Quantitative	-
Membership in farmer organisations: 1 = if the head of household is a member of a farmers' organisation; 0 = otherwise	Binary	-

Source: Authors

3. Results and discussion

3.1 Descriptive statistics

Figure 2 shows that 54.58% of the households in the study were food secure and 32.94% were borderline food secure, compared to 11.84% who were in moderate food insecurity and only 0.64% who were in severe food insecurity.

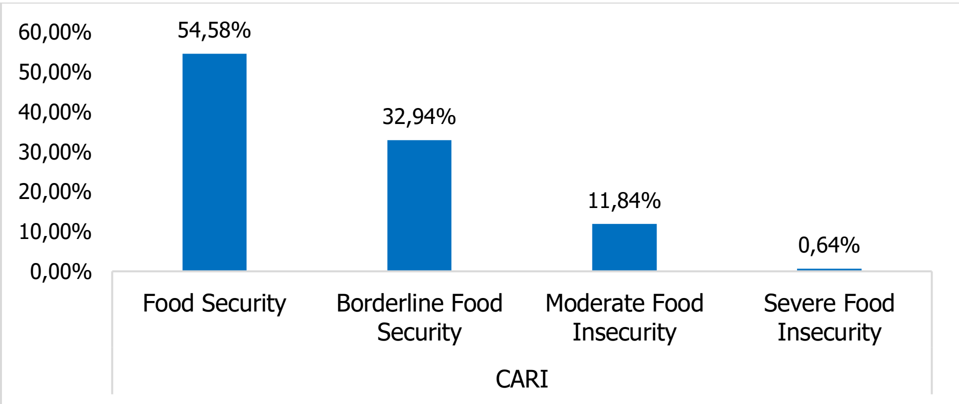

Figure 2: Descriptive statistics of the dependent variable
Source: Authors, based on MARAH/EPA 2021 data

Figure 3 illustrates the distribution of household food security levels according to farm type. The sample consists of 1 709 modernised farms versus 3 115 traditional farms. This table reveals that 87.52% of the households in the sample are food secure. The analysis by farm type indicates that, among the modernised farms, 91.22% are food secure compared to 85.49% for traditional farms. This implies that agricultural modernisation could contribute to improving the level of food security among farming households.

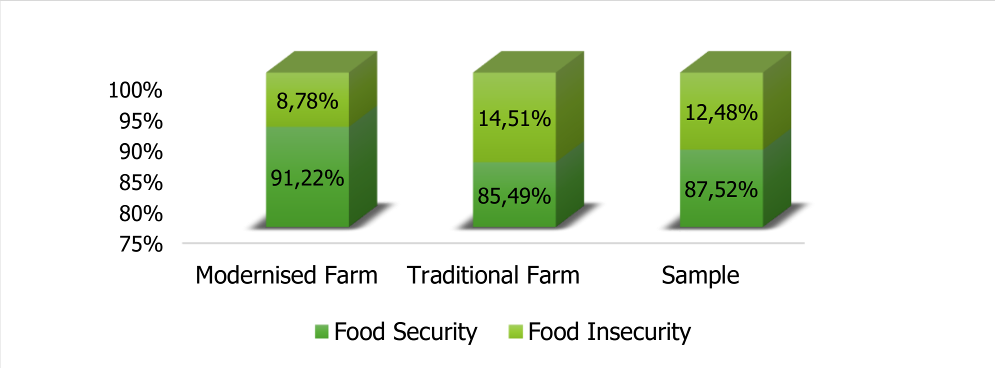

Figure 3: Level of food security according to farm type
Source: Authors, based on MARAH/EPA 2021 data

Table 5 presents the quantitative variables used in the analysis. The results show that the studied sample consists of older individuals. Indeed, the average age of household heads in the study was 50 years. In Burkina Faso, farms are generally small. In this analysis, the results show that households cultivate an average of 4.67 hectares of land. As for the size of the farming household, the average was 10 people per household. National statistics confirm these results. On average, there are between 10 and 11 members in each farming household in Burkina Faso (MARAH 2021). The average income is FCFA 277 213.7.

Table 5 : Statistics of quantitative variables

Variables	Observations	Mean	Std dev	Minimum	Maximum
Age of household head	4 824	50.17	14.22	16	99
Household size	4 824	10.90	5.29	3	22
Income (in FCFA)	4 824	277 213.7	479 657.4	57 600	4 150 000
Cultivated area (in hectares)	4 824	4.67	5.10	0.0089	51.43

Note: FCFA = West African Franc
Source: Authors, based on MARAH/EPA 2021 data

Figure 4 presents the descriptive statistics of the qualitative variables used in model (2). The analysis of the results reveals that 72% of the household heads in the sample were illiterate. The primary education rate for household heads was 9.62%. Furthermore, at the secondary level, the education rate for household heads was 2.24%. For higher education, the rate for household heads was 0.68%. In addition, for madrasah education and literate household heads, the rates were 3.46% and 11.86% respectively.

The analysis of the gender factor shows significant heterogeneity in the sample. Gender is one of the key factors in analysing the explanatory factors of food security. Among the 4 824 households in the sample, only 7.48% were headed by women, compared to 92.52% by men.

Considering access to credit, this variable reveals that only 12.73% of the surveyed household heads had access to agricultural credit. Furthermore, the analysis in Table 6 shows that 21.93% of the surveyed households were members of a farmers' organisation. The results also show that, within the sample, 11.01% of the surveyed household heads engaged in related activities.

As for agricultural modernisation (variable of interest), the analysis in Figure 4 reveals that 35.43% of farms were modernised, compared to 64.57% of traditional farms.

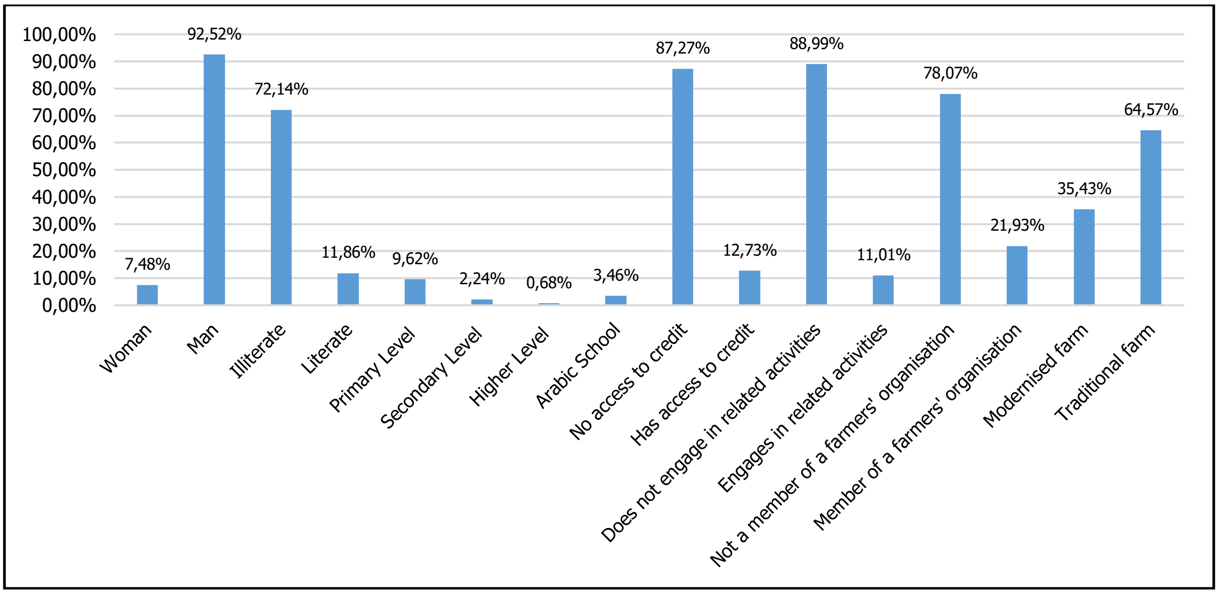

Figure 4: Descriptive statistics of qualitative variables
Source: Authors, based on MARAH/EPA 2021 data

3.2 Estimation results

Table 6 presents the results concerning the effects of agricultural modernisation on food security. The LR test (Prob > chi^2 = 0.0000) indicates that the model is statistically significant. The multicollinearity test performed shows no problem of multicollinearity between the explanatory variables chosen, as all calculated VIFs are below 4 and the mean VIF is 1.13. Furthermore, the linktest results indicate that the model is correctly specified, as the p-value associated with the prediction variable, _hat, is significant, while that associated with the squared prediction variable, _hatsq, is not.

The endogeneity test (Durbin-Wu-Hausman test) rejects the null hypothesis of exogeneity (p = 0.0009). This confirms that the agricultural modernisation variable is indeed endogenous. Furthermore, the strength of the instruments is evidenced by a first-stage F-statistic of 17.86, which exceeds the rule of thumb of 10. This indicates that our instruments (notably the household head's level of education) are not weak and sufficiently explain the variation in modernisation to allow for reliable second-stage estimation.

To address potential endogeneity bias and reverse causality (where wealthier households might modernise more easily), we employed an instrumental variables (2SLS) approach. The Hausman test ($p < 0.01$) confirms that modernisation is endogenous. By using the household head's education level as an instrument, we isolate the specific effect of modernisation. The results demonstrate that even after correcting for this bias, modernisation reduces the risks of food insecurity.

The econometric analysis (Table 6) identifies several major levers that positively influence food security in Burkina Faso, primarily linked to modernisation, education and access to resources. The coefficient for agricultural modernisation is negative and significant at the 1% level, confirming its protective role against food insecurity (up to -3.9% for the borderline threshold). This result corroborates the work of Zou and Mishra (2024) on food stability induced by technical progress. Similarly, access to credit fosters innovation (Guodaar *et al*. 2016) and reduces the risk of insecurity (-3.2% at the borderline threshold; -2.7% at the moderate threshold). Finally, the expansion of areas sown generates productivity gains (Mbétid-Bessane 2014), thereby decreasing vulnerability (-1% at the borderline threshold; -0.8% at the moderate threshold).

In line with human capital theory (Schultz 1961; Becker 1964), education drastically reduces vulnerability, particularly at the tertiary level (-16.8% for the borderline threshold). Conversely, households headed by women or individuals over the age of 45 are more exposed, owing to limited access to productive capital (Amao *et al*. 2017) and declining physical capacity (Sigue *et al*. 2019). Furthermore, household size slightly reduces the risk (-0.3% at the borderline threshold; -0.2% at the moderate threshold), suggesting that large families provide a valuable agricultural workforce (Folefack *et al*. 2012).

Membership in farmers' organisations facilitates the transfer of agroecological skills (Altieri 2002) and reduces the risk of insecurity by -4.7% (borderline threshold). In parallel, engaging in non-farm activities stabilises overall income (Yabile 2013) and mitigates precariousness (-3.4% at the borderline threshold; -2.8% at the moderate threshold).

Although agricultural income is significant, its marginal effect remains weak. This counterintuitive result can be explained, firstly, by the existence of a low-income trap, where the volatility of marginal gains is entirely absorbed by incompressible consumption expenditure, and secondly, by an accumulated wealth effect. Indeed, this stock of wealth is captured by the modernisation variable (which reflects farm capitalisation and the capacity to overcome technological barriers) rather than by current monetary flow. This demonstrates that household resilience depends less on fluctuations in gross income than on safeguarding technical capital and ensuring access to productive assets (Hill 2019).

4. Conclusion and economic policy implications

This paper analysed the effects of agricultural modernisation on household food security in rural Burkina Faso. The data used in this analysis are derived from the Permanent Agricultural Survey (MARAH/EPA 2021). The methodology employed is a combination of statistical and econometric analyses. In the statistical analysis, food security indicators were calculated using the CARI approach. The calculated food security index (FSI) allowed for the regression of household food security status against socioeconomic and demographic variables using an ordered multinomial logit model. The results obtained demonstrate that agricultural modernisation reduces food insecurity among rural households in Burkina Faso.

In short, this research has highlighted the importance of agricultural modernisation in combating food insecurity among rural households in Burkina Faso. In the light of these findings, such modernisation can serve as a lever to improve food security in rural areas. To achieve this, policymakers should deploy several complementary mechanisms. Firstly, land tenure must be secured by simplifying the procedures for obtaining land titles, thereby encouraging producers to invest sustainably in their land. On a technical level, this momentum must be supported by an effective structuring of the certified seed sector, backed by subsidies and local distribution networks. At the same time, it is crucial to facilitate access to production inputs by regulating and optimising the use of chemical fertilisers and pesticides, whilst developing rigorous water resource management to secure yields against climate hazards. Finally, promoting shared mechanisation models will enable smallholders to reach the necessary capitalisation threshold. Future studies, for their part, could analyse the effect of agricultural modernisation on household nutritional security.

Table 6 : Logistic regression results

Explanatory variables	**Ordered logistic regression**	**Marginal effects**			
		FS (1)	**BFS (2)**	**MFI (3)**	**SFI (4)**
Agricultural modernisation	-0.324*** (0.062)	0.073*** (0.013)	-0.039*** (0.007)	-0..32*** (0.006)	-0.002*** (0.0005)
Age of the household head	0.005** (0.002)	-0.001** (0.0004)	0.0006** (0.0002)	0.0005** (0.0002)	0.00003** (0.00001)
Gender of the household head	-0.249** (0.106)	0.056** (0.024)	-0.030** (0.012)	-0.024** (0.010)	-0.001** (0.0007)
Educational level of the household head *Illiterate = reference*					
Literate	0.067 (0.091)	-0.015 (0.020)	0.007 (0.010)	0.007 (0.009)	0.0004 (0.0006)
Primary level	-0.356*** (0.103)	0.080*** (0.022)	-0.045*** (0.014)	-0.032*** (0.008)	-0.001*** (0.0006)
Secondary level	-0.207 (0.208)	0.047 (0.046)	-0.026 (0,027)	-0.019 (0.018)	-0.001 (0.001)
Higher level	-1.277*** (0.412)	0.257*** (0.065)	-0.168*** (0.049)	-0.084*** (0.015)	-0.004*** (0.001)
Arabic school	-0.217 (0.165)	0.049 (0.037)	-0.027 (0.021)	-0.020 (0.014)	-0.001 (0.0009)
Household size per adult equivalent	-0.028*** (0.006)	0.006*** (0.001)	-0.003*** (0.0007)	-0.002*** 0.0006)	-0.0001*** (0.00005)
Access to credit	-0.270*** (0.103)	0.061*** (0.023)	-0.032*** (0.012)	-0.027*** (0.010)	-0.001** (0.0007)
Related activities	-0.285*** (0.096)	0.064*** (0.021)	-0.034*** (0.011)	-0.028*** (0.009)	-0.001*** (0.0006)
Cultivated area	-0.088*** (0.009)	0.019*** (0.002)	-0.010*** (0.001)	-0.008*** (0.0009)	-0.0005*** (0.0001)
Agricultural income	0.000** (0.000)	0.000** (0.000)	0.000** (0.000)	0.000** (0.000)	0.000** (0.000)
Membership in farmer organisations	-0.393*** (0.083)	0.089*** (0.018)	-0.047*** (0.009)	-0.039*** (0.008)	-0.002*** (0.0006)
Cut1	-0.732 (0.152)				
Cut2	1.144 (0.153)				
Cut3	4.283 (0.232)				
Number of observations Pseudo R^2 LR $chi^2(14)$ Prob > chi^2	4 824 0.0502 475.17 0.0000				

Note: *** = p < 0.01, ** = p < 0.05, * = p < 0.1
Source: Authors, from MARAH/EPA 2021 data

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