

*Full Length Research Paper*

# Modernization of family farms improves the sustainability of food security for farm households in Burkina Faso

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Family farms are poorly modernized in Burkina Faso despite their predominance in the country's agriculture and their major contribution to national food production. Convincing evidence of the contribution of family farm modernization to food security is needed to support advocacy. This study used data from recent national longitudinal surveys and Cox semi-parametric regression methods to explore the effect of factors of modernization on the food security of farm households in Burkina Faso. The results showed that the training of agricultural workers, ownership of traction animals, and use of improved seeds reduced the risk of food-secure households falling into food insecurity by 22.8, 21.6, and 14.9%, respectively. These three factors significantly determine the stability of households' food security, suggesting that the modernization of family farms could contribute to the prevention of food insecurity in Burkina Faso. A key strength of this study is that it was able to capitalize on the wealth of these data, which come from national surveys that are representative of farm households at the provincial level, longitudinal and prospective, making it possible to track the same households over time, at an annual frequency.

**Key words:** Agricultural modernization, family farming, food security, Burkina Faso

## INTRODUCTION

Since the colonial period, the Sudano-Sahelian populations have experienced recurrent food crises, making food insecurity a historical marker of their societies and spaces. These populations have been exposed to several forms of food insecurity, ranging from seasonal to persistent (Janin, 2010). For example, the famine of 1972/1973, which led to the creation of the Standing Inter-State Committee for Drought Control in the

Sahel (CILSS), was one of the most serious food crises experienced by the Sudano-Sahelian populations in the twentieth century (Courade et al., 2000; Bonnetcase, 2010). Even today, food insecurity remains an acute problem in Sahelian and West African countries. According to the Cadre Harmonisé analyses of the food and nutritional situation in the Sahel and West Africa, more than nine million people were experiencing a food

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crisis between October and December 2019, including 620,000 considered to be in food emergency status (RPCA, 2019). These situations of food insecurity, which characterize in particular the Sahelian populations, who are more vulnerable to food insecurity (Janin, 2006), are due on one hand to rainfall deficits and land degradation that hamper agricultural and fodder production in the region, and on the other, to insecurity and intercommunity conflicts that prevent the populations from accessing the food produced (Ouédraogo et al., 2007; RPCA, 2019).

As a Sahelian and essentially agricultural country, Burkina Faso is not exempted from the food insecurity situation that prevails in the West African sub-region. In this country, food insecurity is a matter of constant concern and is part of the daily life of many households. For example, in 2008, 83.5% of households felt food-insecure, of which 30% were moderately food-insecure and 5.5% highly food-insecure (DGPER, 2009). This sense of food insecurity is reflected in household food consumption patterns. In 2012, about 57% of Burkinabe households had poor and limited food consumption, mainly dominated by cereals (Burkina Faso, 2012). According to the same source, food insecurity affected more than 35% of households in the 170 communes declared at risk of food insecurity in 2012. Also in 2012, the United Nation's Food and Agriculture Organization (FAO) estimated the number of food-insecure people in Burkina Faso at 1.8 million (FAO, 2012). More recently, between October and December 2019, more than 1.2 million food-insecure people need immediate assistance in Burkina Faso (RPCA, 2019). These figures show that Burkina Faso faces a chronic challenge to ensure sustainable food and nutrition security for its population.

To meet this challenge, family farms can play an important role in addressing the problems of food insecurity. Indeed, the contribution of these family farms is essential to the food supply of the Burkinabe population. For example, the demand for sorghum and millet is fully met by national production, which comes predominantly from family farms. These products represent about 66% of national cereal supplies (Zoundi, 2012; FEWS NET, 2017). In addition, family farms supply the country's major cities with fresh produce (Robert et al., 2018). These family farms have also proven their capacity to supply the national market with locally-produced broiler chickens (Ouédraogo and Zoundi, 1999). Despite this contribution to the country's food supply, Burkina Faso's family farms are poorly modernized, as is its agriculture overall, being characterized by low mechanization and low consumption of agricultural inputs. In 2009, the proportion of farms using a tractor was 0.2% and the amount of fertilizer used on arable land was 9.13 kg/ha in Burkina Faso, compared to 10.46 kg/ha in sub-Saharan Africa and 122.13 kg/ha globally (MAFAP, 2013). This poor modernization of agriculture is most pronounced at the level of small family farms with a surface area of three hectares or less. At this level, Taondyande's (2018)

analysis of the production potential of family farms in Burkina Faso is very illustrative.<sup>1</sup> That analysis revealed that in the 2016/2017 agricultural season, the dose of mineral fertilizer used was 12 kg/ha for very small farms and 19 kg/ha for small farms, while it was 53 kg/ha for large farms. Furthermore, that analysis showed that improved seeds were not much used in Burkina Faso. For the group of very small and small farms, the rate of use of improved seeds was about 1 kg/ha on average compared to 6.6 kg/ha for large farms, which is far below the required rate of 15 kg/ha.

On the strength of this observation, the country has embarked on a process of modernizing its agriculture, which is heavily dominated by family farms (Burkina Faso, 2015a). Family farming is thus increasingly taken into account in this modernization process. The authorities' commitment to the modernization of family farms is reflected in the national food and nutritional security policy, which takes into consideration family-based agriculture and the development of family farms (Burkina Faso, 2013). The agro-sylvo-pastoral, fisheries, and wildlife policy law adopted in 2015 also testifies to this commitment of the Burkinabe authorities to the modernization of family farms. For example, article 116 of this law stipulates that: "Mechanization in the agro-sylvo-pastoral, fisheries, and wildlife sectors must be adapted and accessible to family farmers" (Burkina Faso, 2015b, p. 54, authors' translation). The successful implementation of such strategy to modernize family farms must be supported by convincing evidence of the positive impact of their modernization on food security. This study therefore sought to test the hypothesis that modernizing family farms can lessen the risk of households becoming food-insecure.

Over the past two decades, much work has been done on the issue of food in developing countries, particularly in sub-Saharan Africa (Courade et al., 2000; Babatunde et al., 2007; Ouédraogo et al., 2007; Coulibaly et al., 2008; Beyene and Muche, 2010; Janin, 2010; Yabile, 2011; Zoundi, 2012; Ndobu and Sekhampu, 2013; Gebrehiwot and van der Veen, 2015; Bekele, 2017; Feyisa, 2018). Of these studies, only a few have sought to identify factors associated with food security or insecurity in sub-Saharan Africa, and those have focused mainly on Ethiopia (Beyene and Muche, 2010; Gebrehiwot and van der Veen, 2015; Bekele, 2017; Feyisa, 2018). Using econometric models, these studies confined themselves to the identification of factors associated with food security (or food insecurity) status, but without establishing causal links between these factors and food security. This was due in particular to

<sup>1</sup> Taondyande's study (2018) classified family farms into five groups: very small farms with areas less than 1.2 ha; small farms with areas between 1.2 and 2.1 ha; medium-sized farms with areas between 2.1 and 3.3 ha; fairly large farms with areas between 3.3 and 5.5 ha; and large farms with areas greater than 5.5 ha.

the cross-sectional nature of the data used in these studies, which did not allow causal links to be established between the phenomenon under study and variables that evolve over time. In contrast to previous studies, the present study used recent longitudinal data (panel data) with appropriate analyses (biographical analyses) to assess the impact of family farming modernization factors in Burkina Faso on households' likelihood of not becoming food-insecure.

## LITERATURE REVIEW

Food security is a complex concept that has evolved considerably over time. In 1996, the World Food Summit defined food security in these terms: "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996; FAO, 2008, p.1). This definition, widely used today, has four main dimensions that must be applied simultaneously to achieve food security objectives: physical availability of food, economic and physical access to food, food utilization, and stability of the other three dimensions over time (FAO, 2008). The complexity of the concept of food security has resulted in the existence of several conceptual frameworks that attempt to better explain the linkages between the different dimensions of food security and related concepts, such as ecological, social, economic, and political aspects. These associated concepts contribute to the overall understanding of food security by shedding light on the choices and issues that determine the availability of the food that people need and want (FAO, 2011; Ndoobo and Sekhampu, 2013).

The relationship between food security and the modernization of family farms can be analyzed in terms of the first dimension of food security, which concerns food supply. This supply is determined by the level of food production, size of reserves, and net trade (FAO, 2008; Burkina Faso, 2012). Generally speaking, agricultural modernization can be understood as a modification of agricultural production conditions aimed at improving not only the quantity of production, but also the productivity of the various factors (capital, labor, land) involved in agricultural production (Perrier-Bruslé, 2009). Applying these changes at the family farm level is likely to result in better coverage of household food needs in developing countries. Advocates of family farming believe that profound changes in the production conditions of family farms in developing countries are key to ensuring food security in these countries (Zoundi, 2012; Taondyande, 2018).

In the literature, the relationship between the factors of agricultural modernization and food security has thus far been inadequately examined. Existing research can be divided into two groups. The first includes studies that

directly investigated the factors associated with food security or insecurity; the second group consists of studies that established a link between modernization and agricultural productivity based on the hypothesis that productivity has an influence on food security. The studies that investigated factors associated with food security or insecurity has shown that modern technologies, such as fertilizers and improved seeds, have an influence on the food security of small family farms. In south-western Ethiopia, Feyisa (2018) observed at the bivariate level that households using improved seeds were more food-secure than those not using them. Also in Ethiopia, Bekele (2017) noted in Wolayta that access to improved seeds helped diversify and increase food production of rural households, with a positive impact on food security. With regard to fertilizer, its impact on food security is unclear. While Beyene and Muche (2010) showed that the use of chemical fertilizer positively influenced food security in central Ethiopia, Feyisa (2018) observed, on the contrary, that the amount of fertilizer used was negatively associated with food security. However, studies have shown that fertilizer use has a positive impact on agricultural productivity in Central Africa (Yakete-Wetonoubena and Mbetid-Bessane, 2019) and on global agricultural production (Roberts, 2009).

In addition to modern technologies, some studies have found other variables of agricultural modernization, such as access to agricultural credit and the use of water and soil conservation (WSC) techniques, to be explanatory factors for food security (Beyene and Muche, 2010; Gebrehiwot and van der Veen, 2015). For example, in the Tigray region of northern Ethiopia, Gebrehiwot and van der Veen (2015) assessed the impact of a food security program based on financial loans. That program provided credit to poor households for a range of agricultural activities and training. Their study showed that the program had a positive effect, in that it improved household dietary caloric intake by 772.19 kcal/day per adult. Regarding WSC techniques, Beyene and Muche (2010) showed that these significantly influenced the food security of rural households in central Ethiopia. Households practicing at least one WSC technique were 3.5 times more likely to be food-secure than those practicing none.

Other studies have shown that the modernization of family farms can influence household food security through the increased agricultural yield generated. For example, animal traction, often presented as the driving force behind the modernization of family farming in sub-Saharan Africa, accelerates the execution of cultivation operations, thereby increasing the area under cultivation and, by extension, the quantities produced (Havard et al, 2009). Yabile (2011) showed that ownership of agricultural equipment was associated with lower food vulnerability of populations in four regions of Côte d'Ivoire. In Togo, Saragoni et al. (1992) showed that

applying a mineral fertilizer on a variable crop succession increased the productivity of degraded soils by restoring the physical properties of these soils. Similarly, in northern Burkina Faso, an experimental study conducted by Sawadogo et al. (2008) showed that zaï, a WSC technique, increased crop yields and enhanced the value of eroded land. Using zaï and compost enhanced with burkina phosphate, these authors obtained yields of 1200 kg/ha for sorghum on crusted soils, whereas the most fertile land in the same region usually produces barely 800 kg/ha under normal rainfall conditions. In general, this brief review of the literature shows that modernization of family farms can contribute to achieving food security objectives in developing countries.

## DATA AND METHODOLOGY

### Data sources

The data used in this study are from the Burkina Faso Permanent Agricultural Surveys (EPA) series. The EPA is a panel survey conducted annually since 1993 by the Department of Sectorial Studies and Statistics (DGESS) of the Ministry in charge of agriculture. It covers the entire national territory with representative results at the provincial level. Since the start of the EPA, three panels have been tracked, with a renewal of farm households every five years. Data on food security were collected during the 2008/2009 agricultural season. These data currently cover two panels: crop years 2008/2009 to 2012/2013; and crop years 2013/2014 to 2016/2017.

The present study used data from the latest panel for the 2013/2014 to 2016/2017 crop years. The sample for this panel was obtained through a two-stage random draw and stratified by province and type of producer (small producers from low-potential villages, small producers from high-potential villages, large producers from low-potential villages, and large producers from high-potential villages). At the first level, 1759 administrative villages were drawn with a probability proportional to the size of the villages. At the second stage, 5297 agricultural households were selected by simple random selection without discount. Sample of households tracked fluctuated slightly over the period. The sample consisted of 5,297 farm households in 2014, 5,014 in 2015, 5,079 in 2016, and 5,165 in 2017. This sample instability is related to the entry and exit of some households in the survey clusters. Of all the households tracked, 4,943 were food-secure at least once between 2014 and 2017.

The geographical scope of this panel is all agricultural households in Burkina Faso except those in the urban communes of the following 12 cities: Ouagadougou, Bobo Dioulasso, Banfora, Koudougou, Tenkodogo, Kaya, Fada N'gourma, Po, Gaoua, Dori, Dédougou and Ouahigouya. Each EPA round consists of three distinct phases: the first phase involves enumerating household members and updating basic information. The second phase is for crop forecasting, stock estimates, and production utilization. The third phase concerns the acquisition and the use of agricultural inputs, the estimation of harvests from yield squares and the assessment of the level of food security.

### Study variables

The dependent variable in this study was the length of time (in years) that a farm household was food-secure. The food-secure or food-insecure status of the household was thus a key variable. It

was captured from the household consumption score. This indicator, based on the number of days of consumption of eight food groups during the past week, is a good indicator of household access to a sufficiently energetic diet (Leroy et al., 2015). The eight food groups used are: main foods (rice, corn, tuber,...); peas and lentils; vegetables; fruits; meat and fish; milk; sugar and oil. Weights determined by the World Food Programme (WFP) ranging from 0.5 to 4 were assigned to each food group. The household food consumption score is calculated by first multiplying for each food group its frequency of consumption during the last seven days by its food weight, and then averaging the scores obtained. The score calculation classifies households into two groups: those with a score equal or less to 35 are in food insecure group and those with a score of more than 35 are in food secure group.

The independent variables of interest were: agricultural worker training, measured by the presence of at least one trained agricultural worker in the household; access to agricultural credit, measured by the presence in the household of at least one member who had received agricultural credit; membership in farmers' organizations, measured by the presence of at least one agricultural worker in the household who was a member of a farmers' organization; traction animal ownership, measured by the presence of at least one traction animal in the household; the use of WSC techniques, measured by the presence of at least one household plot being cultivated using WSC techniques; fertilizer use, measured by the use of fertilizer (urea, phosphate, NPK) on at least one household plot; and the use of improved seeds, operationalized by the use of improved seeds (maize, sorghum, fonio, yam, etc.) on at least one household plot. These variables were dichotomous, with the modalities being "yes", if the household possessed the factor, and "no", if otherwise.

These variables of interest were first tested in a survival model before being taken into account in the analyses. Those tests led to the removal of access to agricultural credit from the analyses. In fact, this variable was highly correlated with agricultural worker training, as more than 70% of farm households with access to agricultural credit had at least one trained agricultural worker. As such, agricultural worker training captured the effect of access to agricultural credit. Subsequently, the six variables retained were used to create a composite variable called "degree of agricultural modernization", which was used to test the combined effect of factors of modernization on food security. This variable, also used in the analyses, comprised seven modalities ranging from zero (0) for households with no factors of modernization to six for those with all six of the selected factors of modernization.

The other explanatory variables used to control the effect of factors of modernization were: cotton cultivation (yes, no); agro-ecological region (East, Sahel, Center, North-West, West); rainfall (in mm); sex of the head of household (male, female); age group of the head of household (under 35 years, 35–49 years, 50–59 years, 60 years and over); education of the head of household (educated, uneducated); area per agricultural worker (less than 1 hectare, 1 to less than 3 hectares, 3 to less than 6 hectares, 6 hectares and over); and household size (under 8 persons, 8 to 12 persons, and more than 12 persons). The agro-ecological regions, which correspond to the five environmental and agricultural research regions of the Institute of the Environment and Agricultural Research (INERA) of Burkina Faso, are used to control the effect of biophysical factors such as soil fertility. The use of area per agricultural asset in the analyses is justified by the fact that family farms are not homogeneous and the impact of modernization factors can vary according to the different types of family farms.

### Analysis methods

To assess the impact of agricultural modernization on food security, this study used Kaplan-Meier life tables and Cox semi-parametric

regression. These biographical methods were chosen because of the longitudinal nature of the data. Their implementation was based on a conceptualization of farm households' transition from food security to food insecurity, which is important to explain. A household is at risk of experiencing the event (food insecurity) from the moment that it is in a food security situation. Thus, the observation began as of the date on which the household was first food-secure and continued until occurrence of the event (food insecurity). Households that did not experience the event by the observation end date (2017) were considered right-censored. Thus, censoring occurred if, at the date of the last survey, the household had not yet experienced a situation of food insecurity. The two types of observation exits (occurrence of event, date of survey) were the only ones considered in this study. This design excluded from the analyses households that had never experienced food security during the period. Consequently, these biographical analyses focus on the 4,943 households that experienced food security at least once between 2014 and 2017.

Kaplan-Meier's life table method, which describes events evolving over time, was used to explore the stability of households' food-secure status based on the factors of agricultural modernization. Such tables are used to construct curves representing time distribution before the occurrence of an event (Bocquier, 1996); in this case, a household's becoming food-insecure. Significance tests (logrank tests) were conducted to verify whether the differences observed between households using a factor of modernization and those not using the same factor were significant. Cox semi-parametric regression was used to measure households' risk of falling into food insecurity according to the factors of agricultural modernization. This regression model calculated the effects of factors of modernization and control variables on the annual risk of falling into food insecurity. A significance threshold of 5% was used in this study.

## RESULTS

### Evolution of food security and factors of agricultural modernization

This analysis covered all households tracked between 2014 and 2017, whether they were food-secure or not. It showed that, over the period 2014–2017, the proportion of food-secure farm households declined steadily, from 83.1% in 2014 to 68% in 2017 (Figure 1). The decline in the proportion of food-secure households worsened over that period. In fact, the difference in proportion went from 2.1% between 2014 and 2015, to 5.8% between 2015 and 2016, and 7.2% between 2016 and 2017. These proportion differences are statistically significant from one year to the next at the 5% threshold. These results suggest deterioration in the food status of farm households in Burkina Faso over the period studied. This situation can be related to the insecurity that the country has been experiencing since 2015. According to the Food Crisis Prevention Network, the security situation has aggravated food insecurity and undermined the livelihoods of people in Sahelian countries (RPCA, 2019).

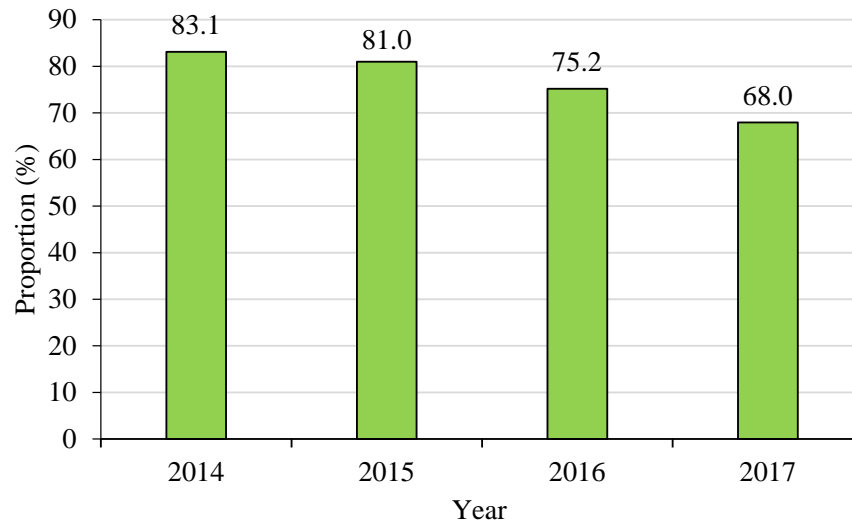
Figure 2 presents the evolution of the factors of farm modernization, based on the proportion of households with access to these factors. The curves show that the factors of agricultural modernization changed little over

the 2014–2017 periods. For all factors, differences between the extremities of the proportions in that the period are below 8%. These differences range from 2.5% for use of improved seeds to 7.1% for membership in a farmers' organization. Moreover, the different factors of modernization evolved discontinuously except for fertilizer use, which increased steadily over the period studied. For example, the proportion of households using WSC techniques and that of households using improved seeds dropped continuously between 2014 and 2016, and then increased slightly in 2017. The same was true for access to credit, which declined between 2014 and 2015 before increasing. While the proportion of households with agricultural workers who were members of farmers' organizations rose steadily from 2015 onwards, it remained below its initial level of 40% in 2014.

### Factors of modernization and household survival in food security

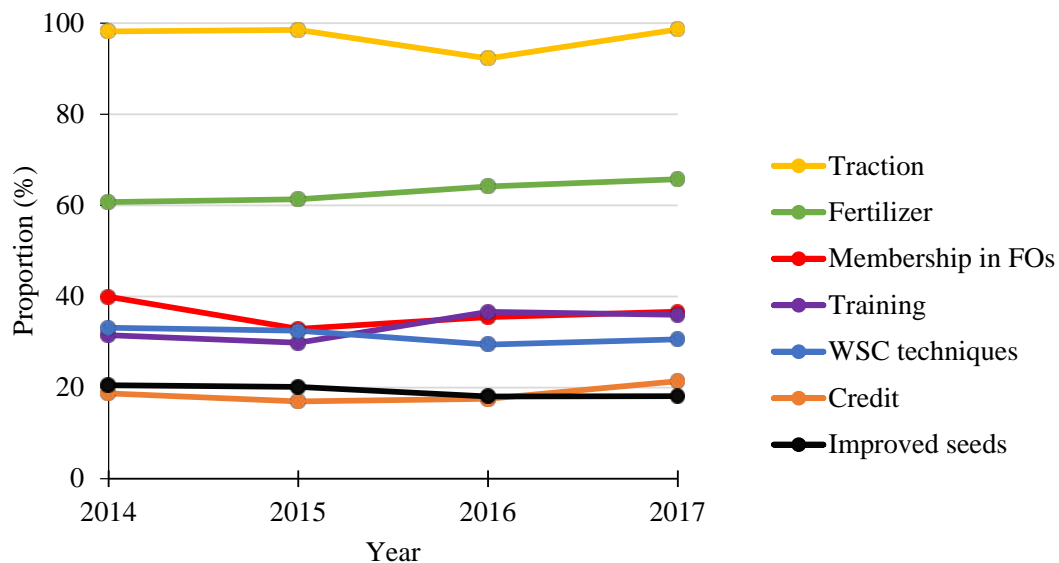
The analysis in this section focused on farm households' stability in food security by measuring the time elapsed between the first observed food security situation from 2014 onwards and the moment when these households became food-insecure. Overall, nearly 41% of households became food-insecure during the period 2014–2017. The curves constructed from the Kaplan-Meier estimators illustrate the timelines of household food security status and the differences according to the factors of agricultural modernization. Figure 3a shows that households with no trained agricultural worker become food-insecure at a faster rate than those with at least one trained agricultural worker. In 2015, 5.3% of households with no trained agricultural worker fell into food insecurity, compared to 3% for those with at least one trained agricultural worker. These proportions were 15.3 versus 11.1% in 2016 and 43.5 versus 35.4% in 2017. The significance test for this factor of modernization showed the difference between these two household groups to be significant at the threshold of 1%.

The curves in Figure 3b show that households with no agricultural workers belonging to a farmers' organization become food-insecure faster than those with at least one worker who did. However, the proximity of the two curves suggests these two groups of households fell into food insecurity in much the same way. This was confirmed by the test of significance for farmers' organization membership, which turned out to be non-significant. In contrast to that factor, ownership of traction animals contributed positively to the stability of food-secure households. Figure 3c indicates that households that owned at least one traction animal fell into food insecurity less quickly than those without a traction animal. For example, in 2016, 13.2% of households that owned at



**Figure 1.** Evolution of the proportion of households in food security from 2014 to 2017.

Source: EPA, 2014–2017 panel.



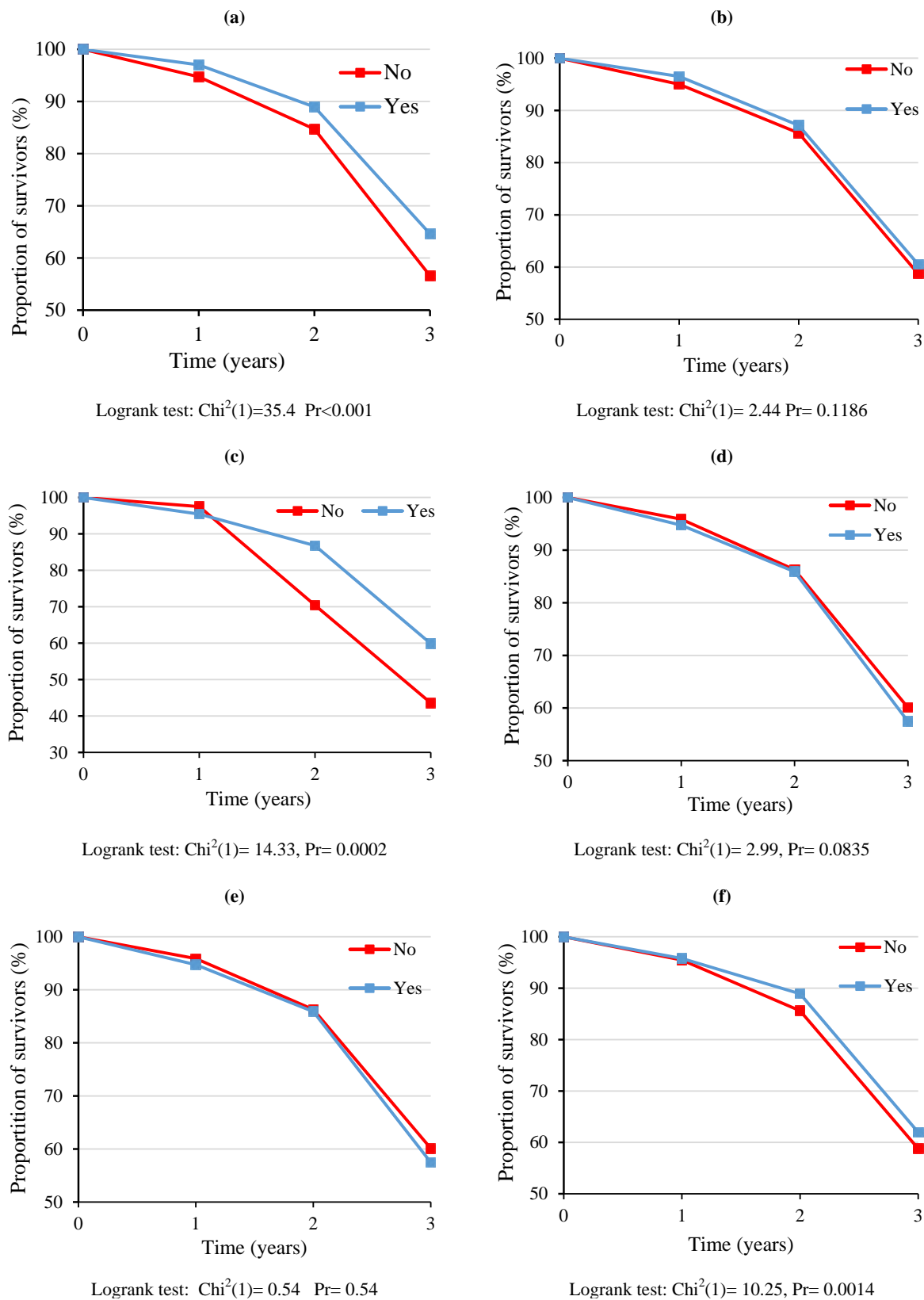
**Figure 2.** Evolution of the factors of modernization from 2014 to 2017.

Source: EPA, 2014–2017 panel.

least one traction animal became food-insecure, compared to 29.6% of households with none. The difference between these two groups of households was significant at the threshold of 1%.

Figure 3d shows that households that used WSC techniques fell into food insecurity slightly faster than those that did not use them. However, the difference between these two groups was not significant at the 5% threshold. Similarly, Figure 3e indicates that households that used fertilizer fell into food insecurity slightly faster

than those that did not use fertilizer. However, the significance test showed the observed difference was not statistically significant. With regard to the use of improved seeds, the results showed that households that used them fell into food insecurity less quickly than those that did not (Figure 3f). The proportions of households falling into food insecurity were 4.5, 14.4, and 41.2% in 2015, 2016, and 2017 respectively for households not using improved seeds, compared to 4.2, 11.1, and 38% in 2015, 2016, and 2017 respectively for those using



**Figure 3.** Household food security survival according to factors of modernization (a) Training of agricultural workers (b) Farmers' organization membership (c) Traction animal ownership (d) Use of WSC techniques (e) Use of fertilizer and (f) Use of improved seeds of family farms. Source: EPA, 2014–2017 panel.

improved seeds.

### **Effects of factors of modernization on household food security**

Analyses in this section focused on factors of modernization that might explain a household's risk of becoming food-insecure based on Cox semi-parametric regression. Table 1 presents these results. Model 1 estimated the combined effect of the factors of modernization, while Model 2 estimated each factor's net effect on households' food security stability. The results of Model 1 showed that the net effects of the degree of agricultural modernization on the food security of farm households were significant at the 1% threshold. Thus, households with one or more factors of modernization were 41.5 to 57.3% less likely to become food-insecure than were households with none. Furthermore, the observation of relative risks indicated a variation in the effects of the degree of agricultural modernization, from the effect of a single factor to the cumulative effect of the six factors of modernization.

Analysis of the results of Model 2 showed that the presence of at least one trained agricultural worker, the ownership of traction animals, and the use of improved seeds significantly determined the stability of households' food security. Thus, households with at least one trained agricultural worker were 22.8% less likely to become food-insecure than households with none. Similarly, households with at least one traction animal were 21.6% less likely to become food-insecure than those with none, and households that use improved seeds were 14.9% less likely to become food-insecure than households that did not use them. On the other hand, the results of Model 2 showed that membership in farmers' organizations, the use of WSC techniques, and the use of fertilizer did not determine households' food security stability at the 5% threshold. These factors of agricultural modernization had no significant effect even in the raw model.

### **Effects of other variables on household food security**

The results of Model 2 showed that cotton cultivation, agro-ecological region, and household size were determining factors in household food security. Cotton cultivation had a negative effect on households' food security stability. Households that grew cotton were 16% more likely to become food-insecure than those that did not. Households in the Sahel were 53.8% less likely to become food-insecure than those in the Western agro-ecological region. On the other hand, households in the Eastern, North-Western, and Central agro-ecological regions were 18, 23, and 47% more likely, respectively, to be food-insecure than were households in the Western region. In terms of household size, larger size was

associated with lower risk of falling into food insecurity. Households with more than 12 persons were 15.7% less likely to be food insecure than those with fewer than eight persons.

The results also indicated that the gender and age of the household head, as well as the area per farm worker, had significant gross effects. Households headed by females were 41.7% more likely to be food-insecure than were those headed by males. Similarly, households with heads aged 60 years and older were 15.3% more likely to be food-insecure than were those headed by a person under 35 years of age. Compared to households with less than one hectare, households with more than three hectares per agricultural worker were 14.3 to 29.5% less likely to be food-insecure. However, the effects of these three variables were insignificant when all the variables in the study were taken into account.

## **DISCUSSION**

### **Evidence of the impact of agricultural modernization on food security**

The results of this study showed that the degree of agricultural modernization was a major determinant of food security for farm households. Overall, accumulating several factors of agricultural modernization significantly reduced the risk of a farm household falling into food insecurity. This suggests that the modernization of family farms is likely to contribute to food security stability for farm households. By considering the effect of each of the factors of modernization, this study showed that agricultural worker training, traction animal ownership, and the use of improved seeds had a significant positive effect on the stability of farm households' food security. Having trained agricultural workers in the household significantly reduced the household's risk of falling into food insecurity. This result is in line with expectations, since the training of farm workers enhances the productivity of agricultural labor and agricultural capital, which implies an increased agricultural yield capable of generating decent incomes (Rolland, 2016).

Furthermore, the results show that traction animal ownership positively determined the food security of farm households. This result confirms to some extent the findings of Ndjadi et al. (2019), who showed that the number of animals in livestock farming influences farm performance. In the context of Burkina Faso, the possession of traction animals, on one hand, facilitates the production and transport of organic manure in the fields and the performance of harvesting work using the cart; and on the other hand, it enables the practice of harnessed cultivation for the ploughing of cotton, cereals, and groundnuts (Havard et al., 2004; Poda, 2004; Dufumier, 2015). The work of Yakete-Wetonoubena and Mbetid-Bessane (2019) have shown that switching from



**Table 1.** Results of explanatory analyses from Cox semi-parametric regressions.

Independent variable	Gross effect	Net effect	
		Model 1	Model 2
<b>Degree of modernization</b>			
0 (No factor)	1.000	1.000	--
1	0.499 (0.093) <sup>***</sup>	0.578 (0.108) <sup>**</sup>	--
2	0.533 (0.097) <sup>***</sup>	0.582 (0.107) <sup>**</sup>	--
3	0.552 (0.101) <sup>**</sup>	0.585 (0.108) <sup>**</sup>	--
4	0.493 (0.091) <sup>***</sup>	0.523 (0.099) <sup>***</sup>	--
5	0.402 (0.078) <sup>***</sup>	0.440 (0.087) <sup>***</sup>	--
6 (All factors)	0.388 (0.103) <sup>***</sup>	0.427 (0.115) <sup>**</sup>	--
<b>Agricultural workers training</b>			
No	1.000	--	1.000
Yes	0.770 (0.037) <sup>***</sup>	--	0.772 (0.043) <sup>***</sup>
<b>Farmer's organization membership</b>			
No	1.000	--	1.000
Yes	0.941 (0.043)	--	1.110 (0.064)
<b>Traction animal ownership</b>			
No	1.000	--	1.000
Yes	0.708 (0.073) <sup>***</sup>	--	0.784 (0.082) <sup>*</sup>
<b>Use of WSC techniques</b>			
No	1.000	--	1.000
Yes	1.078 (0.050)	--	1.057 (0.052)
<b>Use of fertilizer</b>			
No	1.000	--	1.000
Yes	1.034 (0.048)	--	0.986 (0.052)
<b>Use of improved seeds</b>			
No	1.000	--	1.000
Yes	0.823 (0.049) <sup>**</sup>	--	0.851 (0.053) <sup>**</sup>
<b>Cotton cultivation</b>			
No	1.000	1.000	1.000
Yes	0.934 (0.050)	1.190 (0.080) <sup>**</sup>	1.160 (0.082) <sup>*</sup>
<b>Agro-ecological region</b>			
East	1.293 (0.082) <sup>***</sup>	1.197 (0.087) <sup>*</sup>	1.176 (0.086) <sup>*</sup>
Sahel	0.487 (0.054) <sup>***</sup>	0.465 (0.053) <sup>***</sup>	0.462 (0.054) <sup>***</sup>
Center	1.597 (0.085) <sup>***</sup>	1.495 (0.087) <sup>***</sup>	1.472 (0.087) <sup>***</sup>
North-West	1.285 (0.112) <sup>**</sup>	1.304 (0.122) <sup>**</sup>	1.226 (0.118) <sup>*</sup>
West	1.000	1.000	1.000
Precipitation	0.999 (0.0001) <sup>**</sup>	1.000 (0.0002)	1.000 (0.0002)
<b>Sex of household head</b>			
Male	1.000	1.000	1.000
Female	1.417 (0.113) <sup>***</sup>	1.112 (0.097)	1.112 (0.096)
<b>Age group of household head (years)</b>			
Under 35	1.000	1.000	1.000
35–49	0.984 (0.067)	1.002 (0.069)	1.005 (0.069)
50–59	1.095 (0.078)	1.122 (0.082)	1.122 (0.082)
60 and over	1.153 (0.081) <sup>*</sup>	1.145 (0.084)	1.147 (0.084)

Table 1. Contd.

<b>Education of household head</b>			
Not educated	1.000	1.000	1.000
Educated	0.928 (0.047)	0.965 (0.051)	0.963 (0.051)
<b>Area per agricultural worker (ha)</b>			
Less than 1	1.000	1.000	1.000
1 to <3	0.925 (0.068)	1.023 (0.078)	1.020 (0.078)
3 to <6	0.853 (0.064)*	0.992 (0.082)	0.990 (0.082)
6 and more	0.705 (0.056)***	0.868 (0.083)	0.867 (0.083)
<b>Household size (persons)</b>			
Fewer than 8	1.000	1.000	1.000
8–12	0.882 (0.045)*	0.948 (0.052)	0.947 (0.052)
More than 12	0.749 (0.041)***	0.846 (0.053)**	0.843 (0.053)**
<b>Chi<sup>2</sup></b>	--	251.591***	268.025***

\*\*\* Significant at 1%; \*\*, \* Significant at 1 and 5%, respectively.

manual to harnessed cultivation has increased agricultural productivity in Ouham in Central Africa.

In addition, the results of the present study showed that the use of improved seeds is an important determinant of the stability of farming households' food security. This result, which confirms the descriptive analyses of some studies (Beyene and Muche, 2010; Feyisa, 2018), can be explained by the fact that improved seeds ensure better and more diversified crop yields and enable farmers to cope with current environmental challenges, including climate change (Bekele, 2017).

#### Other factors determining household food security

This study showed that cotton cultivation, agro-ecological region, and household size determine the stability of households' food security. Cotton cultivation has a significant influence on households' food security status. Contrary to expectations, households that grow cotton are more likely to become food-insecure than are those that do not grow cotton. This result goes against some studies that observed a positive correlation between cotton production and food production (Raymond and Fok, 1995; Poda, 2004). Such a result raises questions about the management of agricultural production in the cotton-growing areas of Burkina Faso. Poda (2004) noted that certain practices, notably the sale, transfer, and sharing of cereals, were likely to lead farm households in the cotton zone in western Burkina Faso into a situation of food non-self-sufficiency. Another explanation for this result could be related to the volatility of cotton prices from one year to the next, which does not allow farmers that mainly produce cotton to have stable and sufficient revenues to guarantee their food security. Furthermore, the negative effect of cotton cultivation on food security

may be explained in the Burkinabe context by the fact that cotton revenues are not often used to purchase food for household consumption.

The results also show that the agro-ecological region determines the food security of farm households. Households in the Eastern, Central, and North-Western regions were more likely to be food-insecure than were those in the Western region. This result can be explained by the favorable climatic and edaphic conditions in the agro-ecological region of western Burkina Faso. Furthermore, the results showed that, compared to households in the Western region, households in the Sahel region were less likely to become food-insecure. One possible explanation for this result is that households in the Sahel region, in addition to agricultural products, benefit from livestock products (milk, meat, etc.), which could ensure greater dietary diversity and thus a better food consumption score.

Household size was found in this study to be associated with a lower risk, in that the larger the household, the less likely it was to become food-insecure. This result contrasts with what was observed in two studies in Burundi (Zoyem et al., 2008) and Ethiopia (Beyene and Muche, 2010). In those studies, larger household size negatively influenced food security. This difference in results could be explained by household composition in terms of agricultural workers and the use of child labor. In Burkina Faso, child labor is still common, such that most household members aged five years and older are considered agricultural workers (ISSP, 2018).

The results of the study also showed that certain variables such as the sex and age of the head of household and the area per farm worker did not determine household food security, all else being equal. These three variables seemed to affect the stability of households' food security through other variables

ultimately considered as determinants, since these variables had significant effects in the raw model. As such, equitable access to factors of modernization by female heads of households, older heads of households, and households with small farms was likely to ensure stability of food security to the same extent as in households headed by men or with large farms.

## Conclusion

The objective of this study was to explore the impact of the modernization of family farms on the food security of farm households in Burkina Faso. To this end, it tested the effects of factors of agricultural modernization on the stability of households' food security. Agricultural modernization was identified as the training of agricultural workers, membership in farmers' organizations, ownership of traction animals, use of fertilizer, use of WSC techniques, and use of improved seeds. The results of the study showed that the degree of agricultural modernization of a household determined the stability of its food security. Households with one or more factors of agricultural modernization were less likely to become food-insecure than those with no such factors. These results suggest that the modernization of family farms can be an important lever in the prevention of food insecurity in Burkina Faso. The combined effect of factors of modernization suggests that the possession of any factor of modernization is equally likely to reduce the risk of households falling into food insecurity. However, estimations of the effect of each factor of modernization showed that, of the six factors tested, three were the major determinant of food security than the others. These were the training of agricultural workers, the ownership of traction animals, and the use of improved seeds. The government must focus on these modernization factors to significantly improve household food security.

The unobserved effects of some factors of modernization may be related to conceptual limitations that are important to note. First, the complexity of the very concept of food security based on four dimensions could make it difficult to apprehend the effects of certain variables on food security, since this modernization does not act a priori on all dimensions of food security. Second, the approach as perceived in this study implies, on one hand, increased and diversified production of food crops intended primarily for personal consumption and, on the other hand, a reinvestment of income from cash production into household food supply. Once modernized, family farms might shift from food crops to cash crops, and the income earned might not be used primarily for household food supply. Such a scenario would not guarantee the achievement of food security objectives. On the other hand, a key strength of this study is that it was able to capitalize on the wealth of these data, which come from national surveys that are

representative of farm households at the provincial level, longitudinal and prospective, making it possible to track the same households over time, at an annual frequency.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

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