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Incomes and Food Security Management in rural areas of Burkina Faso

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Abstract

Food security is traditionally analyzed using one or the other of the four (4) dimensions that are availability, accessibility, quality and stability. The existing empirical analyzes classify households in two situations (food security and food insecurity) through a threshold they set. However, classifying households to two situations is very limited because it does not reflect the actual situation of households. Moreover, in the analysis of the determinants of food insecurity, qualitative models used by empirical investigations generate loss of information. To address these difficulties, the fuzzy set theory and Tobit model are two complementary approaches to identify households facing food insecurity and find its determinants. This methodology will be adopted to measure the impact of incomes management on food insecurity in rural areas in Burkina Faso.

Keywords: Food insecurity, fuzzy sets theory, Tobit model, Burkina Faso.

1. Introduction

Food security is nowadays an increasingly concern for both analysts and decision-makers in developing countries. Since 2008, the global markets of agricultural products have been experiencing significant progress which has had very meaningful effects on global food security (French Development Agency, 2012). Institutions charged with food issues henceforth have acknowledged the importance of the huge demand of biofuel in the rise of staple food prices (FAO, 2008). Global food security is also threatened by the increased revenues of the emerging countries which trigger a huge demand of food products and contributes to reduce their availability at the global level including a rise in the price of food products. Moreover, the high demographic rate brings about cereal deficits within African and Asian regions (CABRAL, 2007).

In Burkina Faso, cereals have a significant role in households 'consumption with a contribution estimated at 60%. Over the period 2000-2013, this country has experienced only one year of cereal needs coverage deficit. As the surplus on the national level hide disparities within households, they could not guarantee to more than 30% of households to cover their cereal needs with their only domestic production. This was confirmed by the recent food crises of 2008 and 2011 which highlighted the need to support households' resilience for a better sustainable management of food insecurity. Several West African countries have responded to the rise of food price by implementing initiatives aiming at reducing prices fluctuation and enhancing agricultural production (Niger citizens feed Niger citizens (3N) in Niger, the Great Agricultural offensive for food and abundance (GOANA) in Senegal and special operations for distributing inputs in Burkina Faso). To meet this goal, stakeholders should rely on a good assessment of the households' food situation.

However, food security is a domain where the complex natures of concepts, the change of comprehension and analysis frameworks are significant (Janin and Dury, 2012). Maxwell and Frankenberger (1995) have identified more than thirty (30) definitions between 1975 and 1991. In addition to these various definitions, several indicators have been developed for food security analyses. These include the coverage rate of cereals needs and the harmonized framework used by the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS); the food consumption score and the dietary and diversity score used by the United Nations Food and agricultural Organization (FAO); the World Food Program (WFP); the United Nations Children's Fund (UNICEF) and Action Contre la Faim (ACF) and the global hunger index of the International Food Policy Research Institute (IFPRI). These indicators are limited in food security analysis because of the lack of

interrelationships between the four (4) dimensions of food security. In addition, for the only concern of classification, thresholds are arbitrarily chosen for analyses using such indicators. In this regard, they have a different appreciation on food security as evidenced by the case of the Boucle du Mouhoun region. Considered as the high potential region and acknowledged as "Burkina granary", this region still shows poor food and nutrition indicators. Considering these situations, there are still some unclarified aspects about how to classify the food and nutrition situation based on such indicators (Janin and Dury, 2012). The way households manage their incomes coming from agricultural products could explain such situations. Well-managed incomes can allow a household to obtain the nutritional complement on the market.

It is therefore useful to assess the impact of incomes management on food security. Dury and Bocoum (2012) have underlined the multi-causal aspect of food and nutrition insecurity and the related role of agricultural production in Malian Sudan area. It is necessary to take into account the multi-dimensional aspect of food security to achieve a good analysis. Therefore, a multi-dimensional approach (fuzzy set approach) to measure food insecurity and econometric model constitute the appropriate combination to treat of incomes management effect on food insecurity.

The overall objective of this study is to analyze the impact of incomes management on food insecurity in rural Burkina using the fuzzy set theory. To achieve this, a synthetic food security indicator will be developed to assess the impact of incomes management on it.

Achieving the global objectives involves verifying the following hypothesis:

H1: incomes management influence food insecurity within rural areas.

This article is built around four sections to better address the concerns raised by the study. The first part is the state of knowledge on the issue; the second is about the data and methodology used. The third present the results of the study and the last, the conclusion.

2. Literature review

2.1. Theoretical and empirical developments on food security

The concept of food security existed in literature before being created. At the Industrial Revolution Period, Malthus (1798) examines in his works "An Essay on the Principle of Population" the relationship between population growth and the livelihood increase. According to him, the population growth brings about unavailable food for the whole population who in turn will face inadequate livelihoods. Malthus' thesis brings an insight on the relation between food availability and population growth. However, this thesis does not take into account the possibility of the food allocation between the different areas of the world and the possibility of transformation of production modes. Indeed, according to Mr. Benoit-Cattin et al (2012), Sub-Saharan Africa could fill the food gap of its growing population through imports and food aids coming from the rest of the world.

Thus, if there is a Marxist production system, it would therefore be possible to produce the sufficient quantity of goods for all the people around the world. According to Max (1919), the production system brings unavailable food to such a point that this system results into overproduction by favoring capital accumulation. The other limit of Malthus 'idea regarding food security is the inversion of the Malthusian relation between population and livelihood made by Boserup (1965). According to her, from a certain demographic level, production modes will experience gradual changes to ensure the passage from fallow to an intensive agriculture. However, the observation of Boserup's idea is so low that agricultural practices changes are not observed in some African countries despite the high population growth rate.

A new vision of food security emerged with Sen (1981) in his book "poverty and famines". Based on microeconomic foundations, Sen's approach focuses on the ability of individuals to control food through the legal means present in a society, namely the possibilities of production, work and exchange. Food deprivation is interpreted as an insufficient holding of access rights. However, Ravaillon (1997) points out that some people may voluntarily choose to deprive themselves of food while having access rights. According to him, it is a question of inter-temporal arbitration conveying the idea that individuals can choose a degree of hunger now in order to be deprived in the future. Such behavior shows that food insecurity is not the only prerequisite for deprivation and may depend on how the individual manages their access cards.

Beyond the theoretical studies, there are also attempts at empirical explanation of food security at micro and macro level. Given the context of this study, only empirical knowledge at the micro level will be mentioned in this section.

Cabral (2007) examined whether the factors influencing food insecurity depended on the area of residence (rural, urban). To do so, he uses data from the Senegal household survey and estimates a binomial logit model to identify the factors that influence the likelihood of food insecurity in each environment. These results show that the factors that influence food insecurity differ from one area to another. However, the logit model used to explain food insecurity loses some of the information available on the food consumption score (Zoyem et al., 2008). For Zoyem et al, the loss of information is due to the binary treatment of the consumption score in the regression. To cope with this loss of information, they propose to make a regression on the correlates of the logarithm of calorific intake in order to determine the determinants of food insecurity in Burundi.

They conclude that the effect of a variable is not always the same in rural or urban areas. Ilboudo (2009), Ouédraogo et al (2007) used more robust approaches to analyze the food insecurity in Burkina Faso. The first approach combines the fuzzy set approach with the logit model to find the explanatory factors for food insecurity. The latter use the food consumption score and perform a stereotyped regression. Just as Cabral (2007), these approaches could not avoid the loss of information in the regression reported by Zoyem et al.

In short, empirical investigations use partial indicators in the analysis of food insecurity. They are therefore limited by the complexity of food insecurity, which is a multidimensional phenomenon. They also do not permit targeting households in need of assistance. Other investigations that take into account the multidimensional character, falls on a dichotomization or polytomization of the obtained index generating a loss of information. Given these inadequacies in food insecurity analyses, an alternative approach seems appropriate.

2.2. Consensus on the 1996 Concept of Food Security

The concept of food security has evolved over time. The most consensual and widely used definition is that of the 1996 World Food Summit. At this summit, it was retained on FAO's proposal that "food security exists when all human beings have physical and economic access to sufficient, healthy and nutritious food to meet their energy needs and food preferences for a healthy and active life. This latter definition, which integrates the multidimensional nature of food security, has highlighted the need to strengthen household livelihoods at the heart of the development programs of international organizations. Also, food security refers to four dimensions: availability, accessibility, use and stability.

1.3. Indicators for Measuring Food Insecurity

Indicators for measuring food insecurity differ from the analysis scale. According to the literature, at the household level, there are four (4) groups of indicators to assess the situation of food insecurity. There are indicators of food availability, indicators of access to food, indicators of nutritional quality, indicators of stability of supply conditions and synthetic indicators of food insecurity.

- **Food availability indicators**

Availability refers to food supply in sufficient quantity and quality (FAO, 2006) through domestic food production, commercial imports and food aid. This dimension is generally influenced by the high variability of domestic production due to the effects of climatic hazards and the ability of a country to import foodstuffs as compensation for the national deficit.

At the household level, it is usually measured using the food consumption score and the level of the household's production.

- **Indicators of access to food**

Two key elements make up the accessibility of food. These include physical accessibility and economic accessibility (purchasing power). Physical accessibility refers to regular, timely household access to food. It is determined by household production capacity, ease of access to places of food trade (road conditions, markets, means of transport) and the distance between households and these places. Economic accessibility refers to the financial capacity of households to acquire food in markets. The purchasing power of households and the level of commodity prices determine it. It is then a combination of production and trade.

- **Food quality indicators**

The food quality dimension of food security is important because it is not enough for an individual to consume large quantities of food in order to be in a food security situation. It is also necessary that the food consumed meet the needs of the organism and permit the individual to live a healthy and active life (Yelemou, 2007). The quality of food "then focuses on how the body optimizes the various nutrients present in foods. Good practices of care and feeding, food preparation, diet diversity, and food distribution within the household result in an

adequate supply of energy and nutrients. This is in addition to good biological use of the foods consumed, and determines the nutritional status of individuals "(FAO, 2008).

To measure the quality and even the quantity of the diet, the indicator most used is the dietary diversity score (World Food Program (WFP), (2009)).

- **Indicators of stability of supply conditions**

Stability implies the spatio-temporal regularity of food supply in sufficient quantity and quality. However, this is threatened by a number of cyclical factors, including instability in domestic production, lack of storage infrastructure (Yelemou, 2007) and marketing systems, fluctuations in prices, and supply and demand on international markets.

As a result, the first three (3) groups of indicators do not permit targeting households in need of food assistance. Households whose food consumption is low at some point do not necessarily need assistance in the future, while households with high food consumption may need assistance later on. To solve the targeting problem, indicators of survival strategies, the most widely used of which is the survival strategy index (SSI), have been put in place.

3. Methodology of the study

3.1. Data used and their limits

The data used in this study come from the 2011/2012 Permanent Agricultural Survey (EPA). The EPA is a sample survey that covers all the provinces of Burkina Faso according to the administrative division. It uses a two-stage sampling design with first-order stratification induced by the second-degree stratification. In the first stage, the primary units are the villages, drawn proportionally according to their size in number of households and without replacement. To ensure the representativeness of the different types of farm within the same village, it was necessary to switch to a stratification of all agricultural farms.

This stratification is based on a discriminant analysis using two data files (EPA 2006/2007 and General Population Census (GPC) 2006). First of all, a classification of farms is carried out using eight (8) variables of the agricultural module of the GPC (2006), which may influence agricultural production. These variables are: household size, area, plow, cart, draft ox, draft donkey, draft horse, draft camel. This results in a sampling frame for drawn at the first level made up of all the households in the villages drawn at the first level. At the second level, households are selected by simple random drawn without replacement (by province and stratum) according to the size of the final sample. The final sample size is determined by controlling the coefficient of variation of the average estimator and the total coefficient of variation (10% for all provinces); and the sounding effect.

3.2. Method for the development of a food insecurity index based on the theory of fuzzy sets theory

In his work on fuzzy sets, Zadeh (1965) mentions that certain objects encountered do not have a well-defined criterion of membership to the possible classes. These objects do not constitute classes or sets according to the Boolean logic (belong or not). The concept of fuzzy sets provides an ideal framework for dealing with situations in which there is no specific criterion of belonging. It is therefore a very interesting concept to solve the problem of identifying food insecurity. Indeed, all food-insecure households constitute a vague, not to say complex, set. The vagueness comes from the definition of food safety that includes four (4) dimensions.

To prove this, let's consider two households, one with problems of food stability and the other with problems of food accessibility. These two households are obviously food-insecure according to traditional indicators. However, the identification and resolution of the food problems of these households are mutually exclusive. If an accessibility indicator is used, the household with stability problems will not be identified and the proposed solutions will not be in its favor and vice versa. In doing so, prudent behavior would lead to treating the two households differently. With this approach, it is not necessary to define a line of food insecurity.

The application of the fuzzy set theory for the determination of a multidimensional index is done in three (3) steps: which are as follows:

Step 1: Determination of weights

The main concern is how to choose the appropriate method to determine the importance of the dimensions. In fact, choosing an appropriate weight is one of the most fundamental steps in calculating a fuzzy index (Hilaire, 2009). Thus, the selection of weights depends on the researcher's social background and beliefs (Lelli, 2000)1.

[1] Reiterated by Oula BEN HASSINE(2006)

The weighting that will be used in this work is that proposed by Cérioli and Zani which better translates reality (Miceli, 1997). Thus, the weighting of dimension j is given by:

$$w_j = \log\left(\frac{\sum_{i=1}^{n} n_i}{\sum_{i=1}^{n} n_i x_{ij}}\right) \text{ Such as: } \sum_{i=1}^{n} n_i x_{ij} \geq 0$$

(we exclude the dimensions whose level of deprivation is zero for all households).

We can therefore replace the counter j by p and obtain the weighting of the variable of a given dimension.

Step 2: Determination of membership functions

The advantage of the fuzzy set theory is to allocate a gradual transition between the food security and food insecurity situation. It is no longer a question of classifying households in both situations but of considering intermediate situations that can be interpreted as a degree of food insecurity or risk of food insecurity. Thus, for an attribute p, the degree of belonging to the I set of households in food insecurity takes values between 0 and 1.

The general formulation of the membership function is as follows:

$$\mu_I(X_p(n_i)) = \begin{cases} 1 & \text{if } i \text{ does not possess the attribute } p \\ x_p^i & \text{if } i \text{ partially possesses p} \\ 0 & \text{if } i \text{ totally possesses p} \end{cases}$$

x_p^i depending on the nature of the variable X_p

In the case of quantitative variables, the literature offers two types of membership functions. It is the membership function according to the totally fuzzy approach of Cérioli and Zani (1990) and that of the totally fuzzy and relative approach of Chéli and Lemmi (1995). The approach used here is halfway between these two approaches. The thresholds for the continuous variables are determined using a classification. This makes it possible to avoid the arbitrary fixing of the thresholds in accordance with the criticisms of Cheli and Lemmi.

Step 3: Aggregation of different dimensions

At this stage, it is about determining the degree of belonging $\mu_I(n_i)$ of each household to the fuzzy set I of food-insecure households. The problem of aggregation is to find a function h defined on [0,1] such that: $\mu_I(n_i) = h(\mu_{x1}(n_i), \mu_{x2}(n_i), \mu_{x3}(n_i), \mu_{x4}(n_i))$. Among the functions that can be used as an aggregate, the one proposed by Cerioli and Zani will be used. This function1 is an arithmetic average of the various dimensions and is illustrated as follows:

$$\mu_I = \sum_{j=1}^{4} w_j \mu_I(X_j)$$

$$\text{Where } \mu_I(X_j) = \frac{\sum_{i=1}^{n} n_i x_{ij}}{\sum_{i=1}^{n} n_i}$$

We can also calculate the ratio of rural household food insecurity n_i given by:

[1] It can be broken down according to the groups and one can determine the associated contributions.

$$\mu_i(\eta) = \frac{\sum_{j=1}^{4} x_{ij} w_j}{\sum_{j=1}^{4} w_j} \qquad ; 0 \leq \mu_i(\eta) \leq 1$$

3.3. Choice of the econometric model

The aim is to understand the impact of income management on safety based on the previously developed multidimensional index. To do this, a Tobit model is used. The choice of the Tobit is mainly due to the continuous and limited nature of the food insecurity index, which is the dependent variable. According to Zoyem et al (2008), the dichotomous and polytomic model leads to a loss of information in explaining food insecurity. This loss of information is related to the binary treatment of the food insecurity index in the regression.

Consider, $index_i$ the value of the household food insecurity, i and X a vector of variables representing household characteristics that can influence food insecurity. The constraint on the index, the limited variable, is a constraint of belonging to the hard core of food insecurity. The Tobit model is therefore specified as follows:

$$\begin{cases} index_i^* = X_i'\beta + \varepsilon_i & with\ \varepsilon_i \sim N(0, \sigma^2) \\ index_i = \begin{cases} index_i^* & if\ index_i^* \geq \alpha \\ 0 & otherwise \end{cases} \end{cases}$$

In this model, $E(\varepsilon_i / index_i^* \geq \alpha)$ called the inverse ratio of Mills is non-zero and is $\sigma \frac{\phi(X_i'\beta/\sigma)}{\Phi(X_i'\beta/\sigma)}\beta$. Therefore, the Ordinary Least Squares (OLS) estimator of β would be biased and non-convergent. To cope with this problem, the estimation is done by the maximum likelihood method.

3.4. Variable of the model

For the estimation of the Tobit model, the following table gives the variables used and the expected signs.

Table 1: Variables of the Tobit model

Explanatory variables	Expected Sign
Do not use for inputs purchase	Ref.
Use to purchase inputs	-
Do not use for schooling	Ref.
Use for schooling	-
Do not use for food purchase	Ref.
Use for food purchase	-
Do not use for socio-cultural ceremonies	Ref.
Use for socio-cultural ceremonies	+
Do not use for purchase of agricultural equipment	Ref.
Use for purchase of agricultural equipment	-
Do not use for habitat construction	Ref.
Use for purchase of inputs	-
Unused income	-
Not literate	Ref.
Literate	-
Rural School	-

Medersa	-
Primary	-
Secondary	-
Higher education	-
Female	Ref.
Male	-
Household size	+
Inactive person	Ref.
Agricultural active person	-
Non agricultural active person	-
Age of head of household	-

Source : Author

4. Results

4.1. Breakdown Decomposition of the multidimensional index according to the dimensions of food security

Table 2 presents the results of the decomposition breakdown of the multidimensional index according to the dimensions of food insecurity. It also gives the d**ecomposition** of breaks down each unidimensional index according to the different attributes of each dimension of food insecurity.

Table 2: Breakdown of the multidimensional index according to the dimension of food security

Attributes / Dimensions	Index	Absolute Contribution	Relative Contribution
Engel's Ratio	0.5251	0.0208	0.0412
Draft animals / members	0.0688	0.0113	0.0225
Other animals / member	0.9991	0.0001	0.0001
Food Stock Arrangement	0.4741	0.0217	0.0431
Availability	**0.2156**	**0.0539**	**0.1069**
Income / member	0.8333	0.0541	0.1074
Area / Member	0.8900	0.0369	0.0733
Off-season crop	0.6683	0.0959	0.1903
Accessibility Group	**0.7480**	**0.1870**	**0.3710**
Food consumption score	0.7100	0.0441	0.0875
On-farm consumption of livestock production	0.3553	0.0667	0.1324
Quality Group	**0.4435**	**0.1109**	**0.2199**
Lack of food	0.5582	0.0557	0.1105
Fear of scarcity	0.6697	0.0460	0.0912
Annual coverage of needs	0.6211	0.0506	0.1005
Stability Group	**0.6093**	**0.1523**	**0.3022**
Food insecurity Group		**0.5041**	**1**

Source: Our calculations based on EPA 2011/2012 data

The table shows that the multidimensional index of food insecurity measured in rural areas is 0.5041. In other words, 50.41% of rural households in Burkina Faso are structurally food insecure in terms of our deprivation indicators.

Based on unidimensional indices of food insecurity, accessibility and stability are identified as dimensions with high levels of deprivation. Thus, the main causes of rural food insecurity are accessibility (74.8%) and stability (60.93%). On the other hand, availability (21.56%) seems to be a minor problem compared to other dimensions. However, the quality of food is poor because 44.35% of rural households are qualitatively food insecure. By analyzing the three main causes of food insecurity, households are severely deprived of all indicators (income, land, off-season farming) of the accessibility dimension. It is also the same case for stability. In terms of quality, it is rather the fact that households do not consume their own livestock production (71.08%), which places them in food insecurity.

It can be seen that the classification of the dimensions according to the extent of the cause to food insecurity is observed at the level of the contributions but with fewer differences than the level of the indices. Indeed, accessibility contributes at 37.10% to rural household food insecurity, stability to 30.22%, quality to 21.99% and availability to 10.60%.

4.2. Decomposition of the multidimensional index according to the socio-economic characteristics of households

The results of the breakdown of the multidimensional index according to the socio-demographic characteristics of the head of household are presented in Table 3 below.

Table 3: Breakdown of the multidimensional index (in %) according to the socio-economic characteristics of households

Gender	Index	absolute contribution	Relative contribution
Male	0,4836	0,47153804	0,93537961
Female	0,5888	0,03257605	0,06462039
Total	-	0,50411409	1
Education level			
Not literate	0,4967	0,40327054	0,79995889
Literate	0,4738	0,03857344	0,07651728
Rural School	0,4879	0,01489032	0,0295376
Medersa	0,4260	0,01115799	0,02213386
Primary	0,4528	0,03146475	0,06241593
Secondary	0,4161	0,00442743	0,0087826
Higher education	0,4592	0,00032961	0,00065384
Total	-	0,50411408	1
Marital status			
Single	0,5077	0,00777718	0,01542742
Married	0,4836	0,4631924	0,91882458
Widower / Widow	0,5926	0,02734138	0,05423649
Divorced	0,5687	0,00366792	0,00727597
Free Union	0,4396	0,00213519	0,00423553
Total		0,50411407	1
Occupational status			
Agricultural active person	0,4879	0,48850548	0,96903753
Non agricultural active person	0,4808	0,00538859	0,01068923
Inactive person	0,5467	0,01022003	0,02027325
Total	-	0,5041141	1

Source: Our calculations based on EPA 2011/2012 data

- **Breakdown according to the gender of the head of household**

The breakdown by gender of the head of household indicates that rural households headed by women (58.88%) are more vulnerable to food insecurity than those headed by men (48.36%) are. This could be explained by the fact that men control resources. The traditional right of ownership of land is in favor of men. Women with limited access to land cannot produce abundantly to ensure their food security. The paradox is that male-headed households contribute more to overall food insecurity (93%). The reason could be related to the numerical importance of these households in rural areas.

- **Breakdown according to the education level of the head of household**

There is a slight difference in the level of education of the head of household in terms of exposure to food insecurity. Indeed, households whose heads are not literate are more vulnerable to rural food insecurity (49.67%). They also contribute nearly 80% to overall food insecurity. 45.92% of households with heads of higher education level are also food insecure. However, the contribution of these households to overall food insecurity is almost nil. For households with heads of secondary, "medersa" and primary education levels, food insecurity rates are 41.61%; 42.6% and 45.28% respectively.

- **Breakdown according to the marital status of the head of household**

The results in Table 3 show high levels of food insecurity among widowed (59.26%), divorced (56.87%) and unmarried (50.77%) heads of households. Households with married and free-union heads have an exposure to food insecurity below 50%. However, married couples are the largest group contributing to rural food insecurity (91.8%).

- **Decomposition according to the occupational status of the head of household**

The analysis of the breakdown of the multidimensional index of food insecurity according to the occupational status of the head of household (Table 3) shows that 54.67% of households with inactive heads are structurally food insecure. However, their contribution to overall food insecurity is only 2%. Households with agricultural active persons as heads of households are less vulnerable to food insecurity (48.79%), but they contribute 96.90% to the formation of the level of the multidimensional index. This is due to the high number of such households in rural areas.

4.3 Impact of income management on food security

- **Validation of the tobit model and global and individual significance**

The results shown in Table 4 show that the model is globally significant. Examination of the table indicates that the variables "savings", "use of income for equipment acquisition", "for the purchase of agricultural input", "for habitat improvement" and "for the purchase of means of transport" influence food insecurity at 5% level of risk.

- **Interpretation of results**

The saving variable decreases the food insecurity index by about 0.024%. Not using one's income is synonymous with saving; this allows the household to cope with lean seasons and reduce fears of food shortages during the year. This result corroborates the descriptive analyzes that show that members of households who do not use their incomes are relatively fewer in need of food. Rather, they have good prospects of meeting food needs and are not afraid of food shortages.

The use of income for the acquisition of farm equipment reduces the value of the food insecurity index by 0.059%. When a household uses its income to acquire agricultural equipment, it increases its production capacity, hence its production and ultimately food availability for the household. This result is in line with that obtained by Ouédraogo (2012), which shows using a DEA model that the productivity of farmers in Burkina Faso increases with agricultural investments.

Using income to buy agricultural inputs reduces the food insecurity index by 0.092%. This is because the purchase of agricultural input makes it possible to improve yield and hence production, all other things being equal.

Using its income for habitat or the acquisition of a means of transport decreases the food insecurity index by 0.053%. This result is explained by the results of descriptive statistics that show that 97.45% of households using their income to improve housing and transport are agricultural active persons. These households thus get income that improve their access to food.

The gender of the head of household also affects food insecurity; indeed, being a female head of household increases the food insecurity index by 0.084%. This is because rural women have less access to land and have few income-generating activities. As shown by the exploratory analyses, the average area per head held by women-headed households is on average 0.55 ha while that of households headed by men is 0.81 ha. Also, the

average per capita income of households headed by men is higher than women-headed households by 32% (96550 FCFA as against 65530 FCFA).

When the household size increases by one person, the food insecurity index increases by 0.002%. Analysis of our data shows that per-head acreage, draft and other animals per head decrease with household size. However, these elements are essential for production to ensure food availability. This is in line with that of de Malthus (1798) that a growing population reduces the availability of food for its consumption.

The level of education of the head of household significantly influences the household's food security situation. The model results indicate that the higher the level of education, the less the household is exposed to food insecurity (the reduction rate is 0.036% for heads of households with primary education level, 0.056% for those with medersa education level, and 0.094% for households with secondary education level). These results are explained by the mastery of improved techniques and technologies.

The age of the head of household contributes to reducing the food insecurity index; when it increases by one year, the household food insecurity index falls by 0.00063%. An exploratory analysis of our data shows that households with elderly heads have a good prospect of meeting food needs. The experience accumulated over time allows them to better manage their income for the well-being of their family members,

Regarding the occupational status of the head of household, it contributes to reducing the insecurity index by 0.068% when the head of household is an agricultural active person.

- **Verification of the hypothesis**

H_1 : income management influences rural food insecurity.

To test this hypothesis, we use the LR-test whose null hypothesis is, $H_0 = a_1 = \cdots = a_j = 0$ (in our case $j = 7$). Otherwise, all of the coefficients that capture income management are zero.

At the 5% threshold, the test results given in Table 5 show that income management significantly influences rural food insecurity.

Conclusion

The objective of this study was to assess the impact of income management on rural food insecurity. Given the multidimensional nature of food insecurity, the fuzzy set theory was used to find a measurement indicator. The indicator thus obtained is broken down either by size or by group. The purpose of this breakdown was to identify the causes of food insecurity and to target the groups most affected. Also, using Forgy's k-means algorithm (1985), the hard core of food insecurity has been identified. Finally, the impact of income management on food insecurity is assessed using a Tobit model.

The results from the fuzzy measure indicate that 50.41% of rural households are structurally food insecure. The two main causes of household food insecurity are accessibility (74.8%) and stability (60.93). Quality is also not within the reach of households because 44.35% of households are deprived. Also, the breakdown shows that households with a widowed or divorced household head are most vulnerable to food insecurity. The hard core identified shows that 38.26% of households are vulnerable to a food crisis.

The Tobit model shows that the use of income for agricultural investment, housing and transport, as well as saving, reduces rural food insecurity. In addition, the Tobit model indicates that increasing the size of the household, having a woman as head of household increases the level of food insecurity. On the contrary, increasing the age of the head of household, having a head of household that is a non-agricultural active person, or having the primary, middle and secondary education levels, decreases the household's food insecurity index.

Finally, the verification of our hypothesis concluded that income management influences rural food insecurity.

Table 4: Results of Tobit Model Estimates

Regression of the Tobit Dependent variable: index Log-likelihood: -653, 29395	Number of observations = 3769 LR chi2 (17) = 323.07 Prob> chi2 = 0.0000 Pseudo R^2 = 0.1982		
Explanatory variables	Marginal Effet[1]	T	P>t
Income for input	-0,0923396	-8,93	0,000 * *
Income for schooling	-0,0141059	-1,64	0,101
Income for food	-0,0012995	-0,20	0,842
Income for ceremonies	-0,0085853	-1,07	0,283
Income for Equipment	-0,0593424	-5,53	0,000 * *
Income for Habitat	-0,0532505	-5,44	0,000* *
Unused income	-0,023719	-2,40	0,016 * *
Level			
Literate	-0,0069812	-0,58	0,564
Primary	-0.0364141	-2.71	0.007* *
Rural School	-0.003883	-0.21	0.835
Medersa	-0.0564516	-2.58	0.010 * *
Secondary	-0.0942793	-2.58	0.010 * *
Higher Education	-1.083785	-	-
Gender of the head of household	0.0845399	6.32	0.000 **
Household size	0.0021173	1.81	0.070 *
Head of household status			
Agricultural active person	-0.0682888	-2.92	0.004 **
Non-agricultural active person	-0.0391469	-1.03	0.305
Age of the head of household	-0.0006341	-2.62	0.009 **
Constant	-	21.04	0.000 **
/sigma	-		
Summary Obs. : 1956 observations censored on the left if index <= 0.5094564 1813 uncensored observations 0 observations censored on the right			

Source: Our calculations based on EPA 2011/2012 data

Table 5: Hypothesis Test Result

Likelihood-ratio test (Assumption: N revenu nested in revenue)			LR chi2(7)=231. 72 Prob > chi2=0.0000			
Models	Obs	ll(null)	ll(model)	df	AIC	BIC
Without income utilisation patterns	3769	-814.83	-	12	1562.313	1637.127
With income utilisation patterns	3769	-814.83	-653.2939	19	1344.588	1463.045

Source: Our calculations based on EPA 2011/2012 data

[1] The marginal effect represents the increase in the index of households that are in the hard core. Its interpretation is therefore related to this hard core.

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