# FOOD INSECURITY AND VULNERABILITY IN RURAL BURKINA FASO: AN APPROACH USING A STEREOTYPE LOGISTIC REGRESSION MODEL

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***Abstract:*** The regularity of the food crises in the countries of the Sahel challenges more one on the need for looking further into the studies on the food risk of insecurity. This study thus proposes to study the food vulnerability of the rural populations in Burkina Faso. This not only in terms of consumption of energy as suggested by Ouedraogo et al. (2007), but in terms of risk of a household to know the phenomenon being given its socio-economic and demographic characteristics. The study use dated from the permanent agricultural survey of 2006 conducted in rural areas by the Directorate of Foresight, Foods and Agricultural Statistics of Burkina Faso. Using the approach of the World Food Programme, three levels of vulnerability were built on the basis of total dietary energy available of the rural households. The stereotype logistic regression model proposed by Anderson (1984) allowed the estimate of the food risk of insecurity and the identification of its explanatory factors. It arises from the estimates that the size of the farm and the activities of diversification are the key variables of the food vulnerability of the households. In a specific way the size of the farm contributes to reduce by 33 percent the risk of extreme vulnerability of the rural households. The results challenge the authorities on the need for improving the agricultural outputs but also to encourage the mechanisms of solidarity as well as the activities of diversification such as gardening, handicraft and the gathering.

***Keywords:*** Food vulnerability, Food insecurity, stereotype logistic regression model

## I. INTRODUCTION

In Burkina Faso as in some countries of the Sahel, the food crises become recurrent compounding the issue of vulnerability to food insecurity. Since the 1990s, institutions such as FAO and CILSS have addressed food insecurity in African countries under an administrative perspective (region, province...) and using aggregate statistics (Janin, 2009). The ability of regions to cope with food insecurity is analyzed taking into account the accessibility to the market (market price) and climate forecasting systems. The concept of vulnerability has therefore focused more on supply shocks (drought, locust invasion, inflation of food prices ...). However, it is accepted that the livelihoods of people is affected by the risk of food insecurity and their ability to take them into account in their activities (C. Lovendal, 2004). Analysis of household behavior, in other terms, the strategies they undertake to avoid food insecurity is now a great interest since it comes to take action targeted toward groups considered as moderately or highly vulnerable. This study aims to examine vulnerability to food insecurity of rural households in Burkina Faso. This not only in terms of energy consumption as suggested by Ouedraogo et al (2007), but mainly in terms of risk for a household to suffer from food insecurity being given its socio-economic and demographic. It is organized into three parts: 1.Definitions concepts, 2.Méthodologie, 3. Estimation and discussion.

## II. DEFINITION CONCEPTS

*Vulnerability and Food Security*

In this study we define vulnerability as the probability that a household knows a given level of food insecurity ( Kruijk and Rutten (2007)). The World Food Programme distinguishes vulnerability into three categories: the extreme vulnerability, moderate vulnerability and non-vulnerability. The extreme vulnerability appears when the dietary energy consumption of a household is less than 90% of its energy minimum requirement. The vulnerability is moderate when the dietary energy consumption is between 90% and 100% of energy

minimum requirement. If the dietary energy consumption of the household is higher than the minimum requirement the household is non-vulnerability to food insecurity (Ouedraogo et al, 2007). *Food safety*

According to the World Food Summit in 1996, food security exists when all people, at all times have physical access, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and preferences food for healthy and active living.

## III. METHODOLOGY

**Specifying a model**

We explain the probability of the household vulnerability with a given information on their livelihoods, their socio-economic, demographic collected by Burkina Faso agricultural survey in the period 2006/2007. For that we define an ordered categorical variable that equals 0 if the household is not vulnerable, 1 if the household is moderately vulnerable and 2 if the household is extremely vulnerable.

Thus we have:

$$y_i = \begin{cases} 0 \to if\ \ y_i^* \le c_1 \\ 1 \to if\ \ c_1 \le y_i^* \le c_2 \,, \forall i = 1...N \\ 2 \to if\ \ y_i^* \ge c_2 \end{cases}$$

Where $c_1$ and $c_2$ are the thresholds and $y_i^* = x_i^{'} a + v_i$ with $v_i \square\ iid(0, \sigma_v)$ and $\frac{v_i}{\sigma_v}$ follows a distribution function $F\left[ Logit(0, \frac{\Pi^2}{3}) \right]$.

We use household consumption in one year to build our three levels of vulnerability. The technique used for the calculation of this consumption is described below. We assume that the probability for a household to belong to a group $(y = j \text{ où } j = 0,1,2)$ depends on a number of socio-economic and demographic ($x_k$). We integrate in our model the non hazard ratio to take into account a probably selection bias. The vector of household characteristics is represented by the vector $x = (x_1, .., x_p)$

$$\begin{cases} P(y_i = 0) = P(y_i^* \le c_1) = F(\frac{c_1}{\sigma_v} - \frac{x_i^{'} a}{\sigma_v}) \\ P(y_i = 1) = P(c_1 \le y_i^* \le c_2) = F(\frac{c_2}{\sigma_v} - \frac{x_i^{'} a}{\sigma_v}) - F(\frac{c_1}{\sigma_v} - \frac{x_i^{'} a}{\sigma_v}) \\ P(y_i = 2) = P(y_i^* \ge c_2) = 1 - F(\frac{c_2}{\sigma_v} - \frac{x_i^{'} a}{\sigma_v}) \end{cases}$$

Therefore, the log-likelihood of our sample which means, the logarithm of the probability to observe our sample is given by:

$$\log L(y, \tilde{a}, \tilde{c}_1, \tilde{c}_2, \sigma) = \sum_{i=1}^{N} \left\{ y_{i0} \log\left[F(\tilde{c}_1 - x_i\tilde{a})\right] + y_{i1} \log\left[F(\tilde{c}_2 - x_i\tilde{a}) - F(\tilde{c}_1 - x_i\tilde{a})\right] + y_{i2} \log\left[1 - F(\tilde{c}_2 - x_i\tilde{a})\right] \right\}$$

The parameter estimation will be done by maximizing the log likelihood. The validity of our model would be gained if the so-called parallel regression assumption is not violated. The assumption of parallel regression is tested using the Brant test (1990).

If this assumption is violated, stereotype regression model (Anderson, 1984) will be used. Given the above notation, the model of Anderson (1984) is defined as follows:

$$\Pr ob(y = s \mid x_{i1}, ..., x_{ip}) = \frac{\exp(\beta_{0s} + \phi_s \sum_{j=1} x_{ij} \beta_j)}{\sum_{t=1}^{k} \exp(\beta_{0t} + \phi_t \sum_{j=1}^{p} \exp(x_{ij} \beta_j))}$$

Where:

$\beta_j$ : Logistic regression function

$\phi_s$ : Distance between the groups.

Anderson recommends that $\phi_0 = 0$ and $\phi_k = 1$, where k is the number of explanatory variables, to make the model identifiable (Lunt, 2001). If the relationship between explanatory variables and the dependent variable is ordinal (the case of this study), the ordinal nature of the model is ensured by the condition $\phi_0 = 0 \ge \phi_1 \ge ... \ge \phi_{k-1} \ge \phi_k = 1$. It should be noted that the estimate will be made on a working sample which corresponds to two thirds of the households in our data base and the third selected randomly for testing the goodness of fit of our models.

**Explanatory Variable and meaning of their action on the variable of food insecurity**

Our sample contains 3685 households and we retain at all 20 explanatory variables as follows. The explanatory variables selected are grouped into three categories as follows: Demographic, Economic Factors and diversification activities.

*Demographic characteristics*: household size , gender of household head (gender-cm)

*Economic Factors*: Buyer net, Size of farm , Seller Net , participation in the mechanisms of solidarity as a donor Participation in solidarity mechanisms as beneficiary (soldcad), Constitution of initial stocks (stc1) Stockpile end Consumer products Livestock (Cheptel).
*Diversification activities:* Number of workers in gardening (nbrecmara) Number of workers engaged in an income generating activity (nbreagr) Number of workers in the practice of farming (nbreelevag), Number of migrants (nbremigrat) Number of workers in the handicraft activities (nbreartisan), Number of workers in the picking activities (nbrecueill) Number of workers in the fishing (nbrepech);

**Data**

The data used for this study come from Burkina Faso agricultural survey for 2006 to 2007. This survey is a PPS sample design into two degrees. The units in the first degree are the villages and those of the second degree are the farmers. The survey questionnaire enables to set a balance between supplies and utilizations of each product used by each household member between Octobers of the year n-1 to September of year N. In supply, the following information is collected for each product: Production; Purchase; Gifts; Initial stock. In utilization the following are collected, Sale, Closing stock, Gifts. We then deduce the consumption by the balance of supplies and utilizations. All this information is collected in the local unit of measurement (ULM) and per household member, which improves the quality of responses. In addition, production is measured objectively based on square yield and opening and closing stocks of grain are weighed by the interviewer. The food energy conversion table (FAO, 1996) is used to convert physical quantities into food energy.

## IV. ESTIMATES AND INTERPRETATIONS OF RESULTS

The Ordered logistic regression is globally significant as indicated by the p-value associated to chi-2 test (Prob> chi2 = 0.0000). The probably heteroskedasticity has been corrected. It should also be noted the non-confirmation of selection bias by non-significance of the Mills ratio at 5% level.

But before interpreting the results of the estimates, we must ensure the stability of the coefficients (called parallel regression hypothesis). Indeed, as the regression gives one coefficient by predictor, it is necessary to test the hypothesis that the coefficients are generally stable regardless of the ways that groups are compared in pairs. The hypothesis was tested using the test of Brant.
This test leads us to reject the hypothesis of regression parallel (annexe). So, ordered multinomial logit model is not adapted for estimating the risk of food insecurity. It should be as suggested by the literature, to estimate a stereotype logistic model. The table below shows respectively the marginal effects of the predictors on vulnerability of the household to food insecurity.

**Interpretation of results: determinants of risk of food insecurity**

The stereotype logistic model (table in annexe) reveals that the size of household farm influences significantly the level of vulnerability. The effect of the size of the farm is the most important in determining the risk of household to food insecurity. In fact, increasing it to one hectare increase by about 21% (table below) the likelihood of a household to remain in a situation of no risk to food vulnerability and reduces the household extreme vulnerability by about 19%. As production grows naturally with the cultivated area, more this area is important, most production would be well. It will therefore result that households with large farm sizes are less inclined to a high level of food insecurity. In reality it should be noted that because of the production is calculated from yields, the effect of farm size could be summarized in the effect of agricultural yield.

*The role of diversification activities on household vulnerability*

The expansion of the business portfolio of a household is effective in avoiding a situation of vulnerability much more pronounced. Indeed, diversification variables relating to the picking, fishing, income generating activity (IGA), and the migration lessen the risk of food insecurity or vulnerability. The model highlights the effectiveness of activities such as migration and fishing in household strategies to escape from their situation of extreme vulnerability. More specifically, in one household, one more person in the practice of migration and fishing respectively reduced by 2.4% and 6.3% risk that a household finds himself in a situation of extreme vulnerability. In addition, IGA and gardening activities while having a relatively smaller marginal effect on reducing the risk of food insecurity are also significant in the strategies of households.

**Table 1:** Marginal effect calculated from the logit stereotyped

| Variables | Marginal Effect : Stereotype logistic regression model | | |
|---|---|---|---|
| | Non vulnérable | Moderately vulnerable | Extremely vulnerable |
| Number of migrants in the household | 0,0270535 *** | -0,0023747 | -0,0246788 |
| Number of assets in gardening | 0,000452* | -0,0000397 | -0,0004124 |
| Number of assets in handicraft | 0,0136569 | -0,0011988 | -0,0124581 |
| Number of assets in fishing | 0,0691412** | -0,006069 | -0,0630722 |
| Number of assets in picking | 0,0092573** | -0,0008126 | -0,0084448 |
| Size of farm | 0,2089315*** | -0,0183393 | -0,1905923 |
| Number of assets in IGA | 0,01062** | -0,0009322 | -0,0096878 |
| Net buyer | 0,069631*** | -0,0060811 | -0,0635499 |
| Net seller | -0,1085043* | 0,0098194 | 0,0986848 |
| Household size | -0,061452*** | 0,005394 | 0,056058 |
| Gender of household head | -0,0692502** | 0,0060785 | 0,0631716 |
| Gifts | 0,0569465** | 0,0042969 | -0,0427976 |
| Donations | -0,0137235 | -0,001224 | 0,0124995 |
| Initial stock | -0,1046281*** | 0,007408 | 0,0972202 |
| final stock | 0,0153982*** | -0,0013916 | -0,0140066 |
| Nonselection hazard | -0,042172 | 0,0037017 | 0,0384703 |
| * significant at 10% ; ** significant at 5%; *** significant at 1% | | | |

The influence of diversification activities is related to the improvement of household income that allows them to use the market in case of a deficit in production compared to their food needs. For example, in the case of migration, much relatively recent work has shown how migrants quickly develop coping skills in urban areas, particularly the proliferation of small informal businesses (Thiombiano, 2008).

*Role of solidarity mechanisms in reducing the risk of food insecurity.*

Donations and gifts are made under the family and social ties between households. It should be noted that donations reduce household food availability while increasing by the gifts. The level of vulnerability of households is strongly influenced by them. More specifically, the gifts that households receive from others in difficulties, improve the level of vulnerability of these. They decrease by about 4.3% probability that the household remains in a situation of extreme vulnerability and increase by about 4.7% chance to remain non-vulnerable. Instead, donations are not significant in determining the vulnerability of households to food insecurity. Support for households through food gifts thus appears as a powerful socio-cultural instrument to struggle against the food vulnerability of rural households in Burkina Faso.

*Determinants related to household characteristics*

Among this category of determinants, there are common findings in studies on poverty; household size and gender of household head variables strongly influence the risk of being in a situation of extreme and non-vulnerability.

**Predicted probabilities of different level of vulnerability**

We now focus on estimating the risk of food insecurity and the number of person not vulnerable, moderately vulnerable and extremely vulnerable.

If all variables are conditioned at their average level, it would have been in 2006, 67.81% chance of finding a non-vulnerable household in rural and a risk of 8.91% and 23.27%, respectively, to meet a person moderately vulnerable and extremely vulnerable. So it can be considered that 32% of rural households have experienced food insecurity this estimate is close to the results of Kaboré and Taondyandé (2009).

The estimate of the number of different levels of vulnerability is as follows: Let be

n the size of the rural population;

$y \in \{\text{non vulnérable, moyennement vulnérable, extrêmement vulnérable}\}$

$N_Y$ Number of household in a given level of different vulnerability;

$x$ Represents the explanatory variables of the estimated model.

So $$N_Y = \Pr(y / x) * n$$

The above table gives the predicted probabilities that could be regarded as the measure of the risk or vulnerability to food insecurity of rural households. In absolute terms, the rural population size in 2006 was 11,000,000 (DGPSA, 2006).

| | **Proportion of households in the sample** | **Predicted probability** | **Population** |
|---|---|---|---|
| **Non vulnerable** | 54,75 | 67,81 | 7.459.566 |
| **Moderately vulnérable** | 6,79 | 8,91 | 980.282 |
| **Extremely vulnérable** | 38,46 | 23,27 | 2.560.151 |
| **Total** | 100 | 100 | 11.000.000 |

## V. CONCLUSION

This study intended to study the food vulnerability of rural populations in Burkina Faso. This, in terms of risk of a household to know the phenomenon being given its socio-economic and demographic. Estimates of the stereotype logistic model allowed the estimation of the risk of food insecurity and identify its underlying factors. It appears that the farm size is the key variable of food vulnerability of households. Indeed the increase in farm size. Moreover, the diversification of business portfolios in the household can reduce the probability of household to be vulnerable. These results therefore challenge the authorities on the need to improve production yields of households but also to promote mechanisms of solidarity and diversification activities such as gathering and gardening activities. The results of this work can be improve by using multilevel model to make estimations at regional level.

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## Ordered logistic model estimates

| Variables | odinary logistic regression model | |
|---|---|---|
| | Coefficient | Robust Standar Error |
| Number of migrants in the household | -0,235774 | (2.94)*** |
| Number of assets in gardening | -0,082782 | (1.67)* |
| Number of assets in handicraft | -0,108299 | (1.45) |
| Number of assets in fishing | -0,275438 | (1.87)* |
| Number of assets in picking | -0,07257 | (2.01)** |
| Size of farm | -1,570527 | (4.19)*** |
| Number of assets in IGA | -0,080508 | (1.96)** |
| Net buyer | -0,881623 | (3.06)*** |
| Net seller | 0,3463874 | (1.64)* |
| Household size | 0,5480765 | (3.81)*** |
| Gender of household head | 0,4295146 | (1.82)* |
| Gifts | 0,2389709 | (1.88)* |
| Donations | 0,0522348 | (0.48) |
| Initial stock | 0,3634356 | (2.50)** |
| final stock | 0,5953954 | (2.72)*** |
| Constitution de stocks finaux | -0,360708 | (2.65)*** |
| Nonselection hazard | 2,368073 | (1.88) |
| Observations | | |
| Robust z statistics in parentheses | | |
| * significant at 5%; ** significant at 1% | | |

| **Brant Test** | | | |
|---|---|---|---|
| Brant test of Parallel Assumption | | | |
| **Variable** | chi2 | p>chi2 | df |
| **All** | 50.91 | 0.000 | 19 |
| Number of migrants in the household | 4.43 | 0.035 | 1 |
| Number of assets in gardening | 0.31 | 0.580 | 1 |
| Number of assets in handicraft | 1.58 | 0.208 | 1 |
| Number of assets in fishing | 5.56 | 0.018 | 1 |
| Number of assets in picking | 2.27 | 0.132 | 1 |
| Size of farm | 8.25 | 0.004 | 1 |
| Number of assets in IGA | 0.27 | 0.604 | 1 |
| Net buyer | 4.69 | 0.030 | 1 |
| Net seller | 0.01 | 0.905 | 1 |
| Household size | 11.40 | 0.001 | 1 |
| Gender of household head | 4.67 | 0.031 | 1 |
| Gifts | 6.48 | 0.011 | 1 |
| Donations | 4.25 | 0.039 | 1 |
| Initial stock | 8.29 | 0.004 | 1 |
| final stock | 3.95 | 0.047 | 1 |
| Constitution de stocks finaux | 1.42 | 0.233 | 1 |
| Nonselection hazard | 9.08 | 0.003 | 1 |
| A significant test statistic provides evidence that the regression parallel regression assumption has been violated | | | |