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Determinants of Food Insecurity in Rural Areas in Mali

Sidina Ali Diallo[1*], Kimseyinga Savadogo[2], Abel Tiemtore[2], Soumaïla Diarra[3], Diakalidia Kouyate[1,4] and Bréhima M Sangare[1]

[1]Faculty of Economics and Management, University of Social Sciences and Management of Bamako, Bamako, Mali.
[2]University de Ouaga II, Faso, Burkina.
[3] Système d'Alerte Précoce (SAP)- Bamako, Mali.
[4] King Abdulaziz University, Faculty of Environmental Sciences, Department of Arid Land Agriculture, Saudi Arabia.

Authors' contributions

This work was carried out in collaboration among all authors. Author SAD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KS, AT and SD supervised the analyses of the study. Author DK and BMS revised the manuscript, managed the references and ordered the manuscript in the AJAEES guidelines. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this study is to identify the determinants of households' food insecurity in rural areas in Mali, ranked among the most exposed to this phenomenon. The study used data from the national food security and nutritional survey in March 2016. The estimation of the econometric logit model by the maximum likelihood method revealed that regional location, age of household head, household size, level of education of the household head, welfare index and incomes' diversification sources are the main determinants of households' food insecurity in a rural area in Mali. The analysis shows that age of household head, size of household and practical of recession cropping affect positively food insecurity while the educational level of household head, welfare index and

**Corresponding author: E-mail: sidinaalidiallo@gmail.com;*

incomes 'diversification sources affect negatively food insecurity. These determinants are pillars on which policy maker might rely to reduce food insecurity. Therefore, it is desirable for government to orientate more the food insecurity fight programs towards the most affected regions, to prioritize households head with advanced age and those whose size is high, and promote recession cropping during the food insecurity fight plan, improve household education level, promote the household's welfare and sensitize the households to diversify the sources of their income.

Keywords: Food insecurity; logit model; food consumption score; rural area of Mali.

1. INTRODUCTION

The realization of the lack of progress in food security at the global level sparked from the mid-1990s onwards a series of reactions ranging from the organization of several world food summits to the increase in aid for agricultural development and food security. One of these most important summits was the one on the Millennium Development Goals (MDGs). These objectives were adopted at the United Nations General Assembly in 2000 by leaders from the South and the North with the first millennium objective of reducing poverty and hunger by half for 2000-2015. The fight against food insecurity in the world has therefore become an international commitment. In July 2003, African leaders also made a commitment in Maputo to allocate at least 10% of their budget to agriculture to increase agricultural production by 6% and thereby reduce hunger. More than a decade after Maputo, and the MDGs have been renewed with the Sustainable Development Goals (SDGs) for 2015-2030, but the food situation remains a constant concern, especially in West Africa. According to estimates by the Food and Agriculture Organization of the United Nations, 805 million people were chronically undernourished worldwide between 2012-2014. The vast majority of these undernourished people live in developing countrieswith791 million people over the same period.

In Mali, the [1] revealed that food insecurity affects 25% of the population. It is felt more in rural areas (26.5%) than in urban areas (16%). The survey also revealed that except for the Kayes region, certain circles in the other regions have a high proportion of food insecurity households. Nara (49.6%), Bougouni (42.8%), Bla and Tominian (45.4%) each, Bandiagara and Koro 41% and 47% respectively, Diré and Gourma-Rharous (41.3%) and (71.7%), Ansongo (48.9%) and finally Abeibara and Tin Essako (47.9%) and (45.6%).

The causes of food insecurity can be divided into two groups. Some structural and others cyclical, [2]. The first causes are the factors linked to the natural endowment of the country. These include, for example, the state of natural resources (land degradation, degradation of plant cover, etc.), the state of household poverty (monetary poverty, cereal poverty, etc.) and the condition of agricultural equipment (modern or traditional equipment). Annual variations in rainfall (drought/deficit, flood/abundance, etc.), market failures (increase in food prices, increase in factors of production, etc.), natural disasters (locust invasion and grain-eating birds, etc.), social conflicts (conflict between breeders and farmers, popular uprising etc.) constitute the economic causes. The food insecurity observed in Mali takes all of these forms.

In addition, the prices of the main cereals consumed in rural areas increased strongly from 2011 to 2012. On the rural markets, prices were 188 F CFA / Kg for millet compared to106 F / Kg, 178 F CFA / Kg for sorghum compared to104 F CFA / Kg and 145 F CFA / Kg for maize compared to102 F CFA / Kg [3]. This affects the purchasing power of rural households and makes them vulnerable to food insecurity.

Faced with the harmful consequences that food insecurity represents for the rural development and the economic life of the country, the Malian State in addition to the commitments made at the international and continental level, has developed strategies and programs to fight against food insecurity. These measures include the adoption in 2002 of the National Food Security Strategy (SNSA), the creation in 2004 of the Food Security Commission (CSA) directly attached to the Presidency of the Republic and the adoption in 2005 of the National Food Security Program (PNSA, 2005-2015), aimed at providing a sustainable response to structural problems of food insecurity. Unfortunately, these policies do not reach the most vulnerable populations, integrate very few nutrition issues and weakly address the factors that influence the food status of households. It is, therefore, necessary to stop and analyze, identify and

understand the factors that most influence food insecurity in rural areas in Mali.

This study is a contribution to the existing literature on the subject. Knowledge of the determinants of food insecurity should allow for the development of better strategies and better allocation of public and private resources in the fight against and prevention of the phenomenon. It will allow the food security system to anticipate the food vulnerability of households by monitoring socioeconomic and demographic characteristics.

The main objective of this study is to identify and analyze the determinants of food insecurity in rural areas in Mali. To better understand and achieve this objective, it is important firstly to determine the level of food insecurity among rural households by region, and secondly, to identify the socio-economic and demographic factors that influence household's food insecurity in rural areas in Mali.

In accordance with the objectives, two hypotheses are tested.

1- Household food insecurity varies by region.
2- Socio-economic and demographic factors influence household food insecurity.

The work is structured in three parts. The first reviews some empirical foundations and the choice of analysis tool for the subject. The second part presents the definition and the model used to achieve the objectives set. And finally, the third part focuses on the results obtained.

2. LITERATURE REVIEW

2.1 Historical Concept of Food Security

The concept of food security appeared in the 1970s. According to the Food and Agriculture Organization of the United Nations (FAO), this concept have several definitions. For FAO, there is food security when all human beings on the planet have, at all times, physical and economic access to sufficient, safe and nutritious food, enabling them to meet their energy needs and food preferences to achieve a healthy and active life. Food security can be understood as the ability to build a food system that provides all people with a long-term nutritionally adequate food supply [4].

For [5], food security consists of producing a food supply, which, in sufficient quantity and quality, allows rural food producers to feed themselves as well as to sell their surpluses in order to earn a satisfactory income to encourage their productivity and satisfy solvent demand of rural non-food producers as well as that of urban residents. From this definition, he distinguishes two dimensions of food security, restricted and general dimensions. The restricted dimension aims to secure the food supply. This means producing all the basic foods necessary to satisfy the supply of food products required by the rural (self-consumption) and urban populations, to ensure the marketing of these products to have income for the acquisition of agricultural inputs. The second dimension, called the general dimension consists firstly in making non-food agricultural production profitable (cash crop) so those rural households can acquire the food that they do not produce and, secondly, in promoting adequate conditions so that the urban populations of the secondary economic sectors (industry) and tertiary (trade and services) can also acquire the factors of production which they need.

2.2 Empirical Foundations

Due to the importance of hunger and undernourishment to the world's governments, many researchers and development institutions are increasingly interested in food security in all its dimensions. From today, the literature on this topic is abundant and diverse.

2.2.1 Dimension of residence area

In the study of the measures and determinants of food insecurity in Burundi using the calorific approach, [6] used the basic module of the QUIBB survey (Indicators Questionnaire of Well-being Base) with households designed by the World Bank to monitor the achievement of the Millennium Development Goals (MDGs). This module did not allow the measurement of household exposure to food insecurity using the calorific in take approach. In 2006, Burundi introduced an additional consumption module in this survey to measure poverty. After estimation, they concluded that residence (urban/rural, region), physical capital (land, animals) and human capital (education, occupation, mental or physical disability, and household size) can expose households to food insecurity. Based on an analysis at the 1400 Kcal threshold, they show that the incidence of food insecurity varies from single to double between rural and urban areas (35% versus 16%). They also show that

the exposure to food insecurity is lower if the household head is educated or employed.

Similarly, [7] studies the factors of food insecurity in rural and urban areas in Senegal. Using a logistic regression, he finds that the individuals most exposed to food insecurity are those located in rural areas. He also finds that many important common factors explain food insecurity in rural and urban areas including farm size, non-farmer status, self-consumption and area of residence. In addition to these factors, he also finds that membership in the "senior executives" group, access to income from livestock and transfers are specific for rural areas. Diversifying sources of income and/or consumption is a strategy that can influence the status of the household with respect to food insecurity phenomenon. This behaviour refers to the wallet theory according to which the household or individual is required to diversify his wallet to prevent the risk.

2.2.2 Production dimension

According to [8], the production plays an important role in determining the risk of undernourishment. In studying the correlations between food security and poverty, they show that variables relating to agricultural yields have an impact on the probability of being short of calories.

Similarly, according to [9], strong fluctuations in agricultural production seem to be the most determinant among the factors that contribute to food insecurity in sub-Saharan Africa. Agriculture contributes nearly 90% to meeting food needs and is the main source of domestic product. The performance of the agricultural sector, therefore, determines both the availability and access to food for the vast majority of the population. Also, he believes that low productivity and structural poverty lead to persistent food insecurity. He also notes that the food crisis in sub-Saharan Africa can be explained by the combination of several factors, the most important of which are the stagnation or even the decline in food production per capita due to rapid population growth with the gains of agricultural productivity, the lack of foreign exchange and the poverty of the populations.

2.2.3 Socio-economic factors dimension

[10] studied the determinants of food security in Africa. Their method was based on a panel data approach and more specifically the fixed effects model chosen after the application of the Hausman specification test. The results obtained by this method clearly show that the contribution of agriculture to food security is largely significant. As for demographic growth, it has a significant, but negative impact on food security.

[11] examines the role of household characteristics in determining food security in Kenya. The results indicated that the marital status and educational level of the household head play a significant role in determining household food security. Other characteristics such as the size of the field and the area allocated for cereal or grain production are also significant.

From this literature review, we retain three dimensions of food security: the place of residence, production and socio-economic factors. Indeed, just like production, place of residence and socio-economic factors have an impact on household food security. Also, it emerges that the work has focused the most on the relationship between poverty, calorie consumption, the four dimensions of food security (availability, access, stability, and use) and socio-economic factors and food security/insecurity.

Our study is resumed in rural areas in Mali. It is focused on socio-economic and demographic factors as determinants using data from the national food security and nutritional survey [Enquête Nationale sur la Sécurité Alimentaire et Nutritionnelle‘‘ENSAN’’ (2016)].

2.2.4 Choice of analysis tool: food consumption score (FCS) index

To understand the food situation in most developing countries, a composite indicator, standardized from [12] called the food consumption score is generally used. This score is based on two main concepts. Firstly, the diversity of the diet (represented by the number of individual foods or food groups consumed during the week preceding the survey) and secondly, the frequency of consumption by the household of foods expressed in the number of days during the reference period using data collected at the household level. This is a proxy indicator of food consumption and therefore of access to food.

It is calculated by multiplying the frequency of the eight food groups during the last seven days preceding the survey by a weight assigned to each food group based on the nutritional value of those. The sum gives the overall composite score for the household.

2.5 Calculation Formula

$$\mathbf{FCS} = \mathbf{a_{staple}x_{staple}} + \mathbf{a_{pulse}x_{pulse}} + \mathbf{a_{vegetable}x_{vegetable}} + \mathbf{a_{fruit}x_{fruit}} + \mathbf{a}_{animal}\mathbf{x_{animal}} + \mathbf{a_{sugar}x_{sugar}} + \mathbf{a_{dairy}x_{dairy}} + \mathbf{a_{oil}x_{oil}}$$

Where:

FCS= Food consumption score
$\mathbf{a_i}$=Weight assigned to each food group
$\mathbf{X_i}$= Frequencies of food consumption or Number of days of consumption relating to each food group (≤ 7 days)

The values of the scores thus calculated for each household are reported on a scale from 0 to 112. The standard thresholds 28 and 42 were established by WFP for Mali to determine three categories of household food consumption:

$FCS \leq 28 \Rightarrow$ a poor food consumption score
$FCS > 28$ and $\leq 42 \Rightarrow$ a borderline food consumption score
$FCS > 42 \Rightarrow$ an acceptable food consumption score

The first two scores classifies the household in food insecurity while the last classifies it in food security.

- ✓ A low FCS corresponds to basic food consumption, mainly composed of cereals and often accompanied by plant products and sugar.
- ✓ A borderline FCS corresponds to an almost equal diet with a meal generally composed of cereals, plant products, often accompanied by legumes, oil or sugar, and occasionally a source of animal protein.
- ✓ An acceptable FCS refers to households that have a fairly diversified diet, characterized by the consumption of cereals, meat or fish, milk, sugar and incidentally vegetables.

3. CONCEPTUAL AND MODEL APP-ROACH

3.1 Conceptual Approach

The concept of food security has been defined many times by the international community and has evolved considerably over time. One of the most fundamental changes has been the shift from an initial conception of food security based on the reliable availability of food to the contemporary notion where food is one element in a complex social context determining livelihood. This social context, and the balance of power between the various interest groups that constitute it, is an essential factor in the food security situation.

Food security at the individual, family, national, regional, and global levels exists when all human beings have, at all times, physical and economic access to sufficient, safe and nutritious food to meet their energy needs and food preferences to lead a healthy and active life, [13].

The concept of food security covers four main dimensions:

- ✓ The availability of sufficient quantities of natural food and appropriate quality in all parts of the national territory, whatever the source of this food (local production, import or food aid),
- ✓ Access by all people to necessary resources to acquire the food required for a nutritious diet. These resources include both monetary resources and the access rights necessary to produce food,
- ✓ The stability of access to food, which means the population's access to food cannot be jeopardized by any natural or economic shock,
- ✓ Satisfactory use of food that is not threatened by health problems (drinking water, sanitation or medical infrastructure).

The concept of nutritional security complements that of food security by adding to it the availability of health services and the knowledge by the population of the good practices necessary for the good health of the members of the household, essential for the full development of their potential. Nutritional security also includes

eliminating major mineral and vitamin deficiencies, which are often associated with and worsen each other.

Food requirements (dietary needs) represent the amount of energy and nutrients required for a given healthy individual to develop and lead a normal life. These needs are generally expressed daily and vary according to the category of person (age, weight, physiological state - for example growth, pregnancy or breastfeeding - and level of activity).

Food consumption represents the amount of food consumed by a given individual in a limited time. The volume and composition of this consumption vary according to the income of the individual (and of the household of which he/she is a member), the population group of which he/she belongs (rural, urban) as well as social and cultural factors that determine the nature of the food it consumes.

Food self-sufficiency is the ability to meet all the food needs of a population through domestic production alone.

Food sovereignty is presented as "the right of populations, communities, and countries to define their food, agricultural, territorial as well as labour and fishing policies, which must be ecologically, socially, economically and culturally adapted to each specificity. Food sovereignty includes a true right to food and food production, which means that all people have the right to healthy food, culturally and nutritionally appropriate, as well as to food production resources and the capacity to ensure their survival and that of their society"

Food insecurity refers to the situation of populations who are below the threshold required to feed themselves from their production and/or their annual income and who are forced to consume their savings, sometimes to sell their means of production or to seek solidarity [14].

Vulnerability is a situation of exposure to risk factors, but also the difficulty of coping with the situation, the inability to defend oneself. An individual can be considered vulnerable if he is subjected to risks of lack of food or if he suffers strong consequences of this lack, or even more if he suffers the combined effects of these two elements.

3.2 The Method

3.2.1 The model

The model used to analyze the determinants of food insecurity is a binomial logit model that estimates the probability of a household being more or less exposed to food insecurity.

The approach consists of explaining the dichotomous variable $\{y\}$, which designates food insecurity, taking the value 1 if the household is affected by food insecurity and 0 otherwise from a set of p variables ($x_1, x_2, ..., x_p$).

To do this, the sample is thus subdivided into two groups:

- ✓ households suffering from food insecurity ($y = 1$)
- ✓ and those that are not ($y = 0$).

Theoretically, we assume that the probability of a household belonging to the first group $y = 1$ depends on some socio-economic and demographic factors.

$$y_i* = x_i\beta + \varepsilon_i \quad (1)$$

Where y_i* is an unobservable latent variable describing the food situation of household i. It decides the value of y_i as follows:

$$y_i = \begin{cases} 1 \text{ if } y_i* > 0 \\ 0 \text{ if } y_i* \leq 0 \end{cases} \quad (2)$$

An estimate of the probability that a household belongs to class 1 while knowing that it is characterized by all the factors X_i is given by the following logistic function:

$$P_i = \Pr ob(y_i = 1) = \Pr ob(y* > 0) = \Pr ob(\beta_0 + \beta_1 x_i + \varepsilon > 0) = \Pr ob(\varepsilon_i > -(\beta_0 + \beta_1 x_i)) = \Lambda(\beta_0 + \beta_1 x_i) \quad (3)$$

With:

P_i , the probability that household i is food insecure;

y_i , the insecurity status of household i;

x_i , the explanatory variables;

$\Lambda(\bullet)$, the distribution function of the logistic law, which can be written in the following general form:

$$P_i = \Pr ob(y_i = 1) = \frac{1}{1+\exp(-\eta_i)} \quad (4)$$

We can predict the logarithm of the ratio between the probability of being affected by food insecurity and the probability of not being affected by the phenomenon.

$$\eta_i = \log\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_p x_p \quad (5)$$

The x_i represent the explanatory variables and the β_i the parameters to be estimated.

3.2.2 Data analysis

The data used in our study come from the National Survey on Food and Nutrition Security conducted in March 2016 across the entire Malian territory. It was based on a stratified random sample drawn at 2 degrees (levels). The primary sampling unit, also called a cluster, is the Enumeration Section (ES) as defined in the General Population and Housing Census (RGPH) of 2009. The secondary unit is the household, defined here as a set of related or unrelated people, living under the same roof (or in the same concession), sharing the same meals, recognizing the authority of the same individual called Head of Household (HH) and whose resources or expenses are also common, at least in part. This concept refers to the economic household.

In total, 9,802 households were surveyed including 7,651 rural households (on which our analysis is focused), with the main objective of updating key food security indicators to understand the current food security situation and household nutrition, as well as its evolution over the next 6 months.

4. RESULTS AND DISCUSSION

4.1 Descriptive Analysis

The explanatory variables are crossed with the explained variable to see the relationship between them. Chi-square (Chi2) is also applied to test the significant level of variables.

4.2 Food Insecurity by Regions

Sikasso is the most productive region in Mali but steels in food insecurity at 32.71%. That may be explained by the low diversification of the diet that makes the Sikasso region. Households living in this region consume meals low in protein, unlike pastoral areas where the consumption of meat, fish and milk is higher. However, the households from Gao are in food insecurity at 40.15%, unlike the Kidal region where only 8.43% of households suffer from food insecurity. According to the chi-square test, the region of Gao is the most affected by food insecurity and the region of Kidal the least affected at the 5% threshold.

4.2.1 Level of education of the head of household and food insecurity

The level of education is assumed to have an influence on the food situation of households. An educated household generally has good dietary behaviours than an uneducated one.

In rural areas, we note that the level of education increases, the attendance decreases due to voluntary cession, school failure, parental disinterest, financial problem, school costs. Thus food insecurity is negatively correlated with the level of education of the head of household at 95%. An increase in the level of education of the head of household leads to an improvement in the food situation.

4.2.2 Welfare index and food insecurity

The welfare index is an indicator that allows us to assess the standard of living. Households with a "Very low" welfare index are generally the most affected by food insecurity (32.64%) compared to those with a "Very high" index (16.30%). The proportion of food insecurity decreases as economic welfare improves.

The bivariate analysis shows that food insecurity and the welfare index show a strong relationship between them. The chi-square statistic (98.57) is greater than the theoretical value (9.49) at 4 degrees of freedom.

Table 1. Food groups and weights justification

N°	Food items	Food groups	Weight	Justification
1	Maize , maize porridge, rice, sorghum, millet pasta, bread and other cereals	Cereals and	2	Energy dense, protein content lower and
2	Cassava, potatoes and sweet potatoes	Tubers		poorer quality (PER less) than legumes, micro-nutrients (bound by phytates).
3	Beans. Peas, groundnuts and cashew nuts	Pulses	3	Energy dense, high amounts of protein but of lower quality (PER less) than meats, micro-nutrients (inhibited by phytates), low fat.
4	Vegetables and leaves	Vegetables	1	Low energy, low protein, no fat, micro-nutrients
5	Fruits	Fruits	1	Low energy, low protein, no fat, micro-nutrients
6	Beef, goat, poultry, pork, eggs and fish	Meat and fish	4	Highest quality protein, easily absorbable micro-nutrients (no phytates), energy dense, fat. Even when consumed in small quantities, improvements to the quality of diet are large
7	Milk yogurt and other dairy	Milk	4	Highest quality protein, micro-nutrients, vitamin A, energy. However, milk could be consumed only in very small amounts and should then be treated as condiment and therefore reclassification in such cases is needed.
8	Sugar and sugar products	Sugar	0.5	Empty calories. Usually consumed in small quantities.
9	Oils, fats and butter	Oil	0.5	Energy dense but usually no other micro-nutrients. Usually consumed in small quantities

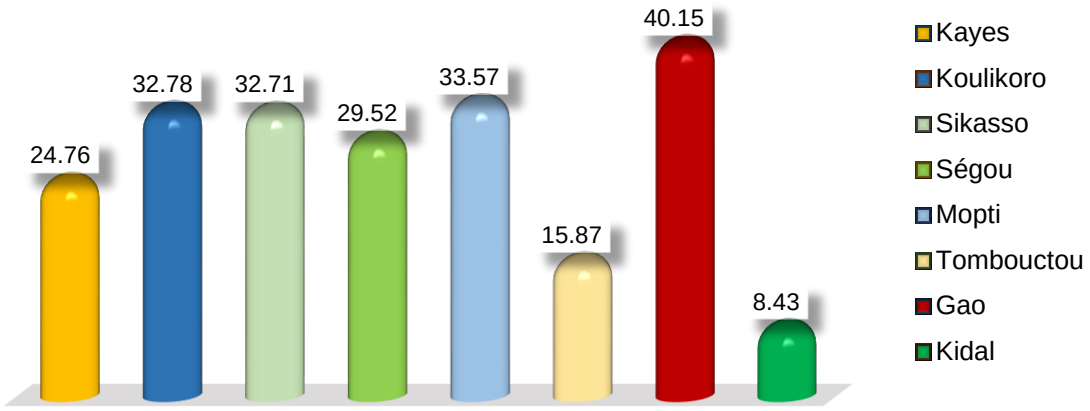

Fig. 1. Food insecurity by region (%)

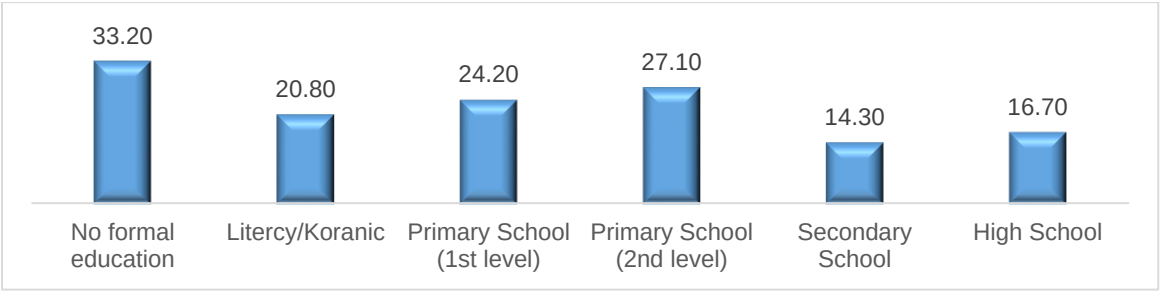

Fig. 2. Food insecurity by level of education of household head (%)

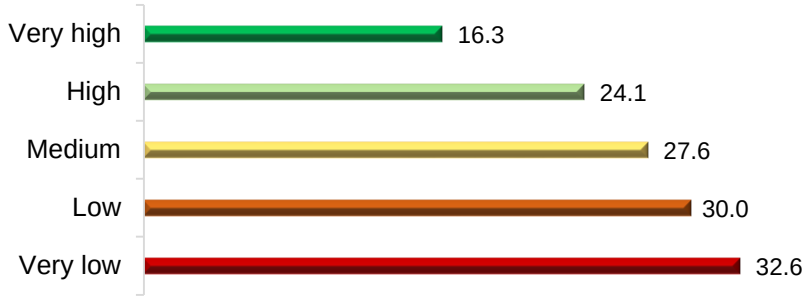

Fig. 3. Food insecurity by welfare (%)

4.2.3 Food insecurity and socio-demographic characteristics

Almost all households are headed by men in rural areas (94%). More than half of them (58%) are the 35-59 age group. Regarding size, it is positively correlated with food insecurity. The result shows that food insecurity increases with the age of the household head. The same result is observed by the household size. The chi-square test confirms that there is a significant relationship at 5% between these two variables and our variable of interest, food insecurity.

4.2.4 Food insecurity and sources of income diversification

Rainfed agriculture is the main activity of households in rural areas. It is assumed that in addition to this practice, households that make a

secondary activity as a source of income diversification are more often less exposed to food insecurity. The practice of this activity differs from one region to another. The practices of breeding, recession cropping, fishing, food trade, handcraft, money transfer and transportation contribute to the improvement of the food situation of rural households.

Table 2. Households' distribution per region

Region	Number of households
Kayes	1,063
Koulikoro	1,216
Sikasso	1,210
Segou	1,184
Mopti	1,306
Tombouctou	593
Gao	499
Kidal	580
Total	7,651

4.3 Econometric Analysis

The model makes it possible to estimate the probability of a household being more or less exposed to food insecurity. The estimate is made by the maximum likelihood method. A positive sign increases the risk of household food insecurity while a negative sign reduces this risk.

4.4 Region of Residence

Compared to the reference variable (Kidal region), all the regions are significant at 1% except the Kayes region which is significant at 5%. However, except for the region of Tombouctou, the other regions have positive coefficients. This result reflects the fact that a household, belonging to these regions increases its risk of food insecurity.

On the other hand, households living in the Tombouctou region are less vulnerable to food insecurity. The transhumant and nomadic livestock is concentrated (85% of the animals) in the northern regions including Tombouctou. The pure production of staple crop is not able to guarantee the food security of the households which practice it. This state means that the consumption of meat and milk is more important in those regions (where coefficient of meat, milk and related products are 4, 4). As a result, the northern region including Tombouctou have a high food consumption score. Also, the odds ratio confirms these facts by showing that the risk of being food insecure is 0.766 times lower for households belonging to the Tombouctou region compared to 1.283; 1.887; 1.584; 1,728 and 1,760 times respectively for the region of Kayes, Sikasso, Ségou, Mopti and Gao.

4.4.1 Education level of the household head

The results of the estimate show that all the other levels are significant except the 2nd cycle fundamental level and above compared to the reference modality (No formal education). Thus, this level of significance is 1% accompanied by negative signs implying that the fact for a head of household to be educated reduces the exposure of his family to food insecurity.

The odds-ratio analysis also shows that the risk of being food insecure is 0.575; 0.720; 0.623 times respectively for the levels Literate / Koranic, primary school(1st cycle), secondary compared to no formal education.

4.4.2 Economic welfare index

The results show that all welfare quintiles are significant at 1% and all have negative

Table 3. Food insecurity and socio-demographic characteristics

Socio-demographic Characteristics		Food Insecurity (%)		Test
		No	Yes	
Sex of household head	Male	72.80	27.20	$\chi^2_{0.05}$ = 0.15
	female	71.92	28.08	P=0.700
Age of household head	17-34 years	77.58	22.42	$\chi^2_{0.05}$ =14.98
	35-59 years	73.06	26.94	P=0.001
	60 year and over	70.64	29.36	
Household size	Less than 5	76.86	23.14	$\chi^2_{0.05}$ =18.91
	5-9 members	70.53	29.47	P=0.000
	10 and over	72.37	27.63	

Source: authors' construction based on data from ENSAN, March 2016

coefficients. Since the reference modality is "Very low", households with a high welfare index are less vulnerable to food insecurity compared to the reference modality. Welfare is therefore negatively correlated with food insecurity.

By observing the odds ratio, we can see that the risk of food insecurity decreases with welfare. This risk is 0.810; 0.692; 0.557 and 0.366 times for the welfare to be Low, Medium, High, and Very High, respectively.

4.4.3 The age distribution of household head

The age of household head affects productivity and household income. Indeed, the result indicates that compared to the reference modality “17-34 years”, the modality “35-59 years” has a positive but not significant coefficient unlike the modality “60 years and over” which is significant at 5% with a positive sign. There is therefore a 1.280 times chance for a head of household aged 60 and over to be food insecure than to be food secure.

4.5 Household Size

Household size was also found to be positively correlated with food insecurity, as was the age of the household head. In addition to having positive coefficients, the other two modalities are also significant at 1%. This would mean that the larger the household size, the more exposed the household to food insecurity. Thus, these are sizes "5-9 members" and "10 and over".

The risk of being food insecure is 1.393 times for households of size "5-9 members", and 1.509 times for those of size "10 and over".

4.5.1 Sources of income diversification

Being dependent on the alone rainfed agriculture activity in rural areas is synonymous with food insecurity. The literature review teaches us that households that engage in other activities to diversify their income are less affected by food insecurity.

The recession crop has a positive coefficient and is significant at 5%, which implies that households that practice this activity are exposed to food insecurity compared to the reference modality "money transfer". However, the other activities all have negative coefficients and are all statistically significant at 1% except the transportation (significant at 5%) indicating that the practice of these activities reduces the exposure of households to food insecurity.

Table 4. Sources of income diversification and food insecurity

Income diversification source		Food Insecurity (%)		$\chi^2_{0.05}$	P-Value
		No	Yes		
Breeding	No	67.98	32.02	21.84	0.000
	Yes	73.94	26.06		
Gardening	No	69.17	30.83	7.44	0.049
	Yes	74.30	25.70		
Recession cropping	No	73.16	26.84	10.79	0.001
	Yes	65.99	34.01		
Irrigation water practice	No	73.15	26.85	3.54	0.060
	Yes	70.48	29.52		
Fishing	No	72.46	27.54	13.42	0.000
	Yes	84.83	15.17		
Food trade	No	72.49	27.51	12.37	0.000
	Yes	85.00	15.00		
Handcraft	No	72.27	27.73	12.75	0.000
	Yes	79.71	20.29		
Traditional mining	No	72.55	27.45	3.68	0.055
	Yes	77.43	22.57		
Transportation	No	72.55	27.45	9.97	0.002
	Yes	85.59	14.41		
Money transfer	No	72.27	27.73	12.75	0.000
	Yes	79.71	20.29		

Source: authors' construction based on data from ENSAN, March 2016

Table 5. Estimation results

Variables	Coefficients	Standard Errors	Odds-ratio
Kidal	Ref		
Kayes	0.249**	0.097	1.283
Sikasso	0.635***	0.091	1.887
Segou	0.460***	0.90	1.584
Mopti	0.547***	0.088	1.728
Tombouctou	-0.267***	0.128	0.766
Gao	0.565***	0.120	1.760
17-34 years	Ref		
35-59 years	0.160	0.098	1.173
60 years and over	0.246**	0.105	1.279
Less than 5 members	Ref		
5-9 members	0.332***	0.083	1.393
10 and over	0.411***	0.085	1.509
No formal education	Ref		
Literate or Koranic	-0.554***	0.061	0.575
Primary School (1st level)	-0.329***	0.098	0.720
Primary School (2nd level)	-0.091	0.148	0.913
Secondary school	-0.724***	0.222	0.484
High school	-0.473	0.330	0.623
Very low	Ref		
Low	-0.211***	0.078	0.810
Medium	-0.368***	0.082	0.691
High	-0.585***	0.091	0.557
Very high	-1.005***	0.114	0.366
Money transfer	Ref		
Breeding	-0.468***	0.068	0.626
Gardening	-0.167***	0.065	0.846
Recession cropping	0.250**	0.111	1.284
Fishing	-1.151***	0.217	0.316
Handcraft	-0.336***	0.122	0.714
Food product trade	-0.655***	0.228	0.519
Transportation	-0.682**	0.272	0.506
LR Chi-square 486.22			
p-value 0.000			

****, ** respective significant at 1% and 5%, Source: author's construction based on data from ENSAN, March 2016*

The areas cultivated in recession crops have strongly decreased due to the drought. They also experience low productivity. In addition, the availability of soil moisture is affected by environmental factors (climate, hydrology, hydrogeology, soil properties) but also by agricultural practices. Despite this state, households continue to practice this culture hoping for a better day. That explain its positive sign.

The risk for a household of being food insecure given that it practices recession crop increases by 0.284 compared to the practice of other activities. However, this risk decreases by 0.846 respectively 0.714; 0.626; 0.519; 0.506 and 0.316 for the practice of gardening, handcraft, breeding, food products trade, transportation and fishing.

4.6 Model Prediction

The model's ability to classify a household as being food insecure knowing that it has been effectively examined as such is 19.09% while its ability to classify a household as being food secure knowing also that it has been examined considered as such is 92.54%. The model predicts households' food security better than households' food insecurity. It could be that there are unobservable variables that could better explain food insecurity such as imitation effects in food consumption. In most of rural areas, we observe that households attempts to do the

same food consumption by imitating others households' food consumption. The model correct classification rate is 72.53%.

5. CONCLUSION AND RECOMMEN-DATIONS

Our research aims to identify the determinants of food insecurity in rural areas in Mali using a binomial logit model. The results of the estimate show that factors exert a significant influence on food insecurity. Indeed, the region of residence, the size of the household, the age of household head, the level of education of household head, the well-being index and the diversification of income sources are found to be important determinants in explaining food insecurity.

Following theoretical predictions, the results of our study are consistent with these predictions with data from ENSAN March 2016. A descriptive analysis was first performed followed by econometric analysis. The data confirm that household food insecurity varies by region and that socio-economic and demographic factors influence household food insecurity.

The state of empirical studies shows that the rural areas are more exposed to food insecurity than the urban areas [6,7]. As our study focused only on rural areas, we found that some rural areas are more exposed to food insecurity than others. Areas with high animal consumption (northern regions) are less exposed than areas with high agricultural production.

Our analyses show that large size households are more vulnerable to food insecurity than small ones. One of the explanations for this maybe the dependency ratio between assets and liabilities. As [15], size also positively impacts food insecurity in rural Mali, particularly households' compound of "5-9 members" and "10 and over".

School attendance is low in rural areas unlike in urban areas, although it is a factor in improving the food and nutritional situation by learning good agricultural practices, family economics and food consumption. Our results show that education is negatively correlated with food insecurity. This result is similar to that obtained by [16-17] and [6].

Age is an important factor in agricultural productivity. It is assumed that young people have more workforce than old people. This implies that productivity increases when one is young than when one is old. As a result, households headed by young people are less exposed to food insecurity compared to those headed by older people (60 years and over). The result predicted by [18,16].

Welfare is assumed to increase the quality of household food consumption. This prior assumption has been confirmed by our data which indicate that household food consumption improves as household welfare improves.

Agriculture is the one and only main activity of the vast majority of households in rural areas. The practice of this activity is essentially seasonal because it is linked to rainfall. Generally, households that practice another activity in addition to rainfed agriculture are less vulnerable to food insecurity. This practice of a secondary activity is a form of income sources diversification allowing households to prevent the risk of hunger.

From the analysis, some significant factors have identified that effect negatively and positively on food insecurity. Among the negative factors, including the practice of breeding, of which 80% of the rural population practices this activity. This practice is significant and reduces the risk of food vulnerability. Similarly, the practice of fishing, handicrafts, food trade, and transportation also significantly reduce the vulnerability of households to food insecurity. This result corroborates that of [7].

During the off-season period, households practice gardening and recession crops. These crops remain quite important for reducing hunger, especially in rural areas. They offer an alternative occupation to producers during the post-season and help improve the diet and nutritional status of populations through a supply of vitamins and minerals. However, the producers of these crops constantly face problems of water, inputs and others.

The scientific interest of this investigation lies in the fact that the conclusions allow us to determine or know the variables of food insecurity. These determinants constitute the levers on which the Malian policymakers can rely to achieve a more efficient national level of food security. These results require the implementation of several recommendations that we deem appropriate by the Malian State and its technical and financial partners:

- Focusing programs to combat food insecurity more towards the regions most

affected (Kayes, Sikasso, Ségou, Mopti and Gao)by food insecurity;

- Prioritize households whoseheadsare60 years of age and over as well as those whose size exceeds 5 members in hunger relief efforts;
- Promote recession crops by improving farmers' knowledge and agricultural practices for better optimal use of soil moisture;
- Encourage education in rural areas, especially for no education level;
- Promote the welfare of rural populations through the implementation of protected/improved wells;
- Sensitize households to diversify their source of incomes.

This study does not take into account the cereal stock per household, the cereal area sown per household, as well as the rainfall. Indeed, other authors such as [9], [8] and [7] have established a relationship between cereal production and food security. Similarly [15] and [11] found a relationship between the cereal area planted and food security. We hope that other future studies will consider these aspects.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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