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Determinants of Food Insecurity in Rural Households in the Kayes and Koulikoro Regions of Mali

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Abstract: The objective of this paper is to, empirically; determine the factors that influence food security in the Kayes and Koulikoro Regions of Mali. The study is based on data from EMOP-2019, a permanent survey conducted by the National Institute of Statistics (INSTAT). The sample consists of 970 households, including 421 households in the Kayes region and 549 households in the Koulikoro region that responded to the food insecurity question. The descriptive statistics indicate that the prevalence of food insecurity is higher in female-headed households than in male-headed households in both regions. They also show that the prevalence of food insecurity is higher in households headed by people with no education in Kayes than in households headed by people with education. In contrast, in the Koulikoro region, it is higher in households headed by people with primary education. The results of the regression of the Logit model reveal that, among the factors that determine food insecure households in the Kayes and Koulikoro regions are the nature of the job, the practice of secondary activities, the type of activity practiced by the household, the size of the household, and the share of food expenditures in total expenditures. These factors significantly increase the probability that the household will become food insecure. These determinants work against food security. The level of education of the head of the household has a positive influence on the level of food insecurity of the household but in a decreasing manner.

Keywords: Food Insecurity, Households, Determinants, Kayes, Koulikoro

1. Introduction

Improving the performance of the agricultural sector is one of the key solutions to food insecurity [14]. Soil infertility and overexploitation of agricultural land have led to a decline in agricultural yields. Farm incomes are relatively low and food insecurity is taking hold by making access to inputs and improved seeds difficult. A relatively balanced diet allows each individual to maintain or restore his health stock [20]. Many farm households are unable to feed themselves due to fluctuating food prices. Relatively poor and vulnerable residents suffer the most from higher food prices [25, 10]. Agricultural households are the most affected by food insecurity in Africa [9, 24]. The factors that affect food insecurity differ according to the type and absence of agricultural policies in favor of small farmers to improve their resilience to weather shocks [5].

Adequate food availability achieved through markets or other means at the national, regional and household levels is the cornerstone of nutritional well-being. At the household level, food security implies physical and economic access to food that is sufficient in quantity, quality, safety and cultural acceptability to meet individual needs. A household's food security depends on its income and assets, such as land and other productive resources. Ultimately, food security is related to the accessibility of adequate food at the household level, that is, the ability of households and individuals to obtain sufficient and nutritionally adequate food under all circumstances [8].

Ensan Mali [11] classifies the food security situation of households according to WFP's Consolidated Approach for Reporting Indicators of Food Security (CARI). This CARI methodology takes into account the two key dimensions of food security: i) short-term status, for which the food consumption score is the key indicator; ii) access to food,

which is measured in relation to the household's economic vulnerability (share of expenditures devoted to food); and, iii) depletion of household assets (use of coping strategies). A household is declared food insecure when it experiences (significant) food consumption deficiency, marginal ability to meet minimum food needs only through accelerated livelihood depletion or extreme (or worse) livelihood loss resulting in significant food consumption deficiencies.

Mali's economy is highly dependent on the primary sector: agriculture, livestock, fishing and forestry account for 68.0% of the active population. This sector is itself dependent on factors mainly of a climatic nature, such as recurrent droughts and floods. The unstable security situation since 2012 and the effects of climatic hazards, mainly in the Kayes and Koulikoro regions, continue to have a negative impact on household living conditions. The deterioration in livelihoods (livestock, crops, sources of income, employment, reduction in economic activities, etc.) and the resulting unusual movements of livestock and increasing size of households have particularly heightened the vulnerability of households to food insecurity in these regions. In addition, we note food insecurity related to cropping and livestock production (animal damage, diseases, and crop pests). According to the latest report by the United Nations Office for the Coordination of Humanitarian Affairs in Mali (OCHA), published in September 2019 on the humanitarian situation in Mali, over 3.9 million Malians are food insecure.

At the national level, statistics indicate that 29% of households are food secure; 55% are slightly food insecure; 14% are moderately food insecure; and 2% are severely food insecure. Household food insecurity in the regions of Kayes and Koulikoro is estimated at 12.3% and 16.8% respectively, compared to an annual average of 16% [11].

The implementation of various interventions under the Government's National Response Plan in collaboration with humanitarian agencies, mainly in the north and center of the country, has contributed to a stabilization or even an improvement in food security according to the results of the ENSAN conducted in September 2018 [11]. Nevertheless, households remain vulnerable and not very resilient to shocks, particularly in the center and west of the country, which are still suffering from the after-effects of the security crisis and climatic hazards. To this end, the main concern was to determine whether the household had difficulty feeding itself during the last six months of the year. In this context, the objective of this study is to identify the determinants of household food insecurity in the Kayes and Koulikoro regions. In order to achieve this objective, we use a logit model to identify the determinants of food insecurity in rural households in these regions. Thus, the work is outlined in the following plan.

After the introduction, we present in a first section the literature review, in a second the methodology. The results are presented and discussed in the last section and finally the work ends with a conclusion.

2. Literature Review

Using data 1-2-3 (2012) published in September 2014, from the National Institute of Statistics (INS), covering a sample of 20,114 households, Bolingo [8] attempts to empirically prove the determinants that exert a negative or positive influence in urban and rural Congolese areas on food security. He shows that the determinants of food insecure households include household size, gender of the head of household, and level of education. In particular, he showed that the size of the household (more than 8 members), the level of education of the head of the household and gender are the main variables that positively condition the probability of a household being food secure.

Rural farm households in the North West Province of South Africa have food security constraints. Across the four districts, 76 out of 144 households were studied. Logistic regression results, by Ijatuyi and al. [15], on factors influencing food security showed that variables such as age of household head, household food rate, total cost of production, farm income, and health expenditure had a significant impact on household food security.

In determining the effect of agricultural marketing on food security among smallholder farmers in Polokwane Municipality, Capricorn District, South Africa, Oluwatayo and Rachoene [19] use primary data collected from 56 farmers in the study area. The results showed that household age (negative and significant), marital status (negative and significant), education level (positive and significant), farm size, number of workers employed, type of mechanization, and level of marketing are the determinants of food security in the study area.

Time series data from the Central Bank of Nigeria Statistical Bulletin (2019) were used to investigate the role of local farmer-investors in agricultural productivity and food shortage mitigation using Johansen's co-integration (long-run) and Granger causality (short-run) techniques. The data involved 145 farmers. Nnaemeka [18] using logistic regression revealed that age, total cost of production, farm income, and health expenditure are significant factors that positively influence farmers' food security.

Abdullahi and al. [1] empirically examine the determinants of food insecurity among households in Katsina State, Nigeria. The primary data involved a sample of 384 households determined based on the Krejcie & Morgan (1970) sampling table cited by Abdullahi and al [1]. The results of the logistic regression reveal that food availability, accessibility, utilization and stability are the major determinants of food insecurity in Katsina State and have a significant impact on food insecurity in the study area (P<0.05).

Collecting data on a sample of 652 agricultural households from the Integrated Modular Survey on Living Conditions of Households conducted by (INSAE) in 2015, Saliga and Alinsato [20] analyze the food security of agricultural households in Borgou Department. The results of the estimation of the Logit regression model conducted revealed

that agricultural households in Borgou Department have a relatively high chance of being food secure if they adopt pluriactivity. The probability of being food secure is relatively high when farm households practice cash crop farming compared to households that adopt food crop farming in Borgou department. It finds a significant negative correlation between household size and food security. The level of education of the head of the household has a positive and significant effect on food security (Jensen [16], Saliga et Alinsato [20]) and a negative and significant effect on food insecurity [16].

Faridi and Wadood [12] use the 2005 Household Income and Expenditure Survey (HIES), which provides valuable data on household income, expenditure, consumption, savings, housing conditions, education, employment, health and sanitation, water supply, and health services to investigate the determinants of household food security status in Bangladesh. Different household characteristics appear to be highly correlated with the food security indicator, which could be useful in identifying food insecure households. The regression results show that education level positively and significantly affects household food security. The age of the head of household has a negative and significant impact on household food security. The results show that wage earners, whether they are day laborers or salaried workers, are less well off in terms of food security than self-employed workers, whether they are agricultural or not.

Using data from the 1998-2001 food security supplements of the Current Population Survey (CPS-FSS), Bartfeld and Dunifon [6] examine interstate variation in household food security. The results show that a strong food security infrastructure is particularly beneficial for households that are economically vulnerable but have incomes above the poverty line. Almost all of the observed state differences in food security can be explained by state differences in demographic and contextual characteristics. The education level of the household head negatively affects food insecurity. The results show that the chance of becoming food insecure for a household increases with the number of children in the household. In a sample of 30,938 observations from the same source from 2001 to 2012, Hamersma and Kim [13] assess whether adolescents' participation in the labor market can influence the food security of children in their families. They find that a working teenager reduces the predicted probability that children in a family have very low food security in an economically and statistically significant way.

Using data from 3,298 food crop farmers in Pakistan, Ahmad and al. [4] suggest that households that have adapted to climate change have statistically greater food security than those that have not. The results also show that education of household heads, livestock ownership, house structure (masonry and with electricity), crop diversification, and off-farm income are among the factors that increase food security of farm households and their impacts are statistically significant. Variables that are significantly negatively associated with food security levels include age of household head, food expenditure management, households with less

than 12.5 hectares of land defined as marginal (cultivating less than 6.25 hectares) and small (cultivating >6.25 to <12.5 hectares). Farmers in cotton-wheat, rice-wheat, and rain fed cropping systems are more food secure than those in mixed cropping systems where farms are relatively small and high tube well water use contributes to soil salinity.

Agidew and Singh [2] assess the determinants of food insecurity among rural agricultural households in the Teleyayen sub-watershed in Ethiopia. The study used 215 households. It was found that 20.9 and 79.1% of the sampled households are food secure and food insecure, respectively. The majority of food insecure households are headed by youth, who own less than 1ha of agricultural land. On average, male-headed households are more food secure than female-headed households. The result of the binary logistic regression revealed that lack of agricultural land, poverty, recurrent drought and climate change, lack of rainfall and land degradation are determinants of this food insecurity. However, the gender of the household head, political support, land redistribution, farmland topography, soil fertility and erosion do not have a significant influence. The age of the household head and the size of the household have a negative effect on food security.

Biringanine [7] falls under the theme of Food Security and seeks to identify socio-economic factors that can explain the nutritional status of public and private sector workers in the city of Bukavu. The result of the binary logistic model shows that the level of education as well as the rate of access to food resources explain the food security of the groups under study. In addition, the ordered multinomial regression made possible by the calculation of the Food Consumption Score showed that being in the public sector, the share of income devoted to savings, access to food resources, and the age of the household reduced the chance of the household having sufficient food. Finally, household income and the share of income spent on food increase the chance of the household having sufficient food.

Using household surveys in Guatemala and Honduras, Alpízar and al. [5] explore the prevalence of food insecurity among smallholder farmers that is both recurrent (seasonal) and episodic (resulting from extreme weather events). They analyze factors associated with both types of food insecurity and document farmers' coping strategies. Of the 439 households surveyed, 56% experienced recurrent food insecurity, 36% experienced episodic food insecurity due to extreme weather events, and 24% experienced both types. Food insecurity among smallholder farmers was correlated with socio-demographic factors, e.g., age of head, household size, and education negatively and significantly affect recurrent household food insecurity. Permanent migration has a positive effect on episodic food insecurity. Asset ownership also has a significant effect. Factors affecting food insecurity differed by type and prevalence of food insecurity. The results highlight that gender has a significant negative effect on episodic food insecurity.

Sambo and al. [21] study the food security status of 355 farm households in the local municipality of Nkomazi, South

Africa. The majority of the respondents were women. In addition, respondents between the ages of 61 and 70 and those who had only completed elementary school were also in the majority. Just under half of the respondents had more than 21 years of farming experience and had large households (6-10 members). Although most farm households in the study area were food secure, overall household food insecurity was very high. Marital status, education level and annual household agricultural income were positively and significantly associated with food security. Primarily elderly people with low levels of education practice farming.

To analyze income inequality and food security status of farmers in southeastern Nigeria, Abia State, Agwu and Oteh [3] use a sample of 180 households. The study accessed farmers' income inequalities, determined farmers' food security status, and estimated factors influencing farmers' food security in the study area. The majority of the study households, about 68.57%, were food insecure. The regression results showed that age of the household head, education level of the household head and monthly income of the household head were the main determinants of food security status.

To estimate food security status and identify determinants of food security among households receiving government subsidies in a township in Kwakwatsi, South Africa, Sekhampu [22] uses data from a 180 household survey. A logistic regression model was estimated based on this data with household food security status (i.e., food security and food insecurity) as the dependent variable and a set of demographic variables as explanatory variables. It was found that approximately 38% of the sampled households are food secure. The results of the regression analysis showed that total household income, household size, employment and marital status of the household head, employment status of the spouse are significant determinants of food security in the region. Household size and marital status of the household head were negatively associated with household food security. Age, gender, and education level of the household head were not significant predictors of household food security.

This study adds to the literature devoted to the analysis of the determinants of food insecurity. It takes into account the nature of the job held by the head of the household and the exercise of a secondary activity by the head of the household in order to combat food insecurity, in addition to the traditional socio-demographic determinants. One of the specificities of such a study in Mali is the empirical determination of the effects of these variables on household food security.

3. Methodology

3.1. Specification of the Regression Model

In this study, we identify the determinants of food insecurity in rural households in the Kayes and Koulikoro Regions of the Republic of Mali. The literature is quite extensive and recent on the analysis of the nutritional status of individuals. The phenomenon is modeled econometrically to identify the socioeconomic and demographic realities of the different study areas. Thus, we draw on Abdullahi and al. [1] empirically examining the determinants of household food insecurity in Katsina State, Nigeria; Sambo and al. [21] on the food security status of farm households in Nkomazi Local Municipality, South Africa and Oluwatayo and Rachoe [19] on determining the effect of agricultural marketing on food security among smallholder farmers in Polokwane Municipality, South Africa.

On the other hand, the Monte Carlo method, shows that the parameter estimates and their accuracies obtained by Probit models are generally little different from Logit models [8]. According to Greene (2002, p. 667) and Gujarati (2004, p. 612) cited by Tarno [23], Logit and Probit models are very similar. In this context, the choice question is therefore moot. Being more user-friendly from the point of view of mathematical manipulations, Logit is more widely used than Probit.

We know that when the independent variables are not normally distributed, the estimators of the Logit model are more robust than those of the discriminant analysis. In this work, we capture the phenomenon of food insecurity through food availability. The key question, from the EMOP-2019, that households responded to was: In the past 6 months, has the household had difficulty feeding itself? If the household answers yes (y=1), then the household is food insecure, otherwise (y=0) the household is not food insecure. Our sample will therefore be subdivided into two categories. We seek to explain the dichotomous variable y designating food insecurity.

The probability of a household belonging to the first group (y=1) is a function of a number of socio-economic and demographic characteristics. An estimate of this probability is given by the following logistic function:

$$\begin{cases} y = 1, & \text{if the houshold is food insecure} \\ y = 0, & \text{if not} \end{cases} \tag{1}$$

$$\begin{aligned} P_1 = P(y_i = 1) = P(y^* > 1) &= P(\beta_0 + \beta_1 x_1 + \varepsilon_i > 0) \\ &= P(\varepsilon_i > \beta_0 + \beta_1 x_1) \\ &= \varphi(\beta_0 + \beta_1 x_1) \end{aligned}$$

with $\phi(.)$ the distribution function of the logistic law. $\tag{2}$

$$P_1 = P(y_i = 1) = \phi(\beta_0 + \beta_1 x_1) = \frac{e^{(\beta_0 + \beta_1 x_1)}}{1 + e^{(\beta_0 + \beta_1 x_1)}} = \frac{1}{1 + e^{(-\beta_0 + \beta_1 x_1)}}$$

By generalizing, we can state that:

$$P_1 = P(y_i = 1) = \frac{1}{1 + e^{(\psi_{ij})}} \tag{3}$$

By performing a transformation of equation (3), the logarithm of the ratio of the probability of becoming food insecure to the probability of not becoming food insecure can be predicted as follows:

$$\psi_{ij} = \ln\left(\frac{P_{ij}}{1 - P_{ij}}\right)$$

We note that P_{ij}, being a probability, is constrained to take values between 0 and 1, while ψ_{ij} can take any real value. The probability of being food insecure predicted by equation (3) thus also follows from a transformation of ψ_{ij}.

Indeed, the Logit model is a model where the log-odds ratio, ψ_{ij} is obtained by a linear combination of the explanatory variables:

$$\psi_{ij} = \ln\left(\frac{P_{ij}}{1 - P_{ij}}\right) = \beta_0 + \beta_{ij}x_{ij} + \ldots + \beta_{qi}x_{ij}$$

Where x_{ij} the represent the explanatory variables and the β_{ij} the parameters to be estimated.

The econometric model to be estimated, by region, is of the form:

$$Food - in\sec = \beta_0 + \beta_1 Resi + \beta_2 Ma\_status + \beta_3 Injury\_HH + \beta_4 Nat\_job$$
$$+ \beta_5 Lev\_edu + \beta_6 Gender + \beta_7 Type\_act + \beta_8 Sec\_act$$
$$+ \beta_9 Age\_HH + \beta_{10}HH\_size + \beta_{11}Share\_food\_\exp + U_i$$

3.2. Data Source

The study area covers the regions of Kayes and Koulikoro, administratively the first and second regions of Mali. Both regions are located in the west of the country, with the first region being in the extreme west. The EMOP surveys cover all regions of the country. The data are extracted from the EMOP-2019 survey, conducted by the National Institute of Statistics (INSTAT). After processing, it covered a sample of 421 households and 549 households in the Kayes and Koulikoro regions, respectively. Food security is one of the components of the EMOP survey. In the Kayes region, 60.8% of households are food insecure compared to 32.8% in the Koulikoro region.

The definition and terms of the variables are recorded in the table below. In addition to the traditional socio-demographic variables, we use the health status of the head of household, the nature of the job held by the head of household and the CARI indicator, i.e., the share of food expenditures in total household expenditures (less than 50% for food secure households; between 50% and 65% for households vulnerable to food insecurity; between 65% and 75% for moderately food insecure households and at least 75% for food insecure households).

***Table 1.** Description of variables.*

Variables	Kayes (Obs.)	Koulikoro (Obs.)	Definition and Terms
Food safety	421	549	The head of the household experienced difficulties in feeding the household (Yes=1; No=0)
Place of residence	421	549	The environment where the household lives (Urban=1; Rural=0
Marital status	421	549	Marital status of head of household (Monogamous=1; Polygamous=2; Widowed=3)
Injury to the head of the household	421	549	Head of household was injured during the last 3 months (Injured=1; Not injured=0)
Nature of the job	421	549	Nature of the job held by the head of the household (; Continuous=1; Irregular=2)
Level of education	421	549	The level of education attained by the head of the household (Without instruction=4; Primary=3; Fundamental=2; At least secondary=1)
Gender	421	549	Gender of the head of the household (Male=1; Female=0)
Type of activity	421	549	Type of activity carried out by the head of the household (Cereal and other crops=1; Livestock=2; Crop and livestock=3)
Secondary activity practice	421	549	Head of household has a secondary activity (Affirmative=1; Negative=2)
Age range	421	549	Age of the head of household (Less than 35 years=1: Between 35 and 45 years=2; Between 46 and 55 years=3; Between 56 and 65 years=4; More than 65 years=5)
Household size	421	549	The number of people living in the household (Less than 5 pers=1; Between 5 and 10 pers=2; Between 11 and 15 pers=3; More than 15 pers=4)
Share of food expenditures	421	549	Share of household food expenditures in total expenditures (%) (Less than 50=1; Between 50 and 65=2; Between 66 and 75=3; More than 75=4)
Total	970		

Source: Authors based on data from EMOP-2019, Mali.

4. Presentation and Discussion of Results

4.1. Descriptive Statistics

The results of the descriptive statistics, related to the prevalence of food insecurity, obtained from the processing of the data in SPSS 21, are recorded in Tables 2-6.

***Table 2.** Cross-tabulation of household gender and food security.*

Region	Variables	Terms and conditions	Food insecurity (%)	Food security (%)	Chi2 test Pearson
Kayes	Gender of head of household	Male	60.0	40.0	Chi2(1)=2.916[c]
		Woman	81.3	18.7	Prob.=0.088

Region	Variables	Terms and conditions	Food insecurity (%)	Food security (%)	Chi2 test Pearson
Koulikoro	Gender of head of household	Male	32.7	67.3	Chi2(1)=0.542[d]
		Woman	50.0	50.0	Prob.= 0.462

Source: Authors based on data from EMOP-2019, Mali.

The analysis in Table 2 indicates that the prevalence of food insecurity is higher in female-headed households than in male-headed households in both regions. It is higher in the Kayes region (81.3%) and is estimated at 50.0% in the Koulikoro region. This result seems obvious because women are in a more precarious economic situation. Indeed, female-headed households have fewer productive assets, earn less income and use more coping strategies to acquire food.

Table 3. Crossover of residence and food security.

Region	Variables	Terms and conditions	Food insecurity (%)	Food security (%)	Chi2 test (Pearson)
Kayes	Place of residence	Urban	66.1	33.9	Chi2(1)=0.807
		Rural	59.9	40.1	Prob.= 0.369
Koulikoro	Place of residence	Urban	33.8	66.2	Chi2(1)= 0.039
		Rural	32.6	67.4	Prob.= 0.843

Source: Authors based on data from EMOP-2019, Mali.

The results in Table 3 show that the prevalence of food insecurity in urban households is higher than in rural households in both regions (Kayes, Koulikoro). The prevalence is relatively higher in the Kayes region (66.1%) compared to the Koulikoro region (33.8%).

Table 4. Cross-tabulation of marital status and food security.

Region	Variables	Terms and conditions	Food insecurity (%)	Food security (%)	Chi2 test (Pearson)
Kayes	Marital status of head of household	Monogamous	60.2	39.8	Chi2(2)=1.590
		Polygamous	60.6	39.4	Prob.= 0.452
		Widow(er)	80.0	20.0	
Koulikoro	Marital status of head of household	Monogamous	29.0	71.0	Chi2(2)=7.141
		Polygamous	39.7	60.3	Prob.= 0.028
		Widow(er)	50.0	50.0	

Source: Authors based on data from EMOP-2019, Mali.

Table 4 shows that in the Kayes and Koulikoro regions, the prevalence of food insecurity in widowed households is higher than in households headed by a monogamous or polygamous husband. It is 80.0% in widowed households in Kayes and 50.0% in those in Koulikoro.

Table 5. Household size and food security cross-reference.

Region	Variables	Terms and conditions	Food insecurity (%)	Food security (%)	Chi2 test (Pearson)
Kayes	Household size	Less than 5 people	52.7	47.3	
		Between 5 and 10 people	66.1	33.9	Chi2(3)=5.513
		Between 11 and 15 people	56.3	43.8	Prob.= 0.138
		More than 15 people	63.1	37.9	
Koulikoro	Household size	Less than 5 people	16.0	84.0	
		Between 5 and 10 people	34.1	65.9	Chi2(3)=19.647
		Between 11 and 15 people	43.1	56.9	Prob.= 0.000
		More than 15 people	37.7	62.3	

Source: Authors based on data from EMOP-2019, Mali.

In Table 5, the prevalence of insecurity is highest (66.1%) in households between 5 and 10 persons in the Kayes region. In the Koulikoro region, it is estimated at 43.1% in households with a size of between 11 and 15 persons, and is therefore higher than in other households.

Table 6 shows that the prevalence of food insecurity is higher in households whose heads have no education than in households whose heads have some education. This prevalence is 62.7% for households with no education, 56.0% for households whose head has a basic education, 53.7% for those with primary education, and 50.0% for those with at least secondary education. In the Koulikoro region, the prevalence of insecurity is more pronounced in households whose heads have a primary level of education (56.7%) than in other households in the region.

Table 6. *Cross-tabulation of the level of education of the head of household and food security.*

Region	Variables	Terms and conditions	Food insecurity (%)	Food security (%)	Chi2 test (Pearson)
Kayes	The level of education of the head of the household	Without instruction	62.7	37.3	
		Primary	53.7	46.3	Chi2(3)=2.235
		Fundamental	56.0	44.0	Prob.=0.525
		At least secondary	50.0	50.0	
Koulikoro	The level of education of the head of the household	Without instruction	29.4	70.6	
		Primary	56.7	43.3	Chi2(3)=19.374
		Fundamental	38.2	61.8	Prob.= 0.000
		At least secondary	0.0	100.0	

Source: Authors based on data from EMOP-2019, Mali.

4.2. Econometric Results and Discussion

In this section, we present results on the determinants of household food insecurity in the Kayes and Koulikoro regions. Note that economists are interested in the signs of the relevant variables and the proportional responses of the explained variables to proportional changes in the level of the explanatory variables, i.e., the elasticities. Since the endogenous variable is a probability, the calculation of probabilities allows us to assess the impact of the explanatory variables on the probability of household undernourishment. The coefficients and Odds Ratios of the Logit model are calculated using Stata 12. The results are reported in Tables 7 and 8.

Table 7. *Results of the estimation of the Logit model (Kayes Region).*

	Coef.	Odds ratios	Marg. Effect
VARIABLES	(Std.Err.)	(Std.Err.)	
Place of residence (Ref: Urban)			
Rural Area	-0.538	0.584	0.5934
	(0.336)	(0.197)	
Marital status (Ref: Married monogamous)[1]			
Polygamous	-0.033	0.968	0.603
	(0.249)	(0.241)	
Widow(er)	0.157	1.170	0.643
	(1.007)	(1.178)	
Head of household injured in the last 3 months (Ref: Head Not injured)			
Injured	0.488*	1.628*	0.685
	(0.271)	(0.440)	
Nature of employment of the head of household (Ref: Continuous)			
Irregular	2.055*	7.803*	0.630
	(1.220)	(9.521)	
Level of education of the head of the household (Ref: At least Secondary)			
Without instruction	-0.594	0.552	0.623
	(1.789)	(0.987)	
Primary	-0.9545	0.384	0.545
	(1.806)	(0.695)	
Fundamental	-0.853	0.426	0.567
	(1.832)	(0.780)	
Gender of the head of household (Ref: Male)			
Female	1.267	3.549	0.825
	(0.823)	(2.920)	
Type of activity (Ref: Cereal and other crops)			
Breeding	0.834	2.302	0.750
	(1.229)	(2.830)	
Culture and Breeding	2.852**	17.325**	0.949
	(1.362)	(23.597)	
Practice a secondary activity (Ref: Affirmative)			
Negative	0.466*	1.594*	0.680
	(0.268)	(0.426)	
Age range of head of household (Ref: Under 35)			
Between 35 and 45 years old	-0.517	0.597	0.544
	(0.335)	(0.200)	
Between 46 and 55 years old	-0.084	0.919	0.638
	(0.341)	(0.313)	
Between 56 and 65 years old	-0.536	0.585	0.539
	(0.377)	(0.221)	
Over 65 years old	0.101	1.106	0.676
	(0.432)	(0.477)	

	Coef.	Odds ratios	Marg. Effect
Household size (Ref: Less than 5 people)			
Between 5 and 10 people	0.742**	2.101**	0.661
	(0.295)	(0.619)	
Between 11 and 15 people	0.318	1.375	0.570
	(0.373)	(0.512)	
More than 15 people	0.704*	2.022*	0.653
	(0.411)	(0.831)	
Share of food expenditures in total expenditures (Ref: Less than 50%)			
66 and 75%.	2.529**	12.538**	0.577
	(1.122)	(14.063)	
More than 75% of the total	2.750**	15.644**	0.626
	(1.095)	(17.124)	
Constant	-3.756**		
	(1.651)		
Observations	421	421	421
LR chi2(21)	45.84	45.84	
Prob > chi2	0.0013	0.0013	
Pseudo R^2	0.0813	0.0813	

[1]We note the absence of single people in the sample
Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Moving from the group of households whose heads were not injured in the last three months of the year to those whose heads were injured, the chance that the farm household is food insecure increases by 0.685. Thus, households whose heads were injured in the last three months of the year are 1.628 times more likely to be food insecure than those whose heads were not injured. The chance of a household being food insecure increases by 0.630 when moving from households with a continuously employed head to those with an irregularly employed head. Households with an irregularly employed head are 7.803 times more likely to be food insecure than those with a continuously employed head.

Moving from the group of households headed by cereal and other crops to those headed by livestock and crops, the odds increase with food insecurity by 0.949. These types of households are 17.325 times more likely to be food insecure than those that grow cereals and other crops. The fact that the head of the household does not practice a secondary activity increases his or her chance of being food insecure by 0.680. Households whose head does not engage in a secondary activity are 1.594 times less likely to be food secure than those whose household engages in a secondary activity. The results also indicate that households with less than 5 persons, those with between 5 and 10 persons and those with more than 15 persons have a probability of being food insecure of 0.661 and 0.653 respectively. Households with 6 to 10 people and more than 15 people are 2.101 and 2.022 times less likely to be food insecure in the Kayes region than those with less than 5 people.

From the group of households whose share of food expenditures in total household expenditures is less than 50% to those whose share of food expenditures in total household expenditures is between 66% and 75%, and greater than 75%, the probability increases with food insecurity, respectively by 57.7% and 62.6%. Households whose share of food expenditures in total expenditures is between 66% and 75%, and those whose share is greater than 75% are 12.53 and 15.64 times more likely to be food insecure than their counterparts whose share is less than 50%. This is explained by the fact that, in the Kayes region, 98.1% of households are between 11 and 15 persons and more than 15 persons. These results are confirmed by Saliga and Alinsato [20], Ensan Mali [11] and refuted by Alpízar and al. [5]. In other words, households whose share of food expenditures in total expenditures is between 66 and 75%, and above 75% are very large households.

Table 8. *Results of the estimation of the Logit model (Koulikoro Region).*

	Coef.	Odds ratios	Marg. Effect
VARIABLES	(Std.Err.)	(Std.Err.)	
Place of residence (Ref: Urban)			
Rural area	-0.216	0.806	0.323
	(0.290)	(0.233)	
Marital status (Ref: Married monogamous)[1]			
Polygamous	0.200	1.222	0.353
	(0.234)	(0.286)	
Widow(er)	0.599	1.820	0.436
	(1.037)	(1.887)	
Head of household injured in the last 3 months (Ref: Head Not injured)			
Injured	0.076	0.927	0.319
	(0.216)	(0.201)	
Nature of employment of the head of household (Ref: Continuous)			

	Coef.	Odds ratios	Marg. Effect
Irregular	0.557**	1.745**	0.378
	(0.239)	(0.417)	
Level of education of the head of the household (Ref: At least Secondary)			
Without instruction	Omitted	Omitted	
Primary	1.465***	4.328***	0.601
	(0.325)	(1.404)	
Fundamental	0.677*	1.967*	0.426
	(0.411)	(0.808)	
Gender of the head of household (Ref: Male)			
Female	0.939	2.558	0.526
	(1.213)	(3.103)	
Type of activity (Ref: Cereal and other crops)			
Breeding	-0.407	0.666	0.242
	(0.712)	(0.474)	
Culture and Breeding	1.546***	4.694***	0.649
	(0.484)	(2.273)	
Practice a secondary activity (Ref: Affirmative)			
Negative	0.319	1.376	0.390
	(0.431)	(0.593)	
Age range of head of household (Ref: Under 35)			
Between 35 and 45 years old	0.478	1.613	0.310
	(0.438)	(0.706)	
Between 46 and 55 years old	0.389	1.475	0.293
	(0.451)	(0.666)	
Between 56 and 65 years old	0.850*	2.339*	0.384
	(0.458)	(1.072)	
Over 65 years old	0.947*	2.578*	0.405
	(0.512)	(1.320)	
Household size (Ref: Less than 5 people)			
Between 5 and 10 people	0.865***	2.376***	0.358
	(0.315)	(0.748)	
Between 11 and 15 people	0.970**	2.637**	0.380
	(0.379)	(1.000)	
More than 15 people	0.592	1.807	0.304
	(0.447)	(0.808)	
Share of food expenditures in total expenditures (Ref: Less than 50%)			
50 and 65%.	-0.177	0.838	0.264
	(0.477)	(0.400)	
66 and 75%.	0.266	1.305	0.347
	(0.481)	(0.627)	
More than 75% of the total	0.550	1.734	0.405
	(0.508)	(0.881)	
Constant	-2.768***		
	(0.696)		
Observations	547	547	547
LR chi2(21)	70.61	70.61	
Prob > chi2	0.0000	0.0000	
Pseudo R^2	0.1019	0.1019	

[1]We note the absence of single people in the sample
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Moving from the group of households whose heads are continuously employed to those whose heads are irregularly employed, the chance that the household is food secure decreases by 0.378. Households with irregular employment are 1.745 times more likely to be food insecure than those with a continuously employed head. The illiteracy rate in the region is high at 52.1% [11]. With reference to the level of education (at least secondary) to combat food insecurity, the results indicate that households whose head has a primary level of education have a 60.1% chance of becoming food insecure and those whose head has a basic level of education 42.6%. The effect of education on the level of household food insecurity is positive and decreases as the level of education increases. It is interesting to note that households whose head has a primary level of education are more likely to be food insecure than those whose head has a basic level of education (4,328 times and 1,967 times respectively). The level of household food insecurity decreases with the level of education of the household head. These results are refuted by Bolingo [8] and confirmed by Jensen [16], Kehinde and Favour [17]. In Koulikoro, the higher the level of education of the head of the household, the less likely the household is to become food insecure, as households whose head has a basic level of education are 1,965 times more likely to

become food insecure, compared to 4,328 times for those with primary education. Moving from the group of households whose heads grow cereals and other crops to those whose heads grow livestock and crops, the odds increase with food insecurity by 0.649. These types of households are 4.694 times more likely to be food insecure than those who grow cereals and other crops. With reference to heads of households whose age is less than 35 years, the results show that the age of the head of household has a positive and significant effect on household food insecurity. These results are confirmed by Oluwatayo and Rachoene [19] and refuted by Alpízar and al. [5]. The household is exposed to food insecurity the older the head becomes. From the group of households composed of less than 5 people to those with a size between 5 and 10 people, and between 11 and 15 people the probability of falling into food insecurity increases by 0.358 and 0.380, respectively. The latter are, respectively, 2.376 times and 2.637 times more likely to be food insecure. Food insecurity increases with household size in Koulikoro. These results are confirmed by Saliga and Alinsato [20] and refuted by Alpízar and al. [5].

5. Conclusion

This study analyzes the determinants of food insecurity among rural households in the Kayes and Koulikoro regions of the Republic of Mali. It is based on data from the EMOP-2019. The results of the regression of the Logit model, carried out, revealed that rural households in both regions are less likely to be food secure as long as they have an irregular employment status. In addition, the type of activity practiced by the household (crop and livestock) as well as the size of the household exert positive and significant influences on household food insecurity. Indeed, a household of a large size is likely to have difficulty meeting the food needs of its family members. In the Kayes region, the fact that a household does not engage in a secondary activity increases the chance that it will become food insecure. In the same region, the deterioration of the health status of the head of household (an injury) works against food security. In order to fight against food insecurity in the Kayes and Koulikoro regions, it is urgent to put in place continuous employment policies and to promote and encourage the practice of secondary activities.

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