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Food Security and Resilience: An Experimental Study of Household food consumption in the Central Region of Mali

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ABSTRACT

Mali is a Sahelian country and structurally vulnerable to food insecurity and malnutrition caused by the recent humanitarian crises the country has faced. The aim of the present study was to assess household food consumption and identify the essential determinants for increasing household dietary diversity and improving one of the pillars of food security for local populations in the locality of Bankass and Koro. The data from the household survey around 1396 households was subjected to an ordinal probit model to perform the econometric analysis. The results showed that the evaluation of household consumption was necessary to properly guide the household food basket in decision making. Our analysis showed a statistically significant relationship for households in Koro at 1% for households that consume fruit, meat and dairy products at Bankass, leaves, sour foods, oil and fats are also consumed by very few households, but only fruit at the 5% and 10% thresholds. However, households in the study area have access to five food groups to ensure their household food consumption. A total demand for cereals, tubers and vegetables was observed to be unavailable to households. About 90% are not able to satisfy the essential food needs of their household. In conclusion the base of daily meals is essentially composed of cereals, fats, sugars and condiments and complemented by the consumption of animal proteins and leafy vegetables. Opportunities for diversifying household diets in a crisis or shock situation in a community still remains an issue despite the humanitarian response households need to support their socio-economic reintegration.

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INTRODUCTION

Mali is a Sahelian country and structurally vulnerable to food insecurity and malnutrition. As a result, the humanitarian crisis began in 2012 in northern Mali and now we are witnessing devastation in central Mali (Ibrahim and Zapata, 2018). This crisis has

caused significant losses to livelihoods (livestock, crops, sources of income, employment, reduced economic activities, etc.). These crises have continued to pose serious protection risks for civilians, limiting people's access to basic social services but also humanitarian access to these populations. The

National Food and Nutritional Security Survey conducted in February 2017 by INSTAT showed that the prevalence of food insecurity is around 25%, and more than 22% of households live with moderate hunger and 3.6% of households are affected by severe hunger, with the main causes being difficulties in accessing food and problems with food use INSTAT et al. (2017). The management of this humanitarian crisis, socio-political crisis and climatic hazards on the living conditions of populations by INSTAT & DGSHP (2022) will have a great impact on the food diversity score. On average, six categories of food groups must be consumed by a household during seven days, three of which are primary and three are optional (Workicho et al., 2016).

In this context, the problem of food insecurity in Mali has become a topical issue, compounded by persistent insecurity in the center of the country (FAO, 2021). However, the United Nations and most studies have mandated the right to food a universal human rights principle, that every human being has the right to food and the fundamental right to be free from hunger (UN, 2015). However, the minimum dietary diversity for children aged 6 to 23 months is the combination of at least four of the seven recommended food groups: cereals (fonio), legumes (soybeans), seeds (peanuts), and fish (fry) (Fogny et al., 2017). Household food access is defined as the ability to access sufficient quality and quantity of food to meet the nutritional needs of all household members to enable them to lead productive lives (Workicho et al., 2016).

Despite the economic performance and the implementation of nutrition baskets for households in humanitarian crises, the latter has not improved the nutritional quality of the latter. The concept of nutritional diversity has not yet been integrated into the planning and evaluation of agricultural and food policy systems. The age of household head and the number of their wives are good indicators of farmers' income (Zongo et al., 2016). The success of agricultural systems has evolved primarily on the basis of crop yields, economic output, and cost-benefit ratios (Remans et al.,

2014). Indeed, in seeking to improve the efficiency of household food access and knowing the volume of barriers most of these organizations face in measuring household food access (FAO, 1997). The state of food security and nutrition in the world was estimated at 815 million in 2016, the number of undernourished people in the world and the prevalence of stunting was 22.9%. Yet, it is important to agree on appropriate indicators of household food access impact given the wide variety of activities implemented by collaborating agencies (FAO, 2021). The households consulted do not feel they have the choice to diversify their diets for reasons of accessibility, availability of foodstuffs, and or least procreation. To address these difficulties, this study was initiated to assess household food consumption and identify the key determinants that can increase household food diversity and improve one of the pillars of food security for local populations in the Bankass and Koro Circles.

This study will present the following architecture: the methodology adopted, on the household food consumption in the Central Region of Mali were discuss and conclusion.

MATERIALS AND METHODS

Theoretical framework

Subsequently, the issue of dietary diversity has been studied by several authors, but with different approaches and locations, since we are looking for opportunities that will explain the determinants of diversified consumption, which is why this article was initiated to address this concern. However, very little information is available on the diversification of household food consumption in crisis situations. To better reflect a quality diet, the number of different food groups consumed was calculated rather than the number of different foods consumed. The recall period for household food consumption information is 7 days. For a threshold below 6 groups low diversity, between 6 and 8 groups were medium diversity, above 8 groups and high diversity (Swindale and Bilinsky, 2006). In the Mopti region still remains vulnerable, as

their strategy index remains below the national average, even though it has decreased compared to previous surveys.

We use the approached develop from Fanta project write by Swindale and Bilinsky (2006) The dietary diversity score was calculated by summing the scores of the different food groups consumed Tuckman and Kennedy (2011). The value of this variable ranged from 0 to 12. The question of dietary diversity is based on the consumption of food groups consumed in a reference period obtained by Rashid et al. (2008), Onyango et al. (2003) and Ruel (2003). The SDAM variable is calculated for each household for consumption of the 12 food groups recommended by Swindale and Bilinsky (2006) for which respondents should indicate consumption daily, weekly, monthly, or if they did not consume any. Ruel (2003) calculated the dietary diversity score by summing the scores of the different food groups consumed. The scoring from Workicho et al. (2016), was used and food groups consumed at least once a week were given a score of 1 and those that were not consumed were given a score of 0.

The use of the empirical model in functional diversity has developed with nutrition to measure the diversity of functional traits in a given area. Schleuter et al. (2010); Smith et al. (2016). Indeed, INSTAT et al. (2016), showed in their report published in February 2016 that, the food strategy index was at its lowest level with a score of 1.9 points, which denotes a degraded improvement of the food security situation within households. Econometric analysis with cross-sectional data is usually associated with problems of heteroskedasticity and multi-collinearity and the effect of outliers in the variables. Multi-collinearity among explanatory variables can lead to imprecise parameter estimates Kouma (2019). The report of the Fanta II Household Food Insecurity Measurement Workshop designated by Swindale and Bilinsky (2006), for information on activities to develop a generic and universally applicable measurement instrument used to construct an experimental Household Dietary Diversity

Score (HDDS) in various national and cultural contexts. It is designed to reflect household dietary diversity on average among all members. For very complex reasons, this household dietary diversity question exposes the different food groups that a household must consume over a period of time (Workicho et al., 2016). The analysis of the curve trend on the number over the number of months of adequate supply corresponds to the determinant of household food access measures over a given reference period (Ruel, 2003). This measure goes back into the analysis on the measure of adequacy between dietary diversity as a complementary and interesting indicator and food access (Rashid et al., 2008). It should therefore be integrated into the analysis and considered in systems planning

Description of study area

The study took place in two circles in central Mali, in the internally displaced persons sites of the circles of Bankass and Koro, which are linked to the capital region by a road. These circles are created by Law No. 99-035 of August 10, 1999 on the creation of territorial communities of circles and regions. The circle of Bankass is located at 13° 40' north, 3° 40' west. The circle of Koro, is a territorial collectivity of Mali in the region of Mopti located at 14° 20' north, 2° 50' west of Mali INSTAT (2022). The study site was show in Figure 1

Data source

The data sources are those collected by the coordination of the mobile rapid response team to act on the response of humanitarian actors in the circles of the Mopti Region. We consider these data to be a cross-sectional study conducted during the period from August to September 2019 and the unit of observation was the household represented by the head of household or a household member. The tool use of this collected is the questionnaire used by USAID Fanta project to describe the method to calculate the dietary diversity score.

This data collection was organized and supervised by a technical team as part of the resilience research. For the purposes of this study, and in accordance with scientific standards, we selected households from the database using the RAOSOFT. The sample size for our study was determined online and then randomly selected in Excel for the selection of eligible households. These sizes varied according to the environment and socioeconomic concepts of 745 households in the Bankass department and 651 households in the Koro department, which allowed us to compile information on 1396 households. These concepts are the main elements of food security and the practice of household resilience, which often refers to the individual or collective. The collection team was composed of a research assistant, and three (3) interviewers were sufficient for the administration of data via tablets set up on the platform ONA. The tool used to collect information was the standard questionnaire used by the mobile rapid response team for displaced persons. Socio-demographic information: gender, age group, area of residence, level of education, household size, and economic information on the living conditions of households and their main sector of activity as well as their food consumption. The descriptive and empirical statistical analyses were carried out using Stata software.

Empirical model

Empirical research methods were used to help integrate theoretical research with practice. Traditional knowledge or superstition has been endorsed for too long (Liesenfeld and Richard, 2009). In the interest of this study, we used the ordinal probit regression model where we had several explanatory variables to model the variable to be explained

$$Y = \beta_1 + \beta_2 X_{2i} + \dots + \beta_K X_{Ki} + \varepsilon_{i,\dots,n}$$

$$\begin{cases} y_i = 1, & \text{if } x' \beta_i + \varepsilon_i > 0 \\ y_i = 0, & \text{if } x' \beta_i + \varepsilon_i \leq 0, \end{cases}$$

with $i = 1, 2, \dots, n$,

Where x is an explanatory variable vector $\beta_1, \beta_2, \dots, \beta_n$, are conformal parameter vectors, and the estimation error terms $\varepsilon_1, \varepsilon_2, \dots, \varepsilon_n$,

are distributed as a multivariate normal distribution with zero means, unit variance, and a contemporaneous correlation matrix. However, $R = [\rho_{ij}]$ with density $\phi(\varepsilon_1, \varepsilon_2, \dots, \varepsilon_n; R)$

The likelihood contribution for an observation is the standard n-variable normal probability. If we apply this to our consumption model we will have

β_i = Weight assigned to food group
 Xi_1 = Number of days of consumption related to each food group (≤ 7 days).

Y is the household. The model can be explained by various sources of random error, including:

- The existence of measurement errors in the variables
- The existence of explanatory variables that are not included in the relationship
- Total number of food groups consumed by household members takes the sum of the values of the 12 food categories either (0) or (1).

$$\frac{Pr(y_1, \dots, y_n)}{x} = \int_{-\infty}^{(2y_1-1)x' \beta_1} \dots \int_{-\infty}^{(2y_n-1)x' \beta_n} \phi(\varepsilon_1, \varepsilon_2, \dots, \varepsilon_n; ZRZ) \varepsilon_1, d\varepsilon_n, \dots, d\varepsilon_2 d\varepsilon_1,$$

Where $Z = diag[2y_1 - 1, \dots, 2y_n - 1]$

We seek to estimate, frame, and test the values of the coefficients $\beta_1, \beta_1 \dots \dots \beta_k$, as well as that of the joint variance σ^2 , of the hazards. Maximum likelihood estimation maximizes the sample likelihood function, which is a product of the probabilities (2) over the sample observations.

The estimation approach relies on a very generic framework based on penalized maximum likelihood, where any (parametric) distribution can in principle be used, and smoothers (representing several types of covariate effects) are implemented using penalized regression curves Liesenfeld and Richard (2009). Computing the maximum likelihood function using a multivariate normal distribution requires multidimensional integration, and a number of simulation methods have been proposed to approximate

such a function, with the simulator being widely used Belderbos et al. (2004). This study followed the simulator approach using the Stata routine of Cappellari and Jenkins (2003), to estimate the model. The classification used to distinguish three groups of food within households. The basket is low for households having consumed less than three (3) food groups; between 4 and 5 food groups (medium basket) and six (6) food groups and read for (high basket). Table 1 represents characteristic of food groups considered in this study used by USAID (Swindale and Bilinsky, 2006).

The marginal effects of the explanatory variables : (cereal, tubercula, vegetable, leafy, fruit, meat and poultry, milk and dairy product, sugar, oil butter, spice condiment drink) on the propensity to adopt each of the different adaptation measures were calculated as

follows: $\partial P_i / \partial X_i = \phi(x' \beta_i) \beta_i$, $i = 1, 2, \dots, n$, where P_i is the probability (or likelihood) of event i (i.e., increased use of each coping measure), $\phi(\cdot)$ is the standard univariate normal cumulative density distribution function, X and β are the vectors of the repressors and model parameters, respectively (Hassan et al., 1996). Univariate probit models can be viewed as a restrictive version of the multivariate probit model with all off-diagonal error correlations set to zero i.e., $\rho_{ij} = 0$ for $i > j$) cited by Belderbos et al. (2004) and Wang et al. (2014). Thus, the ordinary probit model is a classical econometric model that can be modified for other applications, either by changing the functional relationship or by questioning one or more of the assumptions underlying the probit model.

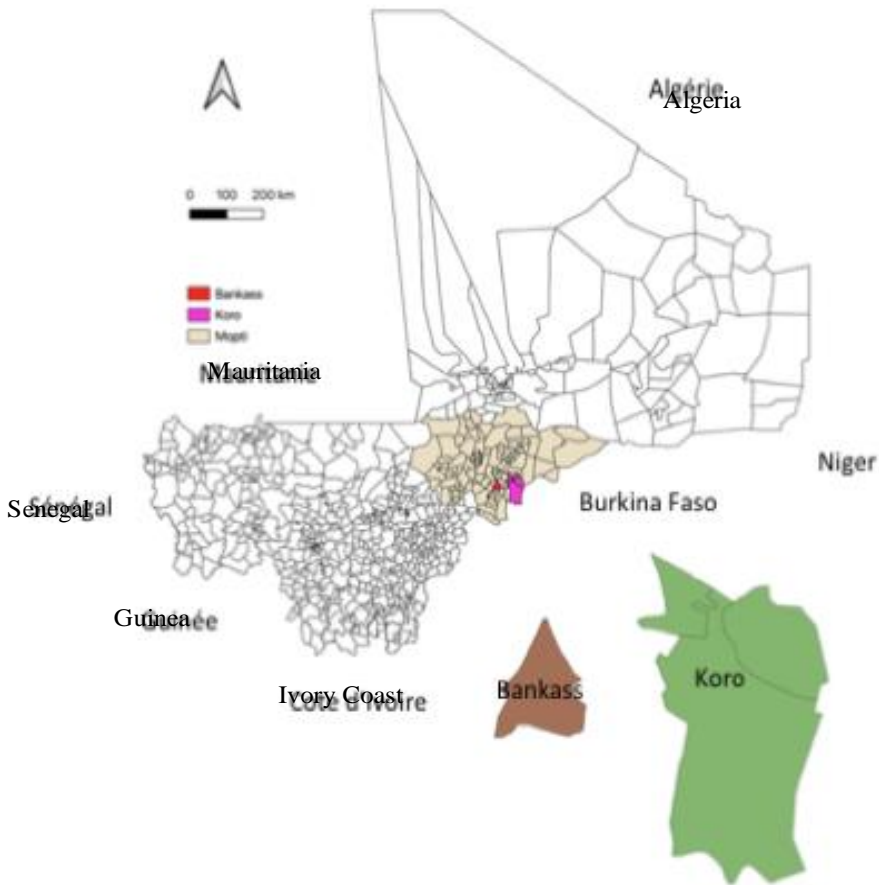


Figure 1: Map of area study.

Table 1: Household Food Basket characteristic.

Description of variables	Composition of food groups in a market basket
Cereals	Burghul, corn, ground corn, wheat, millet, rice, sorghum, bread, pasta (between 0-7)
Tubers	Cassava, potatoes and sweet potatoes, other tubers, plantain/allocco
Vegetables	Cowpeas/beans, lentils, peanuts, pumpkin seeds, wild nuts
Leafy	Amaranth, kale, Jewish mallow (Molokai), spinach, pumpkin leaves, cassava leaves, tomatoes, eggplant, cucumber, Kousa/zucchini, okra, onions, cabbage, salad
Fruits	Papaya, apricot, melon, grapefruit, mango, banana, orange, apple, dates, wild fruits
Meat and poultry	Cow, goat, sheep, camel, chicken meat, wild game, other birds, eggs, fish /dried or fresh
Milk and dairy products	Portion of whole milk, yogurt, cheese (does not include a small amount for tea)
Sugar	Sugar, honey, jam, sweetened soda, cookies, cakes, candy, cookies
oil, butter	Cooking oil, butter, coconut, fat
Spices, condiments, drinks	Spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic drinks

RESULTS

Socio-economic characteristics of respondents

According to the survey data, 67.84% were men and 32.16% women. We were able to interview 89.76% married, 8.02% widowed or divorced and 1.4% single. The average level of education of those interviewed was at least 6 years of formal education, which is equivalent to the first cycle of basic education in Mali Table 2. Men were slightly more advanced in formal education than women. The minimum age of both sexes surveyed was estimated to be 17 years, men were slightly older than women, and the average age of all respondents was about 48 years. This study focused on internal moving population at nearly 60%. The average household size was evaluated and compared to the data from other studies and was confirmed to be around 6 persons in the households which agreed with the result of the RGAH. The main source of household income been agriculture and livestock raising (71.8%), while tailors, craftsmen and masons accounted for 28.2%.

The survey shows that during the twelve months of the year preceding the survey, the majority of households (90%) were unable to

satisfy the family's food needs. Growing insecurity, hunger, and lack of money make it difficult to access food due to many causes. Table 3 showed that approximately 39% of households were forced to reduce the ration/quantity of food they usually consume during meal times on average 3 out of 7 days. In addition to these coping strategies, it was noted that more than 59% of households tried to reduce the amount of food consumed by adults so that small children could eat, 70% preferred to reduce the number of meals per day, and 63% undertook to borrow food or money. In exception of Cereals which were consumed more than 5 times over the 7 days by 87.1% of household, the most food groups are consumed less than 3 times over the 7 days. The HDDS obtain is 3.6 categories of food consumed by households in crisis situations. frequency food groups consumed highlights the low consumption of tubers, vegetables, leafy, fruit, meat and poultry, milk and dairy products, oil and butter. The effects of the environment and the availability of food during the survey period were significant for households that consumed fruit, meat and dairy products and were statistically significant for

households in Koro at 1%. In Bankass, leaves, sour foods, oil, and fats are also consumed by very few households, but only fruit was statistically significant at the 5% and 10% levels. However, households in the study area had access to five food groups to ensure their household food consumption.

Regression Results for Quantitative Analyses

Overall, the data indicated that households had easy access to leaves, fruits, meat, milk and other dairy products, sugar, spices, condiments and beverages, which were

statistically significant at 10%, 5% and 1%. All in all, there is not a normal distribution on the different categories of food groups at the level of the collection area. This will allow us to confirm that indigenous and displaced households do not have access to a more diversified diet, which has nutritional consequences in these circles of the Mopti region. This could allow us verify the hypothesis of opportunities for diversified food at the household level in a crisis or shock situation in a community. A total demand for cereals, tubers and vegetables was observed to be unavailable to households Table 4 below describe the detail.

Table 2: Descriptive of respondent’s characteristics.

Descriptive	Bankass		Koro		Grand total	
	Number	%	Number	%	Number	%
Marital status						
Single	12	1,6%	8	1,2%	20	1,4%
Divorced	6	0,8%	5	0,8%	11	0,8%
Married	658	88,3%	595	91,4%	1253	89,8%
Widow	69	9,3%	43	6,6%	112	8,0%
Grand total	745	100,0%	651	100,0%	1396	100,0%
Gender						
Female	276	37,0%	173	26,6%	449	32,2%
Men	469	63,0%	478	73,4%	947	67,8%
Grand total	745	100,0%	651	100,0%	1396	100,0%
Household status						
Autochthone	284	38,1%	263	40,4%	547	39,2%
Host	85	11,4%	40	6,1%	125	9,0%
Internally displaced	371	49,8%	330	50,7%	701	50,2%
Returned	5	0,7%	18	2,8%	23	1,6%
Grand total	745	100,0%	651	100,0%	1396	100,0%

Table 3: Frequency of food groups consumption by household.

Food type	Less than (3)	Mean (4-5)	More than (5)
Cereal	10,0%	2,9%	87,1%
Tubers	96,3%	1,6%	2,1%
Vegetables	93,9%	3,7%	2,4%
Leafy	63,0%	7,5%	29,4%
Fruits	95,8%	2,5%	1,6%
Meat and poultry	88,9%	5,2%	5,9%
Milk and dairy products	86,3%	4,5%	9,2%
Sugar	48,6%	12,4%	39,0%
oil, butter	65,4%	12,3%	22,3%
Spices, condiments, drinks	41,4%	6,8%	51,8%
Average consumption	69,0%	5,9%	25,1%

Table 4: Ordinal probit regression on the household food consumption basket.

Household consumption basket	Bankass 745 R ² = (.006) **	Koro 651 R ² = (.02) ***	Ensemble 1396 R ² = (.007) ***
Cereal	.026(.021)	.013(.025)	.018(.016)
Tuber	.046(.028)	-.034(.043)	-.009(.026)
Legumes	-.011(.027)	-.04(.032)	-.013(.021)
Leaf	-.051(.017) **	-.019(.014)	-.025(.01) *
Fruit	.035(.029)	-.153(.039) ***	-.064(.022) **
Meat and poultry	-.01(.029)	.123(.025) ***	.078(.019) ***
Milk and dairy products	-.003(.016)	.073(.023) **	.015(.013)
Sugar	.045(.02) *	.020(.017)	.025(.013) *
Oils and fats	.034(.017) *	-.022(.019)	.006(.012)
Spices, condiments, drinks	-.026(.018)	-.028(.018)	-.025(.013) *

*; ** and *** are significant a 10%; 5% and 1%. (..) Coefficient and Standard Error

DISCUSSION

Many factors can influence their perception and decision, food habit, as they are no longer in their usual place of residence or they have more comfort and food choices. It is more than the majority of the households surveyed, about 70.4%, had access to a small area of agricultural land, about 500 square meters (m²), of which 14.1% rent land for farming. Thus, it is difficulties initiated to assess household food consumption. Because many households had a not access to land production. These results corroborated by those found by Rashid et al. (2008) and Traoré et al. (2022). He noted that a non-diversified diet stunted growth and various mental disorders, alopecia and sometimes weight gain.

Thus, the households surveyed generally derive their daily income from agricultural labor, which averaged \$50 and could not cover the average monthly burden of the household to survive and have a diet that could be diversified. This result is supported by Kississou et al. (2013) who showed in their study that households in the regions studied spent a significant portion of their budget on food, 77% of it due to the production deficit.

As described in more detail in Yi et al. (2017), values near the optimum, it should be recalled that dietary diversity is a proxy indicator. For measuring the nature of food insecurity in a week's frequency of consumption as well as the calorie, micro, and macro nutrient value of foods consumed Ndiaye (2014) and Coates et al. (2007). The key determinants that can increase household food diversity and improve to crisis period were the humanitarian's response to assure their food security for local populations in the Bankass and Koro Circles. However, small families were observed to be more food secure than medium and large families, indicating that size and food security are negatively related Kennedy et al. (2010); Fouepe et al. (2019), he found that same comments.

The results of the modeling of aggregate household consumption showed that the

consumption of leaves is statistically significant at 10%, which may decrease over time with the scarcity of factors in the Bankass district. On the other hand, more households, according to the opinion of the households in motion at the time of the survey, about 90% are not able to satisfy the essential food needs of their household. Concerning the circle of Koro, in addition to fruits, meat and milk and other dairy products are also statistically significant at 1% and 5% respectively. This result is supported by Rashid et al. (2008) and Tankari (2016) and which showed that the higher is the value of the hunger index, the higher is the risk of food insecurity for a household.

Conclusion

The food security and resilience strategy study highlighted the need for an alternative methodology tailored to local situations. The study confirmed that households did not diversify their food baskets very much and still remained below the household food diversity score defined by the National Nutritional Anthropometric and Mortality Survey. The effects of environment and food availability during the survey period were significant for households that consumed leaves, fruits and meat. However, a total demand for cereals, tubers and vegetables was observed.

The base of daily meals is essentially composed of cereals, fats, sugars and condiments and complemented by the consumption of animal proteins and leafy vegetables. These changes in eating habits were mainly related to the difficulties of access to foodstuffs and the low availability of foodstuffs in and around the markets. The opportunities for diversifying household diets in a crisis or shock situation in a community still remains an issue despite the humanitarian response households need to support their socio-economic reintegration.

In-depth analyses must be conducted. Emphasis should be placed on growth models that provide greater leeway for household

consumption and focus on the number of productive employment opportunities in the market economy sector for people active in the threats. However, in order to prevent most households from becoming chronically food insecure in the long term, appropriate measures to consolidate the livelihoods of the population should be taken, such as restoring peace in the area to avoid population displacement, building the capacity of farmers' organizations to facilitate the establishment of solid structures

COMPETING INTERESTS

The authors declare that there are no competing interests regarding the manuscript.

AUTHORS' CONTRIBUTIONS

All authors were responsible for data collection, analysis and interpretation of the data.

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