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### **An Exploratory Analysis of Child Nutritional Status in the Sahel, the Goundam Circle Case Study - Timbuktu Region – Mali**

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#### Abstract

The malnutrition of children (0-59 months) is a public health concern in Africa, particularly in the Sahelian countries. In spite of better agro climatic conditions and agricultural production in many of these countries, the nutritional status of children under-five continues to deteriorate. This working paper summarizes the first results of a series of exploratory analyses initiated by the regional office of FFP in Dakar to understand the underlying causes of child malnutrition in West Africa. Anthropometric and socio-economic data (at village level) from the Goundam Food Security Initiative (GFSI) project carried out by Africare/Mali were used. For this first exploratory phase of analysis, descriptive statistics and factor analyses (Principal Component Analysis - PCA, Multiple Correspondences Analysis - MCA) were used. The results from the analysis reveal that reducing the number of underweight children under-five continues to be a challenge in the study zone with an average rate of stunting varying between 37% and 44% depending on the month and year. However, it becomes worse (severe malnutrition) because of the lack of food. Nutritional status, food access and agricultural production systems are the three main village factors that influence the rate of underweight children under-five. Regarding chronic malnutrition of children under-five, the results of the analyses show that in the Goundam area, seven socio-economic variables are strongly related to stunting, including, by order of importance: 1) Presence of a school in the village, 2) Irrigated Village Perimeter, 3) Improved wells, 4) Practice of market gardening, 5) Production of millet, 6) Distance from the village to the city, and 7) Production of sorghum. The first four variables are negatively correlated to stunting, while the last three variables are positively correlated with the rate of chronic malnutrition.

**Keywords:** food security, child under-five malnutrition, factor analysis

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## Introduction

The malnutrition of children (0-59 months) is a public health concern in Africa, particularly in Sahelian countries. In spite of better agro climatic conditions and agricultural production in many Sahelian countries, the nutritional status of children under-five continues to deteriorate. Within the framework of its food security projects in West Africa, the USAID/FFP is financing food security activities with child nutrition components. However, in many of these Sahelian countries, the impact of these food security projects on the malnutrition of children under-five is below target. This working paper summarizes the first results of a series of exploratory analyses initiated by the regional office of FFP in Dakar to understand the underlying causes of child malnutrition in West Africa. Anthropometric data from the Goundam Food Security Initiative (GFSI) project carried out by Africare Mali were used.

## Context

In 2005, Mali ranked 174<sup>th</sup> out of 177 countries according to UNDP's Human Development Index. Seventy-one percent of its adult population is illiterate and 91% of the population lives on less than \$2 per day. The Malian economy relies on subsistence agriculture, with millet/sorghum, rice, and maize as staple crops. Mali is one of the continent's biggest cotton producers.

According to the latest Demographic and Health Survey (DHS III - Mali 2001), four out of 10 children (38%) in Mali suffered from some kind of chronic child malnutrition and half of them (19%) suffered from severe chronic malnutrition (- 3 standard deviation). About 11% of children were wasted and 33% underweight. Infant mortality due to malnutrition and diseases was 219 per 1,000 births and 51% of this rate is due to malnutrition (DHS III- Mali 2001). Per capita food availability in Mali is highly variable. Mali's agricultural production system is largely dependant on rainfall. Mali is a food insecure country, in particular in the northern regions of Gao, Timbuktu, and Kidal

Located in the northern region of Mali, the circle of Goundam is one of the largest circles<sup>3</sup> in Mali. It covers a total surface of 92,688 km<sup>2</sup> with a total population of 161,988 (census of 1998). The population density is less than 2 people per km<sup>2</sup>. The circle of Goundam where the GFSI project has been implemented is located in the Sahel-Sahara zone of the country with an average rainfall varying between 100 and 300 mm of rain per year. In 2004/2005, the recorded rainfall in the town of Goundam was 114 mm against an average of 140 mm in 2003/2004, and 300 mm in 2002/2003. It is a zone of recessionary farming system around lakes. Recently, these lakes have started to dry up during the off-season because of silting irrigation canals. One notes a massive departure of the population from the villages around these lakes towards the bordering zones of the Niger River and the south.

The NGO Africare has been in Goundam since 1984 with various intervention activities. From the USAID funding, Africare carried out the Community Health Project

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<sup>3</sup> A territorial or administrative division of the country

of Goundam (PSCOM-G) in the circle of Goundam. This project provided to the communities a nutritional control of children, a prevention of diarrhea diseases, services of immunization and medical education.

### **Limits of the study**

This work has been limited by the quality and the quantity of data available at the GFSI project level. For the first phase of the project, only part of the data of the final evaluation has been found. Regarding data on chronic malnutrition (stunting), the survey sampling method has not been applied throughout the different studies conducted (Baseline, mid-term and final evaluation). Furthermore, it has been noticed that in 97% of cases, survey enumerators estimated the age parameter of the children. This means that the results measured for nutritional indexes related to stunting and underweight are not totally reliable (Africare/Mali Goundam Food Security Initiative – Household Survey Results, August 2001, page 5). This anthropometric data quality problem is not unique to the GFSI project. The same problem has been found with the Title II project in Burkina Faso (Africare), Mauritania (WVI), and Niger (PVO consortium).

### **Objectives and Methodology**

The general goal of these analyses is to evaluate the malnutrition status of children under-five in the zones of the food security projects financed by USAID/FFP in West Africa.

#### **Specific objectives:**

- To evaluate the trends of the malnutrition status of children under five, from the project monitoring /impact indicators; and
- To identify the independent variables which may impact the malnutrition status of children under-five in West African countries, case of the GFSI project in the Timbuktu region - Mali.

### **Methods and materials**

**Data collection:** analyzed data were collected from the GFSI project. The following indicators have been analyzed:

- Underweight (percent of children of a given age range with weight-for-age z score less than -2 or less than – 3 standard deviation);
- Stunting (percent of children of a given age range with height-for-age z score less than -2 standard deviation).

These two indicators are part of the USAID/FFP Title II MCH programs impact indicators. The Africare Chad/Mali project is not collecting data on wasting. The data on the underweight variables are collected monthly at the time of the child's growth monitoring. The results are reported at the end of each quarter. For chronic malnutrition

“stunting”, data were collected during the survey of the final evaluation of the project’s first phase (in 2001), during the baseline studies (in 2003), and the mid-term evaluation (in 2005) of the second phase of the project. This information was supported by secondary data collected in the project zone on the food security activities carried out by the project. The statistical unit of analysis is the village. The data provided by the project GFSI are aggregated numbers (i.e. percent per village) from individual household data. The EPINFO software was used by the project to analyze and standardize the collected anthropometric data. Village data were transferred onto the SPSS software at the RFFP/Senegal office for appropriate analyses.

**Statistical analysis:** .for this first exploratory phase of analysis, descriptive statistics and factor analyses<sup>4</sup> (Principal Component Analysis - PCA, Multiple Correspondences Analysis - MCA) were used. The PCA is an exploratory technique of multidimensional data analysis. It was used for the analysis of underweight children data. For the analysis of the stunted<sup>5</sup> children under-five data, the use of the MCA was chosen. For that, the original variable of stunting (continuous variable) was transformed into a qualitative variable with the following three modalities:

- Village slightly affected by the chronic malnutrition of children: less than 20% of children in the village are stunted;
- Village moderately affected by the chronic malnutrition of children: 20% - 39% of children are stunted in the village; and
- Village severely affected by the chronic malnutrition of children: more than 40% of children are stunted.

## Results

### Descriptive statistics

The analysis of anthropometric data collected from the GFSI project on the prevalence of underweight children (under five) over the period from December 2000 to September 2005 shows that this form of malnutrition continues to be a challenge (with rates > 20%) in the study zone. In general, it reaches its peak in June with an average rate varying from 43% to 44% of weighed children. June is considered part of the hungry season (June - September).

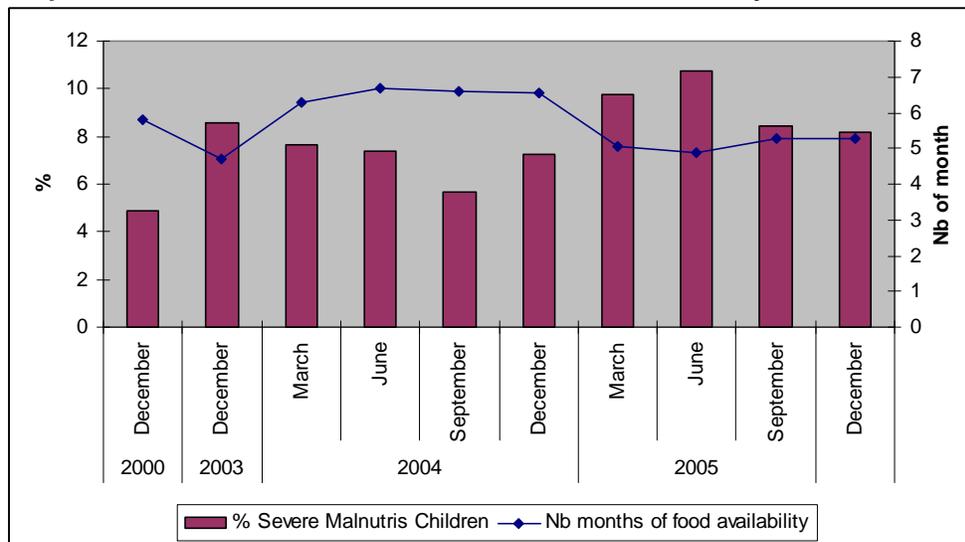
The rate of severely malnourished children (Weight/Age <-3 SD) follows the same trends as that of the rate of global malnutrition. It is largely influenced by the food availability/access at the household level (see graph 1). The minimum rate of severe malnutrition is observed in September. The maximum recorded rate is 11% in June 2005. That means that in June 2005, 11 children out of 100 in the project zone should have been referred to hospitals as emergency cases due to severe malnutrition problems.

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<sup>4</sup> **Principal factors vs. principal components.** The defining characteristic that distinguishes between the two factor analytic models is that in principal components analysis we assume that *all* variability in an item should be used in the analysis, while in principal factor analysis we only use the variability in an item that it has in common with the other items. (from the StatSoft, Inc. (2006). Electronic Statistics Textbook)

<sup>5</sup> Most variables used to characterize the stunting variable are categorical variables.

**Graph 1: Evolution Child Malnutrition and Food Availability**



The rate of underweight children under-five (table 2) is more important among the sedentary population than the pastoralists. The average rate of global (severe + moderate) underweight children under-five in the pastoral zone is 37.5% (CV=38%) against 36%, 40% (CV=26%) and 41% (CV=37%) for the children under-five in the zones of river, Irrigated Village Perimeters (IVP), and of the Lakes respectively (see table 1). However the average rate of severely underweight children is higher among the children of pastoralists (8.84%) than those of sedentary IVP cereal producers (7.60%), and flooded rice growers (6.50%). The rate of severely underweight children in the livestock zone remains lower than the rate of malnourished children living in the villages located around the lakes (9.91%)<sup>6</sup>.

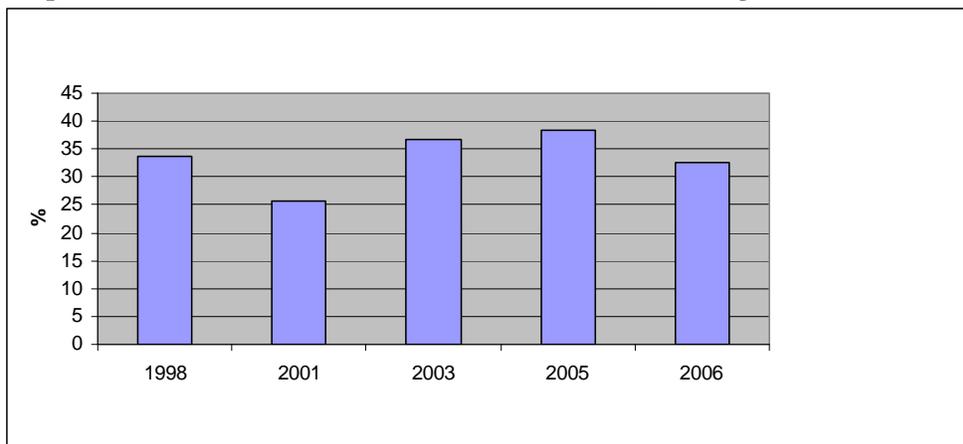
As shown in graph 2, the average rate of stunted children (0-59 months) in 1998 is 34%. In 2001, the first phase of the project impact evaluation covered only focal villages<sup>7</sup> (16 villages). The results of this evaluation reveal an improvement of the stunting rate (26.9%). It should be noted that part of these focal villages has benefited from the support of USAID/Mali funded health project in Goundam (PSCOMG). The second phase of the GFSI project started in 2003 with fifty villages covered which included 10 focal villages of the first phase. The baseline studies of this second phase gave a rate of chronic malnutrition of children (24-59 months) of 36.6%. Furthermore, the results of the midterm evaluation of this second phase show an increase of the rate of stunted children compared to the baseline data. The rate of stunted children increased to 38.5% in 2005 (midterm evaluation results). This increase in the rate of chronic malnutrition can be explained by several factors: the drought, the progressive draining of the Faguibine lake, the early drying of wells, the closing of the Goundam health project (PSCOMG), the lack

<sup>6</sup> The t tests computed are significant at 5% level.

<sup>7</sup> Focal villages= villages that benefited from the project's support

of sufficient health services in the study zone, the absence of adequate financing for the first two years of the GFSI project' second phase. Nevertheless, the stunting rate was reduced to 32.6% in FY 2006 in the study area. Compared to the mid-term evaluation data, the stunting rate was reduced by 6 points. At the same time, the chronic malnutrition rate was 28.4% for the first generation villages of the project against 34% for the new (second generation) villages (Africare Chad Mali FY 2006 Results Report). In 2001, the national rate of stunted children (0-59 months) in Mali was 38% while the average rate in the northern regions (Gao/Kidal/Timbuktu) was 40.1% (DHS III- Mali 2001). However, according to the results of "Enquête globale sur la Sécurité alimentaire et la Nutrition " (AGSVA)<sup>8</sup> – December 2005, the Timbuktu region had a child chronic malnutrition rate of 24%. For the Gao and Kidal regions this rate was 25% and 14% respectively. The rate of stunted children was 46 % for the Sikasso region, 41% for Koulikoro and 38% for the Segou region, which are the main cereal and cotton production regions of the country. The World Health Organisation (WHO) critical level for stunting rate is 30%.

**Graph 2: Evolution of the Chronic Child Malnutrition (Stunting) Rate in Goundam**



<sup>8</sup> Food Security and Vulnerability Assessment organized and funded by WFP and UNICEF Mali

As for the rate of underweight children under-five, the delay in child growth is more concentrated among sedentary farmers than among nomadic pastoralists in the study zone. The rate of chronic malnutrition (24-59 month) was 32.29% in 2005 for the pastoralists as opposed to 35% to 42% for cereal growers (see annex table 7)<sup>9</sup>.

According to the United Nations Children's Fund's framework for the causes of child malnutrition (UNICEF 1990, 1998) and the subsequent extended models. The determinants of child malnutrition can be divided into three levels of causality: immediate, underlying, and basic (Lisa C. Smith, and Lawrence Haddad). The immediate determinants are dietary intake and health status. They are influenced by underlying determinants – food security, care of mothers and children, and health environment quality. These underlying causes are, in turn, influenced by basic determinants. They include the potential resources available to a country or community which are a function of natural resources, access to technology and the quality of human resources. This paper analyses the influence of some of these underlying determinants (agricultural production system, health environment, and education) on child malnutrition in the context of the Sahel region, case of Goundam in Mali.

### **Socio-economic determinants of underweight children under-five**

Child malnutrition is a complex phenomenon whose causes depend on several factors such as structural, economic and socio-cultural. To analyze the pattern of relationships between these factors (variables) and child malnutrition, the factor analysis (PCA) technique was used. For this first exploratory phase the underweight variables - percentages per village of the various groups of malnourished children: severely malnourished (PCTROUGE), moderately malnourished (PCTJAUNE), and well nourished (PCTVERT) - are put in relation with the socio-economic variables of the villages.

The results of the analyses show that the data analyzed can be grouped into five factors or components (see annex table 3). These components account for 67% of the total variance created by the variables analyzed. The interpretation of these components shows that the first represents the “**Production System**”. It opposes an agro-pastoral system (bovine, camel, sheep, millet/sorghum production) to an irrigated farming system (irrigated rice production, Irrigated Village Perimeter (VIP), vegetable market gardening). The agro pastoral zone is characterized by a high rate of severely malnourished children. The second factor “**Village infrastructure**” shows that infrastructure like schools, markets, tube wells (boreholes) and health centers are very strongly correlated. In general, they are located in the same area (large villages, urban centers). According to the results of the analyses, village infrastructure does not have significant direct influence on the variance of the underweight child under-five rate in the short run. The third factor, “**Accessibility to food**” shows that access to food by the household is strongly related to the presence of IVP, improved wells (water availability)

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<sup>9</sup> The t tests computed are significant at 5% level.

and the presence of food secure households in the village. The degree of correlation between the "**Accessibility to food**" component and the variable Percentage of severely malnourished children under-five is weak (0.28). One can conclude that food accessibility by the household in the study zone has a moderate influence on the rate of underweight children under-five in the village. This might be explained by the quality of food offered to the children under-five especially during the hungry season. The fourth factor represents the "**Village nutritional status**". It highlights the importance of access to drinking water, medical services, and the education of women in the reduction of the rate of underweight children under-five. The sign of loading scores (see annex table 3) indicates that an improvement of access to potable water by the population, more specifically children under-five, can reduce the rate of underweight children under-five. This finding has been confirmed by the Africare/Mali project midterm evaluation results (June 2005) that concluded that 4 out of 10 children (39.5%) in the project area had diarrhea during the last two weeks before the survey. Also, a reduction of the distance from the village to the health service delivery point can lower the rate of underweight children under-five. The variable Village nutritional volunteer is positively correlated with the "Village Nutritional Status" component whereas one expected a negative relation. A high number of village nutritional volunteers well trained in the execution of their activities in the village should result in a reduction of the prevalence of the children under-five malnutrition. Probably the variable Village nutritional volunteer has captured other phenomena which positively influence the malnutrition of children under-five. There is a need for more investigation on this issue. These findings corroborate with the results of the GFSI project final evaluation survey (July 2006). These results show that child underweight is strongly related to bloody diarrhea (Chi-2 test value=3.4, p=0.000). Overall, 5% of surveyed mothers have stated that their child under five had bloody diarrhea during the two last weeks before the survey. This rate was 12% among mothers with underweight children. Also, the number of mothers who don't have a sanitation facility (latrine) at home is important among mothers with underweight children (68%) than the global percentage of mothers who don't have a latrine (57%). Also, these findings suggest that the rate of child underweight in the Goundam area is influenced by episodes of fever (Chi-2 test value=2.06, p=0.020) and diarrhea (Chi-2 test value=1.73 p=0.042) of children.

A positive correlation was found between the underweight, chronic malnutrition and wasting indicators in Mali (EDS-III Mali 2001, page 158). The socio-economic variables related to child chronic malnutrition available for the project are much more qualitative than quantitative; therefore, the Multiples Correspondences Analysis (MCA) as an analysis tool is preferred.

### **Socio economic determinants of chronic malnutrition (Height /Age) of children under-five**

The MCA is used to measure the degree of liaison between the qualitative variable of stunting and the other qualitative socio-economic variables of the villages. The interpretation of the different variables' contribution to the formation of the factors

makes it possible to understand the patterns that exist between these socio-economic variables and the stunting level in the village.

As a starting point, the stunting variable was characterized using all the socio-economic variables of the village that could have a significant influence on the growth of the child. This analysis will explore the different relationships between village socio-economic variables and stunting. This analysis uses the crossing tables of the stunting and the other variables<sup>10</sup>. Among the thirty qualitative variables analyzed with the stunting variable, 22 socio-economic variables have significant relationships (Chi-2 test value > 2 or  $p = 0.000$ ) with the chronic malnutrition of children. Seven variables among those have maximum test values (99.9). These 7 variables are much related to stunting. By order of importance, these variables are:

Presence of school in the village, Irrigated Village Perimeters (IVP), improved wells for potable water, market garden, millet crop production, distance of the village to the urban town of Goundam, and sorghum crop production.

The first 5 factors generated following the MCA explains 62% of the total variance created by the original variables. According to the plan of the first two factors, about 40% of the variance created by the original variables is explained by these factors.

The first factor represents the livestock breeding area (bovine, ovine, goat, camel). This area is characterized by the existence of operating tube wells (boreholes), health services with incomplete personnel in general. It corresponds to the desert part of the project zone where the only possible activity is livestock breeding. **This area is less affected by chronic malnutrition of children than the agricultural production area.** These results are confirmed by other studies carried out in Mali which showed that the malnutrition of children under-five is concentrated more in the sedentary zones than in the pastoral zones. One possible explanation of these results is that in the livestock breeder communities, the milk of livestock is directly managed by women. The main use of this milk is for feeding children. In the cereal producer area, the low quality of child and pregnant women's diet is an important determinant of stunting.

The second factor (Component) represents the irrigated crop production system area. It opposes the recessional crop production area (zone of lakes) to the irrigated crops (rice and wheat). **The zone of lakes is characterized by villages where more than 40% of children are considered chronically malnourished (stunted).** This chronic malnutrition can be explained as one of the logical consequences of the environmental degradation of the lakes. For a few years, it has been noted the progressive drying of the Faguibine Lake which constitutes the "economic lung" of the zone. More and more, the irrigation canal of the Faguibine Lake is filled with sand thus preventing the water of the Niger River from reaching the lake. The wells of the villages around these lakes dried up very precociously because of the low level of the water table. During the off-season, the sumps dug in the lakes are the principal sources of drinking water for the population. The irrigated crop production area is where Irrigated Village Perimeters exist. Women grow vegetable crops during the off-season. The villages of the irrigated zone are not far from health delivery points. The improved wells in these villages have water all year

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<sup>10</sup> The Chi-2 statistics associated with each crossing of two variables and the probability of exceeding this value are calculated (test of Chi-2). Each probability is assigned a "test value".

round. They are located in a radius of 30-50 km of the town of Goundam. In FY 2005, the average rate of chronic malnutrition among children under-five in these villages was 34% against 43% in villages around the lakes.

As the results of the MCA show, the chronic malnutrition of children is a structural problem whose solutions require multi-sector interventions such as access to food, health services, hygiene, drinking water, and, the education of women. These findings are validated by the results of the crossing of the stunting variable with the socio-economic variables of the village. The modalities of the seven identified variables have been strongly related to the variable stunting, and all are correlated with the irrigated farming system factor (second component).

## **Conclusion**

The malnutrition of children under-five is a complex and multidimensional phenomenon whose causes depend on several factors (structural, socio-economic and cultural). Results from the analyses reveal that underweight children under-five is a quasi permanent problem in the study zone with an average rate varying between 37 to 44% depending on the months and years. The underweight child rate reaches its peak during the hungry period (June - August) when household food becomes limited. The global underweight of the child under-five is related to the life style of the parents, especially mothers. However, it becomes worse (severe malnutrition) by the lack of food as observed in the study zone. The level of social services in the village (existence of health facilities, access to potable water for children) is also important. The results of the PCA show that nutritional status, food access and production system are the three main factors that influence the rate of underweight children under-five.

The results of the analyses indicate that the rate of chronically malnourished child under-five has been increasing in the study. The Multiple Correspondence Analysis (MCA) results shows that in the Goundam area, seven socio-economic variables are strongly related to stunting, by order of importance: 1) Presence of a school in the village, 2) Irrigated Village Perimeters, 3) Improved wells, 4) Practice of market gardening, 5) Production of millet, 6) Distance from the village to the city, and 7) Production of sorghum. The first four variables are negatively correlated to stunting, while the last three variables are positively correlated with the rate of chronic malnutrition. In other words, chronic malnutrition of children under-five is very important among children whose parents grow millet and sorghum as main crops i.e. zone of lakes (43%). The stunting rate is less in the zones where development potentials exist i.e. livestock zone (32%), village irrigated perimeter zone (35%), river zone (37%). The stunting rate decreases when one moves toward the city. Based on this result, the diversification of agricultural production systems, for example the cultivation of beans or sweet potato in the lakes for household food consumption might be one of the solutions to child under-five malnutrition in the study zone.

The results of exploratory study confirm some of the previous findings about child malnutrition causes in developing countries.

1. Village socioeconomic environment (production system, infrastructures, and health services) are the underlying determinants of child malnutrition. They influence the nutritional status of children under-five through immediate determinants (dietary intake and health status of children).
3. Access to potable water for children and women is a determinant factor for improving children under-five's nutritional status in West Africa.
4. The access of households to food can positively impact children's nutritional status in the Sahel region, but the impact is moderate compared to health and child feeding factors.
5. For the sustainability of nutritional programs, communities should be at the heart of proposed interventions.

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## ANNEX

Table 1: Descriptive Statistic of Underweight Children under-five rate

Form of Underweight	Production system	Average %	S.D	Confidence interval at 95% for the average		Minimum	Maximum
				Lower limit	Higher Limit		
Moderate	Livestock	37.46	14.22	36.54	38.39	0.00	77.78
	Lake	40.86	10.82	40.58	41.15	7.69	73.91
	VIP	40.35	15.05	39.90	40.80	6.90	100.00
	Flooded rice	36.45	13.95	36.12	36.78	0.00	77.78
	Total	38.85	13.51	38.65	39.05	0.00	100.00
Severe	Livestock	8.84	8.19	8.31	9.38	0.00	36.36
	Lake	9.91	6.26	9.74	10.07	0.00	33.33
	VIP	7.60	5.63	7.43	7.77	0.00	26.30
	Flooded rice	6.50	4.96	6.38	6.62	0.00	33.33
	Total	7.96	5.93	7.88	8.05	0.00	36.36

Table 2: Descriptive Statistic of chronic malnutrition of children (24-59 months) rate

Production system	Average %	S.D	Confidence interval at 95% for the average		Minimum	Maximum
			Lower limit	Higher limit		
Livestock	32.29	3.99	31.47	33.11	25.00	36.00
Lake	42.74	9.22	41.98	43.50	21.00	58.00
PIV	35.34	18.25	33.49	37.20	7.00	69.00
Flooded rice	37.09	14.26	35.54	38.65	8.00	75.00
Total	38.64	13.77	37.90	39.37	7.00	75.00

Table 3 : Component Matrix after rotation

	Production system	Components			Nutritional status
		Village infrastructures	Food availability	Village accessibility	
PCT severely malnourished	0.30		0.28		0.42
PCT moderate malnourish.					0.70
CSCOM		0.80			
Improved wells	0.31		-0.62		-0.34
Borehole		0.80			
School		0.83			
Market		0.91			
Village accessibility				-0.82	
Distance/health center		-0.47			0.46
Vegetable garden	-0.63			0.39	
Nutritional volunteers	-0.35			0.56	0.47
Sorghum/corn production	0.30	0.32	0.61		
Camel	0.84				
Bovine	0.85				
PCT category III HH			0.84		
Goat	0.82			0.36	
Distance/Town	0.73				
Nb of month of food availab.	-0.38		-0.66		

Extraction method: Principal Component Analysis.

Rotation method : Varimax with Kaiser normalization.

Rotation converged in 5 iterations.

