MASTER’S THESIS SUBMITTED FULFILMENT OF THE REQUIREMENTS OF THE

MSc DEGREE IN CLIMATE CHANGE AND EDUCATION AT THE UNIVERSITY OF THE GAMBIA

TOPIC

# THE IMPACT OF CLIMATE CHANGE ON CHILD UNDERNUTRITION IN NORTHWEST BENIN


NAME OF STUDENT

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## LIST OF ABBREVIATIONS AND SYMBOLS USED IN TEXT

**AVGAS**: Analyse Global de la Vulnérabilité et de la Sécurité Alimentaire

**ASECNA**: Agence pour la Sécurité et la Navigation Aérienne

**CARDER**: Centre d'Action Régional de Development Rural

**DDS**: Dietary diversity score

**Df**: Freedom degree

**FAO**: Food and Agriculture Organization

**GDP**: Gross Domestic Product

**HAZ**: Height- for- age Z-score

**IFAD**: International Fund for Agricultural Development

**INSANE**: Institut National de la Statistique et de l'Analyse Economique

**PAM**: Programme Alimentaire Mondial

**SCN**: Standing Committee on Nutrition

**SD**: Standard deviation

**UNICEF**: Fonds des Nations Unies pour l'Enfance

**USAID**: United States Agency International Development

**WAZ**: Weight- for- age Z-score

**WFP**: World Food Programme

**WHZ**: Height- for- weight Z-score

**Keywords**: Child, nutritional status, temperature, rainfall, agricultural production.

**ABSTRACT**

Undernutrition among 6–59 months children remain a major public health problem in Atacora. Many studies have focused on the relationship between child nutritional status and climate change. However, the potential effects of climate change on child nutrition have overall received little attention in the study area. The purpose of this research was to examine the impact of climate change on child nutritional children aged 6 to 59 months old in Atacora. A cross-sectional, descriptive design survey was implemented using the random sampling technique to select representative samples of 422 children aged 6-59 months at 350 households' level in Atacora. Questionnaires were administered to the mother and anthropometric measurements were taken. The analysis was performed using R software version 3.3.1. Descriptive statistics were computed and Analysis of variance was used to establish the association between households' ethnicity, mother's schooling, diversity dietary and child nutritional status. A multiple linear regression was performed to explore the relationship between climate variables and agricultural on one hand, an association of agricultural production, climate factors (temperature and rainfall) with child nutritional status on the other hand. Results reveal that there is increasing temperature and decreasing in rainfall. The precipitation is negatively correlated with bean, maize and sorghum yields whereas temperature is positively associated with yam and rice production. The prevalence of stunting (45.5%) is higher as compared to wasting (12.1 %) and underweight (21.1%). Other findings show the positive correlation between stunting, maize and sorghum production, but the association between stunting, rainfall, temperature and yam production is negative.

## BACKGROUND

Food and nutrition are crucial to the immune system, brain and organ development, lean body mass constitution, basal metabolism and general health of an individual (Mujjukizi, Adhiambo, & Ruolahti-virtanen, 2014). It protects and promotes health; reduces mortality, especially among mothers and children; encourages and enables children to attend and benefit from education; and enhances productivity and incomes in adulthood (Thompson, Tirado, Cohen & Aberman, 2008). A nutritious and varied diet is a critical means by which good health can be maintained (Keatinge, Yang, Hughes, Easdown & Holmer, 2011). Clearly, a lack of micronutrients and micronutrients in peoples' diet has serious health consequences (Keatinge et *al*., 2011). Thus, good nutrition makes an essential contribution to the fight against.

Food and nutrition security remains Africa's most fundamental challenge for human welfare and for economic growth (Benson, 2004). The currently available estimates indicate that about 795 million people in the world, over one in nine, were undernourished in 2014–2016; estimates in Africa alone were 233 million people (FAO, IFAD, & WFP, 2015). Undernutrition remains a leading cause of death in children in low- and middle-income countries; this will be aggravated by climate change (Sorgho, Franke, Simboro, Phalkey, & Saeurborn, 2016). Researchers estimate that annually, 6.9 million deaths of children less than 5 years were attributable, directly or indirectly to undernutrition (Phalkey, Aranda-Jan, Marx, Höfle, & Sauerborn, 2015). There is evidence that the number of people at risk of hunger will increase by 10–20% by 2050 due to climate change, with 65% of this population in Sub-Saharan Africa (Krishna Krishnamurthy, Lewis, & Choularton, 2012).

Africa is commonly identified as a region highly vulnerable to climate change because of heavy reliance on climate-sensitive activities, such as rain-fed agriculture and limited economic and institutional capacity to cope with and adapt to climate variability and change (Roudier, Sultan, Quirion, & Berg, 2011). Children are the most vulnerable members of any population, due to their small physical size, physiological and cognitive immaturity, and their dependence on caregivers for safety and protection (Bennett & Friel, 2014). Projections indicate that climate change (local warming up to 3–4 °C) will have an additional 25.2 million malnourished children, 21% more relative to a world with no climate change, almost half of which would be living in sub-Saharan Africa (Tirado, Crahay, Cohen, Hunnes, Denton, Lartey, & Challinor, 2012).

## 1. SCOPE OF STUDY

The study is focused on child undernutrition in Northwest Benin and how shifts in climate (temperature and rainfall) and agricultural productions have contributed to worsening children's nutritional status. In addition, it was looked at the relationship between dietary diversity, household's ethnicity, mother's schooling and child nutritional status, as well as the local responses to the adverse effects of climate change.

## 2. STATEMENT OF THE PROBLEM

The Republic of Benin is a West African country in which agriculture plays an important economic role. The agricultural sector employs about 70% of the population and contributes to 39% of the Gross Domestic Product (GDP) (Awoye, 2015) of Benin. It also provides about 88% of the country's export earnings (Awoye, 2015). Main food crops are maize, millet, sorghum, rice, yams, cassava, beans, fruits such as pineapples, mangos and oranges, and vegetables such as tomatoes, hot peppers, leafy vegetables, carrots, okra, lettuce, aubergines, and onion. High dependence on rain-fed agriculture combined with low socioeconomic development expose subsistence farmers to external shocks such as climate variability and climate change. According to Afouda (1990), Houndénou (1999), Ogouwalé (2006) and Boko (1988) cited by Tidjani (2012) , agricultural season length is shortening and there is increasing of minimum temperature in Benin. The relationship between agriculture and nutrition is simple. Agriculture generates food (macro and micro-nutrients) that ensures good nutrition and good nutrition builds human capital that becomes a nation's labor force for agriculture and other productive activities (SCN NEW, 2010). In Benin, populations rely heavily on agriculture for food security and economic development. However, agricultural production is limited by factors including the vagaries of climate variability and change, lack of modern farming technologies, poor soil and inadequate conditions for storing, preserving and processing food. This means that the country's overall food security, nutrition, and trade conditions are poor. Climate change may worsen a population's living standards by increasing the frequency of adverse weather events. This undermines resilience and may push already poor families into deeper levels of chronic poverty, which can stay with them for generations and has implications for child health and survival.

Benin experienced floods in 2010 which damaged agricultural production and weakened the situation for the most vulnerable communities (Benin's government report, 2011). In Benin, 34% of households have limited food security, another 11% suffer from severely to moderately bad food security, and 1.1 million are considered food insecure (AGVSA, 2013).

Only 55% are considered food secure (AGVSA, 2013). Additionally, results from the 2011 Benin government's report of post-disaster needs assessment showed over one-third of children in the age bracket 6 to 59 months old suffered from chronic malnutrition.

In order to reduce the rate of child undernutrition, several international institutions such as World Food Programme (WFP), World Health Organization (WHO), and the United Nations Children's Fund (UNICEF) have intervened in Benin through food supplementation, fortification and food assistance to children from vulnerable communities. Despite the implementation of food supplementation programmes to improve the various nutritional indicators, there has been no reduction in child wasting in Benin (Burchi, Fanzo, & Frison, 2011).

## 3. RESEARCH QUESTIONS

- ✓ What is the relationship between climate variables and crop yields in the Atacora district?
- ✓ What is the prevalence of child undernutrition in the Atacora district?
- ✓ Is there any relationship between climate variables, crop yields and children's nutritional status in the Atacora district?

## 4. SPECIFIC AIMS

The purpose of this study is to determine the impact of climate change in the prevalence of undernutrition in children aged 6 to 59 months old in Northwest Benin.

Specifically, the study aims at:

- Examining the relationship between climate variables and crop yields in the Atacora district;
- Determining the prevalence of undernutrition in children aged 6 to 59 months old in the Atacora district;
- Examining the relationship between climate variables, crop yields and children's nutritional status in the Atacora district.

## 5. LITERATURE REVIEW

Malnutrition is a challenge to the health and productivity of populations, particularly in low- and middle-income countries. Malnutrition refers to both undernutrition (underweight, wasting, and stunting) and overnutrition (overweight and obesity) as well as to micronutrient deficiencies that may occur in both groups. Furthermore, children born to malnourished mothers are at risk for fetal growth retardation (Black et *al*., 2013; Blössner et *al.,* 2005). Undernutrition during pregnancy is estimated to contribute to 800,000 neonatal deaths annually and to cause 20% of stunting in children under five years old (Black et *al*., 2013; and Bhutta et *al.,* 2013). It is important to note here that the largest burden of current undernutrition is attributed to calorie insufficiency caused by lack of food intake (Black et *al*., 2008). Without accounting for climate change, African countries have long struggled with high levels of malnutrition among children and women of reproductive age. Changes in weather averages, climate variability, and extreme weather events determine the quantity, quality, and stability of crop yields (Porter & Semenov, 2005). A recent study by Myers et al., 2014, confirms that elevated concentration of atmospheric CO2 significantly decreases the concentrations of zinc, iron, and proteins in wheat, barley, and rice, but not in sorghum (the main staple African countries). In countries such as India, where legumes rather than animals is the preferred source of protein, these changes in the quality of food crops will accelerate the largely neglected epidemic of "hidden hunger" or micronutrient deficiency (Myers et *al*., 2014). The IPCC notes that undernutrition linked to extreme climatic events may be one of the most important consequences of climate change due to the very large number of people that may be affected (Confalonieri et *al*, 2009 cited by Akachi, Goodman, & Parker, 2009). The changes in weather pose a fundamental threat to human well-being and health. For instance in Ethiopia and Kenya, two of the world's most drought-prone countries, studies conducted by Watkins, 2007 cited by Tirado et *al*., 2012, revealed that children aged five or less born during a drought are respectively 36% and 50% more likely to be malnourished than children not born during a drought. According to the same author, in Niger, children aged two-year-old or less born in a drought year was 72% more likely to be stunted. A study conducted by Arlappa, Venkaiah, & Brahmam (2011) in India revealed that the severe droughts were associated with vitamin A deficiency in rural pre-school children. In addition, a study was undertaken by Singh et *al*., 2006 (cited by Akachi et *al*., 2009) in the desert area of India where droughts are severe, revealed both stunting and wasting, signs of malnutrition of both long and short durations among children aged 0-5 years.

Several researchers highlighted the relationship between child stunting and rainfall. Grace, Davenport, Funk, & Lerner, 2012 in Kenya found that precipitation has a significant impact on child stunting but the relationship between temperature and child stunting is not significant. Mueller et *al*., (1999) found children from very wet areas with little seasonal variation in rainfall were stunted while those from dry areas with seasonal variation in rainfall and frequent rainfall deficits were considerably wasted in Papua New Guinea, thus indicating that weather variables have different impacts on the different nutritional parameters. On the other hand, Wright, Russell, Gundry, Mucavele, & Vaze (2000) did not observe seasonality as a determinant of underweight children in Zimbabwe. They instead noted geographic factors, diarrhea, poor household food access, and increased workload for women during the wedding and harvest seasons as the main contributors. Extreme rainfall/runoff events and floods, in conjunction with warmer temperatures, may also serve to increase the total microbial load in watercourses and drinking-water reservoirs (Confalonieri et *al*., 2007 cited by Akachi et al., 2009). The rise of sea level provokes salt intrusion into groundwater and consequently decreasing the supplies of fresh water for irrigated agriculture, industrial and domestic purposes. The lack of access to safe drinking water and sanitation affects the health and feeding practices of women and children; water-related diseases, particularly diarrheal diseases, not only directly impairs nutrient absorption but also targets tissues but exacerbating undernutrition not sure what this last part means. Undernutrition predisposes children to different diseases through lowering resistance (Scrimshaw 2003 cited by Akachi et *al*., 2009). Prüss-Üstün et *al*., 2008 (cited by Mciver, Woodward, Davies, Tibwe, & Iddings, 2014) stated that water contamination is the major cause of malnutrition and diarrheal disease, which remain a leading cause of death in children under five years of age. Climate change destabilizes agricultural productivity, increases evaporation and dehydrates soils, and flooding salinizes other arable land and diminishes agricultural areas and productivity. Studies have demonstrated a positive correlation between HAZ (Z scores for height/length-for-age) and available plot size for crops. Brentlinger PE et *al*., (1999) in El Salvador showed that stunting was significantly more prevalent among children whose families cultivated less land.

Crop yields are a function of plot size, among other factors. Temperature, precipitation, humidity, dew, radiation, wind speed, and circulation patterns influence the growth, spread, and survival of crop pathogens. Increased temperature and humidity may promote the proliferation of pest infestations, which can reduce crop yield. Research has demonstrated a positive correlation between crop failure and child growth. However, the findings obtained by Yamano, Lderman, & Hristiaensen (2005) in Ethiopia indicated that crop damage has a large detrimental effect on early child growth (measured in height) among children aged 6 to 24 months, resulting in about a 0.9 cm growth loss over a six-month period compared to communities whose percentage of damaged crop area was 50% lower. According to the same author (Yamano et *al*., 2005); increasing at 10% point in the proportion of damaged plot area corresponded to a reduction in child growth by 0.12 cm (1.8%) over a 6-month period.  In

Ethiopia, postnatal exposure to a crop failure, shock was significantly negatively associated with childhood stunting (Woldehanna, 2010). In Rwanda, children in households that experienced positive production shocks at the time of birth had better HAZ (Akresh, Verwimp, & Bundervoet, 2007). On the other hand, no correlation was found between household crop yields and undernutrition in Northern Laos (Kaufmann S, 2008) and Bangladesh (Stewart, Fauveau, Briend, Yunús', Sarder, & Chakraborty, 1989). Household size and composition, especially the number of children under the age of five, may also influence the rate of undernutrition. Mahyar, Ayazi, Fallahi, Haji Seiid Javadi, Baharan, Javadi, & Kalantari, (2010) found a significant correlation between underweight, stunting and the family size in Qazvin, Iran. Other studies have investigated the relationship between household size, composition, and malnutrition and found that children from large households were at risk of food insecurity and malnutrition in a rural area of the Democratic Republic of Congo (Kismul et *al*., 2015). Similarly, Fikadu, Assegid, & Dube (2014) found that children living in households with three or more children under the age of five were more likely to develop stunting than those living in households with one child under the age of five.

In contrast, Chotard, Mason, Oliphant, Mebrahtu, & Hailey (2010) observed that the prevalence of childhood wasting was dependent on the livelihood pattern. In Kenya, the prevalence of stunting varied according to the dominant livelihood strategy and was highest in mixed farming zones (Grace et *al*., 2012). In Mali, the high prevalence of stunting (particularly in rural areas), underweight, and anemia were predicted in children from households with agricultural, agro-pastoral, and pastoral livelihood patterns and in children living in arid and semi-arid climatic conditions (Jankowska, Lopez-carr, Funk, Husak, & Chafe, 2012). Similar findings were reported from Brazil, where landowners' children showed better nutritional status than share-croppers' and laborers' children (Victora CG et *al*., 1985 cited by Zhan, 1998).

Individual factors such as age, sex and educational level of the mother may have significant associations with undernutrition. A study by Kaufmann (2008) conducted in the Greater Horn of Africa revealed that the educational level of parents is correlated with stunting but not with wasting. Similarly, Mahyar et *al*., (2010) reported a significant correlation between stunting and parents' educational level in Qazvin, Iran. Mother's level of education has been identified as a key risk factor in nutrition outcomes for children, and a lack of education has been associated with different types of undernutrition (Ahmed et *al*., 2012a cited by Ahmed, Barnett, & Longhurst, 2015). Chronic under-nutrition was found to be highest among children with illiterate mothers (Rayhan and Khan 2006 cited Ahmed et *al*., 2015). Others suggest that mothers with practical knowledge rather than high educational level are more effective in ensuring the positive nutritional status of children (Jesmin et al. 2011 cited Ahmed et *al.,* 2015).

In Ghana, sex of the child was independently correlated with wasting (Glover-Amengor, Agbemafle, Hagan, Mboom, & Gamor, 2016). According to the authors, males were more likely to be wasted as compared to females.  While for age, the same authors (Glover-Amengor et *al*., 2016) found out that children younger than 6 months were less likely to be stunted, underweight and wasted as compared to older children 6–35 months. In contrast, Hoddinott and Kinsey, (2001) found that children aged 12 to 24 months lost 1.5-2 cm of growth in the aftermath of droughts in Zimbabwe in 1994 and 1995, although they did not find a similar negative loss among older children. Yamano et *al.,* (2005) also found a negative effect on child growth in height only among children aged 6 to 24 months, but not among older children (Omitsu & Yamano, 2006).

## 6. RESEARCH METHODOLOGY

This section outlines the research design, methodology and data analysis techniques used to assess the impact of climate change on child nutrition in Northwest Benin.

### 6.1. STUDY DESIGN

This study used a cross-sectional, descriptive design.

### 6.2. STUDY AREA

Located in northwest Benin, Atacora district counts nine communes, which are: Natitingou, Kérou, Kouandé, Péhunco, Cobly, Boukoumbé, Matéri, Toucountouna, and Tanguiéta. It shares borders with the Republic of Burkina-Faso in the North, a Donga district in the South, Alibori and Borgou district in the East and Republic of Togo in the West (figure 1).  This district is characterized by one rainy season with a unimodal distribution (peak in August). The rainfall is unpredictable and irregular with an average between 800 and 950 mm per year (Dansi, Adoukonou-sagbadja, & Vodouhe, 2010). The wet season starts from late mid-June to late October while April-May is the dry season. The landscape in this region is composed of Rocky Mountains, with tropical ferruginous soils and wetland (Dansi et al., 2010). The territory of Atacora consists of 772,262 inhabitants unequally distributed in 384 villages (RGPH-4, 2013). The mean population density is 38 inhabitants/km$^2$ (RGPH-4, 2013). The district is inhabited by seven ethnic groups Bariba, Berba, Ditamari, Lamba, Natimba, Wama and Bialli (Dansi and *al*, 2010).The main livelihood of the population is farming and cultivated food crops are maize, sorghum, millet, yam, cassava, rice, peanuts, and beans.

Small livestock and poultry are raised in some households but animals are slaughtered when there is a ceremony or sold when there is an urgent need for money.

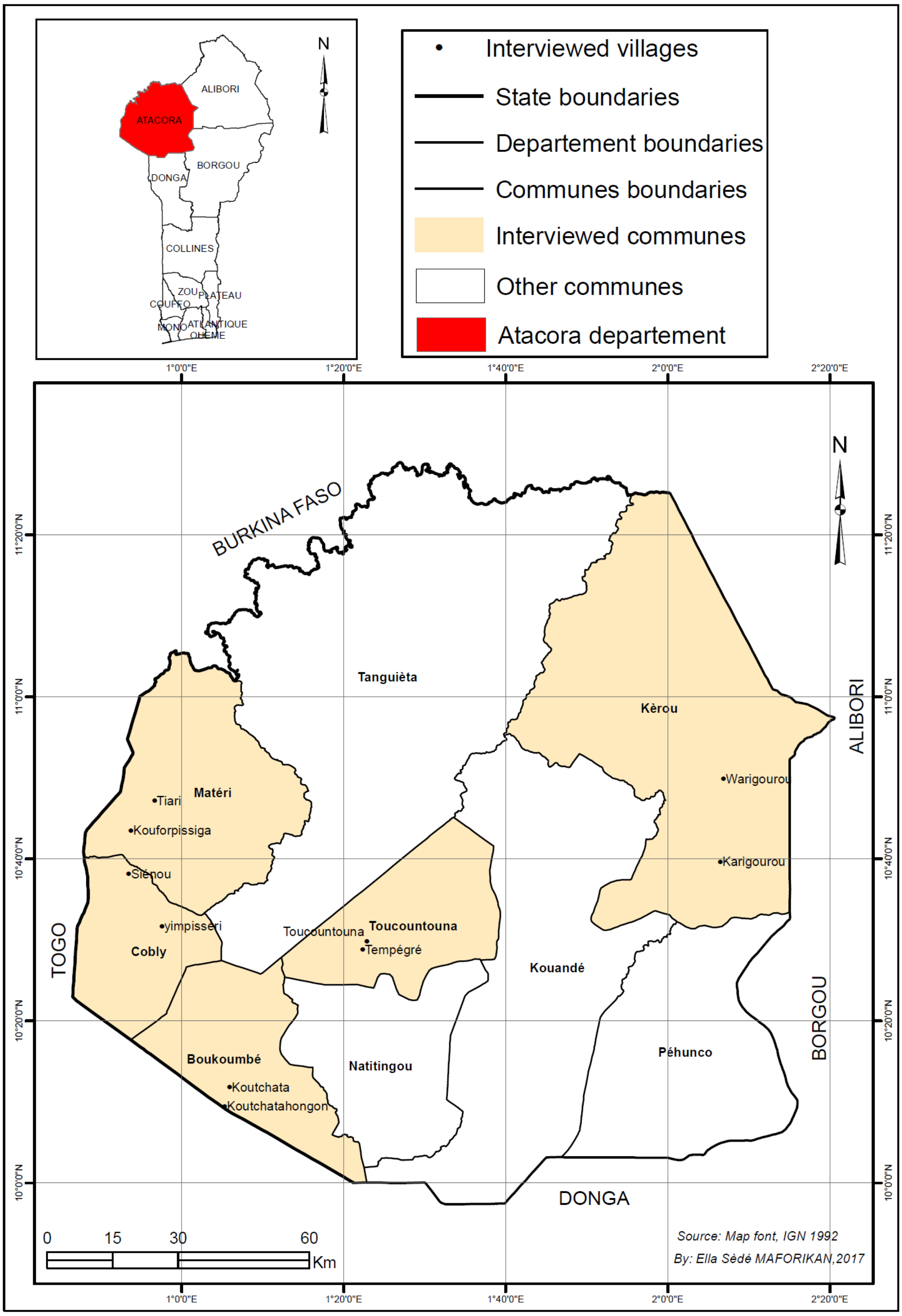


**Figure 1.** Map of Atacora District

## 6.3. SAMPLING

The district of Atacora comprises nine communities. For this study, five communes (Boukoumbe, Cobly, Kérou, Matéri, and Toucontouna) have been selected based on the ethnolinguistic map of Benin and the agricultural potential of each commune (Table 1). Two villages were chosen per commune. Within each village, only the compounds with children under five years old were selected from an updated list of all the heads of households. One child per household was randomly selected. If more than one child is present in a visited household, two children were randomly chosen. In the case a household does not comprise of a child aged 6 to 59 months old; the choice was made for the nearest household of the neighborhood. A survey questionnaire was administrated during face-to-face interviews. Interviews were conducted with men and women who have at least ten years' experience in the agricultural production of different ages (youth <30 years; adults 30–60 years; older persons >60 years). Two focus groups were set upper village and the discussion was held by women and men separately. An exploratory survey was conducted to pre-test the questionnaires and identify the two villages retained in the study.

**Table 1.** Distribution of ethnic groups and agricultural production in each commune of the Atacora district.

| **Atacora district** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Communes** | Ethnic groups | Cereals | | Roots and Tubers | | Legumes | |
| | | Production (tons) | Percen -tage | Productio n (tons) | Perce n- tage | Produ- ction (tons) | Percen -tage |
| **Boukoumbé** | Otamari | 26 240 | 7.49 | 16 204 | 2.13 | 4 567 | 9.36 |
| **Cobly** | Bebèrbè, Gamgamba, Koun -timba, Gourmantché, Bètama -ribè, Tchokossi, Peulh and Dendi. | 17 740 | 5.06 | 23 638 | 3.11 | 4 730 | 9.7 |
| **Kérou** | Bariba, Peuls, Djerma, Yoruba, Aja, Fon, Yom Lokpa, Otamariand | 91 312 | 26.09 | 74 016 | 9.75 | 10 662 | 21.86 |
| **Kouandé** | Bariba, Bètamaribè,Peuls,Yom , Lokpa, Dendi, | 53 496 | 15.28 | 313 837 | 41.33 | 4 469 | 9.16 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Matéri** | Yorouba, Adja, Fon Biali, Laswalbe, Laputibe, Lanutibe, Pianguebe), Gourmantchés, Tantabe. | 39 965 | 11.42 | 21 092 | 2.78 | 7 161 | 14.68 |
| **Natitingou** | wama, Betamaribè | 14 273 | 4.07 | 77 067 | 10.15 | 2 522 | 5.17 |
| **Péhounco** | Bariba | 70 674 | 20.19 | 38 027 | 5 | 4 565 | 9.36 |
| **Tanguiéta** | Otamari, Natimba, Yorouba, Zerma, Haousatché, Peulhs, Dendis, Batombou, Fon, Waaba,Bèbèlibè,Bètammaribè, Gourmatchéba, Kountim -ba, Mossis, Berba. | 23 828 | 6.8 | 39 628 | 5.22 | 6 417 | 13.15 |
| **Toucountouna** | Waaba, Natimba, Bètamaribè, Peulh, | 12 422 | 3.54 | 155 852 | 20.52 | 3 684 | 7.55 |
| **Total** | | 349 949 | 100 | 759 362 | 100 | 48 777 | 100 |

Source: ONASA/CARDER (2015)

## 6.4. ANALYTIC VARIABLES

This study considers three main outcome variables in addition to the independent variables (Table 2).

**Table 2.**Variables included in the study

| Outcomes Variables | Definition | Type | Source |
|---|---|---|---|
| Wasting | Weight-for-height <-2SD | Dichotomous | Primary data collection |
| Stunting | Height-for-age <-2SD | Dichotomous | Primary data collection |
| Underweight | Weight for age <-2SD | Dichotomous | Primary data collection |
| Independent Variables | Definition | Type | Source |
| Sex | Male/Female | Dichotomous | Primary data collection |
| Age | Age at time of observation | Continuous | Primary data collection |
| Mother’s educational level | Mother’s educational level at time of observation | Categorical | Primary data collection |
| Child feeding practices | Lists of all foods consumed both at home and out of the home in the 24 hours preceding the interview | Categorical | Primary data collection |

| | | | |
|---|---|---|---|
| Child medical history | Any signs of illnesses related to undernutrition such diarrhea, anemia, pellagra, rickets, lack of Vitamin A | Categorical | Primary data collection |
| Ethnic groups | Bariba, Berba, Ditamari, Lamba, Natimba, Wama and Bialli | Categorical | Primary data collection |
| Farmers' perception | Farmers' perception of climate change at time of observation | Nominal | Primary data collection |
| Adaptive measures | Strategies developed by farmers to cope with the adverse impacts of climate change | Nominal | Primary data collection |
| Independent variables | Definition | Type | Source |
| Climatological data | Temperature and rainfall | Continuous | Secondary data collection |
| Agricultural production | Cultivated crops | Continuous | Secondary data collection |

## 6.5. DATA COLLECTION

Information on participants' background characteristics such as ethnic group, sex, age, mother's level of education (primary: 0 to 6 years, secondary: 7 to 9 years and tertiary: ten years or more), cultivated crops yield as well the feeding practices and medical history of children were collected from the respondents through one-on-one interview. These variables have been included in this study to see their associations with undernutrition. Child feeding practices were gathered from their mothers using the recall of all foods eaten the prior day before the interview. Respondents were requested to list all the foods consumed both at home and out of the home in the 24 hours preceding the interview. Dietary diversity score (DDS) was computed as the sum of the number of different food groups consumed by the child in the 24 hours prior to the assessment. To measure dietary quality, food groups are categorized into nine groups as recommended by the Food and Agriculture Organization (FAO), (2011). These food groups are: The groups included (1) Cereals, roots, and tubers; (2) vitamin A-rich fruits and vegetables; (3) non rich vitamin A (other) fruit; (4) non rich vitamin A (other) vegetables; (5) legumes and nuts; (6) meat, poultry, and fish; (7) fats and oils; (8) dairy; and (9) eggs.

Child nutritional status in the selected households was determined by taking anthropometric measurements based on UNICEF standard procedures. The health document (medical certificate, health card and ID card of parents) was used to verify child's age. In the case a health document is unavailable, a calendar of local events specifically designed for the province was used to help mother's child to give the birthday of her/his child. Children whose age to the nearest month are unknown by the family, or cannot be ascertained from health books or other sources, were excluded in this study.

A digital SECA weighing scale (Appendix A-1:) was used to measure the weight of the children who wear only light clothing and no shoes. Height was measured with a wooden stadiometer (Appendix A-2) placed on a flat surface. The height of children aged less than 24 months was measured in a recumbent position (Appendix A-4) whilst children aged more than 24 months were measured in a standing position (Appendix A-3). The child's height and weight were recorded twice and the mean value is used in the analyses. Computed Z-scores of weight index for age (WAZ), height for age (HAZ) and weight-for-height (WHZ) were used to assess underweight, stunting and wasting respectively. Stunting is defined as HAZ <-2SD, underweight as WAZ <-2 SD and wasting as WHZ<-2 SD (WHF & UNICEF, 2009).

Other variables to be collected include communities adaptive measures developed to cope with adverse impacts of climate change, farmer's perception of climate change (temperature, rainfall, and storms) over the last five years. To compare the responses from respondents to scientific facts, data concerning agricultural production of cultivated crops chosen as well as climatological data, including temperature (°C), and rainfall (mm) from 1986 to 2016 were collected respectively at CARDER (Centre d'Action Régional de Développement Rural) and synoptic station ASECNA (Agence pour la Sécurité et la Navigation Aérienne) of Benin. The interviewers were trained in collecting anthropometric measurements. The equipment was calibrated before use. After data collection, the questionnaire was used to cross-check in the field and all necessary corrections were made. The questionnaire was in French, the interviews were conducted in French.

### 6.6. DATA ANALYSES

Descriptive statistics (means, frequency, percentage, the standard of deviation and variance) were computed. A multiple linear regression was used to examine the relationship between climate variables and agricultural production on one hand and the association between climate variables, agricultural production, and children nutritional status on the other hand. The excess or deficit of rainfall was computed based following Yabiet Afouda (2012). The prevalence of undernutrition was computed and Analysis of variance (ANOVA) was used to explore the association between dietary diversity, household ethnicity and mother's schooling with Height-for-age Z-score, weight-for-age Z-score and weight-for-height Z-score. A p-value $< 0.05$ was considered significant. All statistical assessments were performed by using

R software version 3.3.1 and the figures were designed using Microsoft Excel spreadsheet software.

# 7. RESULTS

## 7.1. RELATIONSHIP BETWEEN CLIMATE VARIABLES AND AGRICULTURAL PRODUCTION

### 7.1.1. Observed rainfall and temperature trends

The results show that the temperature curve goes upward while the trend curve of rainfall is decreasing (figure 2 and figure 3). This result reveals that there is increasing temperature and decreasing of rainfall. From the figure 4, we can see that the high annual rainfall excess was observed over 1991, 1998 and 2009 period. In contrast, the high annual rainfall deficit was obtained during the years 2012, 2015 and 2016.

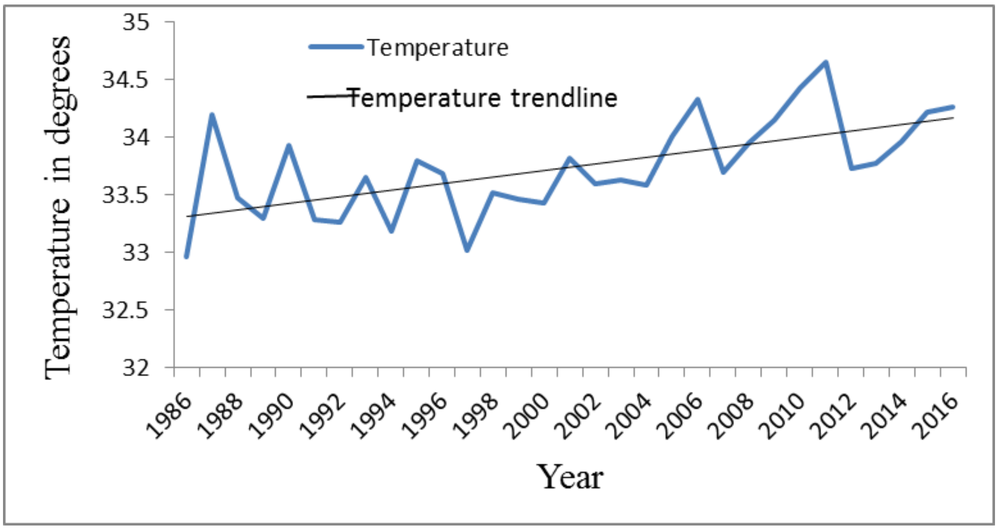


**Figure 2.** Evolution of temperature variability in Atacora (ASECNA data from 1986-2016)

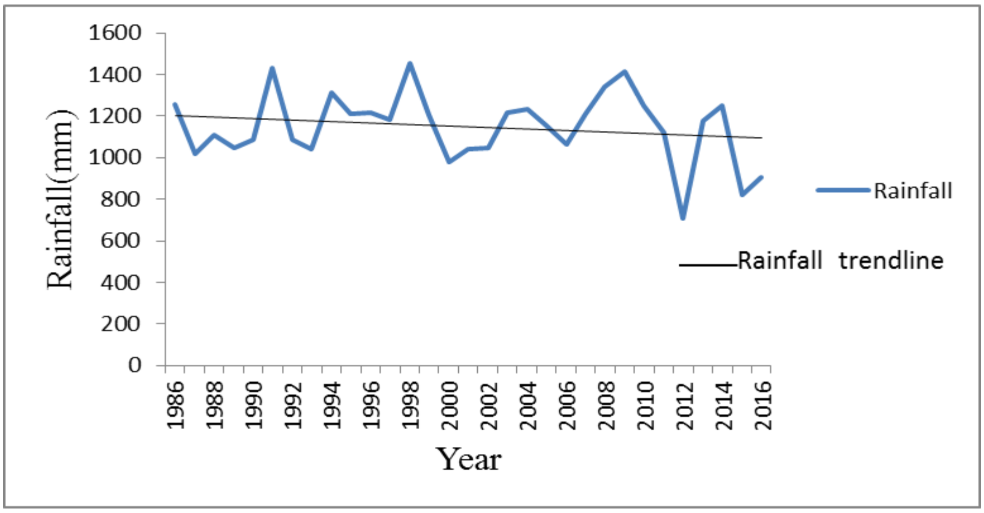


**Figure 3.** Evolution of Rainfall variability in Atacora (ASECNA data from 1986-2016)

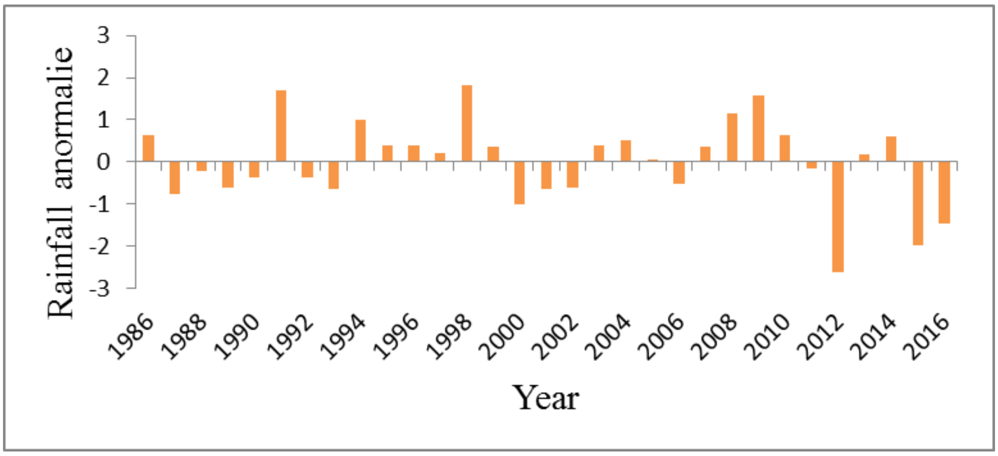


**Figure 4.**Variability of rainfall anomalies from 1986 to 2016 in Atacora

### 7.1.2. Climate variability and crop yields

Benin agriculture is mainly rain-fed; the starting and the length of growing seasons of the staple crops depend on the onset and duration of the rainy season. This means Benin agriculture relies on climate variables. To examine the relationship between climate variables and five staple crop yield (maize, yam, beans, sorghum, and rice), a multiple regression was performed. Those five staple crops were selected because it was the most crops cultivated in the overall study area. The result of multiple regressions reveals that only variable rainfall influenced significatively maize, beans, and sorghum yield whilst temperature had a significant effect on rice and yam yield (Table 3). The assumptions of normality, homogeneity of variance and independent test were checked before to validate the model. The Shapiro-Wilk normality test gives p-value equal 0.2038, 0.4886, 0.1854, 0.3156, 0.4245 for rice, yam, bean, maize, and sorghum respectively. The p-value of each crop is more than 0.05 meaning that the residual value of each staple crop is normally distributed. Durbin-Watson test gives the values 1.1096, 1.5564, 0.91715, 1.4373, and 1.314 for rice, yam, bean, maize, and sorghum respectively. Those values are less than 3; consequently, the value residuals are independent. The p-value of Breusch-Pagan test for rice, yam, bean, maize, and sorghum are 0.3408, 0.3261, 0.05914, 0.1282, and 0.2488 respectively. The p-value is higher than 0.05 then this means there is no significant difference between the variance, i.e. condition of homogeneity is met. All assumptions are met, and then the model is validated. The figures 5 and 6 represent the positive correlation between rice, yam yield and temperature respectively. The positive correlation means the rising of temperature in one unit induces the augmentation of rice and yam yield in 62.2 and 70.5 kilograms respectively. The figures 7, 8, and 9, show the negative correlation between sorghum, bean, maize yield, and rainfall respectively. This result shows that the increase of rainfall induces the diminishing of sorghum, bean, and maize yield to 0.23, 0.31, and 0.78 kilograms respectively.

**Table 3.** Multiple regression results according to climate variables and crop yields

| Dependent variables | Independent variables | Coefficient | Std. Error | t value | Pr(>\|t\| |
|---|---|---|---|---|---|
| Rice | Intercept | -144.1 | 162.25 | -3.26 | 0.002** |
| | Rainfall | -0.45 | 1.45 | -0.31 | 0.75ns |
| | Temperature | 62.25 | 17.5 | 3.55 | 0.001** |
| Maize | Intercept | 2503.67 | 5199.51 | 0.48 | 0.63ns |
| | Rainfall | -0.78 | 0.37 | -2.10 | 0.04 * |
| | Temperature | -2.38 | 150.77 | -0.01 | 0.98ns |
| Sorghum | Intercept | 4072.56 | 1543.91 | 2.63 | 0.01 * |
| | Rainfall | -0.23 | 0.11 | -2.09 | 0.04 * |
| | Temperature | -88.11 | 44.76 | -1.96 | 0.05 ns |
| Bean | Intercept | -511.03 | 2026.53 | -0.25 | 0.80ns |
| | Rainfall | -0.31 | 0.14 | -2.17 | 0.03* |
| | Temperature | 53.08 | 58.76 | 0.90 | 0.37ns |
| Yam | Intercept | -118.47 | 79.44 | -1.49 | 0.14 |
| | Temperature | 70.56 | 31.16 | 2.26 | 0.03 * |
| | Rainfall | 1.49 | 1.05 | 0.3860.38 | 0.70 |

Note: *= Significant at 5%  ns= non-significant

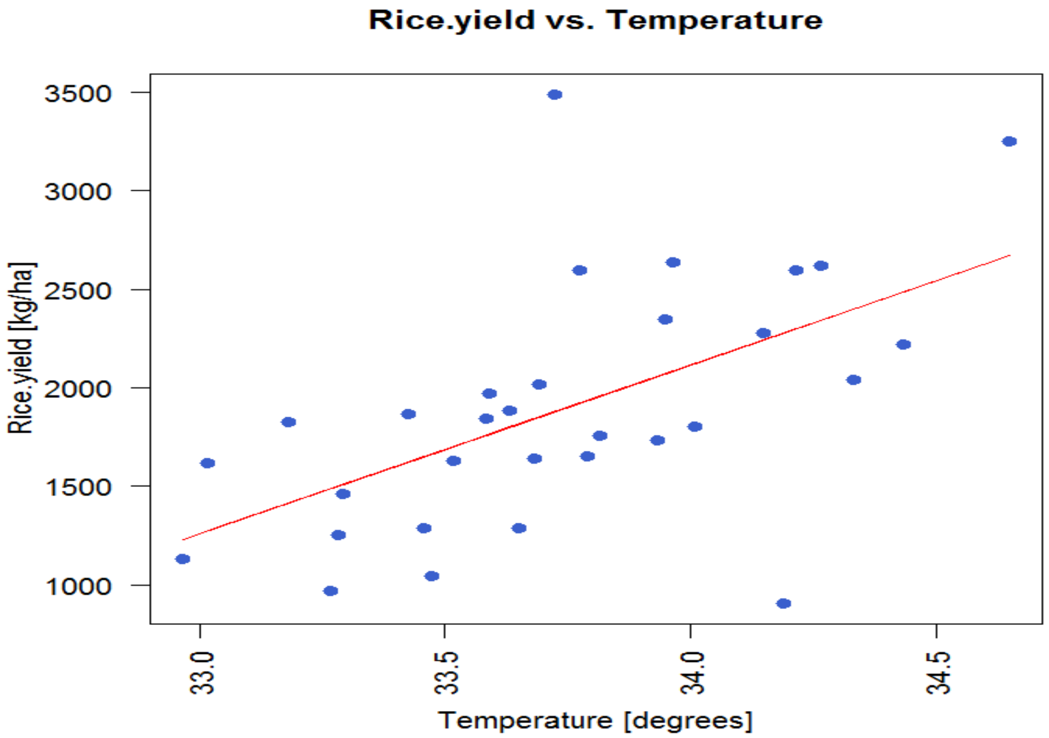


**Figure 5.** Correlation between rice yield and temperature

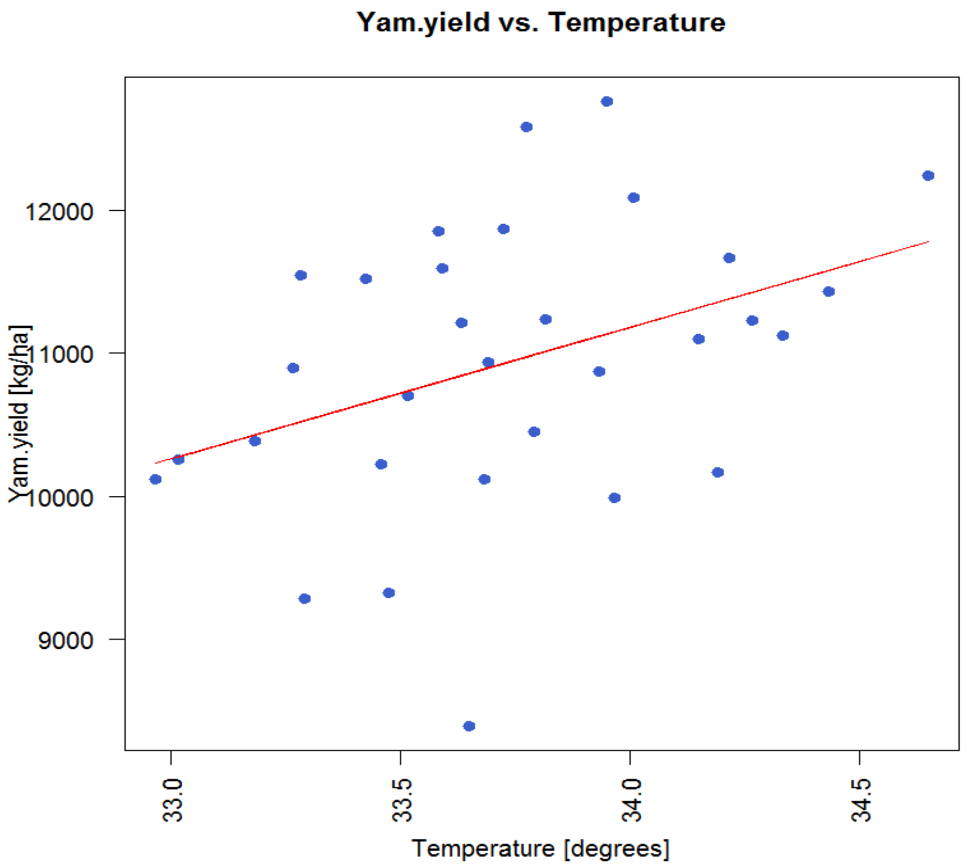


**Figure 6.** Correlation between yam yield and temperature

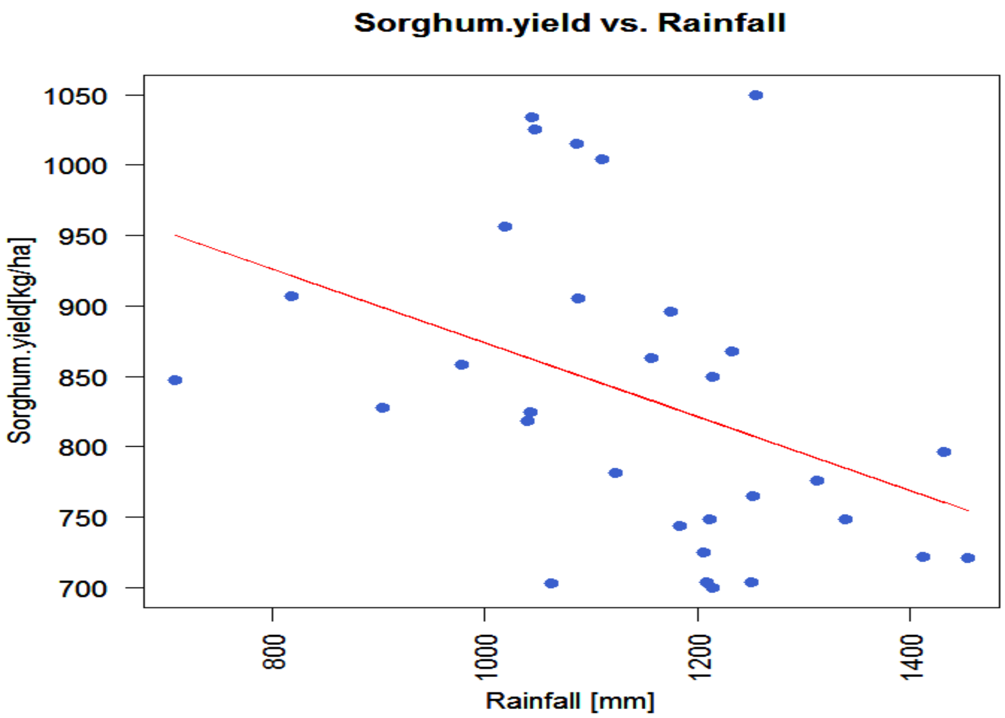


**Figure 7.** Correlation between sorghum yield and rainfall

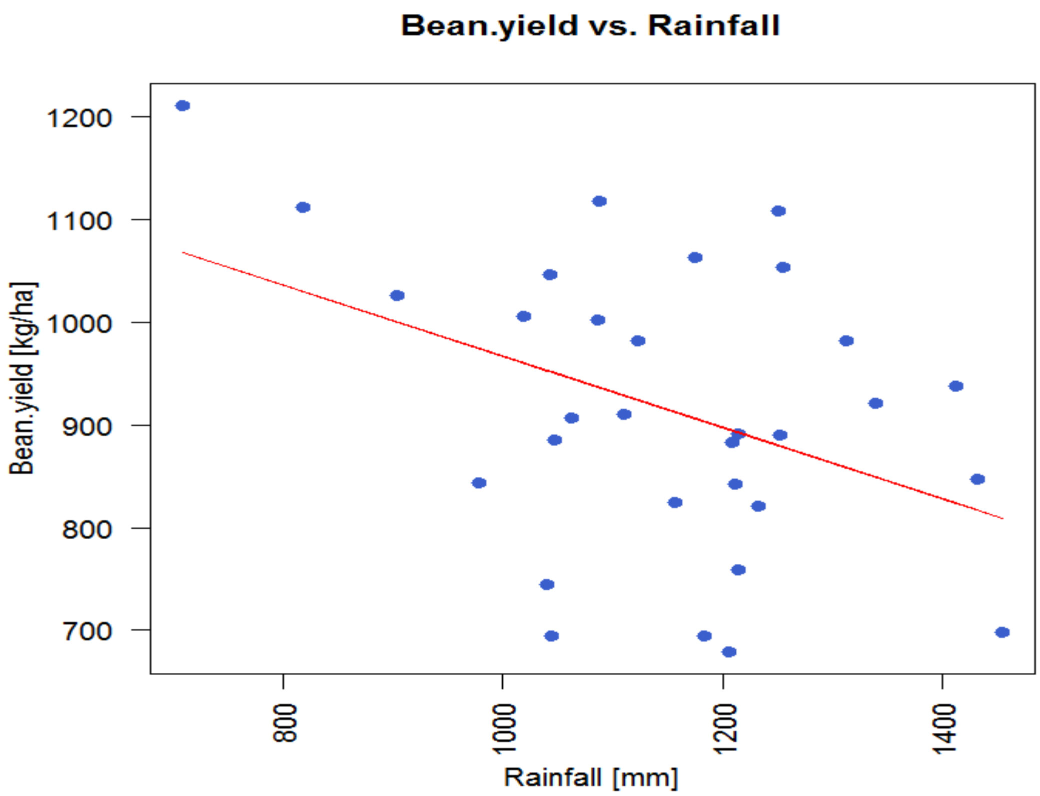


**Figure 8.** Correlation between bean yield and rainfall

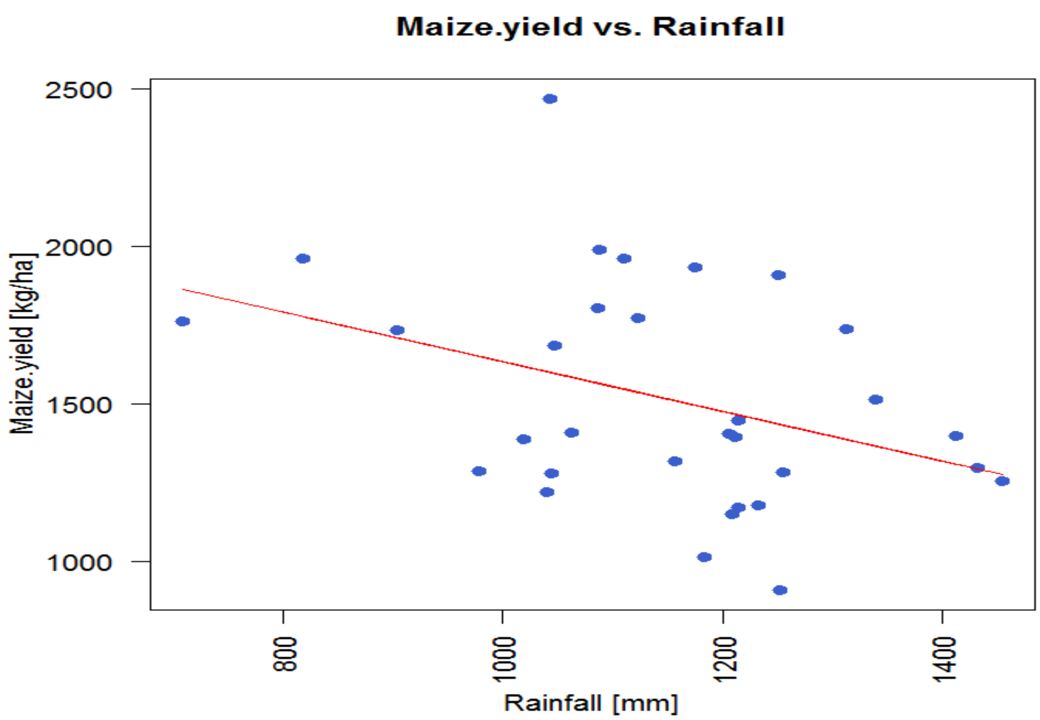


**Figure 9.** Correlation between maize yield and rainfall

## 7.2. PREVALENCE OF UNDERNUTRITION IN CHILDREN AGED 6 TO 59 MONTHS

A total of 422 children were measured in this study. Of those, 50.71% were boys and 49.28% were girls. The prevalence of underweight (height for age <-2SD) was estimated at 21.1% with a severe underweight (height for age <-3 SD) of 9.7%. In terms of wasting, 3.6% of children had a Z-score weight for height <-3 SD whilst 12.1% had Z-score weight for height <-2 SD. For Z-score height for age, 45.5% of children were stunted with 20.9% of children severely stunted. The prevalence of boys for stunting, underweight, and wasting were 50%, 24.8%, and 11.7% respectively. The girls presented 40.9%, 17.3%, and 12.5% respectively for stunting, underweight, and wasting (Table 4). More children were likely to be stunted and underweight as compared to children who were wasted. The boys were more likely to be wasted and underweight as compared to girls. The Figures 10, 11 and 12 represent respectively, the curve of height for age, weight for age, and weight for height of all children included in the sample, compared to the international reference WHO (2006). The results drew from the figures show that the whole distributions of all Z score have shifted downward, revealing that most of the people have been undernourished. Apart from the curve of Z-score weight for height, the curve height for age, weight for age are shifted into left compared to the population of reference. This result notes that greater numbers of children are stunted and underweight as compared to wasting. Data on mother's schooling, groups of food consumed by the child and household ethnicity were collected to see their associations with undernutrition. The groups of food consumed by the child were used to calculate the dietary diversity. The results show that the variable ethnic influence significantly all three indices of undernutrition (Height for age Z score, Weight for age Z score and Weight for height Z score) while mother's schooling does not influence the nutritional status of children (Table 5). The dietary diversity had a significant association with weight for age Z score and weight for height Z score, but not with Height for age Z score (Table 6).

**Table 4.** Percentage of children 6-59 months classified as wasted, stunted and underweight in the Atacora using WHO growth reference 2006

| Prevalence of undernutrition (%) | | All children (n=422) | Boys(n=214) | Girls (n=208) |
|---|---|---|---|---|
| Stunting | <-2Zscore | 45.5 | 50 | 40.9 |
| | <-3Zscore | 20.9 | 21.5 | 20.2 |
| Underweight | <-2Zscore | 21.1 | 24.8 | 17.3 |
| | <-3Zscore | 9.7 | 11.2 | 8.2 |
| Wasting | <-2Zscore | 12.1 | 11.7 | 12.5 |
| | <-3Zscore | 3.6 | 4.7 | 2.4 |

**Table 5.** Mean of Height for age Z score, Weight for age Z score, and Weight for height according to Ethnic group and mother's schooling

| Variables | | Mean | | |
|---|---|---|---|---|
| | | WAZ ±SD | HAZ ± SD | WHZ±SD |
| Mother' schooling | n | | | |
| No education | 370 | -1.17±1.26 | -1.85±1.63 | -0.17±1.52 |
| Primary | 41 | -1.06±1.49 | -2.02±1.46 | 0.06±1.70 |
| Secondary | 11 | -0.45±1.38 | -1.07±2.14 | 0.15±1.32 |
| P-value | | 0.178ns | 0.226ns | 0.512ns |
| Ethnic groups | n | | | |
| Dendi | 3 | 0.086±0.361 | -0.496±0.424 | 0.556±0.384 |
| Berba | 113 | -0.736±0.076 | -1.968±0.102 | 0.488±0.108 |
| Fon | 4 | -0.6±0.384 | -1.295±0.214 | 0.220±0.455 |
| Bariba | 100 | -0.872±0.133 | -1.690±0.157 | 0.144±0.156 |
| Otamari | 81 | -1.307±0.150 | -2.309±0.214 | 0.042±0.185 |
| Peulh | 8 | -0.475±0.383 | -0.825±0.372 | -0.007±0.598 |
| Natimba | 21 | -1.079±0.235 | -1.022±0.426 | -0.721±0.380 |
| Wama | 14 | -1.153±0.218 | 0.942±0.446 | -0.827±0.380 |
| Kouteni | 17 | -1.116±0.360 | -0.856±0.563 | -0.873±0.181 |
| Gourmantché | 24 | -2.07±0.257 | -2.44±0.274 | -1.105±0.267 |
| Yoruba | 4 | -1.897±1.245 | -2.177±1.648 | -1.123±0.612 |
| Oubiero | 33 | -2.739±0.206 | -2.26±0.299 | -2.071±0.156 |
| P-value | | 9e-15 *** | <0.000229*** | <2e-16 *** |

Note: ***= significant at 0.1% level (p<0.001)    ns = non-significant

**Table 6.** Analysis of variance (ANOVA) for dietary diversity

| Dependent variables | | Dietary diversity | Residuals |
|---|---|---|---|
| | Df | 1 | 420 |
| | Sum square | 18.0 | 689.5 |
| Weight for age Z score | Mean square | 17.997 | 1.642 |
| | F value | 10.96 | |
| | Pr ( F>F) | 0.001 ** | |
| | Df | 1 | 420 |
| | Sum square | 7.5 | 1119.1 |
| Height for age Z score | Mean square | 7.494 | 2.664 |
| | F value | 2.813 | |
| | Pr ( F>F) | 0.0943 ns | |
| | Df | 1 | 420 |
| | Sum square | 13.4 | 980.7 |
| Weight for height Z Score | Mean square | 13.431 | 2.335 |
| | F value | 5.752 | |
| | Pr ( F>F) | 0.016 * | |

Note: **= significant at 1% (p< 0.01) *= significant at 5% (p< 0.05)

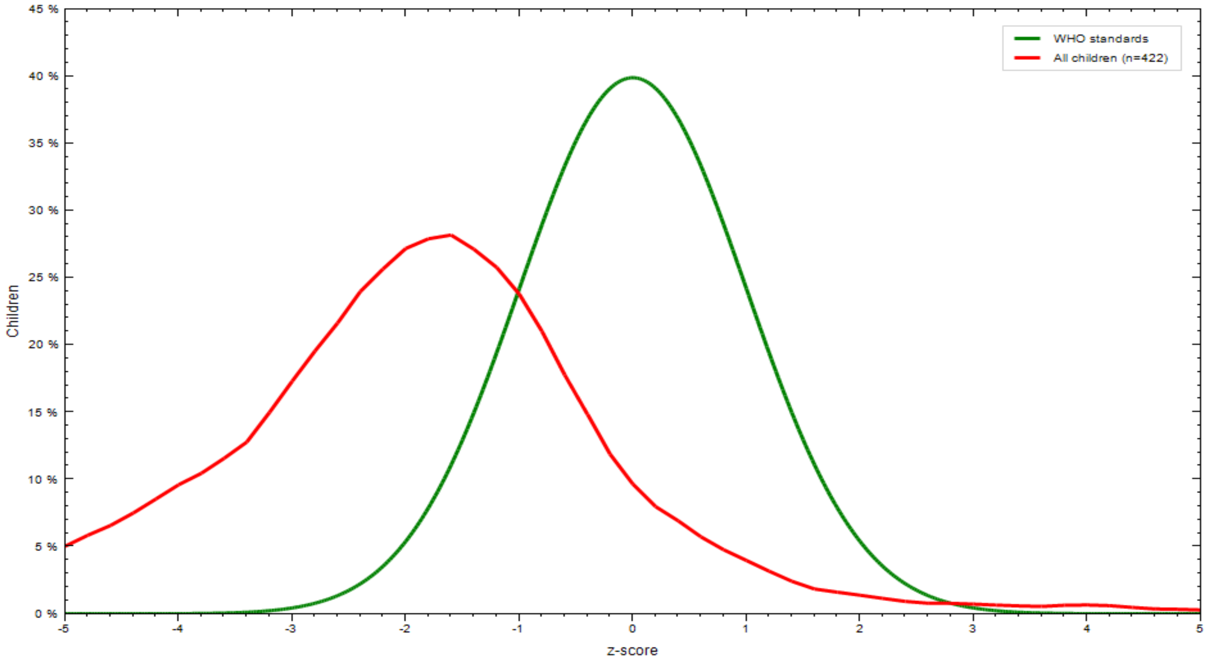


**Figure 10.** Distribution of Z-score of height/age of children in the Atacora compared to international reference data WHO-2006

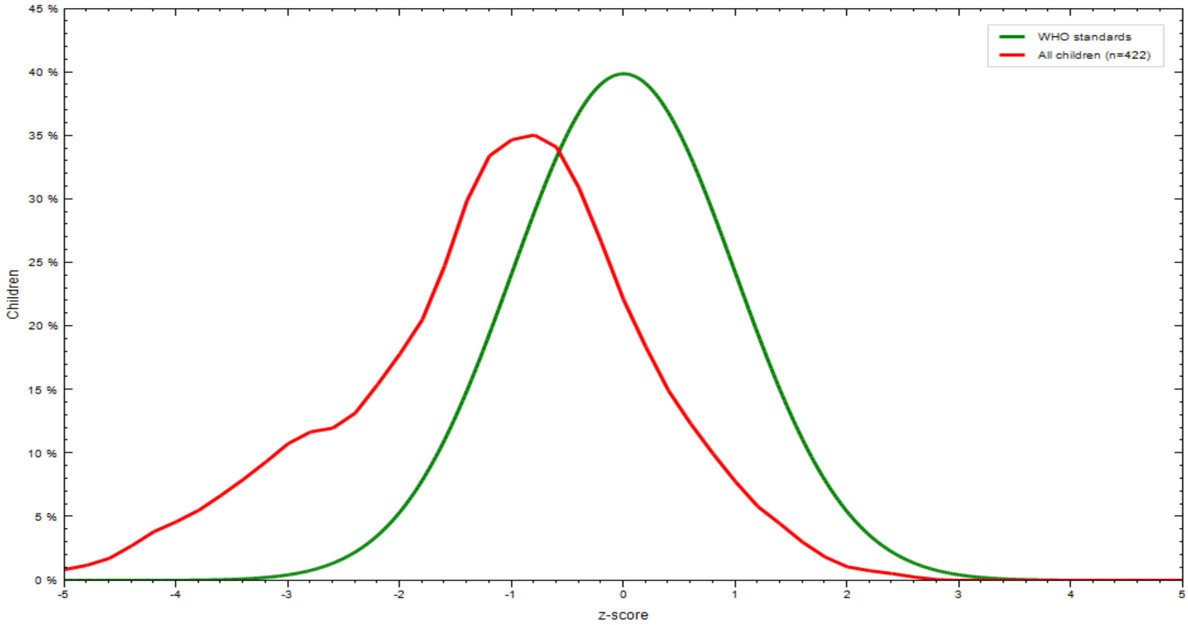


**Figure 11.** Distribution of Z-score of weight for age of children in the Atacora compared to international reference data WHO-2006

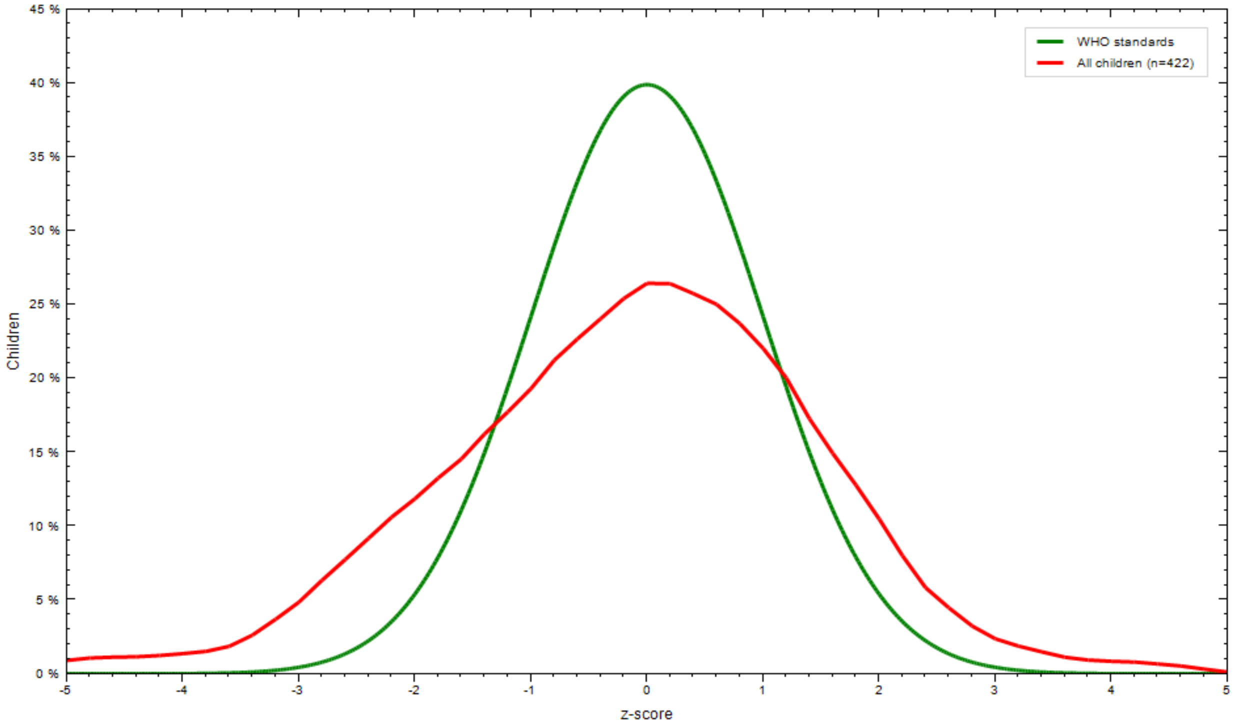


**Figure 12.** Distribution of Z-score of weight for height of children in the Atacora compared to international reference data WHO-2006

## 7.3. RELATIONSHIP BETWEEN CLIMATE VARIABLES, CROP YIELD AND CHILDREN'S NUTRITIONAL STATUS

Agriculture provides food (macro and micro-nutrients) that ensures the welfare of the population. A significant association was found between temperature, precipitation, and food production in this study.The evaluation of the correlation between climate variables, agricultural production and child nutritional status is necessary to fully understand the effects of climate factors and food production on children's health. For this purpose, the multiple regressions were realized. The result shows that neither five staple crops productions nor temperature and precipitation had not statistically a significant influence on weight for height Z score and weight for age  Z score but a significant correlation was found between agricultural production (yam, maize, and sorghum), precipitation, temperature and height for age Z score. Maize and sorghum had a positive significant effect on stunting while temperature, rainfall, and yam had negative coefficient with stunting (Table 7).

**Table 7.** Multiple regression results for climate variability and agricultural productions

| Dependent variables | Independent variables | Coefficient | Std. Error | t value | Pr(>\|t\| |
|---|---|---|---|---|---|
| Weight for height Z score | Rice | 0.13 | 0.07 | 0.511 | 0.660 ns |
| | yam | 0.03 | 0.15 | 0.065 | 0.954 ns |
| | Bean | -0.07 | 0.06 | -0.123 | 0.914ns |
| | Sorghum | 0.1 | 0.14 | 0.279 | 0.807 ns |
| | Maize | 0.07 | 0.17 | -0.410 | 0.722 ns |
| | Temperature | 0.19 | 1.72 | 0.008 | 0.994ns |
| | Rainfall | 0.17 | 0.06 | 0.778 | 0.518ns |
| Height for age Z score | Rice | 10.72 | 5.15 | 7.663 | 0.2148 ns |
| | Yam | -0.21 | 0.05 | --5.149 | 0.0357 * |
| | Bean | -0.21 | 0.18 | -4.298 | 0.0501 ns. |
| | Sorghum | 0.24 | 0.13 | 6.509 | 0.0228 * |
| | Maize | 0.04 | 0.02 | 7.188 | 0.0188 * |
| | Temperature | -1.027 | 0.44 | -8.564 | 0.0134 * |
| | Rainfall | -0.12 | 0.05 | -8.992 | 0.0121 * |
| Weight for age Z score | Rice | -0.17 | 0.07 | -0.604 | 0.607ns |
| | Yam | 0.14 | 0.05 | 0.754 | 0.529 ns |
| | Bean | 0.37 | 0.17 | 0.580 | 0.621 ns |
| | Sorghum | -0.08 | 0.47 | -0.482 | 0.677 ns |
| | Maize | -0.06 | 0.07 | -0.836 | 0.491 ns |
| | Temperature | 2.18 | 1.539 | 0.386 | 0.737 ns |
| | Rainfall | 0.17 | 0.17 | 0.977 | 0.432 ns |

Note: ns= non-significant *= significant at 5%

# 8. DISCUSSION

## 8.1. RELATIONSHIP BETWEEN CLIMATE VARIABLES AND CROP YIELDS

Benin agriculture is mainly rain-fed; the starting and the length of growing seasons of the staple crops depend on the onset and duration of the rainy season. This means Benin agriculture relies on climate variables. The relationship between climate variability and five crop products (maize, yam, beans, sorghum, and rice) were examined through multiple regressions. The curves of temperature and rainfall were designed. The analysis of curves shows there is increasing in temperature and decreasing in rainfall. This finding corroborates the ideas of Eregha, Babatolu, & Akinnubi, (2014) who suggested that temperature in Nigeria is rising over time and rainfall have been declining trend throughout the study period. Results further indicated that only variable rainfall had a negative correlation with maize, beans, and sorghum yield whilst temperature had a positive correlation with rice and yam yield. The findings of the current study are consistent with those of Mikova Kseniia et al. (2015) who found a negative association with sorghum, bean production and rainfall in Rwanda; in Benue State, Nigeria, on one hand, Uger 2017, found that the temperature had the highest influence on yam and PI Ater, BC Asogwa, & Bogbenda, (2017) revealed that the temperature had a positive significant effect on rice output on the other hand. The study conducted in Benin by Awoye, (2015), shows that the main determinant for maize production in Benin is precipitation; for the production of rice the most important predictor is related to temperature and sorghum is found to be influenced only by the variation of precipitations. Conversely, these results contradict the findings of other studies. Mikova et *al*., (2015) in Rwanda shows a positive association between rainfall and maize production. For yam production, A Ayanlade et *al*., (2010) in the Guinea Savanna demonstrated that rainfall total for the growing season months was correlated with the yam yield. Other researchers found a strong correlation between both rainfall and temperature with beans, maize and yam production. Eregha et *al*., (2014) indicate that the temperature had a significantly negative effect on maize production while rainfall had a positive impact on the production of maize in Nigeria. The same author (Eregha et *al*., (2014)) found that temperature had a significantly negative effect on beans from production while rainfall was found to have a positive impact on beans production in Nigeria. Lastly, according to Eregha et *al*., (2014) temperature and rainfall were all found to impact negatively the production of yam in Nigeria. The discrepancies might be due to the difference of the study area and geographical characteristics of the study area. Results from farmers' perceptions of climate change revealed that there is rain scarcity, less rain, increasing temperature and more droughts. A total of 350 households were included in this study. Of those, 21.42% stated there is less rainfall and increasing of temperature; 38.85% revealed more drought and rising of temperature, and 39.71% stated there is rain scarcity and increasing of temperature. Temperature and rainfall are not only factors that can affect main crop products. Other factors might influence crop production such as relative humidity, air temperature, sunlight, CO2 variations, soil aeration and structure, biotechnology use, fertilizer application, use of machinery. In response to climate variation, farms adjust their cropping calendars by shifting either forward or backward the timing of land preparation and seedling, adopt improved crop varieties, use the wetland for agricultural productions, reducing land of long crop seasons and increasing land of improved crop varieties.

### 8.2. PREVALENCE OF UNDERNUTRITION IN CHILDREN AGED 6 TO 59 MONTHS OLD

Suitable nutrition is capital for child growth, health, and development. This study used height-for-age, weight-for-Height, and weight-for-age indices to evaluate the prevalence of undernutrition in children aged 6–59 months. The prevalence of underweight, wasting, and stunting among children under age of 5 years was 21.1%, 12.1%, and 45.5% respectively. There are many similar reports on the prevalence of underweight, wasting, and stunting in different countries. Then, a study conducted in Iran in children aged 0-24 months reported 11.7%, 11.5 and 0.6% for underweight, wasting, and stunting respectively (Mahyar Abolfazl et *al*., 2007). In northern Ghana 27.2%, 8.2% and 17.6% of children aged 0-59 months are considered stunting, wasting and underweight (Glover-Amengor et *al*., 2016). Another study undertaken in Filipino among children aged 6-23 months revealed that the prevalence of children underweight was 18.5%, stunting was 28% and wasting was 10.45% (Ocampo-Guirindola, Garcia-Malabad, Valdeabella-Maniego, & Punzalan, 2016). The prevalence of underweight, wasting, and stunting found in this study is higher than the findings obtained by others. These discrepancies in findings might be due to the difference of the study period, study area, socioeconomic characteristic, health service delivery, and geographical characteristics of the study area. PAM/UNICEF/INSANE (2008, 2014) conducted a survey on child nutritional status in Atacora. For the year 2008, the results show that prevalence of underweight, stunting, and wasting were 22.5%, 42.8%, and 7.8 % respectively. The result of the year 2014 revealed that the percentage of a child considered as underweight, stunted and wasted were 23.5%, 38.9%, and 5.4% respectively. Comparison of values found for prevalence of underweight (21.1%) in this study with those authors, the percent of children underweight has decreased (22.5% in 2008; 23.5% in 2014 and 21.1% in 2017). The reduction of the prevalence of underweight could be due to the interventions of international institutions through food supplementation, fortification and food assistance to children in Atacora. The prevalence of stunting and wasting for this study is higher than prevalence obtained in the Atacora by the same authors over the years 2008 and 2014. These differences are explained by the fact that demographic and the overall analysis survey made by PAM/ UNICEF/INSAE gave the prevalence of the whole department. The high prevalence of wasting in this study could be attributed to the high rate of diarrheal diseases observed two weeks preceding interview day. A study undertaken by YESSOUFOU et *al*., (2016) in the Municipality of Abomey-Calavi revealed that the prevalence of wasting was 7.3%; stunting was 40.8% and underweight was 29.5%. The percent of children that suffered from stunting and wasting in this study is higher than the values found by YESSOUFOU et *al*., (2016) while the prevalence of underweight is low compared to the finding of the same author. This might be due to the difference in climate as well as more infrastructures are concentrated in the southern part of Benin. The prevalence of stunting both found in this study and PAM/ UNICEF/INSAE survey was higher as compared to the prevalence of underweight and wasting. This result shows that stunting remains a problem of greater magnitude than underweight and wasting.

The finding also shows that the prevalence of boys of stunting, underweight, and wasting were 50%, 24.8%, and 11.7%, respectively, while 40.9, 17.3, and 12.5 percent of girl children are stunted, underweight and wasted. This result shows that the percent of girls' children underweight and stunted is lower as compared to boys. Although, this funding differs from study realized in Ghana by Frempong & Annim, (2017) who stated that male children tend to have lower weight-for-age and height-for-age than their female counterparts. This difference appears to be linked to gender distribution, socioeconomic dynamics among the various communities. The finding also indicates that the girl children tend to be wasted than boys. This is in agreement with a study conducted in South Ethiopia by W Tsedweke et *al*., (2016) who demonstrated that wasting was more prevalent in female children compared to male children. The observed relationship between gender and nutritional status might be due to biological and social-cultural differences.

No significant association was observed between mother's schooling between all three indices of undernutrition (weight-for-age, height for age and weight for height) in this study. This result differs from Abolfazl Mahyar et *al*., (2010) in Iran, Francesco Burchi (2009) in Mozambique found a significant association between child nutritional status and mother's schooling. This might be due to the difference of study area, socio-cultural characteristic, and socioeconomic dynamics.

Results reveal that dietary diversity is significantly associated to underweight (p=0.001<0.01), and wasting (p=0.016 < 0.05) but not with stunting (p=0.0943> 0.05). This study's results validate the outcome of the study done in Filipino which noted the association of dietary diversity of children aged 6-23months underweight and wasting but not with stunting (Ocampo-Guirindola et *al*., 2011). Conversely, this result contradicts the finding of Frempong & Annim, (2017) who show a positive association between dietary diversity and stunting. The absence of an association between stunting and dietary diversity may be explained by employing only a one-day, 24-hour food recall as the reference period to assume the usual feeding pattern of children.

Another significant finding of the study is the association between being underweight, stunting, wasting and household ethnicity. The finding reveals children from the Berba, Dendi, Fon Bariba, Otamari, Peulh, Natimba, Wama, Kouteni, gourmanché, and Yoruba ethnic groups have better anthropometric weight-for-height Z-scores than Oubiero ethnic group. For indices, height-for-age Z-score, the ethnic groups such the Dendi, Peulh, Kouteni, Wama, Natimba, fon, Bariba, and Berba ethnic groups have better scores than Yoruba, Oubiero, Otamari, and gourmanché ethnic groups. In terms of weight-for-age Z-score, Dendi, Peulh, fon, Berba, Bariba, Natimba, Kouteni, Wama, Otamari, Yoruba ethnic groups have better anthropometric scores than Gourmanché and Oubiero ethnic groups. This result shows that ethnicity has an important influence on child health in Atacora. This coincides with the conclusion of Frempong & Annim, (2017) who stated that ethnicity may have an important influence on child health in Ghana.

### 8.3. RELATIONSHIP BETWEEN CLIMATE VARIABLES, CROP YIELDS, AND CHILDREN'S NUTRITIONAL STATUS

This study aims to see the association of climatic factors, staple crop productions with children nutritional status. The climate factors such as precipitation and temperature on one hand and five staple crop productions on the other hand, are used to see how those variables influence child nutritional status. The results reveal a significant association between yam (p=0.0357 <0.05), maize (p=0.0228<0.05), sorghum (p=0.0188) productions with stunting but not with underweight and wasting. Maize and sorghum had a significant effect on stunting with a positive coefficient while temperature, rainfall, and yam had a negative coefficient with stunting. It is deducted from these results that maize and sorghum productions improve stunting whereas temperature, rainfall, and yam have not ameliorated stunting. Yam production has a negative relationship with stunting because this product is less consumed or infrequently consuming by the child compared to maize and sorghum that are consumed most of the time by a child. The result further shows that temperature is correlated positively with yam productions whereas maize and sorghum production is negatively correlated with rainfall. The minima and maximum temperature obtained in this study were 33 and 34.5 degrees respectively. For rainfall, the minima and maxima were 800 and 1400millimeter respectively. The reduction of rainfall and high temperature can result in a drought which also brings about low productivity. This is because each crop has their tolerance limit as regards water availability and temperature range. When these tolerance limits are exceeded, the survival of the crops will be threatened and this will have a resultant effect on crop yield in terms of output (Ejikeme and Akpabio, 2017). Several studies established the relationship between stunting and crop yields. In Ethiopia, postnatal exposure to a crop failure shock was significantly negatively associated with childhood stunting (Woldehanna, 2010). In Rwanda, children in households that experienced positive production shocks at time of birth had better Height-for-age Z-score (Akresh, Verwimp, & Bundervoet, 2007). The finding also shows a significant association between precipitation ($p=0.0121<0.05$), temperature ($p=0.0134 < 0.05$) and stunting but not with underweight and wasting. Grace et al. (2012) in Kenya found that precipitation has a significant impact on child stunting but the relationship between temperature and child stunting is not significant. This discrepancy might be due to the difference of the study period, study area, and geographical characteristics of the study area. Our findings also reveal that both climate factors (temperature and rainfall) and staple crop production have an effect on stunting. This result is consistent with that of other study and suggests that climatic factors in addition to livelihoods are influencing stunting (Jankowska et *al*.,2012). Climate variables and staple crop production are not only the factors that can explain the higher prevalence of stunting obtained in this study. This situation may also explain by diseases and child inadequate care. Therefore, UNICEF, 1990 stated that the malnutrition of children under five years is due to inadequate feeding practices, diseases such diarrheal disease, acute respiratory infections and others. The percent of children that suffered from diarrhoeal diseases and anemia two weeks preceding the interview day were 37.67% (159children) and 8.05% (35 children) respectively. The prevalence obtained in Atacora by Demographic and health survey (2012) was 8.43% for diarrheal diseases and 10.28% for anemia. The self-medication is the first option used by parent's child to treat their children who fell ill. Parents bring their children to health centers in the case the child health status is aggravated. Moreover, in all villages that the study is conducted, the health centers are far away from households. The long distance of health centers from households, housing is one of the reasons that explains the choice of self-medication as the first option.

## 9. IMPLICATIONS

The limitation of this study is fact that there is no association between dietary diversity and stunting. This might be explained by the fact that the dietary diversity was measured over a one-day recall period, which may not be an accurate reflection the dietary pattern for a longer period. Therefore, for the further research examining the possibility of using more than 24-hour food recall to look for the effect of quality of food intake using dietary diversity score and stunting can also be explored. Another limitation of this study is that temperature and rainfall are not only factors that may affect crop output. Relative humidity, air temperature, sunlight, $CO_2$ variations, soil aeration and structure, biotechnology use, fertilizer application, use of machinery may influence crop yield. Moreover, further study should be done to explore determinant predictors of crop productions that were not included in the study area. Other research may explore the causes of chronic malnutrition among children aged 6-59 months in Atacora.

## 10. CONCLUSION AND RECOMMENDATION

The study aimed at establishing the relationship between climate factors, crop yields and child's nutritional status. The study used two climatic variables, namely temperature and rainfall in addition to child anthropometric data. Results from the study showed that there is an increase in temperature trend whilst the trend of rainfall is decreasing. It also found that the rainfall is negatively correlated with sorghum, bean and maize productions whereas temperature had the positive association with yam and rice productions. The finding of this study revealed that Beninese children aged 6-59months were suffering from being underweight, stunting and wasting. The prevalence of undernutrition found highlighted the existence of public health concern with 45.5% of children stunting, 21.1% underweight and 12.1% wasting. However stunting, a chronic outcome of malnutrition, is influenced by climate in addition to main crops productions (yam, maize, and sorghum). Maize and sorghum are positively correlated with stunting. In contrast, yam production, rainfall, and temperature are negatively correlated with stunting. The increasing of temperature and decreasing of rainfall will lead to a reduction of maize, yam and sorghum productions which in turn inhibit child health and development. This means, Atacora the semi-arid agroecological zone where farmers depend on rain-fed agriculture, climate change could indeed increase stunting rates. Climatic factors and main crop products are not only predictors of undernutrition in Atacora. The lack of health centers, diseases, household's ethnicity and dietary diversity may be also the determinant factors that explain the high magnitude of undernutrition in Atacora. The programs such AMSANA (Appui Multisectoriel pour la Sécurité Alimentaire et Nutritionnelle Dans l'Atacora) and FBSA (Fonds Belge pour la Sécurité Alimentaire) intervene in the Atacora in aiming at improving food safety and nutritional status of vulnerable groups. The Red Cross provides the plumpy nut for children undernourished to ameliorate their nutritional status. Despite the interventions of those programs in Atacora, stunting still remains very high in this district. Based on results obtained from the study, the following recommendations are suggested:

- ✓ Government should be made effort to improve immunization coverage further;
- ✓ Integrate infection control programs into government policy;
- ✓ Government should be made more effort to invest in health center infrastructures;
- ✓ Educate farmers on mulching technique to reduce the harsh effects of temperature on crops;
- ✓ Government should invest in future water supply expansion and efficiency enhancement through modern-day irrigation systems;
- ✓ Agricultural research institutes should provide high breed yam and sorghum species that survive adverse climatic conditions in the study area;
- ✓ Adequate funding of climate-related research centers by the Government for up to date and timely release of accurate climatic information to help farmers prepare early against unfavorable climatic conditions;
- ✓ Sensitize farmers about the importance of tree planting and his conservation to reduce the effect of increasing temperature on crops.
- ✓ Sensitize parent's child on the importance of nutritional good practices for the welfare of their children

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I'm grateful to the WASCAL program for providing me a full scholarship for this Master's Degree. My sincere thanks to Prof ANNE Baber WALLIS (main supervisor) whose guidance; suggestions improved the overall quality of this study. Despite her busy schedule, she was always willing to discuss my work. Your comments and contributions are highly acknowledged. I would like to thank my parents for their support and by way of encouragement.

I am extremely thankful to Armand MAKPONSE, my husband, for being my 1st reader. Thanks for challenging my ideas, for giving me honest criticisms and always questioning my work. I am grateful to Damien MAKPONSE for his support and contributions to this work.

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**Figures**



**Tables**

**CURRICULUM VITAE**

PERSONAL INFORMATION Ella S. MAFORIKAN

Addresses: BP: 2388 Akpakpa Centre (Cotonou)

Phone: + 2203265573 /+ 229 61-40-65-02

Nationality: Beninese

JOB APPLIED FOR Food processing, teaching

Working experience

Food processing

2012-2014 I work as Responsible of fruits juices production to AFRICA- DELICE S.A.R.L (Benin), (pineapple, ginger, and baobab).

Teaching

2014-2016 Teacher in agriculture's school, College Médji Sékou (Benin)

EDUCATION AND TRAINING

2016: Master of Climate change and Education (Gambia)

2015: Master of Management of Natural Resources and Biodiversity (RESBIO)

Dec. 2011: Optional cycle studies in Nutritious and Food Sciences. Agronomist Engineer Degree (Diplôme d'Ingénieur Agronome), Faculty of agronomic science (FSA/UAC);

Oct. 2010: General studies in agronomy. Bachelor of Science degree in agronomy (Diplôme d'Agronomie Générale), Faculty of agronomic science (FSA/UAC);

Aug. 2006: General knowledge in Biology, mathematics, chemistry, and physics (Second cycle).

Scientific Baccalaureate (BAC série D).

July. 2003: General teaching (First cycle). College Certificate (Brevet d'Etudes du Premier Cycle).

**2016:** Training on Research Methodology (Ghana)

**2016**: Training on Remote Sensing (Ghana)

**2016:** Training on Climate change Impacts, Adaptation and Mitigation (Ghana)

**2016:** Training on Atmosphere Science and West African System (Ghana)

**2016**: Training in Advanced Statistics and Geostatistics (Ghana)

2016: Training in English Courses (Ghana)

2012- 2013: Training on Farm Manager (SONGHAÏ/PNUD)

2011-2012: Training course at the Laboratory of AfricaRice (Benin)

2010- 2011: Training course at the National Office of wood (ONAB), Bohicon town's (BENIN)

2009- 2010: Training course at monograph Village (MV), Djakotomey town's BENIN)

2008- 2009: Training course in Method of Animation and Intervention in Rural Environment (MAIR), Agonlin town's BENIN)

2008- 2007: training course in Discovery Rural Environment (Découverte du Milieu Rural), Pobè town's (BENIN)

2006-2007: Training course in immersion in Rural Environment (IRE), Quidah town's BENIN)

2017: Seminar on Democracy and National Development: Prospects and Challenges University of the Gambia

2017: Seminar on Accessible data, Climate service and Resilience Dakar (SENEGAL)

PERSONAL SKILLS

Mother tongue(s): Goun, French

Other Language(s): English

| Understanding | | Speaking | | Writing |
|---|---|---|---|---|
| Listening | Reading | Spoken interaction | Spoken production | |
| A2 | A2 | A2 | A2 | A2 |

Communication Skill: During training and working period I worked with diverse teams that allow me to work with an individual from a different country.

Organizational skill: working as Responsible for food processing, I experienced on how to manage human resources.

Ella Sèdé MAFORIKAN

**Appendices**

Appendix A: Fieldwork images

Appendix A-1: SECA weighing


Appendix A-2: wooden stadiometer

Appendix A-3: Child measurement in standing position

Appendix A-4: Child measurement in recumbent position

Appendices A-5: Child weight measurement

Appendices A-6: Child severely stunting

**Appendix B**

**Appendix B-1:** Guide for Focus-Group discussion

| Page number : |
|---|
| Date : /_____/_____/_____/ |
| Moderator: |
| Targets: Youths (>20 years) and men more than 65 years |
| Participants number: Youths men more than 65 years |

| **Step 1 : introduction (5 minutes)** | |
|---|---|
| Presentation of study purposes and subjects that will be tackled throughout the conservation. | ✓ Objectives : (1) Evaluate the effects of climate variability on agricultural production in the Atacora district.<br>✓ Evaluate the prevalence of child undernutrition aged 6- to 59 months<br>✓ Establish the relationship between climate variables, agricultural production and child nutritional state<br><br>Discussion subjects: Farmer's perception of climate change; effect of climate variability on agricultural production and adaptation measures. |
| **Step 2 : transition (15 minutes)** | |
| Entry question | Which type of crop did you grow in the village? |
| **Step 3 : discussion (40min)** | |
| Which type of varieties did you grow presently? | |
| Which type of varieties did you grow over the following years? | ✓ 30 years<br>✓ 25 years<br>✓ 20 years<br>✓ 10 years<br>✓ 5 years |
| Vegetative cycle and sowing date for each variety | |

| | |
|---|---|
| Cultivation technique used this year | |
| Cultivation technique used over the following years | ✓ 30 years<br>✓ 25years<br>✓ 20 years<br>✓ 15 years<br>✓ 10 years<br>✓ 5years |
| If cultivation techniques and the crop are growing very, is this change due to: | ✓ Decrease in the amount of rainfall yes□ no □<br>✓ Decrease in the number of days of rainfall: Yes□ No□<br>✓ Increase in the amount of rainfall: yes□ no □<br>✓ Increase of temperature: yes□ no □<br>✓ Decrease of temperature: yes□ no □<br>✓ Increase in the length of drought: Yes□ No□<br>✓ Less drought: yes□ no □<br>✓ Greater tolerance of varieties to drought: yes□ no□<br>✓ Greater tolerance of varieties to pest: yes□ no□<br>✓ Others |
| If the crop varieties are grown are the same over the years, ask the farmers the reasons | |
| Have you observed any changes in crop yield? | Decrease: Yes □ No □<br>The decrease in yield is due to:<br>✓ Increase of weather uncertainty<br>✓ Drought<br>✓ Land degradation<br>✓ Increases of pests<br>Increase: Yes □ No □<br>The increase in yield is due to:<br>✓ Good climate condition<br>✓ Reduction of harvest loss<br>✓ Ease access to fertilizer<br>✓ Government policy<br>✓ Others |

<table>
<tr><td>What yield have you harvested this year for the following crops?</td><td>Superficie:<br><table><tr><td></td><td>Plot size in hectare</td><td>Plot size in local measure ($m^2$)</td><td>Yield (Kilograms or bags)</td></tr><tr><td>Sorghum</td><td></td><td></td><td></td></tr><tr><td>Maize</td><td></td><td></td><td></td></tr><tr><td>Millet</td><td></td><td></td><td></td></tr><tr><td>Fonio</td><td></td><td></td><td></td></tr><tr><td>Yam</td><td></td><td></td><td></td></tr><tr><td>Others</td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>Which adaptive measures do you use apart from short-season varieties and pest resistant?</td><td></td></tr>
<tr><td colspan="2">Step 4: conclusion</td></tr>
<tr><td>○ Acknowledgement<br>○ Give the floor to the participants if they want to ask questions</td><td>Thank you very much to have well replied to our questions.</td></tr>
</table>

| |
|---|
| Page number : |
| Date : /_____/_____/_____/ |
| Moderator: |
| Targets: Women of childbearing age |
| Participants number : |

<table>
<tr><td colspan="2">Step 1 : introduction (5 minutes)</td></tr>
<tr><td>Presentation of study purposes and subjects that will be tackled throughout the conservation.</td><td>✓ Objectives: (1) Evaluate the effects of climate variability on agricultural production in the Atacora district.<br>✓ Evaluate the prevalence of child undernutrition aged 6- to 59 months<br>✓ Establish the relationship between climate variables, agricultural production and child nutritional state<br><br>Discussion subjects: Farmer’s perception of climate change; effect of climate variability on agricultural production and adaptation measures.</td></tr>
<tr><td colspan="2">Step 2 : transition (15 minutes)</td></tr>
</table>

| | |
|---|---|
| Entry question | Which type of crop did you grow in the village? |
| **Step 3 : discussion (40min)** | |
| Which type of varieties did you grow presently? | |
| Which type of varieties did you grow over the following years? | ✓ 30 years<br>✓ 25 years<br>✓ 20 years<br>✓ 10 years<br>✓ 5 years |
| Vegetative cycle and sowing date for each variety | |
| Cultivation technique used this year | |
| Cultivation technique used over the following years | ✓ 30 years<br>✓ 25 years<br>✓ 20 years<br>✓ 15 years<br>✓ 10 years<br>✓ 5 years |
| If cultivation techniques and crop is grown vary, is this change due to: | ✓ Decrease in the amount of rainfall yes□ no □<br>✓ Decrease in the number of days of rainfall: Yes□ No□<br>✓ Increase in the amount of rainfall: yes□ no □<br>✓ Increase of temperature: yes□ no □<br>✓ Decrease of temperature: yes□ no □<br>✓ Increase in the length of drought: Yes□ No□<br>✓ Less drought: yes□ no □<br>✓ Greater tolerance of varieties to drought: yes□ no□<br>✓ Greater tolerance of varieties to pest: yes□ no□<br>✓ Others |
| If the crop varieties are grown are the same over the years, ask the farmers the reasons | |
| Have you observed any changes in crop yield? | Decrease: Yes □ No □<br>The decrease of yield is due to:<br>✓ Increase of weather uncertainty<br>✓ Drought<br>✓ Land degradation<br>✓ Increases of pests<br>Increase: Yes □ No □<br>The increase of yield is due to: |

| | |
|---|---|
| | ✓ Good climate condition<br>✓ Reduction of harvest loss<br>✓ Ease access to fertilizer<br>✓ Government policy<br>✓ Others |
| What yield have you harvested this year for the following crops? | Superficie: |
| Which adaptive measures do you use apart from short-season varieties and pest resistant? | |
| **Step 4: conclusion** | |
| ○ Acknowledgement<br>○ Give the floor to the participants if they want to ask questions | Thank you very much to have well replied to our questions. |

Superficie:

| | Plot size in hectare | Plot size in local measure ($m^2$) | Yield (Kilograms or bags) |
|---|---|---|---|
| Sorghum | | | |
| Maize | | | |
| Millet | | | |
| Fonio | | | |
| Yam | | | |
| Others | | | |

**Appendix B-2:** Questionnaire survey in Atacora

The Impact of Climate Change on Child Undernutrition in Northwest Benin (Atacora)

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I. GEOGRAPHIC AREA

Date: ___/___/___

Interviewer name:

Page number:

Commune: _________

Village: _________

Ethnic group: ________

GPS co-ordinate points of the village. Latitude _______ S and Longitude E _______

I. Individual

A. Farmer's profile:
1. Name of household head:
2. Gender: Masculine ☐ Feminine ☐
3. Age

| <30 | 30-60 | > 60 |
|---|---|---|
| | | |

B. Agricultural and climate
1. Have you dropped some varieties since you started the farming? Yes □ No □

If Yes, which one?
a. List

2. Why did you drop those varieties?

| Varieties | reasons | Varieties | reasons |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

3. Have the seasons been the same, ☐ or different ☐since you started the farming? If different, in what way?
a. Less rain
b. More rain
c. Hotter
d. Others
e. More Drought
f. Less drought
g. Cooler
4. Which adaptive measures do you use to cope with the adverse effects of climate change?

..........................................................................................................................................
..........................................................................................................................................

5. What yield have you harvested this year for the following crop?

| | Plot size in hectare | Plot size in local measure ($m^2$) | Yield (Kilograms or bags) |
|---|---|---|---|
| Sorghum | | | |
| Maize | | | |
| Millet | | | |
| Fonio | | | |
| Yam | | | |
| Others | | | |

6. Have you observed any changes in crop yield during the last ten years?

| | Decrease | Increase | Constant |
|---|---|---|---|
| Sorghum | | | |
| Maize | | | |
| Millet | | | |
| Fonio | | | |
| Yam | | | |
| Others | | | |

If decrease Reason(s)…………………………………………………………..

…………………………………………………………………………………………………

If increase ☐ Reason(s) ……………………………………………………………………

…………………………………………………………………………………………………..

II. ☐ Evaluation of children nutritional status

*A. Mother's schooling*

1. No education ☐
2. Primary: 0-6 years ☐
3. Secondary: 7- 9 years ☐
4. Higher ≥ 10ans ☐

*B. Child characteristics*

1. Commune: 2. Village: 3. Date: ______________
2. Interviewer's name: 4. Household

Kg= kilogram; cm= centimeter

| Household head name | Child Code | Child's name | Gender (M/ F) | Birth day | Weight1 (kg) | Weight2 (kg) | Height1 (cm) | Height2 (cm) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |

C. Children medical History

1. Did your child develop any illness in the last two weeks?

Yes ☐ No ☐

If Yes, which one?

a-………………………………………………………………………………………

b-………………………………………………………………………………………

c-……………………………………………………………………………………….

Symptoms

a-……………………………………………………………………………………….

b-………………………………………………………………………………………

c-……………………………………………………………………………………….

Treatments

a-……………………………………………………………………………………….

| |
|---|
| b-………………………………………………………………………………………………<br>c- |
| 2. Has your child had diarrhea in the last two weeks?<br>Yes ☐ No ☐<br>If yes, for how many days did your child had diarrhea?.................days<br>3. Which treatment did you use to treat the child?......................................<br>…………………………………………………………………………………………………<br>4. Who has prescribed this treatment?<br><br>5. Has your child had anemia in the last two weeks? |
| Yes ☐ No ☐<br>If yes, what were the symptoms?..........................................................<br>…………………………………………………………………………………………………<br>6. How do you know it was anemia?..................................................<br>…………………………………………………………………………………………………<br>Which treatment did you use to treat the child?....................................................<br>…………………………………………………………………………………………………<br>Who has prescribed this treatment?........................................................................... |
| 7. Has your child ever received any medication from health workers over the last 6 months?<br>Yes☐ No ☐<br>If yes, which diseases?...........................................................................................<br>If no, How many months ago?……………………………………………………………… |

C- Child feeding practices

What foods did your child eat yesterday? And frequency?

| Food/dish | Once time/day | More than one/day | Once time/week | More than /week | Rarely | Never |
|---|---|---|---|---|---|---|
| Drinks | | | | | | |
| Porridges | | | | | | |
| Milk and milk products | | | | | | |
| Spreads | | | | | | |
| Bread | | | | | | |
| Deep fried foods | | | | | | |
| oil | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| eggs | | | | | | |
| Fish and seafood | | | | | | |
| Vegetable | | | | | | |
| Meat and meat products | | | | | | |
| Starches | | | | | | |
| Legumes | | | | | | |
| Soups | | | | | | |
| Fruits | | | | | | |
| Snacks | | | | | | |