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SOCIO-ECONOMIC AND CLIMATE CHANGE EFFECTS ON FISHING YIELDS AND FARMING IN THE MONO RIVER BASIN: CASE STUDY OF TOHO LAKE

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PAN AFRICAN UNIVERSITY

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CLIMATE CHANGE

SOCIO-ECONOMIC AND CLIMATE CHANGE EFFECTS ON FISHING YIELDS AND FARMING IN THE MONO RIVER BASIN: CASE STUDY OF LAKE TOHO.

A thesis submitted to the Pan African University Institute of Water and Energy Sciences including Climate Change in partial fulfilment of the requirements for the degree of Master of Science in Water Policy

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DEDICATION

To all African youth for their commitment to the development of the continent.

STATEMENT OF THE AUTHOR

I, Sètondji Grace-Félix HOUNAHO hereby declare that this thesis represents my original work and has not been submitted to another institution for the award of a degree, diploma, or certificate. I also declare that all words and ideas from others works presented in this thesis have been duly cited and referenced in accordance with the academic rules and regulations.

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BIOGRAPHICAL SKETCH

Born in 1993 in Parakou, Benin, I am Sètondji Grace-Félix HOUNAHO, Beninese. Specialist in rural development, water and climate change, I hold a Master's degree in Rural Engineering and Water Management after completing for a Bachelor's degree in Agronomic Sciences oriented towards natural resources management. In 2018, I was among the fourteen (14) students selected and enrolled in the Master's Degree in Water Resources Governance (Water Policy) of the Pan African University Program of the African Union funded by the GIZ (German Cooperation) in Algeria where I conducted my research in collaboration with WASCAL (West African Science Service Centre on Climate Change and Adapted Land Use) for the obtention of the above-mentioned diploma on the topic: socio-economic and climate change effects on fishing yields in the Mono River Basin. My atypical background has given me an excellent understanding of water resources management systems engineering in the context of climate change; also to develop an excellent research methodology and work through the conduct of research work (Environmental impacts of liquid discharges from the food alcohol production plant on the water quality of the Klou River in Benin, published in the American Journal of Applied Chemistry; the management of benthic macroinvertebrates and water quality in the Pendjari Park in north-western Benin).

I have four (04) years of professional experience working for engineering and consulting firms. This has enabled me to develop skills in project planning and management; monitoring and evaluation; development of tools for data collection, analysis and processing; risk management; project management; organization of local committees; basin management; regulatory and economic aspects of water management; technology watch (new pollutants likely to contaminate water); notions in hydraulics, climatology and hydro informatics; human resources management.

In addition, I have a good knowledge of issues related to agriculture, agroforestry, water and climate change. I have a good organizational and leadership capacity, dynamic, responsible and autonomous.

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Lastly, my profound gratitude goes to my family for their moral support and encouragement throughout my course of study.

"It seems always impossible until it is done" Nelson Mandela

ABBREVIATIONS AND ACRONYMS

Sigle	Definitions
NGO	Non-Governmental Organization
DDAEP	Departmental Directorate of Agriculture, Livestock and Fishing
DG- Eau	General Directorate for Water
GDP	Gross Domestic Product
GPS	Global Positioning System
SOFRELEC	Electricity Compagny (Société Fréjusienne d'électricité Sarl)
INSAE	National Institute of Statistics and Economic Analysis
RGPH	General Census of Population and Housing
P. WORKER	Public Worker

TABLE OF CONTENTS

APPROVAL iii
DEDICATION iv
STATEMENT OF THE AUTHOR v
BIOGRAPHICAL SKETCH vi
ACKNOWLEDGMENTS vii
ABBREVIATIONS AND ACRONYMS viii
TABLE OF CONTENTS ix
LIST OF TABLES xi
LIST OF FIGURES xii
LIST OF APPENDIXES xiii
ABSTRACT xiv
CHAPTER 1. GENERAL INTRODUCTION 1
1.1 Background 1
1.2 Problem statement and justification 2
1.3 Research objectives 4
1.4 Research questions 4
1.5 Hypothesis 4
1.6 Overview of the Thesis 4
CHAPTER 2. LITERATURE REVIEW 6
2.1 Definition of concepts 6
2.1.1 Fishing 6
2.1.2 Fish farming 7
2.1.3 Fishing yield 7
2.1.4 Climate change 8
2.2 Effect of temperature and precipitation on fisheries and fish farming systems 8
CHAPTER 3. MATERIALS AND METHODS 10
3.1 Study area 10
3.1.1 Climatic context 11
3.1.2 Topography 11
3.1.3 Vegetation 12
3.1.4 Socio-economics and human environment 13
3.1.4.1 Socio-economic aspects 13
3.1.4.2 Human environment 13
3.2 Methodology 14
3.2.1 Methodological approach for data collecting with target groups 15

3.2.2 Methods for data processing and analysing 17

CHAPTER 4. RESULTS AND DISCUSSION 21

4.1 Description of climate factors 21

4.1.1 Rainfall trends over the period 1985 to 2015 21

4.1.2 Thermometric evolution over the period 1985 to 2015 24

4.2 Description of data from communities along Toho Lake 24

4.2.1 Description of the socio-economic profile of the fishing communities surveyed along the lake .. 25

4.2.2 Description of the study of changes in climatic factors along the lake 28

4.2.3 Description of the study on impacts of changes on communities dependent on the lake's resources 30

4.3 Analytical framework 34

4.3.1 Analysis of the variation in quantities before and after the manifestations of climate change according to the social profile and years spent fishing on the lake 34

4.3.2 Analysis of the variation in the proposed measures according to the social profile and years spent fishing on the lake. 39

4.4 Discussion 45

CHAPTER 5. CONCLUSION AND RECOMMANDATIONS 47

CHAPTER 6. REFERENCES 49

CHAPTER 7. APPENDIX I

LIST OF TABLES

Table 1: Economical activities 13
Table 2: Distribution of villages and numbers of respondents by district 16
Table 3: List of wet, normal and dry years 22
Table 4: Presentation of the variables taken into account for the socio-economic profiling 25
Table 5: Gender representation in the sample & Ethnicity distribution along the lake 25
Table 6: Level of education of respondents 26
Table 7: Marital status of respondents & Hierarchical position of respondents in the household 26
Table 8: Work status of respondents 26
Table 9: Monthly income of respondents 27
Table 10: Description of the age and number of respondents' children 28
Table 11: Number of years living in the municipality 29
Table 12: Year passed in fishing 29
Table 13: Knowing of climate variabilities and changes 29
Table 14: Climate change periodicity 30
Table 15: Time of observation 30
Table 16: Variation in catch quantities 31
Table 17: Reasons for abundance in catches prior to climate change events 32
Table 18: Causes of variation before and after climate change events 32
Table 19: Situation evolution 32
Table 20: Family's needs support 33
Table 21: Structures support 33
Table 22: Measures proposed 33
Table 23: Aggregate effects of each variable on catch quantities (BCC) 34
Table 24: Categorized effects of each variable on catch quantities (BCC) 34
Table 25: Aggregate effects of each variable on catch quantities (ACC) 36
Table 26: Categorized effects of each variable on catch quantities (ACC) 37
Table 27: Results of Chi-2 test and Exact Fisher test 39
Table 28: Results of Chi-2 test and Exact Fisher test 40
Table 29: Results of Chi-2 test and Exact Fisher test 40
Table 30: Results of Chi-2 test 41
Table 31: Results of Chi-2 test and Exact Fisher test 41
Table 32: Results of Chi-2 test and Exact Fisher test 42
Table 33: Results of Chi-2 test and Exact Fisher test 42
Table 34: Results of Chi-2 test and Exact Fisher test 43
Table 35: Results of Chi-2 test and Exact Fisher test 44
Table 36: Results of Chi-2 test 44

LIST OF FIGURES

Figure 1 : presentation map of Lake Toho. 10
Figure 2: Change in population size from 1992 to 2013 along the lake............................. 14
Figure 3: Rainfall index at Athiémé 21
Figure 4: Rainfall index at Houéyogbé... 21
Figure 5: Rainfall index at Lokossa.. 21
Figure 6: Average rainfall regime 23
Figure 7: Evolution in annual average temperature from 1985 to 2015............................. 24
Figure 8: Evolution in average decade temperature 24
Figure 9: Normality of the model residues (BCC) 36
Figure 10: Normality of the model residues (ACC) 39

LIST OF APPENDIXES

Appendix i: Map of the municipalities in the study area I
Appendix ii: Rainfall anomalies_Athiémé II
Appendix iii: Rainfall anomalies_Houéyogbé VI
Appendix iv: Rainfall anomalies_Lokossa X
Appendix v: Meanning of variables XIV
Appendix vi: Recap of field variables analyzed with R packages XV
Appendix vii: Contingency tables for meeting family needs XVI
Appendix viii: Contingency tables for measures proposed XXI
Appendix ix: Questionnaire for fishermen & fish farmers (EN) XXIV
Appendix x: Questionnaire for fishermen & Fish farmers (FR) XXIV

ABSTRACT

Fisheries and aquaculture play an important role in western African sub-region countries. Even if its contribution to GDP is not so important compare to agriculture, decrease in productivity affect communities living along water bodies. In the view to better understand how, this study proposes to assess the socio-economic and climate change effects on fishing yields and fishing farming at the level of lake Toho in the Mono river basin. Rainfall and temperature data were collected and analysed with Excel. Thus, simple random sampling method was used to select 95 fishermen in Athiémé, Lokossa and Houéyogbé villages around this lake. Many packages from R were used and Chi-2 homogeneity test was performed to analyse changes in fishermen profile and fishing yields variations.

The results show an unstable rainfall pattern particularly associated with an upward trend over the target period (1985-2015) and an upward trend in observed temperatures. This increase is conducive to productivity because during high water periods, fish take advantage of high water to reproduce, and the depth of the lakes does not favour fishing. The same is true for temperature. In fact, most fish reproduce well at temperatures between 27°C and 28°C. As fish reproduction is not systematically synonymous with increased productivity, we are witnessing a drop in productivity linked to the disappearance of certain species, due to the non-discharge of the Mono River into the lake since the construction of the dam, the drop in catch quantities linked to the reduction in the size of the fish and the fishing techniques and gear that are not conducive to the sustainability of fishery resources. Furthermore, the study showed through surveys conducted among fishermen that they perceive the decline in fishery resources and the manifestations of climate change and propose measures to cope with this decline and then to satisfy the needs of their families, which vary according to their membership of a socio-ethnic group, their age category, their level of education and the number of years spent fishing on the lake. Among the measures proposed are fish farming, changes in fishing techniques and gear, and the practice of rituals. Fish farming is one of the measures that the study deems effective and sustainable for the management and improvement of the lake's resources and the socio-economic situation of the communities living there.

Keywords: Fishing - Fishing farming - lake Toho

CHAPTER 1. GENERAL INTRODUCTION

1.1 Background

Mankind appeared on the earth in a hostile environment that needed transformation for its welfare. For example, rivers and adjacent land areas have undergone many human transformations. These rivers represent indeed privileged places for residential, commercial and industrial development as well as for leisure, relaxation and the observation of the nature. Their landscapes are often affected for reasons of safety, mobility, comfort and aesthetics. These changes most often are concerned with the construction of infrastructure related to demographic growth and the development of socio-economic activities. Over the years, rivers have thus seen its dynamics as well as its biodiversity modified (Belleau-Arsenault & Robert, 2014). This is amplified with climate change which has become an international issue of concern by the end of the 20th century (Fellous, 2001). Although knowledge about the functioning of the climate systems and the role of greenhouse gas emissions is steadily improving, many questions remain unanswered about the impacts of climate change on anthropogenic and natural systems (Paturel, Dieulin, & Casenave, 2005). With climate change, freshwater ecosystems are particularly at risk. Specially, Climate change will lead to significant changes in the availability of fishing resources and trade, with potentially significant geopolitical and economic consequences, particularly for the countries most dependent on the sector (Barange et al., 2018).

Globally, fisheries and aquaculture make a substantial contribution to the food security and livelihoods of millions of people. Excluding aquatic plants, the sector's total world production peaked at 171 million tonnes in 2016; 53% of this total comes from capture fisheries and 47% from aquaculture (rising to 53% if non-food uses are excluded; (FAO, 2018). The total landed value of production in 2016 is estimated at US$362 billion, of which US$232 billion comes from aquaculture production (FAO, 2018). Marine capture fishery production has been relatively stable since the late 1980s and growth in inland capture fisheries has been limited. This means that growth in aquaculture production is largely responsible for the remarkable increase in global edible fish consumption of 3.2% per year between 1961 and 2016, double the growth rate of the human population. As a result, per capita consumption of edible fish increased from 9.0 kg in 1961 to 20.2 kg in 2015, which has contributed significantly to world food security (Manuel Barange et al., 2018). At the same time, the state of marine resources monitored by FAO continues to deteriorate. The proportion of marine fish stocks fished at biologically sustainable levels has shown a declining trend, from 90% in 1974 to 66.9 percent in 2015 (FAO, 2018), with developing countries performing less well than developed countries (Ye & Gutierrez, 2017). Considerable uncertainty remains about the status of many inland capture fisheries, which make a significant contribution to global food demand, particularly in the poorest and most food-insecure countries. An estimated 200 million people are directly and indirectly employed in the fisheries and aquaculture sector; women account for about 14% of those employed in the primary sector, but this figure rises to 50% if the secondary sector is also included (FAO, 2018).

Livelihoods supported by fisheries and aquaculture activities are therefore of critical importance in many coastal, riparian, island and inland areas, demonstrating the critical importance of providing adequate responses to the threat of climate change: not only are fisheries essential for food, livelihoods and trade, but the state of the resource base limits their capacity to absorb climate shocks, particularly in developing regions where fisheries dependence is greatest (Barange et al., 2014).

1.2 Problem statement and justification

In this context, the development of fisheries and aquaculture is given special emphasis in several Western African sub-region countries. Among these countries, Benin, where fishing and aquaculture is a dynamic and operational sector that provides employment and food for thousands of people. It constitutes a pole for the creation of related activities, including fish processing, marketing, and the repair of nets and canoes for the populations involved. It is estimated that about 60% of the populations living along the coasts of West African countries live from fishing (Fiagan, 2014, Oyédélé et al. 2019), but as the main activity, it is supplemented to an increasing extent by trade with certain border countries such as Togo, Niger and Nigeria's large neighbour by lake, to obtain foreign currency, to the detriment of meeting the food needs of the Beninese people. It remains a harvesting activity and represents a source of protein for the entire population (Djessouho, 2015). Thus, with an almost straight seafront 125 km long and a vast hydrographic network made up of 4 main rivers, the fishing and aquaculture sector plays an important role in Benin's economy with a 3% contribution to GDP (Tossou, 2010, Oyédélé et al. 2019). It employs 15% of the total active population and 25% of the active population in the agricultural sector. It accounts for about 600,000 jobs and provides nearly 30% of the total amount of animal protein consumed (Ayoubi & Failler, 2013).

However, the development of fishing activity in Benin faces many constraints related to the legal framework, which is not adapted to the preservation and rational management of resources, as well as the capacity to implement existing regulations, even if limited (Ayoubi & Failler, 2013). Access to resources by the artisanal segment is free and unrestricted. As fish stocks decline, the large-scale use of prohibited or destructive gear (small-mesh nets, trawling of the coastal strip) is leading to the fact that more than half of the fish caught are immature, accentuating the cycle of depletion. According to FAO data, 2018, the countries most vulnerable to climate change affecting fisheries and aquaculture are those in West and Central Africa and Northwest South America.

Fishing in Benin is subdivided into inland fishing and sea fishing. These two types of fishing are subject to the negative effects of climate variability and change because the main resources on which these activities develop, i.e. the water bodies (for inland fishing) and the sea (for sea fishing), are very prone to climatic risks such as scarcity/insufficiency of rainfall (or, on the contrary, the excess leading to flooding), temperature rise and sea level rise. These climatic factors are compounded by the construction of infrastructure (ports, dams, etc.) that promotes coastal erosion and by population growth that increases pressure on fish stocks. Such a situation makes fishing communities particularly vulnerable to climate variability and change (Codjo, Zannou, & Biaou, 2018). Manifestations include: scarcity of fish in rivers, migration of fish from fishing grounds, stunted growth of fry, hardship of fishing activities, fish kills, proliferation of toxic fish plants (water hyacinth) and simultaneously small fish species such as paralia pelucida and Mysidaceae (Arodokoun et al., 2012). These lead to a decline in income, reduced food availability, worsening poverty, a longer lean season and an increase in vector-borne diseases. In recent years, the fisheries sector's contribution to GDP has been declining (FAO, 2018).

The Mono River basin, which is the focus of our study, also remains under threat from this situation. In its municipalities, the impacts are already being felt in terms of a decline in the quantities of fish and the rarefaction of certain species (Codjo et al., 2018).

At the national level in Benin, several studies have highlighted a decrease in rainfall and an increase in temperature (Afouda, 1990; Houndénou, 1999; Ogouwalé, 2006; Teka, 2010; Jalloh et al., 2013). In the coastal zone, the analysis of data over the last four decades, as well as climate modelling shows a decrease in rainfall and a shortening of rainy seasons (Afouda, 1990; Teka, 2010). This and other studies have often focused on agricultural production in general; and have given little specific attention to the vulnerability of fishing communities to climate variability and change in the coastal zone, although climate change threatens the sustainability and productivity of the sector (Dessouassi, Luc, Hyppolite, Montchowui, & Laleye, 2019) and could also provide opportunities, particularly in aquaculture.

1.3 Research objectives

It is in this context that our study proposes to assess the socio-economic and climate change effects on fishing yields and fishing farming at the level of lake Toho in the Mono river basin. Specifically, the study focused on the: (i) assessment of the climatic factors that influence fish productivity; (ii) description of the socio-economic profile of the communities living along Toho Lake, and (iii) assessment of the influence of socio-economic profiles on fishing performance along the lake.

1.4 Research questions

The research questions are:

- What are the climatic factors that influence fish productivity?
- What are the socio-economic profiles of the fishing communities along the lake?
- How does the socio-economic profile influence fishing yields?

1.5 Hypothesis

The hypothesis are:

- The increase of annual temperature decreased the production and yields of fishing and fishing farming;
- The decrease in the annual precipitation decreased the production and yields of fishing and fishing farming;
- the socio-economic profile influences fishing yields

1.6 Overview of the Thesis

The thesis is organised into 7 main chapters as presented below:

- Chapter 1: presents a general background to the research as well as the current problem necessitating this research. It also spells out the aim objectives, the research questions and the hypothesis;
- Chapter 2: presents the review of relevant literature on the effect of temperature and precipitation on fisheries and fish farming systems; and the history of variability in precipitation and temperature over the past decades in the Mono River basin;
- Chapter 3: describes the materials and methods used to achieve the objectives of this study;
- Chapter 4: presents the results obtained from the study and discusses the results obtained;
- Chapter 5: presents the conclusions drawn from the study and some recommendations;

- Chapter 6: presents the references;
- Chapter 7: presents the appendix.

CHAPTER 2. LITERATURE REVIEW

2.1 Definition of concepts

2.1.1 Fishing

Fishing is one of the oldest production activities of mankind. According to archaeological and historical research, freshwater and sea fishing was widespread in ancient civilizations and is an activity that consists of catching aquatic animals (fish, crustaceans and cephalopods) in their natural environment (oceans, seas, rivers, ponds, lakes, ponds). According to the Food and Agriculture Organization of the United Nations (FAO), a distinction is made between:

- Inland fishing, which is defined as any activity aimed at catching fish and other aquatic organisms in inland waters;
- Sea fishing as any activity to catch fish and other aquatic organisms in marine waters.

The FAO distinguishes between fishing practices that can help us understand and differentiate between types of fishing and the content of their practices. We distinguish as follows:

- Fishing by capture: the collection of aquatic organisms in natural or managed inland waters;
- Recreational fishing: fishing activities carried out by individuals for essentially sporting purposes, although sometimes incidentally to catch fish for private consumption and without resale to third parties;
- Wild fishing: fishing based on natural production and restocking;
- Farmed fishing: fishing by capture fisheries whose sustainability depends on stocking with material from aquaculture installations;
- Managed fishing (also includes fisheries based on farming): activities aimed at introducing or maintaining the presence of one or more aquatic organisms and thereby increasing the total production or the production of certain components of a given fishery beyond a level corresponding to sustainable exploitation by natural processes. The latter relates to a practice that we will discuss later in this work: fish farming.

In the light of these definitions and proposed practices, we will retain as a definition for the continuation of our work that fishing is the activity that consists of capturing aquatic species (fish, crustaceans and cephalopods) both in their natural environment and in a controlled environment (fish farming).

2.1.2 Fish farming

Fish farming is one of the branches of aquaculture define as the production of fish in fresh, brackish or salt water. It is carried out in fresh water, in the sea, in permanent enclosures (ponds) or in floating cages. There are two main families of fish farming:

- production in ponds, with an earthen basin, in which the fish feed completely or partially from the biological production of the environment;
- intensive production in artificial ponds or cages, in which the fish are fed exclusively with feed supplied by the fish farmer. The water is constantly renewed by the current (cages), an intake from a watercourse (ponds) or recycling (case of closed-circuit farming).

2.1.3 Fishing yield

Larousse dictionary, etymologically, proposes five definitions of performance. In a first sense, efficiency is defined as the production evaluated in relation to a standard, to a unit of measurement; then it is the efficiency of someone at work; then it represents the ratio of the energy or a quantity supplied by a machine to the energy or the corresponding quantity by this machine. The last two senses which are completely far from the objective of our study are: the yield is the return on the capital employed or on an amount invested; then the yield represents the ratio of the number of molecules of a chemical reaction product to its maximum theoretical value.

The first definition seems to reflect a better approach to the objectives of the work, however the Encyclopedia, proposes another definition of the concept more adapted. It qualifies the yield as: the way in which an action, a transformation process, a process in which something was initially entered returns the expected or intended result, with the idea that this rendering, return, return can be more or less efficient due to the existence of imperfections, waste, inertia : which often cause the actual performance obtained to differ from the expected performance; or which explain the variability of the performance that must then be observed and measured; or which must be reduced by operators in search of greater efficiency.

In the fishing and fish farming sub-sector, performance is used mainly for three purposes: (i) to estimate the total catches of a fishery during a given time, (ii) to obtain a stock density index, (iii) to measure the quality and success of fishing (Changeux & Gallet, 2002). Thus, the term yield is expressed in a concrete and general way in the form of a ratio between the result obtained and the number of tools necessary for its effectiveness, which in practice will be declined according to different formulations to correspond as closely and as faithfully as possible to the real parameters of each activity. It is in this sense that the FAO establishes the concept of "Maximum Sustainable Yield (MSY)", which is the greatest quantity of biomass that can be extracted on average and in the long term from a fish stock under existing environmental conditions without affecting the reproduction process.

2.1.4 Climate change

Climate Change, according to (IPCC, 2007) is "a change in the state of the climate that can be identified by changes in the mean and /or the variability of its properties, and that persists for an extended period typically decades or longer" (usually 30 years periods or more).

2.2 Effect of temperature and precipitation on fisheries and fish farming systems

The distribution of animal and plant species worldwide is mainly controlled by climate. Each species, whether animal or plant, requires specific climatic conditions essential for its proper development and survival. Thus, when addressing climate change issues, many factors that can influence fish farming systems and fisheries are considered. According to (Lazard, 2017) six components of the environment are likely to be modified as a result of climate change and whose impacts could be directly felt on aquaculture in general and fisheries in particular: sea level rise; temperature change; rainfall, floods and droughts; water availability; degradation of water quality; and ocean acidification. Changes in fisheries, particularly in fish populations, are associated with large-scale climate oscillations (Kodama et al 2002; Rogers 2000). These climatic factors affect the biotic and abiotic elements that influence their numbers and distribution. In this literature review, we will discuss two of these factors, temperature and precipitation.

The latest climate models simulate an average global warming of between 1.8°C (most optimistic scenario) and 4°C (most pessimistic scenario) in 2100. These models also indicate that a stabilization of greenhouse gas emissions no longer allows a decrease in global temperature (Antoine, 2007; IPCC, 2007). Since most aquatic animals are poikilothermic, any change in the temperature of their environment then has an impact on the global metabolism and therefore on growth rate and, by ricochet, on the final yield, on the seasonality of reproduction as well as on the spawning rhythm and fecundity, on the sensitivity to pathogens and toxic substances (Lazard, 2017). Since fish are poikilothermic animals, water temperature affects their growth and that of their larvae (Fontaine & Bail, 2004). The work of Ouizgane et al., 2017 at Deroua Fisheries Farm (Fkih Ben Salah, Morocco) investigated the effect of water temperature variation on growth in Black bass (Micropterus salmoides, warm water fish). This work explains that the increase in temperature leads to an increase in the growth of the species. The experiment conducted by

(Lwamba, Katim, Kiwaya, Ipungu, & Nyongombe, 2015) on Oreochomis niloticus explains that the drop-in temperature has serious consequences on the growth and reproduction of the latter. Studies by Silvera, 1978 Coche, 1982 ; Guerrero & Garcia, 1983 ; Guerrero & Garcia, 1983 ; Parrel, Ali, & Lazard, 1986 ; Lovshin & Ibrahim, 1987 and Azaza, M., Kraiem, & Baras, 2010 have revealed that many factors can significantly affect the production of e.g. O. niloticus, but temperature is the most important factor and low temperatures would be accompanied by low feeding rates.

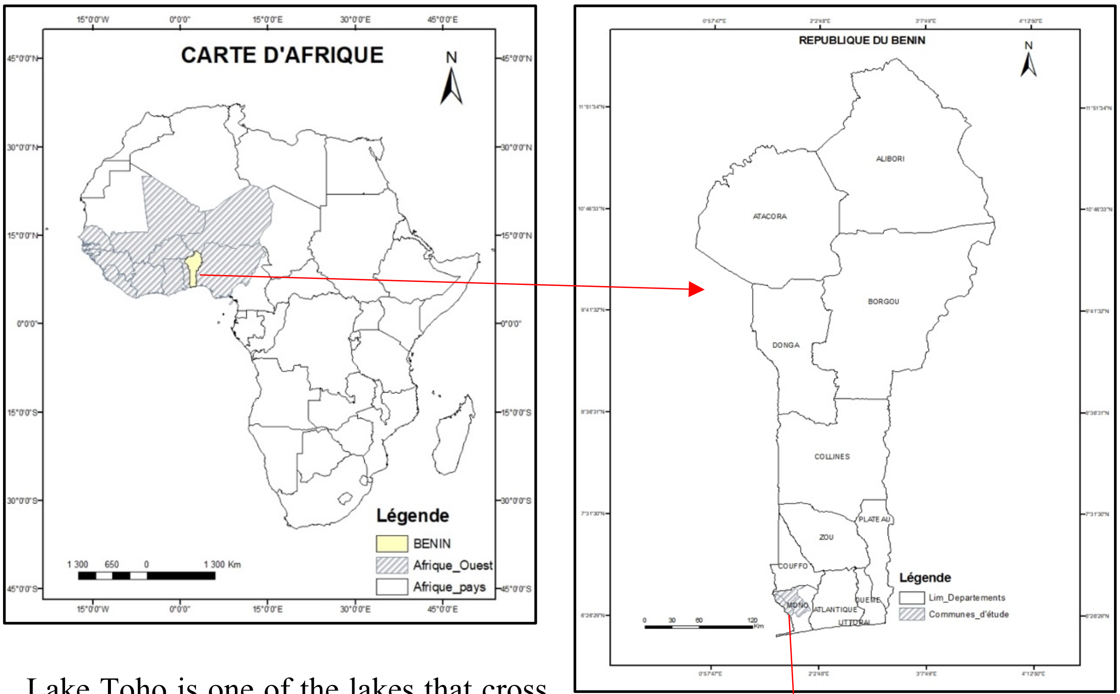
However, there are temperature tolerance thresholds for each species in aquaculture in general, which would mean that species with low average temperatures would decrease or even disappear and species with the highest average temperatures would increase at the limit of their threshold (Antoine, 2007).

We know that the release of heat from the ocean into the atmosphere during El Niño events has effects on global atmospheric circulation, cyclones and hurricanes, monsoons, heat and precipitation, with associated droughts and floods (Reid, 2016,(FAO, 2018)). With regard to rainfall, annual decreases and increases will be observed across Africa (IPCC, 2007). The pockets of floods and droughts caused by these changes will cause, if not already cause, human population displacements. River levels play an important role in the reproduction of aquatic species (Adamou, 2013). Low rainfall prevents the upwelling of fish, for example, in the arms of rivers for the laying of eggs. This threatens the extinction of some fish species and consequently fish yields and production.

CHAPTER 3. MATERIALS AND METHODS

3.1 Study area

The physical framework of this study on climate change and inland fishing yields is lake Toho in the Mono river basin of the Republic of Benin, West Africa.



Lake Toho is one of the lakes that cross the southern-western part of Benin and represents a wealth of surface water shared by the districts of Athiémé, Houéyogbé and Lokossa whose main localities are Kpinnou, Houin and Zoungbonou. It has the shape of a crescent oriented South-North, with a surface area of 9.6 Km^2 at low water level and 15 Km^2 during high water and is located on average during low water from 6°35' to 6°40 latitude North, from 1°45' to 1°50' longitude East. Its average length is 7 Km with 2.5 Km of southern width and about 500m of northern width (Ahouansou, 2003).

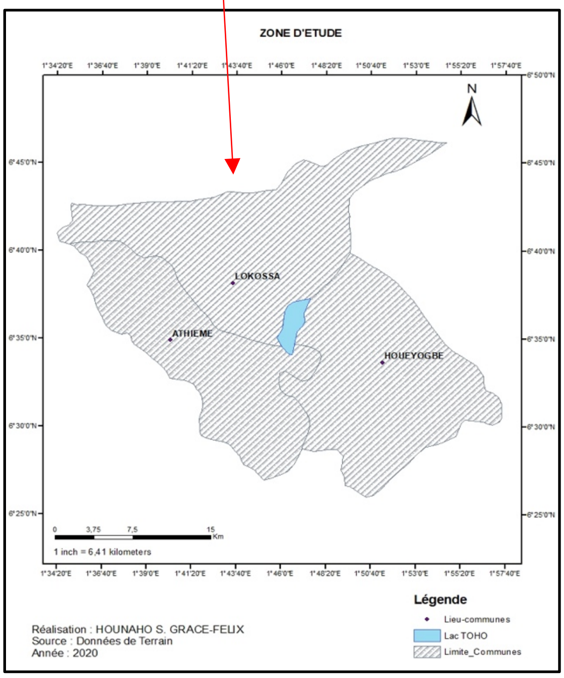


Figure 1 : presentation map of Lake Toho.

3.1.1 Climatic context

Lake Toho is part of the lagoon complex of the Mono river basin, shared by the Togolese and Beninese territory, most of which is located in Togo. The basin in general benefits from two climatic nuances: one in the south (sub-equatorial climate) and the other in the north (humid tropical climate) of the basin (E Amoussou et al., 2014). The variations observed are due to the organization of the West African atmospheric circulation as a whole, both that of the low layers (monsoon and harmattan flows) and those of the middle and upper atmosphere (respectively East African jet and East tropical jet) (Ernest Amoussou, 2011). It is characterized by a climatic seasonality of succession of droughts and floods due to intense rainfall of short duration.

Lake Toho, due to the regions it crosses, benefits from a sub-equatorial climate with an alternation of two rainy seasons and two dry seasons(Djenontin & Guidibi, 2006; Nangbe, 2006). This climate is conducive to polyculture and exuberant vegetation, which has been strongly affected by the demographic pressure experienced in recent decades.

3.1.2 Topography

The lake Toho's topography is typical to the Mono river basin topography which in general presents a softened topography due to its partial covering by sandy-clay alluvium (Ernest Amoussou, 2011). However, it presents different stages that probably mark levels of erosion resumption. The low slopes (average 0.71 m/km) of the fluvio-lagoon system influence the flow velocity and, consequently, the flow/load ratio, the basin geometry and the quantity of materials carried (Klassou, 1996).

3.1.2.1 Relief

The relief of the lake Toho located in Mono river basin is varied. Bordered to the west by the chain of mountains of Togo, its relief in the east is much less pronounced and its central part is even flatter (Sofrelec, 1964). The rivers of the Mono basin and its tributaries are interested in five natural regions which are from North to South: Malfaoassa and Bafilo region, Monts Togo, the peneplain, the Ouatchi region, the Coast. The communes crossed by the Toho Lake (framework of our study) present reliefs which are located between the coastal plain and the transversal of Lonkli-Kétou, a region of clay plateaus and bar land whose maximum altitude rarely exceeds 200m, with more or less pronounced depressions, which gives the whole relief a bumpy aspect. It should be noted that in Athieme the relief is monotonous flat, eroded in places and marked by numerous depressions and banks (cordons) of sand and sandstone. These depressions constitute watersheds or river valleys. They are sheltered by ponds, swamps and shallows.

3.1.2.2 Soils

In Benin, the main types of soil encountered are: tropical ferruginous soils (dominant, representing about 65% of the soil), poorly evolved soils (20%), ferralitic soils (10%), hydromorphic soils (3%) and vertisols (2%) (FAO, 2000). This great diversity also applies to the types of soil found in the Mono basin, because of the natural environment in which they are found (Azontonde, 1991). Thus, in the commune of Houéyogbé there are three zones: a plateau zone with ferralitic soils (Houéyogbé and Dotou region); a valley zone (Zoungbonou, Manonkpon, Davè and Honhoué); and a black earth zone with hydromorphic soils (Tokpa Tohonou and Sohounmè) (Nangbe, 2006). In Athieme, the soils are clayey, black hydromorphic clayey, sandy-clayey or sandy-clayey. They become clogged with seasonal water and are flooded for the most part by floodwaters. In Lokossa, the soils are ferralitic subdivided into ferralitic soil on loose sandy-clay sediment and ferralitic soil on sandstone and sandy-clay colluvial material. The latter erodes very quickly, not only because of its constitution, but especially because of the slope (5 to 8%). Hydromorphic soils, the most important of which is hydromorphic soil on sandy-silt to silty-clay alluvial material. These two types of soils have a texture and structure that do not necessarily favour rapid infiltration of rainwater.

3.1.3 Vegetation

The Mono river basin is crossed by two agro-ecological zones.

- the agro-ecological zone made up of bar land crossing the commune of Houéyogbé;
- the second zone, made of low valley and alluvial formations, covers the communes of Athiémé, Bopa, Comè, Grand-Popo, Lokossa. It is covered with grassy savannah, swampy formations and some mangroves. There is also palm fallow (INSAE, 2016).

Forest vegetation is rare. It is concentrated along the rivers in the form of narrow forest galleries, as well as in a few small islands. Again, this is dry and relatively clear forest (Sofrelec, 1964).

Most of the vegetation along the banks is made up of tall "elephant grass" that reaches 3 to 4 meters, sometimes palm groves and cornfields extend down to the banks (Djenontin & Guidibi, 2006).

3.1.4 Socio-economics and human environment

3.1.4.1 Socio-economic aspects

The most dominant economic activities in the communes of Benin that make up the Mono basin are firstly "Agriculture, Fishing and Hunting", then "Trade, Food and Accommodation" and finally "Manufacturing Industries". The commune of Bopa (73.8%) is the one in which the "Agriculture, Fishing and Hunting" branch is most practiced. As for the branch of activity "Trade, catering and accommodation", the municipalities of Comè (33.1%) and Grand-Popo (25.6%) are those in which it is more dominant (INSAE, 2016).

The populations living along the shores of Lake Toho live mainly from continental fishing and fish farming, the main activity of the young people; however, during the dry season, some market gardening activities develop (Houssou, 2010).

Table 1: Economical activities

Percentage distribution of the active population by district according to sectors of activity

	District of Mono						
	Sum	**Athiémé**	**Bopa**	**Comé**	**Grand-popo**	**Houéyogbé**	**Lokossa**
Activities sector							
Farming, fishing and hunting	45.9	**49.2**	73.8	21.5	35.8	**47.3**	**36.3**
Extractive industries	0.5	0	0	0.3	0.3	1.1	1.1
Manufacturing industries	13.1	16	6.2	16.9	16.2	12.3	15.7
Water, Electricity, Gas and Sanitation	0.2	0.1	0	0.3	0.1	0.1	0.3
Waste treatment and decontamination							
Buildings and Public Works	3.3	2.4	1.7	5.3	3.3	3.1	4
Commerce, Food and accommodation	19.6	18.5	9.9	33.1	25.6	19.6	16.6
Transport and Communication	4.2	3.4	1.6	5.2	6.3	4.4	5.3
Banking and Insurance	0.1	0	0	0.3	0.2	0.1	0.2
Other services	12.2	9.7	6.5	16.3	11.1	11.4	18.9
Undeclared	0.8	0.7	0.4	0.9	1	0.7	1.6
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Headcount	**156,047**	**17,082**	**34,398**	**26,813**	**18,072**	**31,888**	**26,794**

Source : INSAE, RGPH, 2013

3.1.4.2 Human environment

The population of the Department of Mono increased from 360,037 inhabitants (including 174,977 men and 185,060 women) in RGPH-3 in 2002 to 497,243 inhabitants, including 241,554 men and 255,689 women in RGPH-4 in 2013. This represents a sex ratio rising from

94.6 men per 100 women to 94.5 men per 100 women. The density of the department has increased from 224 inhabitants per km² to 310 inhabitants per km². This density varies considerably within the department between 199 inhabitants per km² in the commune of Grand-Popo to 491 inhabitants per km² in the commune of Comè. Two communes out of the six in the department have passed the 10,000 inhabitants mark: Houéyogbé with 101,893 inhabitants and Lokossa with 104,961 inhabitants. The agricultural population is 207,309 inhabitants in 37,639 agricultural households. Apart from the Guen or Mina minorities from Ghana who settled in the regions of Agoué and Grand-Popo, the majority are Adja and related (69.0%), and Fon and related (27.8%). The dominant religion is Vodoun (33.1%); Catholics (20.6%) and other Christians (14.7%) are also found in the department.

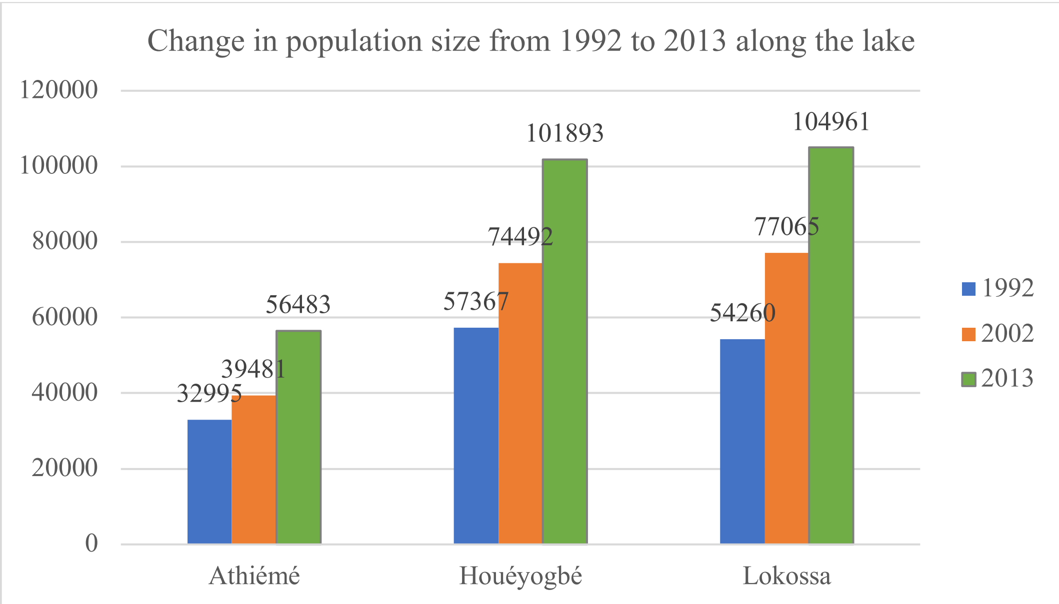


Figure 2: Change in population size from 1992 to 2013 along the lake

3.2 Methodology

The study focused on the socio-economic and climate change effects on fishing and fish farming yields in the Mono basin with Lake Toho as a case study. In this section, we have presented the methodological approach for collecting data from the study's targeted groups as well as the methods for analysing the data. The targeted groups of the study are the fishing and fish farming communities residing in the communes that boarder the Lake Toho (Athiémé, Houéyogbé and Lokossa), the Departmental Directorate of Agriculture, Livestock and Fisheries of Mono, as well as NGOs involved in environmental protection in general.

We also took into account rainfall and temperature data from the communes of interest in order to see the trend of these climatic parameters over the last decades (1985 to 2015) and their influences on fishing and fish farming.

3.2.1 Methodological approach for data collection

The methodological approach for data collection can be summarized in several steps. There are: identification of stakeholders as summarized above; definition of sample size; field survey and justification of techniques/approaches used and materials and tools for data collection.

3.2.1.1 Identification of Study Stakeholders

It is an evidence that everybody is concerned by climate change, but given the objectives of our study, some communities, groups or organizations have more to contribute to the understanding of the study. Thus, fishing and fish farming communities represent the most important group, since they are the ones that directly feel the consequences of climate change on their activity. They represent the primary group of the study, priority was given to heads of fishing and/or fish farming households (over 20 years old) because of the questions addressed, and because they will be able to explain the feelings of the variation in catches and the socio-economic impacts. Lake Toho is surrounded by the districts of Kpinnou, Houin and Zoungbonou, in which six villages have been selected: Hahamè and Azonlihoué in the municipality of Athiémé; Tokpa and Tohonou in the municipality of Houéyogbé, and Vèha and Logbo in the municipality of Lokossa. The selection of villages was based on those that have a real impact on the lake, in terms of the relative importance of fishing among income-generating activities, the demographic weight of each village, its geographical position in relation with the lake and the dominant socio-cultural groups that practice fishing there (Codjo et al., 2018).

A secondary stakeholder group was identified. These are: The Departmental Directorate of Agriculture, Livestock and Fishing (DDAEP); the NGOs involved in supporting environmental protection in the communes of interest.

3.2.1.2 Definition of sample size

Due to time, technical and economic constraints, it was not possible to collect data of all elements of a population in our study. In order to determine the sample size (number of households involved in fishing and/or fish farming), we use Schwartz's (1995) probabilistic theory, which formula is:

$$n = \frac{Z_\alpha^2 * p(1-p)}{m^2}$$

n = sample size

Zα = confidence level according to centered reduced normal distribution (for a α=95% confidence level, **Z** = 1.96)

p = estimated proportion of the population practising fishing and or fish farming

m = margin of error tolerated to within 5%.

The number of persons surveyed is 95. This number was proportionally distributed in the six (06) villages selected in the study area.

The population data by fishing and fish farming municipalities are taken from the RGPH-4 of 2013.

In addition, the person in charge of Monitoring and evaluation of DDAEP, three (03) NGOs were surveyed.

Table 2: Distribution of villages and numbers of respondents by district

Municipalities	Districts	Villages	Nbr of household
Athiémé	Kpinnou	Azonlihoué	15
	Kpinnou	Hahamè	15
Houéyogbé	Doutou	Tokpa	18
	Zoungbonou	Tohonou	16
Lokossa	Houin	Logbo	15
		Vèha	16
		Sum	**95**

3.2.1.3 Field survey and justification of techniques/approaches used

Several techniques associated with both quantitative and qualitative approaches were used to ensure that the data collected would better explain the phenomenon being addressed. After identifying the stakeholders, defining and allocating the sample size, the environmental status of the study area was assessed through direct field observation. Interviews were conducted using a combination of qualitative and quantitative approaches.

The qualitative approach allowed to understand the socio-economic impacts induced by the impacts of climate change on fishing yield and fish farming on the daily life of the communities, an important objective of the study. Surveys were conducted using open-ended survey questionnaires designed with the Sphinx software and validated by the supervisors. Directed, semi-directed or free interviews were done in person or by telephone, depending on the respondent and his or her availability to provide the necessary data. Thus, in the fishing and fish farming communities, the interview was direct and/or semi-direct (semi-directed interview) depending on the level of education of the interviewees. With the NGOs

and state structures, latitude was given to them to receive and fill the questionnaire and return it back later.
The semi-structured interview seemed the most appropriate, due to the fact that the same themes were discussed with each respondent; this fact, together with the freedom in the answers, made it possible to obtain more authentic elements during the survey. Semi-structured interviews, although time-consuming, ensure the quality of the information collected. It is a flexible approach that made it possible to follow up with respondents and address small groups. The qualitative approach also facilitates communication in an intercultural, interlinguistic context and with participants with limited information.
The option of the quantitative approach enabled to understand the evolution of temperature and rainfall over a period of thirty years in recent years (1985 to 2015) in the municipalities of interest. For that, we went to the General Directorate for Water (DG- Eau) to collect those data.

3.2.1.4 Materials and tools for data collection

The materials used are: location maps of the communes of Athiémé, Houéyogbé and Lokossa for the identification of the places and the delimitation of the study area; a GPS (Global Positioning System) to take the geographical coordinates and to do the tracking; a digital camera for field photography. The collection tools are the questionnaires, one of which is administered to the fishermen and fish farmers of the study area, and the second to the Departmental Directorate of Agricultural, Livestock and Fisheries and the NGOs involved in supporting environmental protection in the municipalities of interest.

3.2.2 Methods for data processing and analysing

Once the interviews were completed, the content collected was processed and analysed. Several steps were necessary since the content of the interviews first had to be classified according to the objectives of the study. The most important variables were identified. The results were synthesized and then presented graphically.

3.2.2.1 Methods for data processing

Data processing was done by mainly statistical methods (Sphinx and Excel) on one hand, and the use of the R language on the other hand. Information collected in the field was codified, counted and entered into Sphinx and then transferred in Excel. In Excel, the reread and corrected data was converted under “csv” format in order to be readable in R Studio.

The results obtained after data entry and decoding were analysed and sent to R for graphs and curves in order to aggregate some daily data (temperatures, rainfall heights) into monthly and then annual data and transform them into tables, curves or histograms.

3.2.2.2 Methods for analysing data

Overall, the data were analysed in RStudio by combining several packages needed and this according to the variables to be studied.

The analysis took into account the description of the change over thirty years (1985 to 2015) of the climatic factors that can influence fishing yield (temperature and rainfall); the description of the data collected from the communities living along the lake and then to carry out two fundamental analyses according to the social profile of the respondents (analysis of the variation in catch quantities (yield) before and after the manifestations of climate change and the analysis of the proposed measures) in an analytical framework. The social profile took into account ethnic group, level of education, age, and occupation (primary and secondary occupation for those engaged in secondary activities), and the range of monthly income. The number of years spent fishing on the lake was also taken into account in these analyses.

- **Description of the evolution of climatic factors**

The analysis of the evolution of climatic factors will only take into account rainfall and temperature data in this study.

The nature of the stations (rainfall type) in the municipalities where the study focuses only allowed the collection of meteorological data related to rain (rainfall); nevertheless, the temperature data from the Bohicon station (closer station) are equivalent to those of the study zone. Also, there is no station in the municipality of Houéyogbé, the data of the station of Bopa (closer station) are equivalent to those of the station of Houéyogbé.

The analysis of climate variability is done using statistical tools. The following statistical formulae were used: total rainfall and arithmetic mean; trend plotting, rainfall index.

Totals Rainfall were used to study rainfall quantities and their frequencies. They are calculated by the simple cumulation method: $\sum_{i=1}^{n} n_i$ with n_i = daily and monthly values.

As a parameter of central tendency, the **arithmetic mean** was used to study rainfall patterns over a 30-year period. It is obtained by the equation:

$$\bar{X} = \frac{1}{N}\sum_{i=0}^{n} X_i$$

with N: number of observations

X: monthly observed values

Trend plotting: determination of thermometric and rainfall trends over the period 1985-2015 was done using the method of regression. It consists of a graphical representation of regression line of the affine type which shows the linear evolution and allows the trend to be detected.

The equation for the trend line is in the form: Y = a X + b; “a” is the direction coefficient and represents the slope and “b” a constant.

- If a > 0, there is an upward trend;
- If a < 0, we have a downward trend.

Rainfall index: the index is used to identify dry or deficient sequences, the wet or excess sequences and average or normal sequences on period (1985-2015). This index is determined from the formula:

$$R_i = \frac{X_i - X_{mean}}{\delta}$$

where X_i: rainfall in year i

X_{mean}: average interannual rainfall over the reference period,

δ: standard deviation of the series.

If Ri< 0, the year is dry or deficit,

If Ri = 0, the year is said to be average or normal.

If Ri> 0, the year is wet or excess.

- **Description of data collected from the communities along the lake**

The description of the data collected from the communities living along the lake took into account the socio-economic profile of the fishing communities surveyed along the lake, changes in climatic factors of the lake and the impacts of changes on communities that dependent on the lake’s resources for living.

A descriptive statistic was made. The categorical data were analysed with the library of the "Hmisc" package. It allowed to describe the most representative modalities of the sample as well as their proportion. Continuous data were analysed by combining the libraries of the "pastecs" and "skimr" packages. They made it possible to determine the mean and median values, the standard deviation and the coefficient of variation of these variables. The combination of these two libraries has the advantage of showing the distribution of the variables, which allows to foresee the probable tests to be made for the valorisation of the data.

- **Analytical framework**

In the analytical framework, two studies were carried out, the first focused on the variation in quantities before and after the manifestations of climate change according to the social profile and the number of years spent fishing on the lake where a multiple linear regression was done to determine the social factors affecting catch quantities. For the variables "AGE" and number of years spent fishing ‘’YRS.FSH’’ on the Lake, the analysis categorized them into two main groups. Respondents over 30 years of age and those under 30 years of age, followed by those with 30+ years of fishing experience and those with less. This categorization made it possible to specifically see the effect of each of these groups on the catch quantities before and after the manifestations of climate change as well as the effects on the proposed measures. These effects are significant if the probability associated (p-value) with the regression is less than 5%. For the occupation ("PROF", "SECACT2") and ethnicity ("ETHNY") variables, this categorization was based on the most representative modalities ("Fishermen" and "Sahouè" respectively) while for the education level variable "EDUC" the reference was taken on the highest level of education (University).

The second study focused on the variation in the proposed measures (measures to provide for oneself and one's family in the event that the lake's resources will no longer be truly sufficient to cover these needs and measures to adapt to climate change) according to the social profile and the number of years spent fishing on the lake. To this end, a Chi-2 test was applied to the contingency table in each case in order to study the significance of the variations between the proposed measures (Codjo et al., 2018). There would be a variation between the measures proposed by the fishermen according to their social profile and the number of years spent fishing on the lake if the probability associated with the Chi-2 percentage comparison test is less than or equal to 5%. Some variables required the practice of approximating exact fisher's test because the Chi-2 test presented an error message that needed to be corrected (Falissard, 2019).

CHAPTER 4. RESULTS AND DISCUSSION

4.1 Description of climate factors

Several factors justify climate variability. However, rainfall and temperature are the two factors of interest in this study.

4.1.1 Rainfall trends over the period 1985 to 2015

Calculation of rainfall indices made it possible to distinguish between dry years, normal and wet years. Figures 3, 4, 5 show the evolution of the rainfall index in the stations of Athiémé, Houéyogbé and Lokossa.

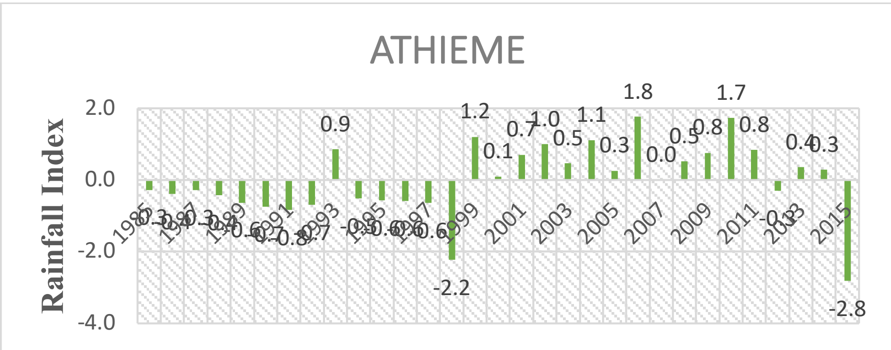


Figure 3: Rainfall index at Athiémé

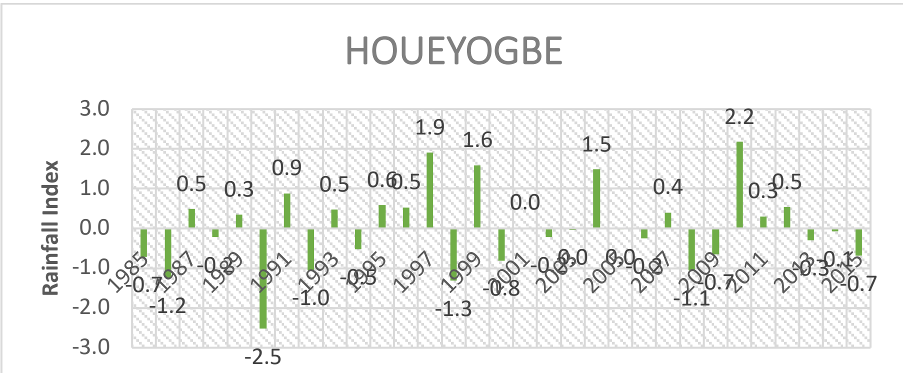


Figure 4: Rainfall index at Houéyogbé

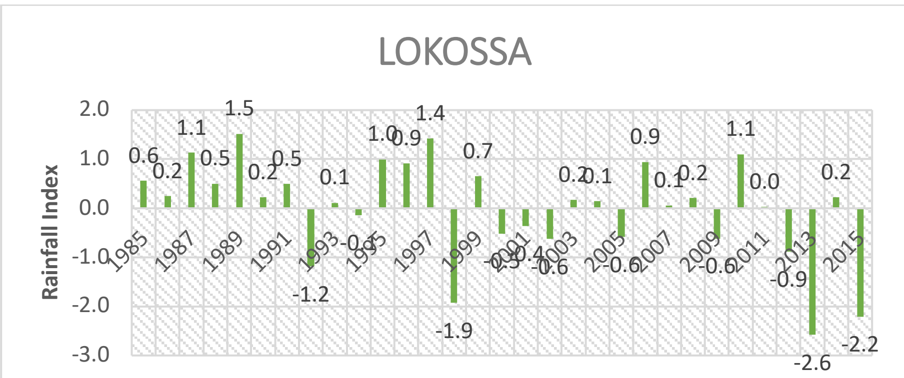


Figure 5: Rainfall index at Lokossa

The analysis of the interannual variability of the rainfall anomalies of the three stations show a general upward trend over the study period. This upward trend is marked by an alternation of surplus and deficit years. Examination of rainfall indices over the period of 1985-2015 reveals an alternation between wet sequences on one hand and dry sequences on the other. The years 1990, 1992, 1998 and 2015 show the highest rainfall deficits marking a generalized drought, while the years 1999, 2003, 2010 and 2014 recorded the highest rainfall surpluses.

Table 3: List of wet, normal and dry years

Period	Municipalities	Humid or Excess (Ri>0)	Normal or Average (Ri=0)	Dry or deficit (Ri<0)
1985 to 2015	Athiémé	**1993;** **1999** to 2006; **2008 to 2011**; 2013; **2014**	2007	1985 to 1992; 1994 to 1998; 2012; 2015
	Houéyogbé	1987; 1989; 1991; **1993**; 1995 to 1997; **1999; 2003; 2004**; 2007; **2009 to 2012**; **2014**		1985 to 1986; 1988; 1990; 1992; 1994; 1998; 2000 to 2002; 2005 to 2006; 2008; 2013; 2015
	Lokossa	1985 to 1991; 1993; 1995 to 1997; **1999; 2003**; **2004;** 2006 to 2008; **2010; 2014**	2011	1992; 1994; 1998; 2000 to 2002; 2005; 2009; 2012; 2013; 2015

Analysis of Table 3 shows that the years 1993, 1999, 2003, 2004, 2008, 2009, 2010 and 2014 are rainy and the years 1985, 1986, 1988, 1990, 1992, 1994, 1998, 2000, 2002, 2005, 2013 and 2015 are exceptionally dry in these municipalities. This evolution shows that there is a real change in rainfall in these three communes and therefore at the whole Lake Toho level.

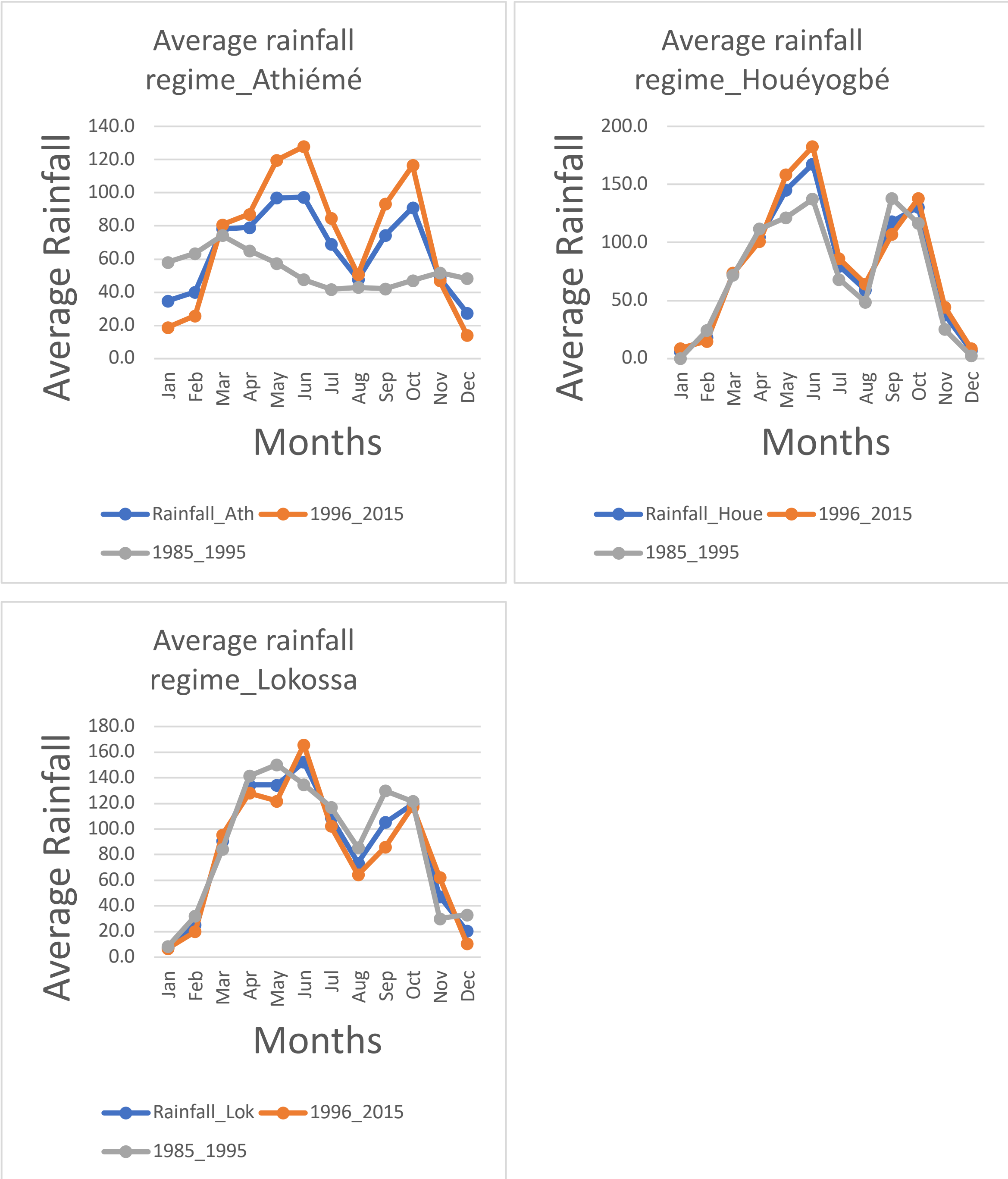


Figure 6: Average rainfall regime

There is a regression from June to August totals rainfall after the break and a slight increase from August to October; this means that the small season is wetter, after the breakup, than the big season. It is the consequence of current climate change. All this justifies the bimodal, characteristic of the climate of the coastal zone in the municipalities and today's changing climate. April, May and June are the wettest months of the year; this would be the basis for the overflows that occur after the great rainy season in the Mono river basin (Amoussou, 2011). It is in this context of rainfall instability that temperature values tend to be more than increase.

4.1.2 Thermometric evolution over the period 1985 to 2015

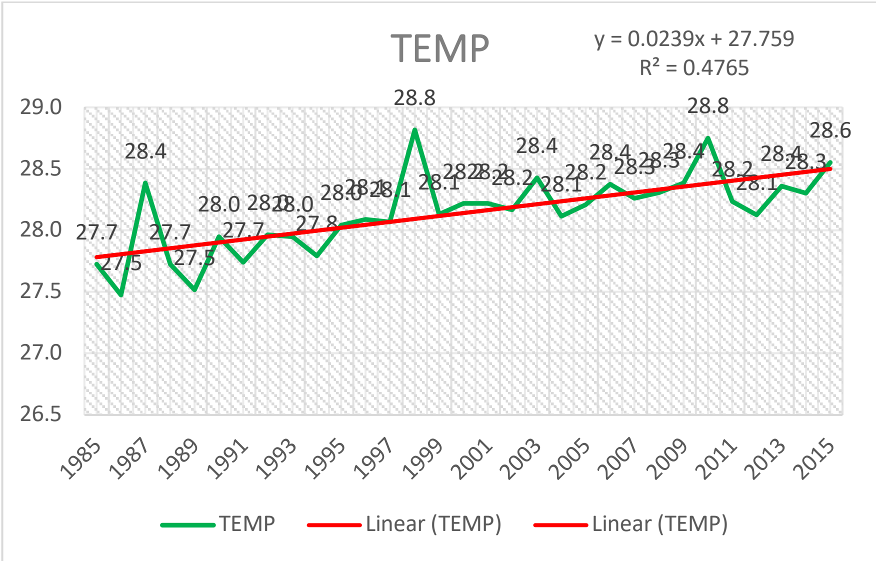


Figure 7: Evolution in annual average temperature from 1985 to 2015

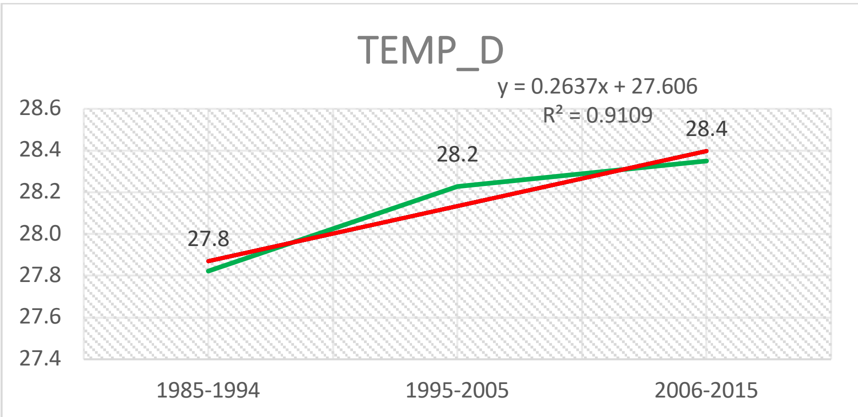


Figure 8: Evolution in average decade temperature

The analysis of temperature data for the period from 1985 to 2015 shows an irregular evolution accompanied by a general upward trend as indicated by the regression line between the years 1994 and 2015. The temperature increase over this period is about 0.6°C. The inter-decadal analysis confirms this general upward trend in temperature.

4.2 Description of data from communities around Lake Toho.

Data were collected from the populations of Athiémé, village of Hahamè, Azonlihoué; Houéyogbé, village of Tokpa, Tohonou, and Lokossa, villages of Logbo and Vèha.

4.2.1 Description of the socio-economic profile of the fishing communities surveyed along the lake

Table 4: Presentation of the variables taken into account for the socio-economic profiling

```
 Format.pval, units
 MT[, PSE[1]]

  9  Variables      95  Observations
--------------------------------------------------------------------------------

Name                     MT[, c("AGE", "NBR.CHL")]
Number of rows           95
Number of columns        2
_______________________
Column type frequency:
numeric                  2
________________________
Group variables          None
```

The description of the socio-economic profile took into account nine (09) categorical variables and two (02) continuous variables.

4.2.1.1 Gender representation and ethnicity distribution along the lake

Table 5: Gender representation in the sample & Ethnicity distribution along the lake

```
GENDER
       n  missing distinct     value
      95        0        1      Male

 Value      Male
 Frequency    95
 Proportion    1
 ---------------------------------------
```

```
ETHNY
       n  missing distinct
      95        0        5

 lowest : Adja    Fon     Haoussa Kotafon Sahoue
 highest: Adja    Fon     Haoussa Kotafon Sahoue

 Value         Adja     Fon Haoussa Kotafon  Sahoue
 Frequency       30       4       1       9      51
 Proportion   0.316   0.042   0.011   0.095   0.537
 -----------------------------------------------------
```

The analysis of the data reveals that our entire sample is "male" as shown in the table 4. Indeed, fishing on Lake Toho is only allowed to men, while women are involved in the transformation and marketing of fishery products. This observation is rooted in traditional values specifying that menstruating women should not go to the water to avoid irritating the water gods. To avoid any disturbance, they are therefore forbidden to fish.

The analysis in Table 5 also shows that the majority ethnic group that fishes on the lake is "Sahouè". It represents about 54% of our sample, followed by "Adja" about 32%. The other ethnic groups practising fishing are "Fon" and the "Kotafon", who are poorly represented in our sample.

[1] PSE <- c("GENDER", "MAR.ST", "ETHNY", "EDUC", "PROF", "SECACT1", "SECACT2", "MTH.ICM", "HRC.PST")

4.2.1.2 Level of education

Table 6: Level of education of respondents

```
EDUC
       n  missing distinct 
      95        0        4 
                                                                       
Value      Advanced or Ordinary level              Non-literate
Frequency                          30                        25
Proportion                      0.316                     0.263
                                                                       
Value                  Primary school                University
Frequency                          38                         2
Proportion                      0.400                     0.021
--------------------------------------------------------------------------------
```

Table 6 presents the level of education of the surveyed communities living around the lake. It shows that about 40% of the surveyed communities is at a primary school level, about 32% at high school and secondary school level and 26% are non-literate and two young university students who fish during the university holidays. Their presence in the sample is essentially justified by the situation of Covid-19, which led to the closure of classrooms and the online courses. This allowed them to return from the university city to engage in fishing activities.

4.2.1.3 Marital status and Hierarchical position of respondents in the household

Table 7: Marital status of respondents & Hierarchical position of respondents in the household

```
MAR.ST
       n  missing distinct 
      95        0        4 
                                              
Value      Divorced  Married   Single  Widowed
Frequency         5       78       11        1
Proportion    0.053    0.821    0.116    0.011
----------------------------------------------
```

```
HRC.PST
       n  missing distinct 
      95        0        3 
                                                
Value       Child contibutor    Child in care
Frequency                 12                1
Proportion             0.126            0.011
                                                
Value      Husband head of household
Frequency                         82
Proportion                     0.863
---------------------------------------------
```

The majority of those surveyed are "Married" and “Husband chief of household” (table 7). They represent about 82% of the sample. However, there were a few cases of divorced (5%), widowed (1%) and single, most of them children contributing to their household expenses (11%).

4.2.1.4 Work status

Table 8: Work status of respondents

```
PROF

       n  missing distinct 

      95        0        9 
```

```
lowest : Artisan         Carpenter       Cook            Farmer          Fisherman
highest: Fisherman       P.Worker        Student         Taxi driver     Tradi.Med.Pract

Artisan (12, 0.126), Carpenter (2, 0.021), Cook (1, 0.011), Farmer (11, 0.116),
Fisherman (60, 0.632), P.Worker (2, 0.021), Student (2, 0.021), Taxi driver (4,
0.042), Tradi.Med.Pract (1, 0.011)
--------------------------------------------------------------------------------
SECACT1
       n  missing distinct
      95        0        2

Value         No   Yes
Frequency     20    75
Proportion 0.211 0.789
--------------------------------------------------------------------------------
SECACT2
       n  missing distinct
      76       19        6

lowest : Breeder   Farmer    Fisherman Hunter    Other
highest: Farmer    Fisherman Hunter    Other     Trader

Value        Breeder    Farmer Fisherman    Hunter     Other    Trader
Frequency          7        31        35         1         1         1
Proportion     0.092     0.408     0.461     0.013     0.013     0.013
--------------------------------------------------------------------------------
```

Table 8 presents the working status of the respondents. From its analysis, it emerges that approximately 63% of surveyed people have fishing as their main activity. The remaining groups with variable proportions (farmers, stockbreeders, traders, craftsmen) practise fishing as a secondary activity. 79% of the respondents stated that they practice secondary activities, out of which 46% of practice fishing. These statistics show that all the people surveyed practice fishing either as their main activity or as a secondary activity.

4.2.1.5 Monthly income of respondent and poverty threshold

Table 9: Monthly income of respondents

```
MTH.ICM
       n  missing distinct
      95        0        5

lowest : 0 to 50000    100001 to 150000 150001 to 200000 50001 to 100000  Plus de 200000
highest: 0 to 50000    100001 to 150000 150001 to 200000 50001 to 100000  Plus de 200000

Value      0 to 50000 100001 to 150000 150001 to 200000  50001 to 100000   Plus de 200000
Frequency          25               11                1               56                2
Proportion      0.263            0.116            0.011            0.589            0.021
```

```
-------------------------------------------------------------------------
```

Table 10: Description of the age and number of respondents' children

```
                     AGE      NBR.CHL
nbr.val        95.0000000  90.0000000
nbr.null        0.0000000   4.0000000
nbr.na          0.0000000   5.0000000
min            20.0000000   0.0000000
max            70.0000000  20.0000000
range          50.0000000  20.0000000
sum          3892.0000000 531.0000000
median         37.0000000   4.0000000
mean           40.9684211   5.9000000
SE.mean         1.4959784   0.5297751
CI.mean.0.95    2.9703001   1.0526519
var           212.6053751  25.2595506
std.dev        14.5809936   5.0258880
coef.var        0.3559081   0.8518454
```

Data summary

```
Name                     MT[, c("AGE", "NBR.CHL")]
Number of rows           95
Number of columns        2
_______________________
Column type frequency:
numeric                  2
________________________
Group variables          None
Variable type: numeric
```

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
AGE	0	1.00	40.97	14.58	20	28.5	37	54	70	▇▂▃▃▂
NBR.CHL	5	0.95	5.90	5.03	0	3.0	4	7	20	▇▃▁▁▁

Table 9 presents the distribution in terms of monthly income of the respondents, showing that the monthly household income varies from 50,000 to 100,000 CFA francs, corresponding to \$85 and \$172. This level of income easily reflects the fact that the population lives below the poverty threshold, since the median number of children per household is 4 at a risk of 5% (table 10). The median age of respondents is thirty-seven (37) years.

4.2.2 Description of the study of changes in climatic factors along the lake

```
MT[, MCL²]

 4  Variables      95  Observations
--------------------------------------------------------------------------------

Name                     MT[, "TM.OBS"]
Number of rows           95
Number of columns        1
_______________________
Column type frequency:
numeric                  1
```

[2] MCL <- c("YRS.PSD", "YRS.FSH" ,"CC.KNW", "CC.PER")

```
________________________
Group variables         None
```

The description of the changes in climatic factors along the lake (population perceptions) took into account four (04) categorical variables and one (01) continuous variable.

4.2.2.1 Number of years living in the municipality and fishing

Table 11: Number of years living in the municipality

```
YRS.PSD
       n  missing distinct
      95        0        5

lowest : 10 et 20 years  20 a 30 years     30 and more      5 a 10 years     Less than 5 years
highest: 10 et 20 years  20 a 30 years     30 and more      5 a 10 years     Less than 5 years

Value      10 et 20 years     20 a 30 years      30 and more     5 a 10 years Less than 5 years
Frequency              13                30               48                3                 1
Proportion          0.137             0.316            0.505            0.032             0.011

-------------------------------------------------------------------------------------------
```

Table 12: Year passed in fishing

```
YRS.FSH
       n  missing distinct
      95        0        5

lowest : 10 et 20 years 20 a 30 years  30 and more       5 a 10 years       Less than  5 years
highest: 10 et 20 years 20 a 30 years  30 and more       5 a 10 years       Less than  5 years

Value    10 et 20 years     20 a 30 years       30 and more      5 a 10 years  Less than 5 years
Frequency            26                17                38               13.                  1
Proportion        0.274             0.179             0.400             0.137.             0.011

----------------------------------------------------------------------------------------------
```

Tables 11 and 12 show the number of years spent in the village and the number of years spent fishing on Lake Toho, respectively. Analysis of the two tables shows cumulatively that more than 80% of the people surveyed have lived in the selected villages for more than 20 years, and about 60% have been fishing on the lake. On a wider scale, a total of about 90% have been fishing for more than 10 years. This shows the relevance of the answers obtained on climate change in recent decades.

4.2.2.2 Climate variability and known change

Table 13: Knowing of climate variabilities and changes

```
CC.KNW
       n  missing distinct     value
      95        0        1       Yes

 Value       Yes
 Frequency    95
 Proportion    1
 --------------------------------------------------------------------------------
```

Table 14: Climate change periodicity

```
CC.PER
       n  missing distinct
      95        0        3

Value      Every decade Every season   Every year
Frequency             5           14           76
Proportion        0.053        0.147        0.800
--------------------------------------------------------------------------------
```

Table 15: Time of observation

```
     nbr.val      nbr.null       nbr.na          min          max        range
  95.0000000    0.0000000    0.0000000    5.0000000   30.0000000   25.0000000
         sum       median         mean      SE.mean CI.mean.0.95          var
1215.0000000   11.0000000   12.7894737    0.7381607    1.4656354   51.7637178
     std.dev     coef.var
   7.1947007    0.5625486
```

Data summary

Name	MT[, "TM.OBS"]
Number of rows	95
Number of columns	1
Column type frequency:	
numeric	1
Group variables	None

Variable type: numeric

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
data	0	1	12.79	7.19	5	7	11	15	30	▇▃▁▁▁

All respondents said that they have felt variations in climatic factors (Table 13) with 80% of people saying that they feel it every year, compared to 14% and 5% for those who feel it every season and every decade respectively (Table 14). The manifestations are characterized by: Irregular rains, Floods, Insufficient rains, Late rains, Early cessation of rains, Higher temperatures, Less intensive harmattan, Drought.

According to the respondents, these events have been observed in the region for an average of twelve (12) years (Table 15). For them, the probable causes of observed changes are: temperature increase, gas emissions into the atmosphere, deforestation, the natural climate cycle and the fury of the gods.

4.2.3 Description of the on impacts of changes on communities that dependent on the lake's resources for living

```
MT[, EIC3]

  6  Variables      95  Observations
--------------------------------------------------------------------------------
```

[3] EIC <- c("RZN.BCC", "COZ.VAR", "SIT.EVO", "NDS.SUP", "STR.SUP", "MESURES")

```
Name                       MT[, c("BCC.QT", "ACC.QT"…
Number of rows             95
Number of columns          2
________________________
Column type frequency:
numeric                    2
________________________
Group variables            None
```

The description of the impacts of changes on the communities that live on the lake's resources took into account six (06) categorical variables and two (02) continuous variables.

4.2.3.1 Observed variations in catch quantities

Table 16: Variation in catch quantities

```
                  BCC.QT      ACC.QT
nbr.val        95.0000000  95.0000000
nbr.null        0.0000000   0.0000000
nbr.na          0.0000000   0.0000000
min             7.0000000   2.0000000
max            50.0000000  15.0000000
range          43.0000000  13.0000000
sum          2250.0000000 586.0000000
median         22.0000000   5.0000000
mean           23.6842105   6.1684211
SE.mean         1.0938352   0.3187506
CI.mean.0.95    2.1718355   0.6328868
var           113.6651736   9.6521837
std.dev        10.6613870   3.1067964
coef.var        0.4501475   0.5036615
```

Data summary

```
Name                       MT[, c("BCC.QT", "ACC.QT"…
Number of rows             95
Number of columns          2
________________________
Column type frequency:
numeric                    2
________________________
Group variables            None
```

Variable type: numeric

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
BCC.QT	0	1	23.68	10.66	7	15	22	30	50	▇▇▇▇▁▁
ACC.QT	0	1	6.17	3.11	2	4	5	7	15	▅▇▁▁

The various changes observed have not remained without impact. The fishing communities feel it every day in their catches. Table 16 presents the variations in quantities. In fact, before the manifestations of climate change, the average catch was 23.68 Kg/day. According to the respondents, there has been a considerable decrease in catch these recent years, leaving the average catch at about 6.16 Kg/day. This situation is experienced with difficulty by the population and explains the level of poverty of these communities who live below the poverty threshold with their families.

4.2.3.2 Causes of the observed variations

Table 17: Reasons for abundance in catches prior to climate change events

```
 RZN.BCC 
        n  missing distinct 
       95        0        6 

 lowest :  Lower population density Autochthonous species     Discharge from Mono river Don't 
have any idea       Fishing technics 
 highest: Autochthonous species     Discharge from Mono river Don't have any 
idea       Fishing technics          Indigenous faith 

 Lower population density (1, 0.011), Autochthonous species (2, 0.021), 
 Discharge from Mono river (86, 0.905), Don't have any idea (1, 0.011), Fishing 
 technics (1, 0.011), Indigenous faith (4, 0.042) 
 -------------------------------------------------------------------------------- 
```

Table 18: Causes of variation before and after climate change events

```
 COZ.VAR 
        n  missing distinct 
       95        0        2 

 Value      Increase in water level       Population growth 
 Frequency                       84                      11 
 Proportion                   0.884                   0.116 
 -------------------------------------------------------------------------------- 
```

Before the manifestations of climate change, catches (fishing yields) were much better. One of the reasons for this is that the Mono River flows into the lake during the rainy season, bringing in a significant number of fingerlings and new species of fish. But since the construction of the dam on the main river of the basin which is the Mono between Benin and Togo, there has been a decline. Respondents expressed this reason for 90% (Table 17). This reason thus appears to be the main reason for the presence of certain species and the quantity of catches. Then, they emphasized the practice of worshiping deities (4%), the population size which was small compared to today where we are witnessing a demographic pressure and consequently a pressure on resources (1%), fishing techniques and gear (1%). Indeed, in recent years, controls by the structures in charge of managing aquaculture resources have forced fishermen to regulate fishing gear. They have also noted the presence of certain species considered indigenous to the area (2%).

Table 18 presenting the causes of the variations before and after the manifestations of climate change shows that the main problem expressed by the respondents is the increase in the water level (88%). Indeed, the heavy floods observed since 2010 make fishing difficult. The fish are hiding at the bottom of the lake and it is difficult to catch them.

4.2.3.3 Adaptation Measures Proposed

Table 19: Situation evolution

```
SIT.EVO
       n  missing distinct    value
      95        0        1      Yes

Value      Yes
Frequency   95
Proportion   1
--------------------------------------------------------------------------------
```

Table 20: Family's needs support

```
 NDS.SUP
       n  missing distinct
      95        0        8

 lowest : Conversion in artisan  Conversion in breeder  Conversion in designer Conversion in
driver   Conversion in farmer
 highest: Conversion in driver   Conversion in farmer   Conversion in hunter   Conversion in
masonry  Conversion in trader

 Conversion in artisan (1, 0.011), Conversion in breeder (31, 0.326), Conversion
 in designer (1, 0.011), Conversion in driver (2, 0.021), Conversion in farmer
 (57, 0.600), Conversion in hunter (1, 0.011), Conversion in masonry (1, 0.011),
 Conversion in trader (1, 0.011)
 --------------------------------------------------------------------------------
```

Table 21: Structures support

```
STR.SUP

       n  missing distinct    value

      95        0        1       No

Value      No

Frequency  95

Proportion  1

-------------------------------------------------------------------------------
```

Table 22: Measures proposed

```
MEASURES
       n  missing distinct
      95        0        5

lowest : Change fishing gears Prayer Ritual practices Ritual practices Suggest fish farming
highest: Change fishing gears Prayer Ritual practices Ritual practices Suggest fish farming

Value      Change fishing gears               Prayer     Ritual practices
Frequency                    32                    4                    3
Proportion                0.337                0.042                0.032

Value          Ritual practices Suggest fish farming
Frequency                    20                   36
Proportion                0.211                0.379
--------------------------------------------------------------------------------
```

The respondents also gave their views on the evolution of the climate change situation (table 19), what they would do if the lake's resources were no longer permanently able to meet the needs of their families (table 20), as well as proposed measures to ensure sustainable management of the resources in the light of the situation (table 22).

In fact, as table 21 shows, the populations do not benefit from any support either from State structures or from NGOs (Non-Governmental Organizations). To this end, the interview with the Departmental Directorate revealed that it only intervenes in the management of the lake. All the people surveyed answered "yes" to the question on the evolution of climate change. In this context, the analysis of table 20 shows that in order to meet their needs and those of their families, 60% of the respondents will convert to agriculture. 32.6% will become farmers (with a particular ambition to farm fish), 2.1% will become motorcycle taxi drivers and the rest will take up various other activities such as hunting, crafts, masonry and trade, the respective proportions of which are 1%.

However, in discussions (table 22), several measures have been proposed to adapt to the situation in order to continue to practice the activity of fishing. The most common measures are the promotion of fish farming and the change of fishing gear, which account for 37.9% and 33.7% respectively. The second most common measure is the practice of rituals to beg the favour of the gods (24.3%), compared to 4% for people practicing exogenous religions (Christianity and Islam).

4.3 Analytical framework

4.3.1 Analysis of the variation in quantities before and after the manifestations of climate change according to the social profile and years spent fishing on the lake

4.3.1.1 Analysis of the variation before the manifestations

Table 23: Aggregate effects of each variable on catch quantities (BCC[4])

```
Single term deletions

Model:
MT$BCC.QT ~ AGE.B[5] + ETHNY + EDUC + YRS.FSH.B[6] + PROF + SECACT2
          Df Sum of Sq    RSS    AIC F value  Pr(>F)
<none>                 4273.9 350.25
AGE.B      1     44.13 4318.1 349.03  0.5576 0.45846
ETHNY      4    914.56 5188.5 356.98  2.8888 0.03066 *
EDUC       3    823.44 5097.4 357.64  3.4680 0.02229 *
YRS.FSH.B  1    323.20 4597.1 353.79  4.0836 0.04827 *
PROF       7    819.50 5093.4 349.58  1.4792 0.19438
SECACT2    4    652.32 4926.2 353.04  2.0605 0.09881 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table 24: Categorized effects of each variable on catch quantities (BCC)

[4] BCC : Before Climate Change

[5] MT$AGE.B<-ifelse(MT$AGE>30,1,0)

[6] MT$YRS.FSH.B <- ifelse(MT$YRS.FSH=="30 and more",1,0)

```
Call:
lm(formula = MT$BCC.QT ~ AGE.B + ETHNY + EDUC + YRS.FSH.B + PROF +
    SECACT2, data = MT)

Residuals:
     Min       1Q   Median       3Q      Max
-23.4632  -3.4037   0.3516   5.1132  16.7606

 Coefficients: (1 not defined because of singularities)
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                    14.4065    12.4148   1.160  0.25098
AGE.B                           2.4635     3.2990   0.747  0.45846
ETHNYAdja                      -5.5617     3.6014  -1.544  0.12835
ETHNYFon                        0.8301     5.9604   0.139  0.88975
ETHNYHaoussa                  -13.2394     9.3714  -1.413  0.16347
ETHNYKotafon                  -13.0546     4.7108  -2.771  0.00764 **
EDUCAdvanced or Ordinary level 11.6917     6.8256   1.713  0.09246 .
EDUCNon-literate                9.1606     7.3333   1.249  0.21699
EDUCPrimary school              1.9857     6.7259   0.295  0.76895
YRS.FSH.B                       7.4822     3.7026   2.021  0.04827 *
PROFArtisan                     1.0813    10.4511   0.103  0.91798
PROFCarpenter                  11.9902    12.3594   0.970  0.33631
PROFCook                       -6.0982    13.7190  -0.445  0.65845
PROFFarmer                    -10.2470    10.1394  -1.011  0.31671
PROFP.Worker                   -4.5518    11.7249  -0.388  0.69938
PROFStudent                    -3.5365    11.3844  -0.311  0.75727
PROFTaxi driver                -8.3770    10.4112  -0.805  0.42457
PROFTradi.Med.Pract            -0.5129    13.5411  -0.038  0.96993
SECACT2Breeder                  5.6013    10.3873   0.539  0.59193
SECACT2Farmer                   6.9015     9.7343   0.709  0.48138
SECACT2Hunter                 -18.3379    13.7842  -1.330  0.18899
SECACT2Other                    1.4635    13.0068   0.113  0.91083
SECACT2Trader                       NA         NA      NA       NA
---

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 8.896 on 54 degrees of freedom
  (19 observations deleted due to missingness)
Multiple R-squared:  0.5243, Adjusted R-squared:  0.3393
F-statistic: 2.834 on 21 and 54 DF,  p-value: 0.001086
```

Table 23 shows the aggregate effect of each variable on catch quantities prior to climate change manifestations. Its analysis reflects the fact that at a 5% risk only the variables "ETHNY", "EDUC" and "YRS.FSH.B" express a statistically significant difference with associated probabilities of 3%, 2% and 4% respectively. Since these variables are categorical variables, a specific analysis of each modality category is required. Hence the analysis of the categorized effects which results are summarized in Table 24 express the fact that within the modalities of the variable "ETHNY" only the ethnic group "Kotafon" expresses a statistically significant difference compared to the reference ethnic group "Sahouè" (p-value= 0.7%). The other ethnic groups (Adja, Fon, Haoussa) show non-statistically significant differences. The Kotafon therefore tend to fish on average 13Kg/day less than the other ethnic groups.

Regarding the modalities of the variable "YRS.FSH.B", there is also a difference in catch quantities that is barely statistically significant (p-value= 4.8% ≈ 5%). Indeed, respondents with less than 30 years of fishing experience tend to harvest more than those with more experience. This would indicate that experience does not guide the art of fishing. But considering the Fisher approach on the strength of probability, we can conclude in this case that these results are similar and therefore that the categorical difference cannot be significant. The same applies for the "EDUC" variable.

From the study of Tables 23 & 24, partial conclusion can be drawn: variations in catch quantities before the manifestations of climate change as a function of social profile and the number of years spent fishing on the lake is based on ethnic group membership. The Sahouè are the main actors in the mastery of the art of fishing.

- **Evaluation of the normality of a model residues**

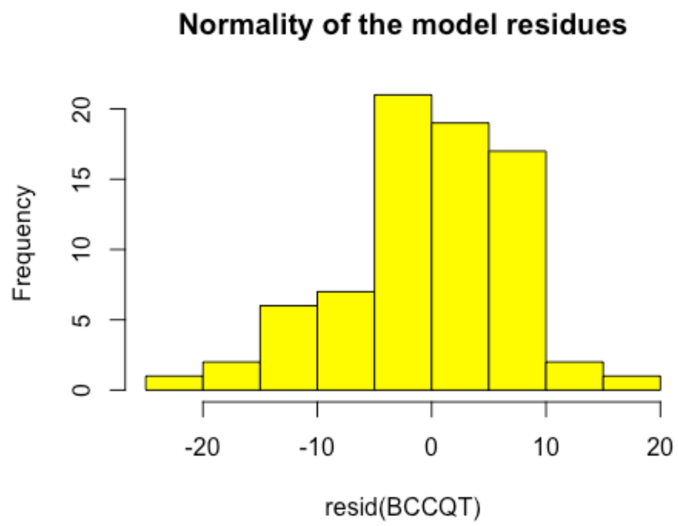


Figure 9: Normality of the model residues (BCC)

```
Shapiro-Wilk normality test

 data:  resid(BCCQT)
 W = 0.9635, p-value = 0.02775
```

The evaluation of the normality of the model residuals sufficiently shows that the residuals of our regression are normal and therefore our test results are reliable.

4.3.1.2 Analysis of the variation after the manifestations

Table 25: Aggregate effects of each variable on catch quantities (ACC[7])

```
 Single term deletions
```

[7] ACC : After Climate Change

```
Model:
MT$ACC.QT ~ AGE.B + ETHNY + EDUC + YRS.FSH.B + PROF + SECACT2
          Df Sum of Sq    RSS    AIC F value    Pr(>F)    
<none>                 249.16 134.24                      
AGE.B      1     8.911 258.07 134.91  1.9313  0.170325    
ETHNY      4   135.218 384.38 159.19  7.3264 8.661e-05 ***
EDUC       3    85.182 334.34 150.59  6.1538  0.001122 ** 
YRS.FSH.B  1    47.406 296.57 145.48 10.2742  0.002267 ** 
PROF       7   141.211 390.37 154.36  4.3720  0.000668 ***
SECACT2    4    27.130 276.29 134.09  1.4700  0.224125    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table 26: Categorized effects of each variable on catch quantities (ACC)

```
Call:
lm(formula = MT$ACC.QT ~ AGE.B + ETHNY + EDUC + YRS.FSH.B + PROF + 
    SECACT2, data = MT)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.5298 -0.9972  0.0000  0.7899  5.0438 

Coefficients: (1 not defined because of singularities)
                              Estimate Std. Error t value Pr(>|t|)    
(Intercept)                     6.8550     2.9975   2.287 0.026148 *  
AGE.B                           1.1070     0.7965   1.390 0.170325    
ETHNYAdja                      -0.6821     0.8695  -0.784 0.436237    
ETHNYFon                        5.9212     1.4391   4.114 0.000133 ***
ETHNYHaoussa                   -1.9562     2.2627  -0.865 0.391128    
ETHNYKotafon                   -1.3920     1.1374  -1.224 0.226317    
EDUCAdvanced or Ordinary level  2.7201     1.6480   1.651 0.104645    
EDUCNon-literate                0.5404     1.7706   0.305 0.761394    
EDUCPrimary school             -0.3711     1.6240  -0.229 0.820090    
YRS.FSH.B                       2.8656     0.8940   3.205 0.002267 ** 
PROFArtisan                    -2.9266     2.5234  -1.160 0.251238    
PROFCarpenter                  -1.1467     2.9842  -0.384 0.702294    
PROFCook                       -4.5751     3.3124  -1.381 0.172908    
PROFFarmer                     -6.6897     2.4482  -2.733 0.008476 ** 
PROFP.Worker                   -2.1442     2.8310  -0.757 0.452092    
PROFStudent                     1.1070     2.7487   0.403 0.688751    
PROFTaxi driver                -7.6504     2.5138  -3.043 0.003609 ** 
PROFTradi.Med.Pract            -7.3679     3.2695  -2.254 0.028307 *  
SECACT2Breeder                 -2.8659     2.5080  -1.143 0.258200    
SECACT2Farmer                  -2.5003     2.3503  -1.064 0.292157    
SECACT2Hunter                  -7.4564     3.3282  -2.240 0.029202 *  
SECACT2Other                   -2.8930     3.1405  -0.921 0.361038    
SECACT2Trader                       NA         NA      NA       NA    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.148 on 54 degrees of freedom
  (19 observations deleted due to missingness)
Multiple R-squared:  0.6461,	Adjusted R-squared:  0.5084 
F-statistic: 4.694 on 21 and 54 DF,  p-value: 2.329e-06
```

Table 25 shows the overall effect of each variable on catch amounts after climate change events. Its analysis reflects the fact that at the 5% risk, only the variables "ETHNY", "EDUC", "YRS.FSH.B" and "PROF" express a statistically significant difference with associated probabilities of 0.008%, 0.1%, 0.2% and 0.06% respectively. As these variables are categorical variables, a specific analysis of each category of modality is required. Hence the analysis of categorical effects whose results summarized in Table 26 express the fact that in the modalities of the variable "ETHNY" only the ethnic group "Fon" expresses a statistically significant difference from the reference ethnic group "Sahouè". (p-value= 0.001%). The other ethnic groups (Kotafon, Fon, Haoussa) show non-statistically significant differences. The Fon therefore tend to fish on average 5Kg/day more than the other ethnic groups.

With regard to the modalities of the "YRS.FSH.B" variable, there is also a statistically significant difference (p-value= 0.2%) in catch quantities. Indeed, respondents with less than 30 years of fishing experience tend to fish more than those with more experience. This could be explained by the slight difference expressed in their catch quantities. Those with more than 30 years of experience feel the effects of climate change more acutely and expressed this with a large difference between the pre and post change amounts.

In terms of the "PROF" variable, only the "Farmer" modality shows a statistically significant difference (p-value=0.8%) at a risk of 5%. In fact, respondents whose main activity was farming tended to fish about 6.7 kg less per day than those whose main activity was fishing. The other modalities present differences but are not statistically significant at the 5% risk. The same observation is made for the "EDUC" variable modalities (no statistically significant categorical differences).

The study of Tables 25 and 26 therefore allows to partially conclude that the variations in catch quantities after the manifestations of climate change according to the social profile and the number of years spent fishing on the lake are based on ethnicity, the number of years spent fishing and occupation (specifically the main activity). The Sahouè are the main actors in mastering the art of fishing on Toho Lake; people with less than 30 years of fishing experience feel the effects less and express less variation in catch quantities. The place of fishing activity in the daily battle for survival also influences catch quantities. For example, professional "Fishermen" have the highest catch amounts both before and after the manifestations of climate change.

- **Evaluate the normality of the residues of a model**

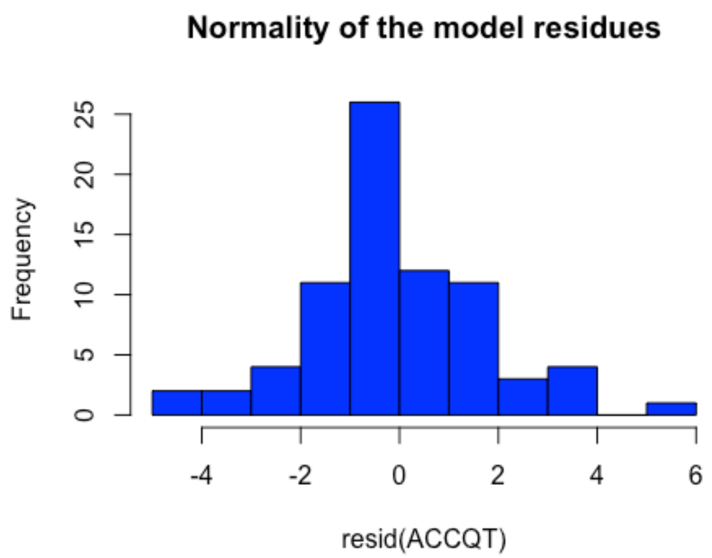


Figure 10: Normality of the model residues (ACC)

```
  Shapiro-Wilk normality test

 data:  resid(ACCQT)
 W = 0.98623, p-value = 0.0585
```

The evaluation of the normality of the model residuals sufficiently shows that the residuals of our regression are normal and therefore our test results are reliable.

4.3.2 Analysis of the variation in the proposed measures according to the social profile and years spent fishing on the lake.

4.3.2.1 Analysis of variations in proposals for meeting family needs

- **According to "ETHNY"**

Table 27: Results of Chi-2 test and Exact Fisher test

```
Warning in chisq.test(MT$ETHNY, MT$NDS.SUP, correct = FALSE): Chi-squared
 approximation may be incorrect

  Pearson's Chi-squared test

 data:  MT$ETHNY and MT$NDS.SUP
 X-squared = 17.402, df = 28, p-value = 0.9402

  Fisher's Exact Test for Count Data

 data:  MT$ETHNY and MT$NDS.SUP
 p-value = 0.4276
 alternative hypothesis: two.sided
```

Tables 27 illustrates the variations in the measures proposed by respondents to meet the needs of their families according to ethnicity when the situation of declining fishery resources will continue to be felt. The results of the Chi-2 and Fisher's Exact tests show that there is no variation in the measures proposed (p-value>5%). This means that it cannot be concluded that the various conversion activities take ethnicity specifically into account.

- **According to "AGE"**

Table 28: Results of Chi-2 test and Exact Fisher test

```
Warning in chisq.test(MT$AGE.B, MT$NDS.SUP, correct = FALSE): Chi-squared
 approximation may be incorrect

  Pearson's Chi-squared test

 data:  MT$AGE.B and MT$NDS.SUP
 X-squared = 6.4601, df = 7, p-value = 0.4872

  Fisher's Exact Test for Count Data

 data:  MT$AGE.B and MT$NDS.SUP
 p-value = 0.667
 alternative hypothesis: two.sided
```

Tables 28 reflects the variations in the measures proposed by respondents to meet the needs of their families according to age groups when the situation of declining fishery resources will continue to be felt. The results of the Chi-2 and Fisher's Exact tests show that there is no variation in the measures proposed (p-value>5%). This means that it cannot be concluded that the different conversion activities take account of the specific age group.

- **According to "EDUC"**

Table 29: Results of Chi-2 test and Exact Fisher test

```
Warning in chisq.test(MT$EDUC, MT$NDS.SUP, correct = FALSE): Chi-squared
 approximation may be incorrect

  Pearson's Chi-squared test

 data:  MT$EDUC and MT$NDS.SUP
 X-squared = 11.816, df = 21, p-value = 0.9444

  Fisher's Exact Test for Count Data

 data:  MT$EDUC and MT$NDS.SUP
 p-value = 0.9589
 alternative hypothesis: two.sided
```

Tables 29 reflects the variations in the measures proposed by respondents to meet the needs of their families according to the level of education when the situation of declining fishery resources will continue to be felt. The results of the Chi-2 and Fisher's Exact tests show that there is no variation in the measures proposed (p-value>5%). This means that it cannot be concluded that the different conversion activities take account the specific level of education.

- **According to "PROF"**

Table 30: Results of Chi-2 test

```
Warning in chisq.test(MT$PROF, MT$NDS.SUP, correct = FALSE): Chi-squared
approximation may be incorrect

 Pearson's Chi-squared test

data:  MT$PROF and MT$NDS.SUP
X-squared = 58.97, df = 56, p-value = 0.3675
```

Tables 30 reflects the variations in the measures proposed by respondents to meet the needs of their families according to the profession when the situation of declining fishery resources will continue to be felt. The results of the Chi-2 test shows that there is no variation in the measures proposed (p-value>5%). This means that it cannot be concluded that the different conversion activities take account the specific level of profession.

- **"YRS.FSH" Determine the percentages before the Chi-2 test or Exact Fisher test**

Table 31: Results of Chi-2 test and Exact Fisher test

```
Warning in chisq.test(MT$YRS.FSH.B, MT$NDS.SUP, correct = FALSE): Chi-squared
approximation may be incorrect

 Pearson's Chi-squared test

data:  MT$YRS.FSH.B and MT$NDS.SUP
X-squared = 4.8672, df = 7, p-value = 0.6762

 Fisher's Exact Test for Count Data

data:  MT$YRS.FSH.B and MT$NDS.SUP
p-value = 0.8985
alternative hypothesis: two.sided
```

Tables 31 reflects the variations in the measures proposed by respondents to meet the needs of their families according to the years spent fishing when the situation of declining fishery resources will continue to be felt. The results of the Chi-2 and Fisher's Exact tests show that there is no variation in the measures proposed (p-value>5%). This means that it cannot be concluded that the different conversion activities take account the specific categories of experience years fishing in region.

4.3.2.2 Analysis of variations in the proposed measures

- **According to "ETHNY"**

Table 32: Results of Chi-2 test and Exact Fisher test

```
Warning in chisq.test(MT$ETHNY, MT$MESURES, correct = FALSE): Chi-squared
approximation may be incorrect

 Pearson's Chi-squared test

data:  MT$ETHNY and MT$MESURES
X-squared = 50.834, df = 16, p-value = 1.687e-05
```

Table 32 shows the variations in the measures proposed by the respondents for the sustainable management of the lake's resources according to ethnicity in the face of climate change. The results of the Chi-2 and Fisher's Exact tests show that there are substantial and sustainable variations in the proposed measures (p-value<5%). This leads to the partial conclusion that the different measures for sustainable resource management take into account ethnicity specifically.

In fact, it is noted that the Sahouè, although seriously divided in the proposals, support the idea of fish farming in the majority (50%), followed by the idea of changing fishing gear and the practice of rituals which share the remaining 50% up to 25% for each of them.

As for the Adja, it is the idea of changing fishing gear that wins (53.33%), followed by the practice of rituals (26.33%) and fish production (20%).

The fons, although poorly represented in the sample, mostly opt for fish farming (75%) and the practice of rituals (25%).

The Kotafon, also poorly represented, are mainly in favour of changing fishing gear (33.33%) and the practice of rituals (43.43%). They nevertheless give a place in their proposals to fish farming (22.22%). The only Haousa present in our sample gives a full place to faith.

Overall, from this analysis, it appears that despite the supportability of the variations in opinion in relation to the measures, the idea of fish production remains an important alternative for the populations living along the river with a supported idea of the practice of rituals and the changing of fishing gear in order to prioritize the capture of species that are already adults.

- **"AGE" Determine the percentages before the Chi-2 test or Exact Fisher test**

Table 33: Results of Chi-2 test and Exact Fisher test

```
Warning in chisq.test(MT$AGE.B, MT$MESURES, correct = FALSE): Chi-squared
approximation may be incorrect

 Pearson's Chi-squared test
```

```
data:  MT$AGE.B and MT$MESURES
X-squared = 14.352, df = 4, p-value = 0.006253

 Fisher's Exact Test for Count Data

data:  MT$AGE.B and MT$MESURES
p-value = 0.003777
alternative hypothesis: two.sided
```

Table 33 shows the variations in the measures proposed by the respondents for the sustainable management of the lake's resources according to age group in the face of climate change. The results of the Chi-2 and Fisher's Exact tests show that there are substantial and sustainable variations in the proposed measures (p-value<5%). This leads to the partial conclusion that the different measures for sustainable resource management take into account the age group specifically.

Indeed, it is noted that young people (under 30 years of age) mainly share the idea of changing fishing gear (52.63%), followed by the idea of fish production (36.84%). It is also noted that the practice of rituals is not very important for its age group (10.52%), while the elderly (30+) give it importance for about 31% of the respondents. It is not, however, the measure proposed in the majority of cases; fish farming still holds a predominant place in this age group (38.59%). Changing fishing gear also accounts for 21.05%.

Overall, according to age, fish farming and gear changes are the most proposed measures.

- **"YRS.FSH" Determine the percentages before the Chi-2 test or Exact Fisher test**

Table 34: Results of Chi-2 test and Exact Fisher test

```
Warning in chisq.test(MT$YRS.FSH.B, MT$MESURES, correct = FALSE): Chi-squared
approximation may be incorrect

 Pearson's Chi-squared test

data:  MT$YRS.FSH.B and MT$MESURES
X-squared = 14.482, df = 4, p-value = 0.005905

 Fisher's Exact Test for Count Data

data:  MT$YRS.FSH.B and MT$MESURES
p-value = 0.003793
alternative hypothesis: two.sided
```

Table 34 shows the variations in the measures proposed by the respondents for the sustainable management of the lake's resources according to the number of years spent in fishing in the face of the manifestations of climate change. The results of the Chi-2 and Fisher's Exact tests show that there are substantial and sustainable variations in the proposed measures (p-value<5%). This leads to the partial conclusion that the different measures for sustainable resource management take into account number of years spent in fishing specifically.

In fact, it is noted that people with less than 30 years spent fishing on the lake mainly share the idea of changing fishing gear (43.85%), followed by the idea of fish production (40.35%). It is also noted that the practice of rituals is weakly present in the suggestions (15.25%), while the people of 30+ give it a high priority for about 40% of the respondents. It is the measure most frequently proposed. However, the idea of fish production still holds a predominant place among this category of people (34.25%). Change of fishing gear 18.42% Overall, the years of experience that should reflect the observations of the age categories does not accurately reflect this. Fish production and fishing ritual practices are the most proposed measures.

- **"EDUC" Determine the percentages before the Chi-2 test or Exact Fisher test**

Table 35: Results of Chi-2 test and Exact Fisher test

```
Warning in chisq.test(MT$EDUC, MT$MESURES, correct = FALSE): Chi-squared
approximation may be incorrect

 Pearson's Chi-squared test

data:  MT$EDUC and MT$MESURES
X-squared = 7.7503, df = 12, p-value = 0.8043

 Fisher's Exact Test for Count Data

data:  MT$EDUC and MT$MESURES
p-value = 0.7862
alternative hypothesis: two.sided
```

- **"PROF" Determine the percentages before the Chi-2 test or Exact Fisher test**

Table 36: Results of Chi-2 test

```
Warning in chisq.test(MT$PROF, MT$MESURES, correct = FALSE): Chi-squared
approximation may be incorrect

 Pearson's Chi-squared test

data:  MT$PROF and MT$MESURES
X-squared = 26.002, df = 32, p-value = 0.7635
```

Table 31 shows the variations in the measures proposed by the respondents for sustainable management of the lake's resources according to occupation, number of years and level of education regarding the manifestations of climate change. The results of the Chi-2 and Fisher's Exact tests show that there are no substantial and sustainable variations in the proposed measures (p-value>5%). This leads to the partial conclusion that the different measures for sustainable resource management do not take into account the profession and level of education specifically.

4.4 Discussion

Africa is one of the continents most vulnerable to climate change and variability, aggravated by the interaction of multiple challenges at various levels with low adaptive capacity. Lake Toho in southern Benin and the communities living around it are exposed to climate change consequences. Due to the combined effects of these changes and variability and the use of destructive fishing practices such as hand fishing and the use of fine-mesh nets and pots, the fishery resources of Lake Toho have been declining steadily (Codjo et al., 2018). The construction of large hydroelectric dams on the Mono River has also caused changes in the hydrological regime. These changes have also led to changes in the balance of the environment with negative impacts on the life of the populations and the economy of the regions. The example of the Aswan dam is particularly significant in this respect (Rossi, 1996). Unregulated fishing techniques and gear are destructive practices of fishery resources since they lead not only to the destruction of fish eggs and fry but also of spawning habitats while compromising the reproduction and renewal of species (Codjo et al., 2018). The decline in fishery resources has been perceived through indicators such as the disappearance of certain aquatic species such as Pelmatochromis guntheri (Sauvage, 1882), Hemichromis fasciatus (Peters, 1857), Parophiocephalus africanus (Teugels and Daget, 1984), Clarias agboyiensis (Sydenham, 1980), Gymnarchus niloticus (Cuvier, 1829), Notopterus afer (Gonther, 1868) and Heterotis niloticus (Ehrenberg, 1829, Cuvier, 1829), with a considerable decrease in catch quantities (by more than 50% per the survey conducted in this study). These results are confirmed by the work of *Codjo et al.,* in 2018, which, beyond the disappearance of the species, explains the decrease in catch quantities by the decrease in the size of fish taken, to which his work adds the high price of fish and the decrease in smoked and dried fish. He added the inventory of the specific richness of the ichtyofauna of Toho Lake, which successively reveals 32 species of fish (Hounkpè, 1996), 25 species of fish (Ahouansou, 2003) and 20 species of fish (Comlan & Adite, 2019). This work shows that we are indeed witnessing the disappearance of certain fish species from Lake Toho. The issue of fishing techniques is similar to the one on the Mai Ndombe lake where the extinction of some fish species such as Hydrocynus goliath (Boulenger, 1898), Distichodus lusosso (Schilthuis, 1891), Schilbe grenfelli (Boulenger, 1900) was dealt with following the use of non-selective and non-regulatory fishing techniques and the too large number of artisanal fishermen (Luhusu & Micha, 2013). As the socio-economic situation of the fishermen worsens and their latency to convert to another activity, there is pressure on the resources of the lake, the capture of young fish obviously compromises the integrity and sustainability of the resource and then forces the strict supervision of the authorities in charge of the sub-sector. This situation is the same on Lake Tanganyika in Burundi where fishermen use gillnets with too small mesh size and seine nets with mosquito netting to catch fish in large numbers, including larvae and fry, thus threatening biodiversity and the maintenance of exploited stocks (Mukabo et al., 2017; Mushagalusa, Micha, J-C, Ntakimazi, & Muderhwa, 2015). The majority of the people surveyed in this study proposed not only changing fishing gear and techniques but also developing income-generating activities such as controlled fish production (fish farming). Indeed, the development of fish farming or aquaculture constitutes an alternative for the sustainable management of the resources of Lake Toho. It is an activity that is well thought out but non-existent within the community living around the lake. Its development would improve the socio-economic conditions of the communities and ensure sustainable management of the resources.

CHAPTER 5. CONCLUSION AND RECOMMANDATIONS

This study examined the socio-economic and climate change effects on fishing yields in the Mono Basin with a case study on Lake Toho. It observed the effects of variations in climatic factors such as rainfall and temperature on the productivity of Toho Lake. The analysis of climate data shows an unstable rainfall pattern particularly associated with an upward trend over the target period (1985-2015) and an upward trend in observed temperatures. This increase is conducive to productivity because during high water periods, fish take advantage of high water to reproduce, and the depth of the lakes does not favour fishing. The same is true for temperature. In fact, most fish reproduce well at temperatures between 27°C and 28°C. As fish reproduction is not systematically synonymous with increased productivity, we are witnessing a drop in productivity linked to the disappearance of certain species, due to the non-discharge of the Mono River into the lake since the construction of the dam, the drop in catch quantities linked to the reduction in the size of the fish and the fishing techniques and gear that are not conducive to the sustainability of fishery resources. Furthermore, the study showed through surveys conducted among fishermen that they perceive the decline in fishery resources and the manifestations of climate change and propose measures to cope with this decline and then to satisfy the needs of their families, which vary according to their membership of a socio-ethnic group, their age category, their level of education and the number of years spent fishing on the lake. Among the measures proposed are fish farming, changes in fishing techniques and gear, and the practice of rituals. Fish farming is one of the measures that the study deems effective and sustainable for the management and improvement of the lake's resources and the socio-economic situation of the communities living there.

This study is only a draft in terms of the whole aspect that the impact of climate change on yields should address. Indeed, there is a need to develop an economic model that will take into account the yields of the lake over the years of the study and the climatic factors that influence yields (temperature and rainfall), but the study was faced with the inexistence of data on fishing yields on the lake during this period.

However, some suggestions are worthy of the attention of local and national political authorities for the restoration of the ecosystem and the improvement of the conditions of the communities. These are:

- The development of fish farming, which is non-existent along the lake,
- Strict control of fishing gear,

- Improvement or education of fishing communities on more appropriate fishing techniques.

CHAPTER 6. REFERENCES

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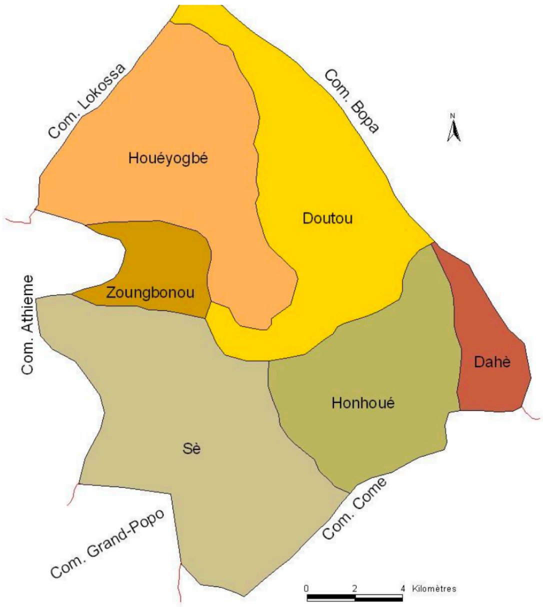
CHAPTER 7. APPENDIX

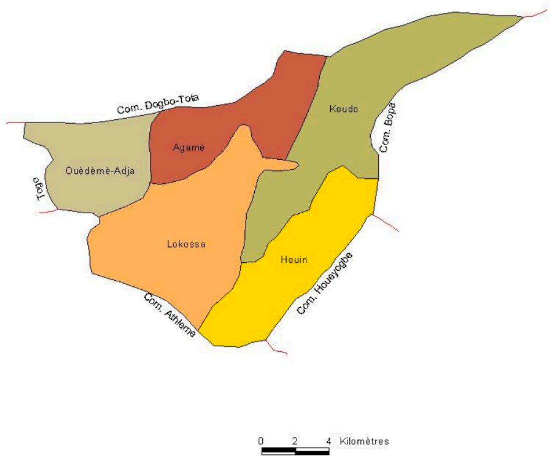
Appendix i: Map of the municipalities in the study area

Map of the municipality of Athiémé

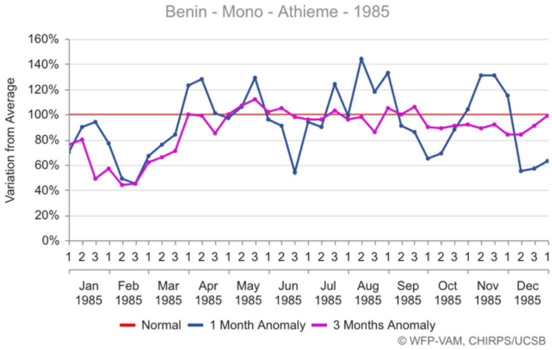
Map of the municipality of Houéyogbé

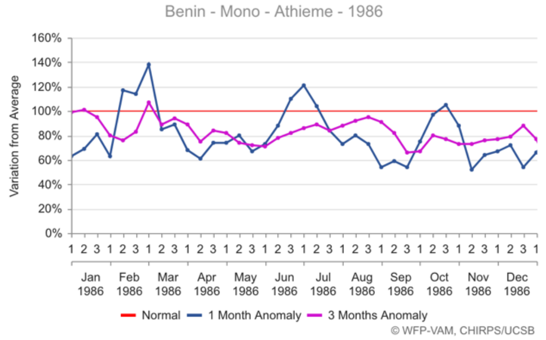


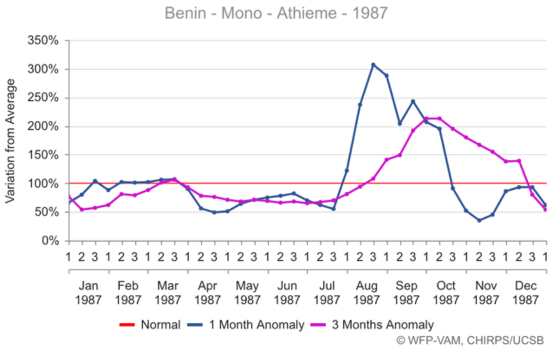
Map of the municipality of Lokossa

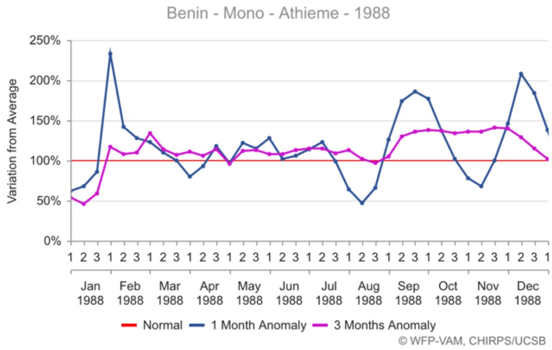


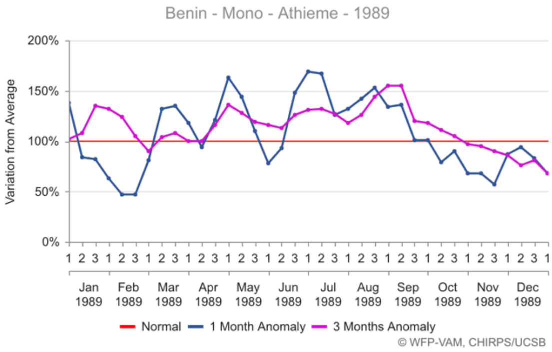
Appendix ii: Rainfall anomalies_Athiémé

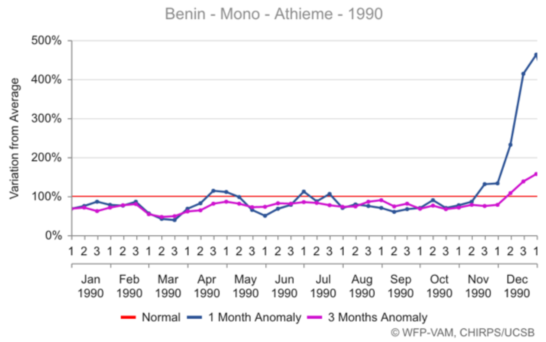


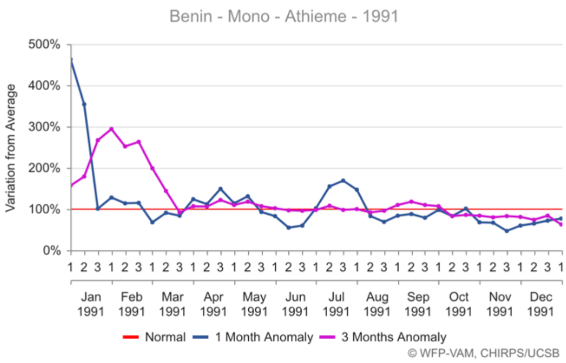


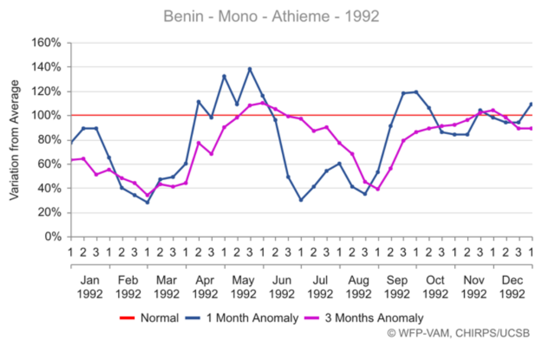


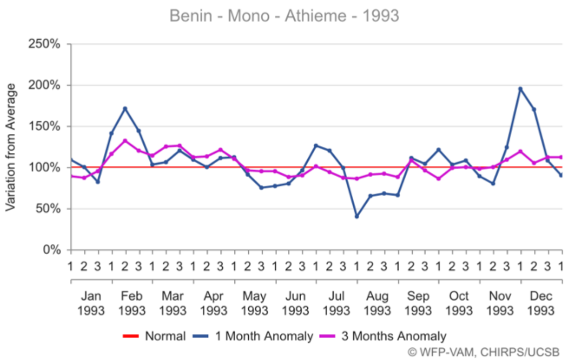


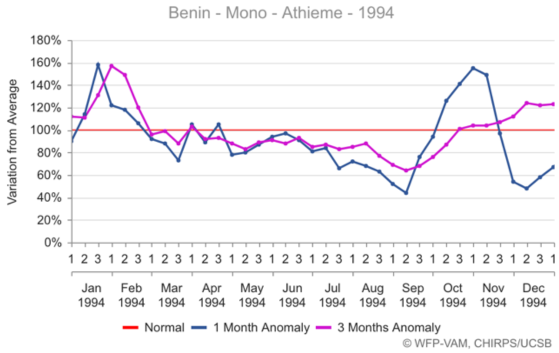


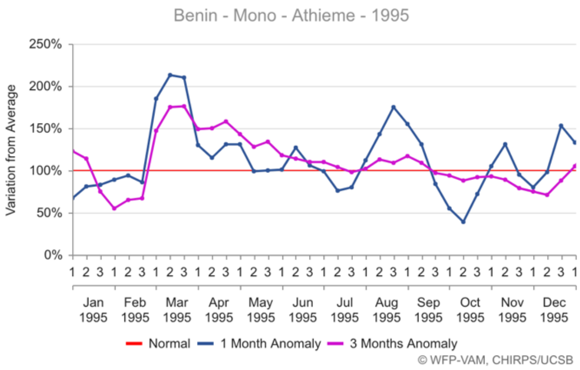


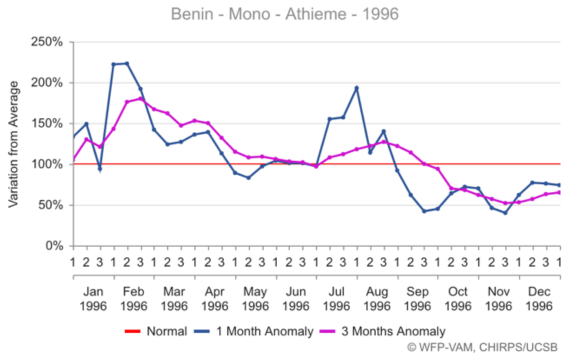


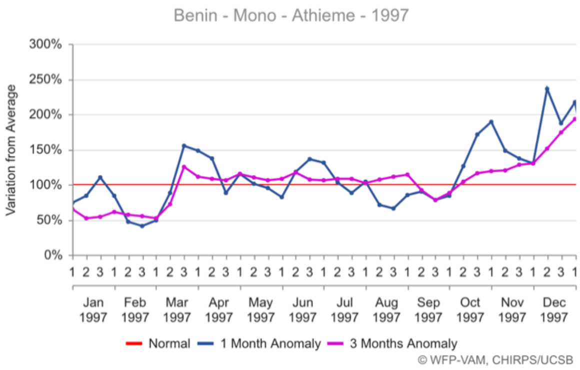


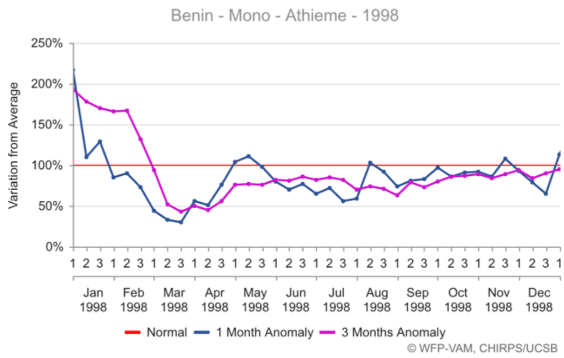

Benin - Mono - Athieme - 1993
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

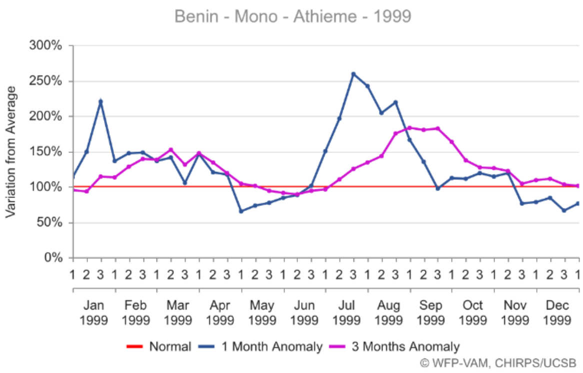

Benin - Mono - Athieme - 1994
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

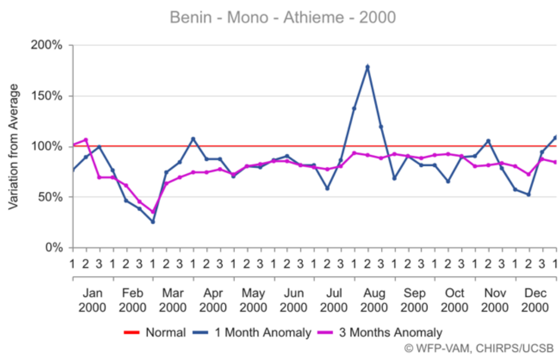

Benin - Mono - Athieme - 1995
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

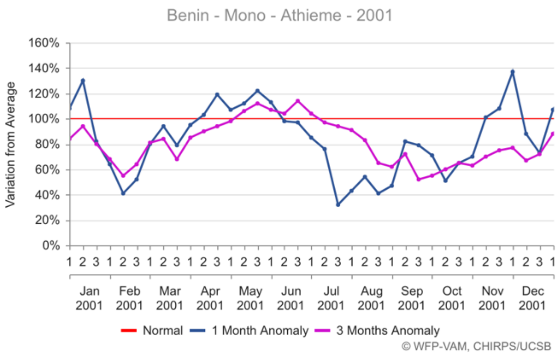

Benin - Mono - Athieme - 1996
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

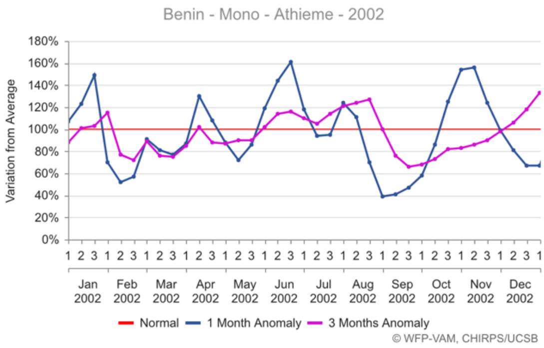

Benin - Mono - Athieme - 1997
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

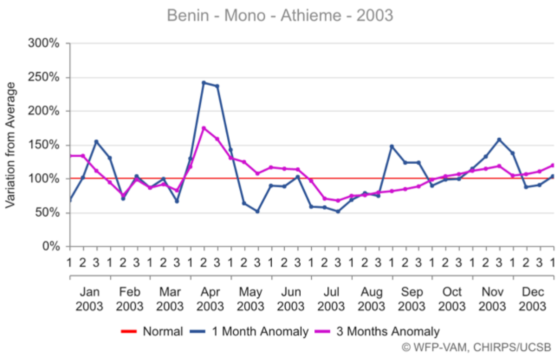

Benin - Mono - Athieme - 1998
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

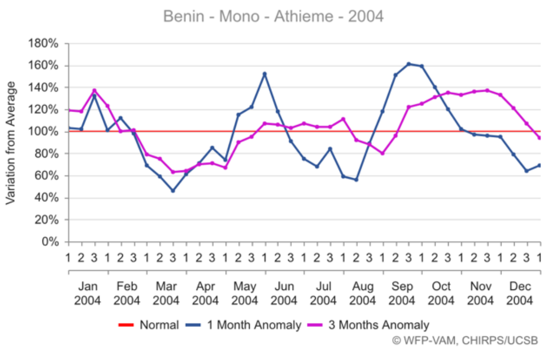

Benin - Mono - Athieme - 1999
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

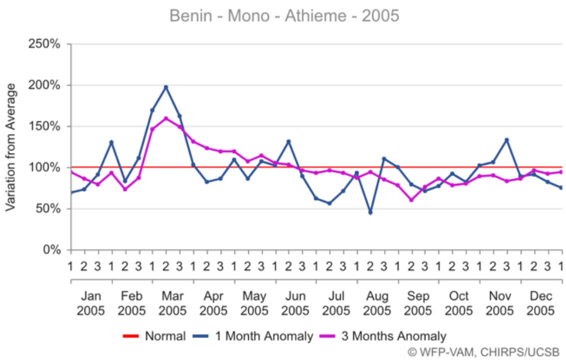

Benin - Mono - Athieme - 2000
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

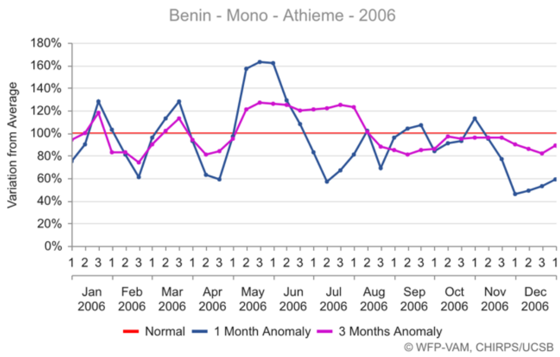

Benin - Mono - Athieme - 2001
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

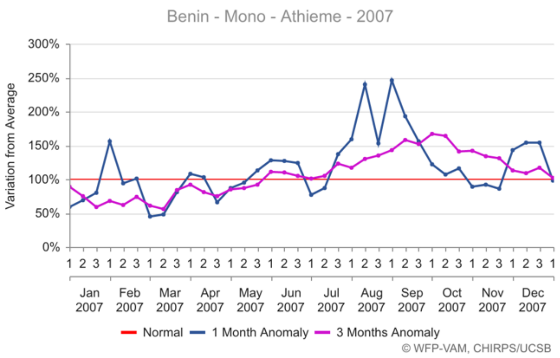

Benin - Mono - Athieme - 2002
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

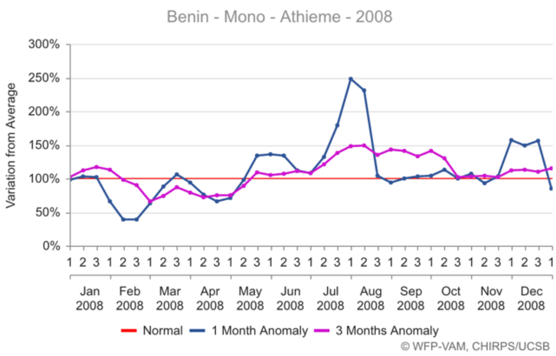

Benin - Mono - Athieme - 2003
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

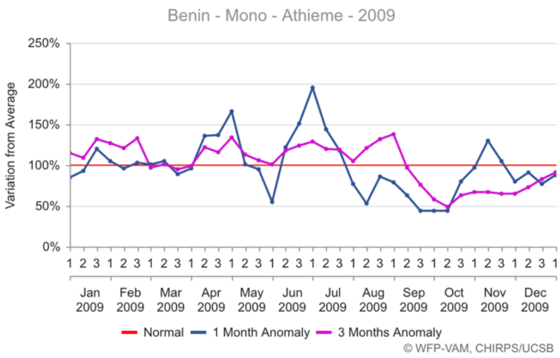

Benin - Mono - Athieme - 2004
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

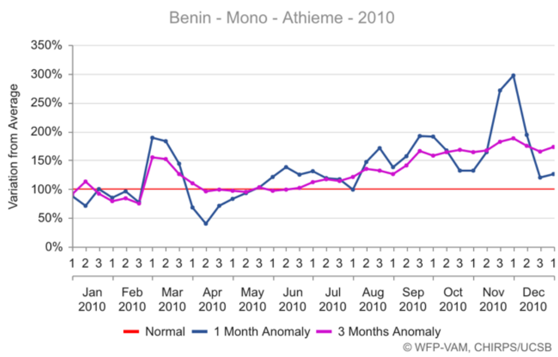

Benin - Mono - Athieme - 2005
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

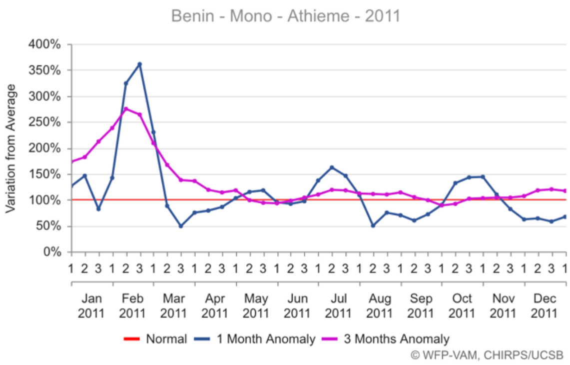

Benin - Mono - Athieme - 2006
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

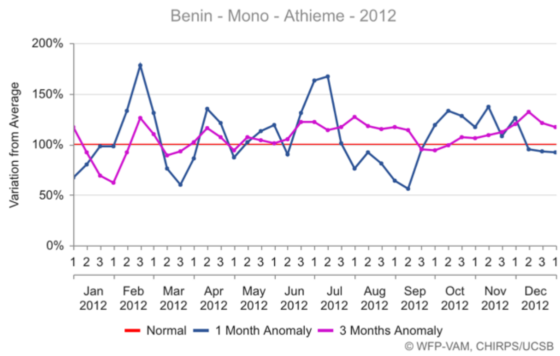

Benin - Mono - Athieme - 2007
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

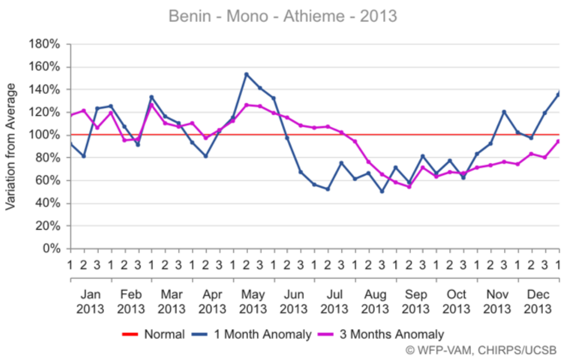

Benin - Mono - Athieme - 2008
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

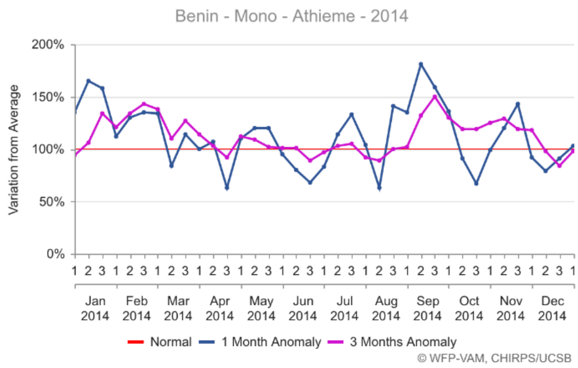

Benin - Mono - Athieme - 2009
Variation from Average
Jan 2009 Feb 2009 Mar 2009 Apr 2009 May 2009 Jun 2009 Jul 2009 Aug 2009 Sep 2009 Oct 2009 Nov 2009 Dec 2009
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

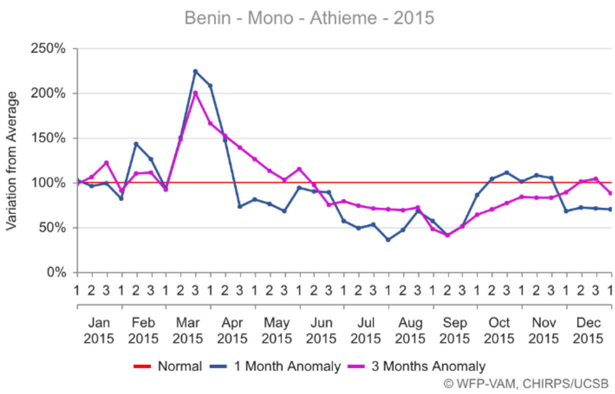

Benin - Mono - Athieme - 2010
Variation from Average
Jan 2010 Feb 2010 Mar 2010 Apr 2010 May 2010 Jun 2010 Jul 2010 Aug 2010 Sep 2010 Oct 2010 Nov 2010 Dec 2010
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB


Benin - Mono - Athieme - 2011
Variation from Average
Jan 2011 Feb 2011 Mar 2011 Apr 2011 May 2011 Jun 2011 Jul 2011 Aug 2011 Sep 2011 Oct 2011 Nov 2011 Dec 2011
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

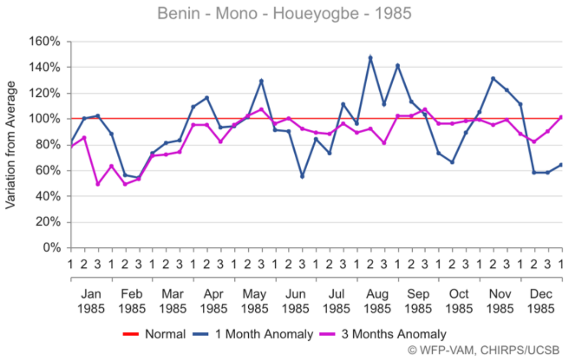

Benin - Mono - Athieme - 2012
Variation from Average
Jan 2012 Feb 2012 Mar 2012 Apr 2012 May 2012 Jun 2012 Jul 2012 Aug 2012 Sep 2012 Oct 2012 Nov 2012 Dec 2012
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

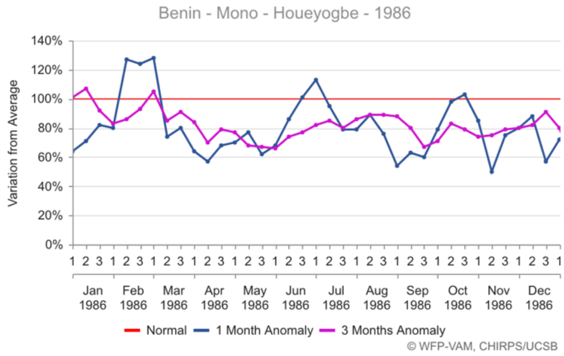

Benin - Mono - Athieme - 2013
Variation from Average
Jan 2013 Feb 2013 Mar 2013 Apr 2013 May 2013 Jun 2013 Jul 2013 Aug 2013 Sep 2013 Oct 2013 Nov 2013 Dec 2013
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

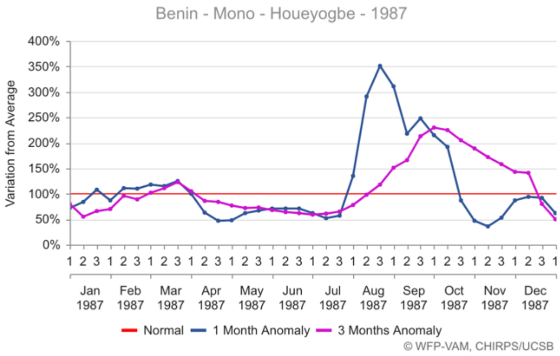

Benin - Mono - Athieme - 2014
Variation from Average
Jan 2014 Feb 2014 Mar 2014 Apr 2014 May 2014 Jun 2014 Jul 2014 Aug 2014 Sep 2014 Oct 2014 Nov 2014 Dec 2014
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

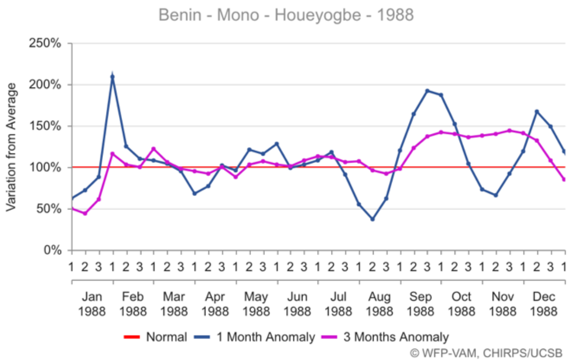

Benin - Mono - Athieme - 2015
Variation from Average
Jan 2015 Feb 2015 Mar 2015 Apr 2015 May 2015 Jun 2015 Jul 2015 Aug 2015 Sep 2015 Oct 2015 Nov 2015 Dec 2015
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

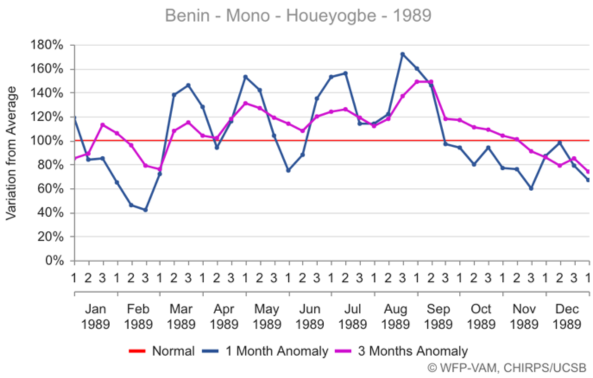
Appendix iii: Rainfall anomalies_Houéyogbé

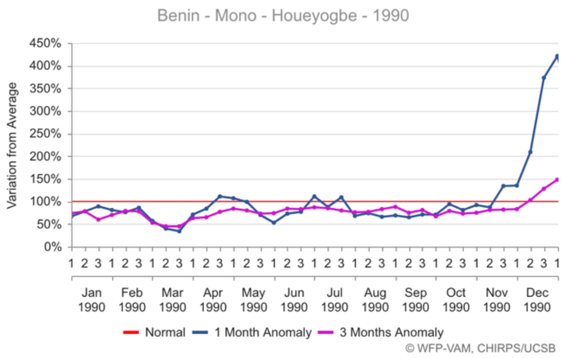


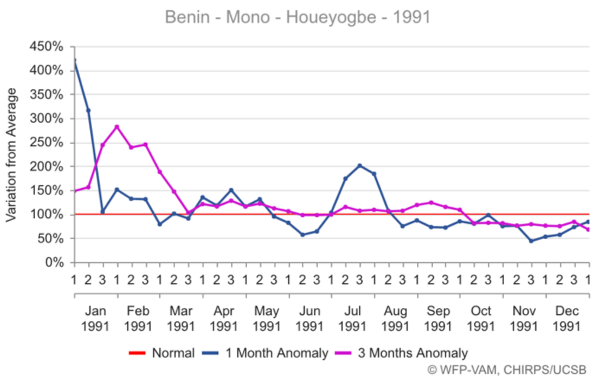


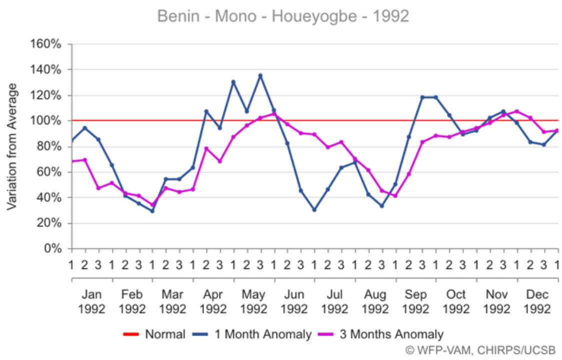


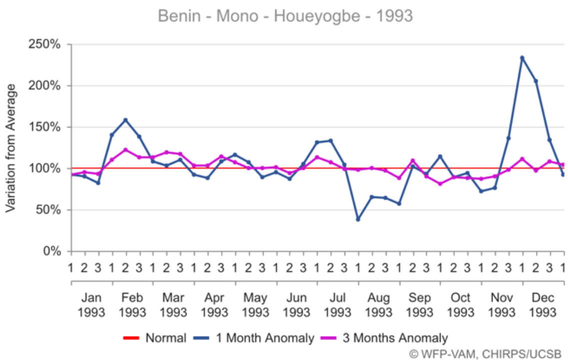


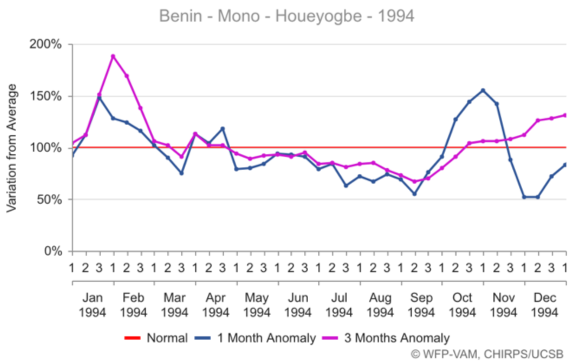


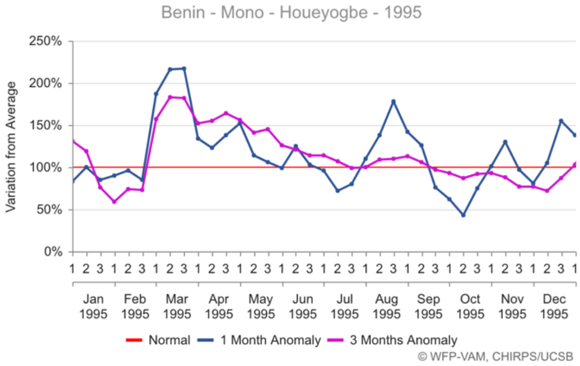


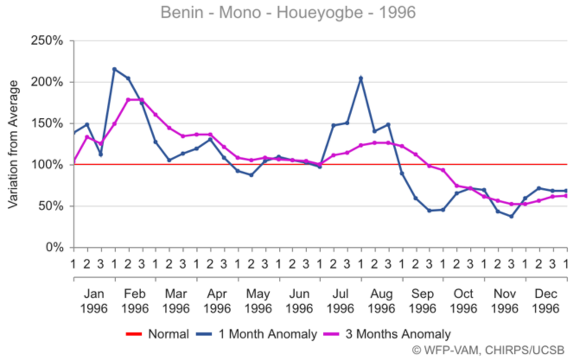


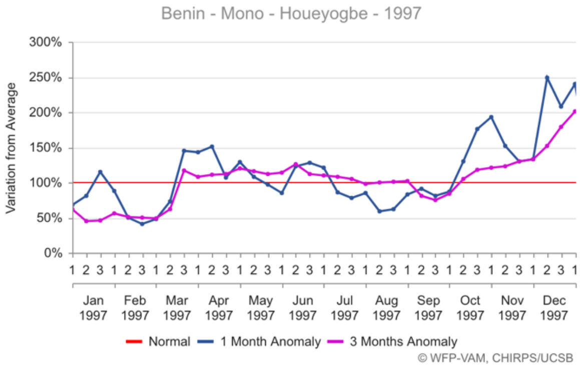


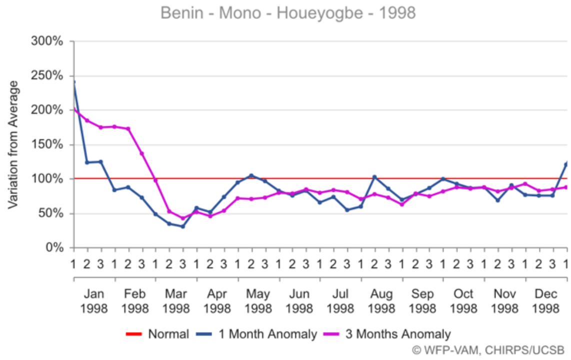

Benin - Mono - Houeyogbe - 1993
Variation from Average
250%
200%
150%
100%
50%
0%
Jan 1993 Feb 1993 Mar 1993 Apr 1993 May 1993 Jun 1993 Jul 1993 Aug 1993 Sep 1993 Oct 1993 Nov 1993 Dec 1993
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

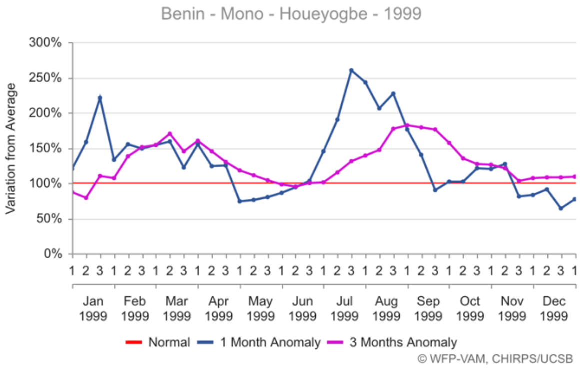

Benin - Mono - Houeyogbe - 1994
Variation from Average
200%
150%
100%
50%
0%
Jan 1994 Feb 1994 Mar 1994 Apr 1994 May 1994 Jun 1994 Jul 1994 Aug 1994 Sep 1994 Oct 1994 Nov 1994 Dec 1994
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

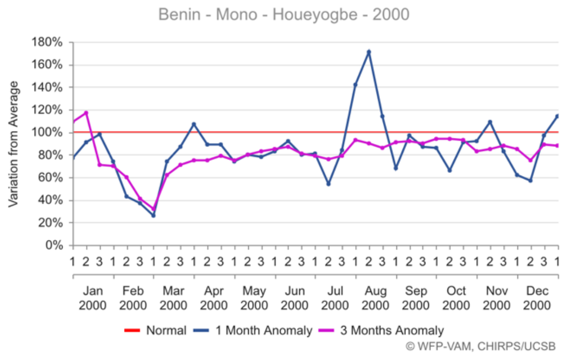

Benin - Mono - Houeyogbe - 1995
Variation from Average
250%
200%
150%
100%
50%
0%
Jan 1995 Feb 1995 Mar 1995 Apr 1995 May 1995 Jun 1995 Jul 1995 Aug 1995 Sep 1995 Oct 1995 Nov 1995 Dec 1995
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

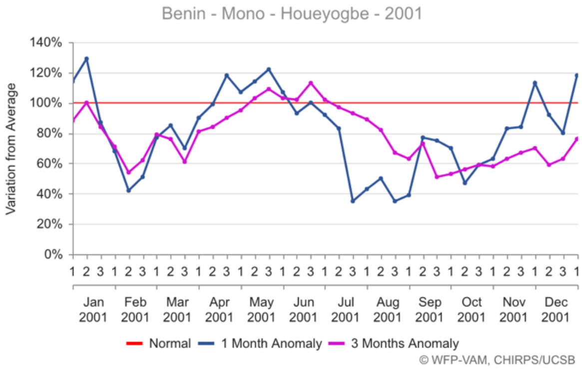

Benin - Mono - Houeyogbe - 1996
Variation from Average
250%
200%
150%
100%
50%
0%
Jan 1996 Feb 1996 Mar 1996 Apr 1996 May 1996 Jun 1996 Jul 1996 Aug 1996 Sep 1996 Oct 1996 Nov 1996 Dec 1996
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

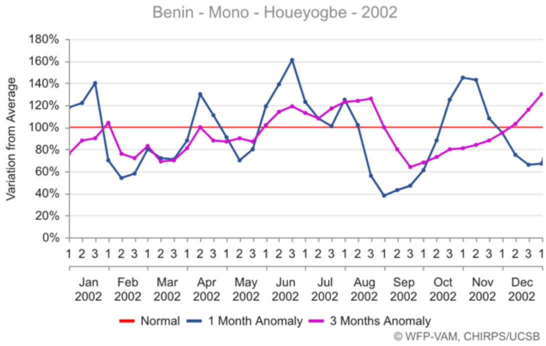

Benin - Mono - Houeyogbe - 1997
Variation from Average
300%
250%
200%
150%
100%
50%
0%
Jan 1997 Feb 1997 Mar 1997 Apr 1997 May 1997 Jun 1997 Jul 1997 Aug 1997 Sep 1997 Oct 1997 Nov 1997 Dec 1997
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

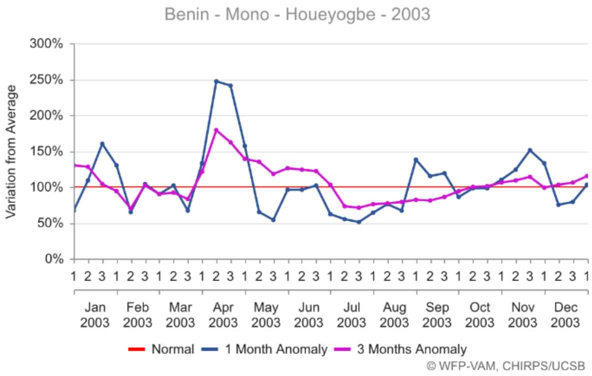

Benin - Mono - Houeyogbe - 1998
Variation from Average
300%
250%
200%
150%
100%
50%
0%
Jan 1998 Feb 1998 Mar 1998 Apr 1998 May 1998 Jun 1998 Jul 1998 Aug 1998 Sep 1998 Oct 1998 Nov 1998 Dec 1998
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

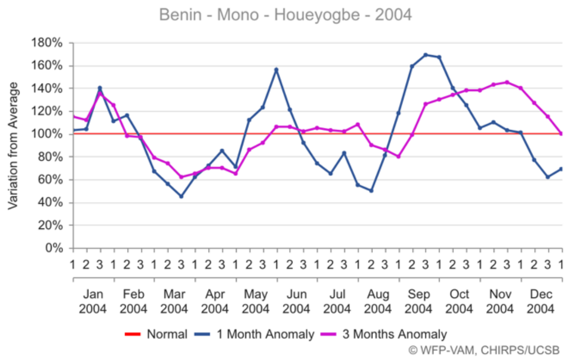

Benin - Mono - Houeyogbe - 1999
Variation from Average
300%
250%
200%
150%
100%
50%
0%
Jan 1999 Feb 1999 Mar 1999 Apr 1999 May 1999 Jun 1999 Jul 1999 Aug 1999 Sep 1999 Oct 1999 Nov 1999 Dec 1999
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

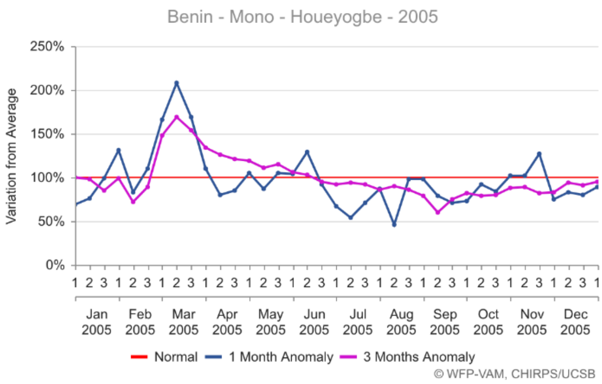

Benin - Mono - Houeyogbe - 2000
Variation from Average
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
Jan 2000 Feb 2000 Mar 2000 Apr 2000 May 2000 Jun 2000 Jul 2000 Aug 2000 Sep 2000 Oct 2000 Nov 2000 Dec 2000
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

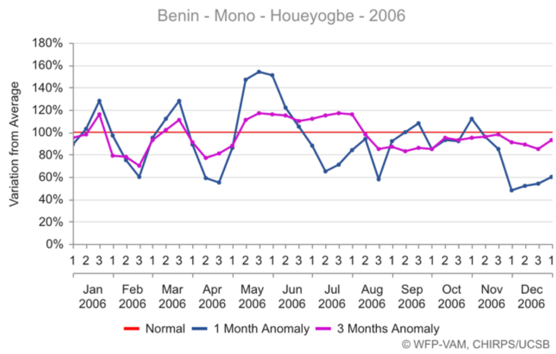

Benin - Mono - Houeyogbe - 2001
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

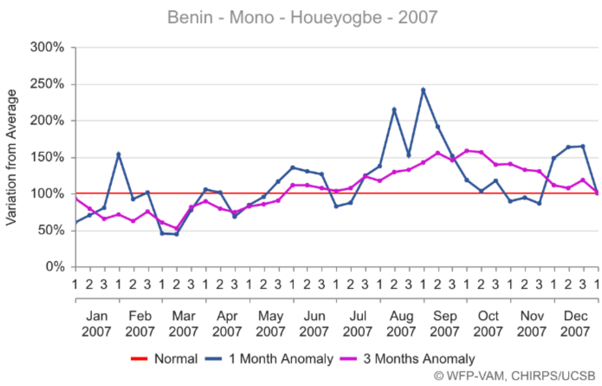

Benin - Mono - Houeyogbe - 2002
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

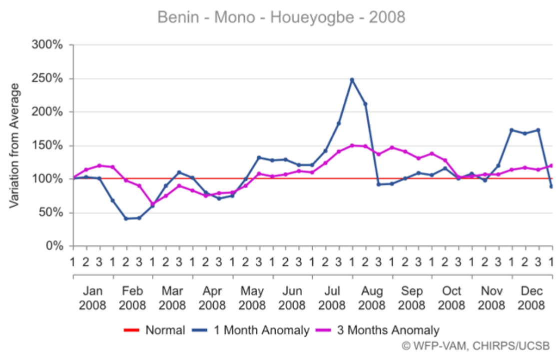

Benin - Mono - Houeyogbe - 2003
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

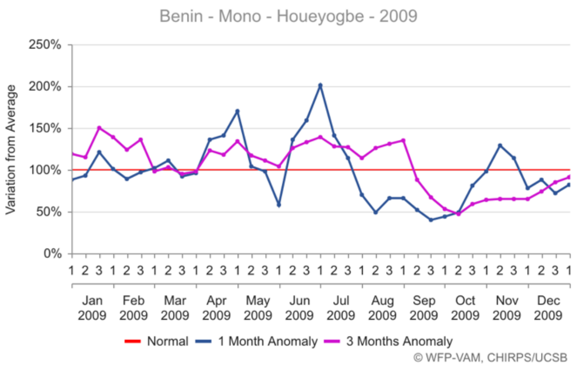

Benin - Mono - Houeyogbe - 2004
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

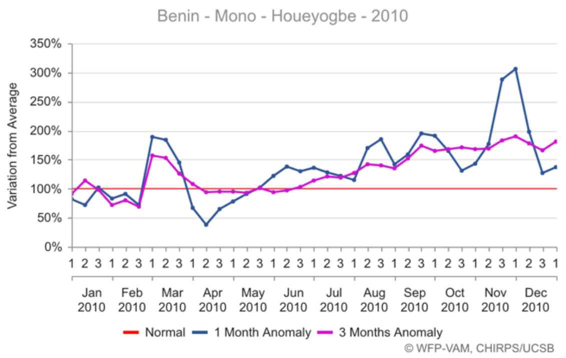

Benin - Mono - Houeyogbe - 2005
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

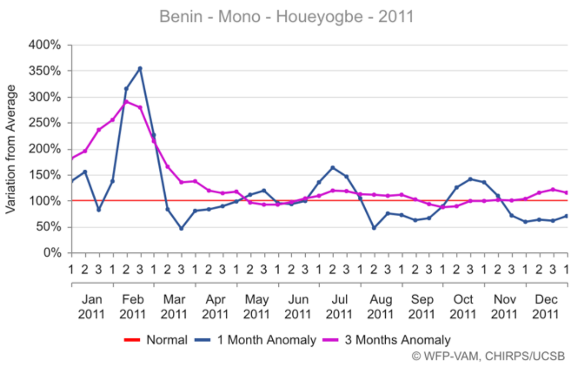

Benin - Mono - Houeyogbe - 2006
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

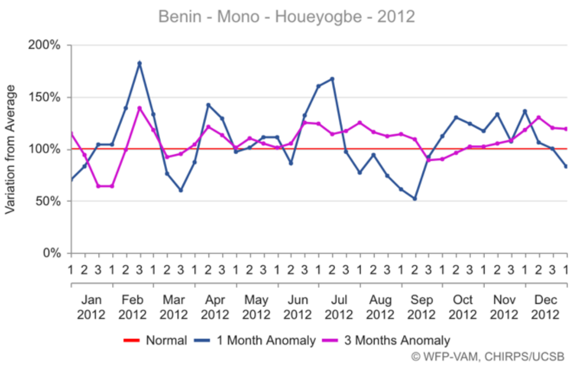

Benin - Mono - Houeyogbe - 2007
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

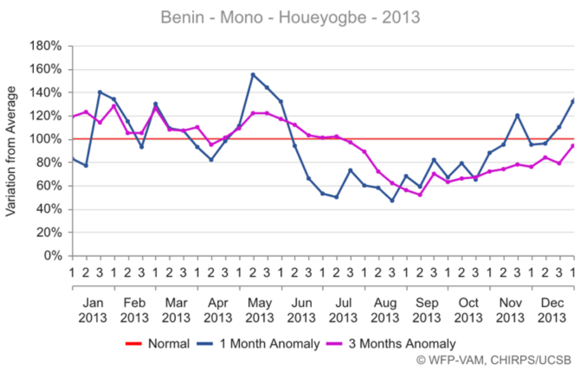

Benin - Mono - Houeyogbe - 2008
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

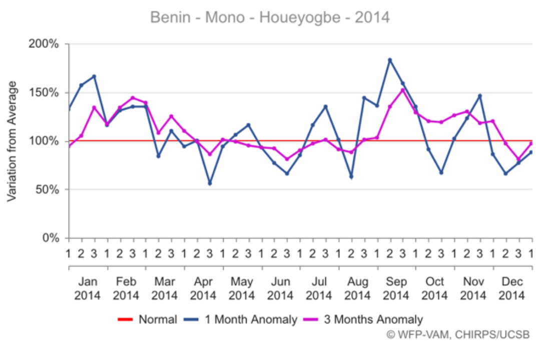

Benin - Mono - Houeyogbe - 2009
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

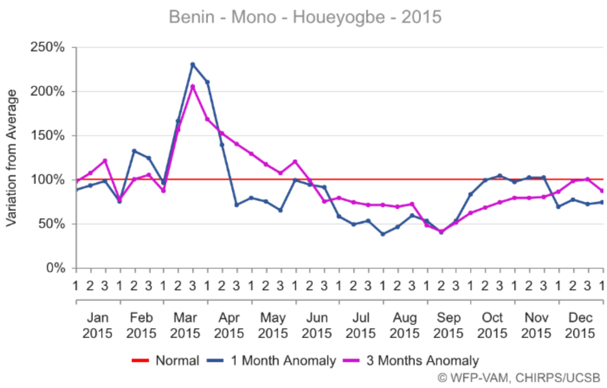

Benin - Mono - Houeyogbe - 2010
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB


Benin - Mono - Houeyogbe - 2011
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

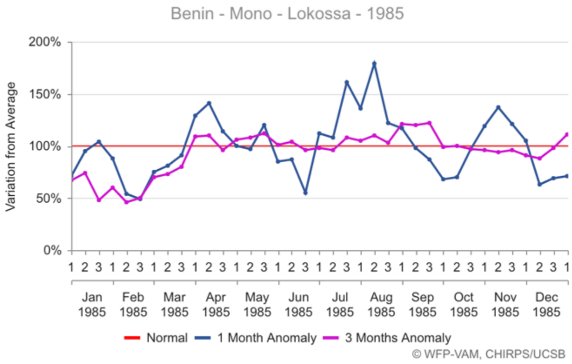

Benin - Mono - Houeyogbe - 2012
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

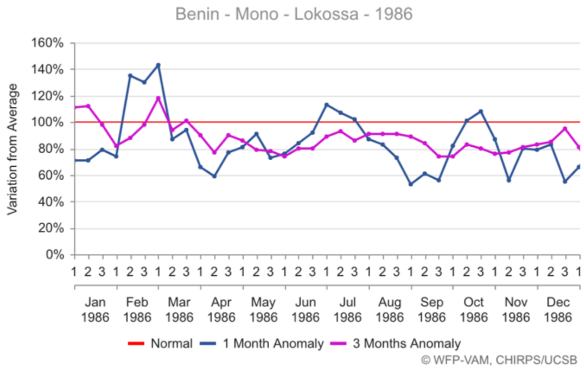

Benin - Mono - Houeyogbe - 2013
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

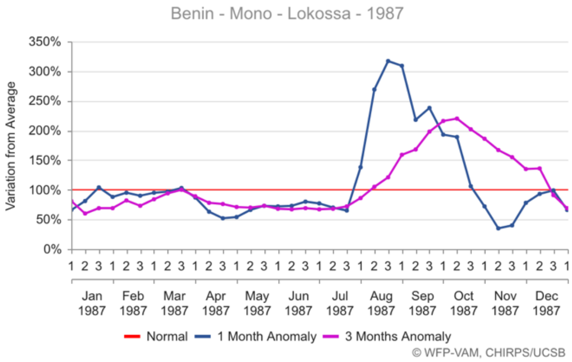

Benin - Mono - Houeyogbe - 2014
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

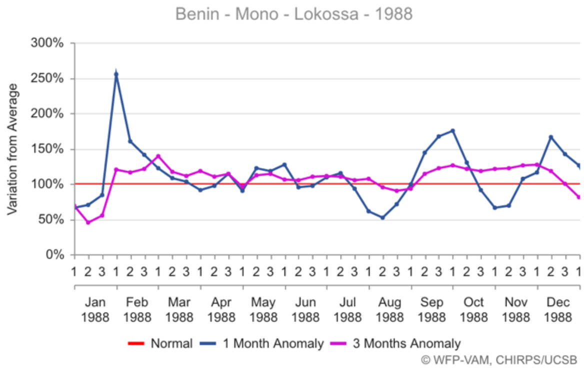

Benin - Mono - Houeyogbe - 2015
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

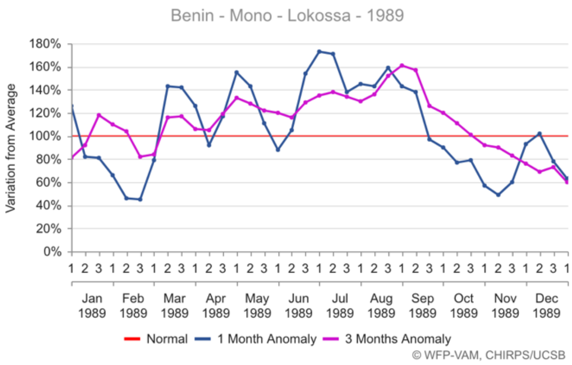
Appendix iv: Rainfall anomalies_Lokossa

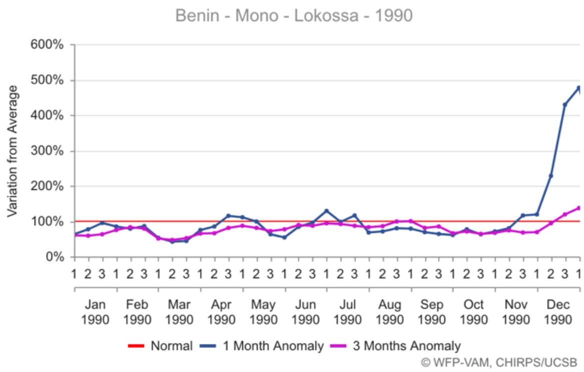


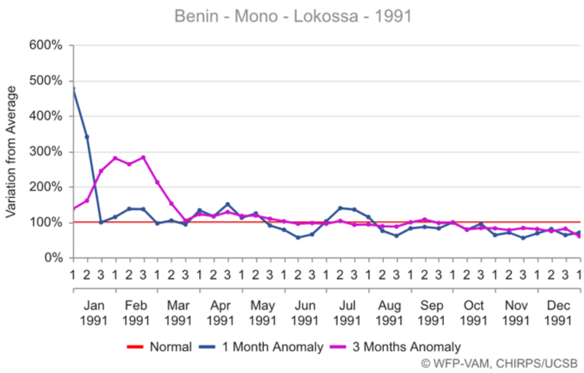


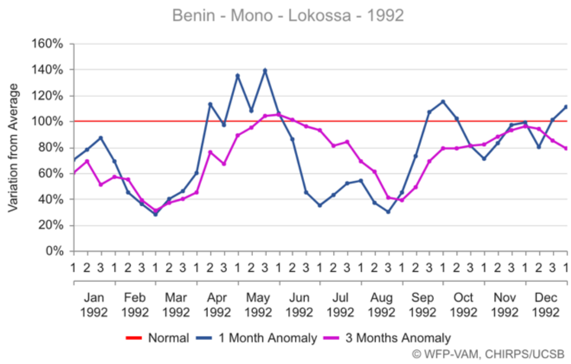


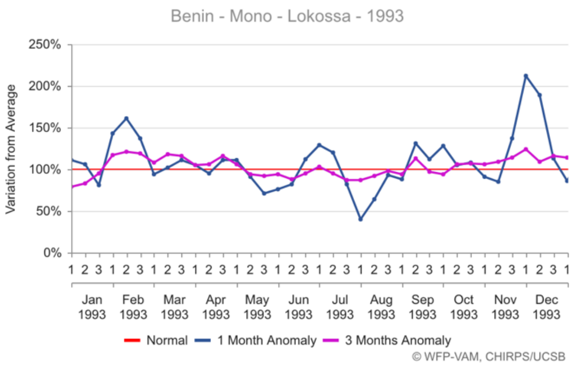


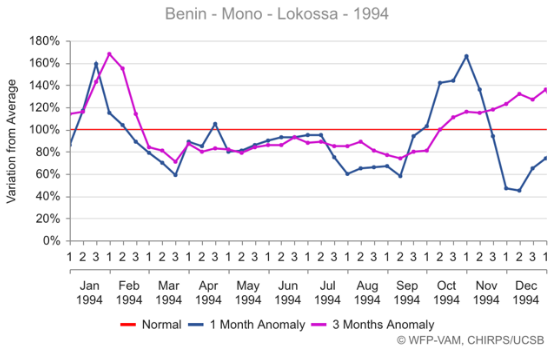


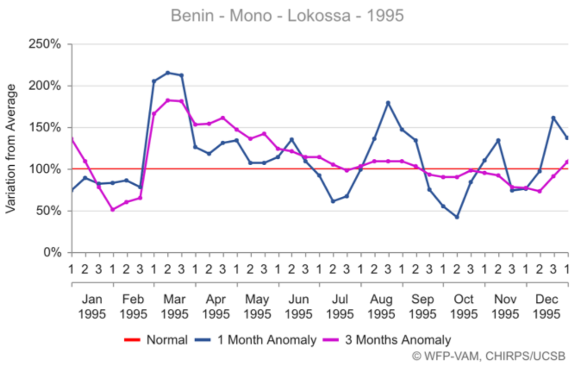


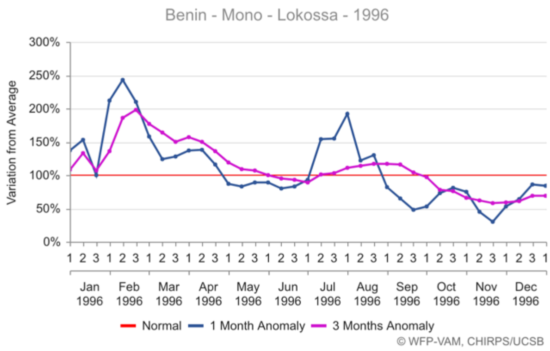


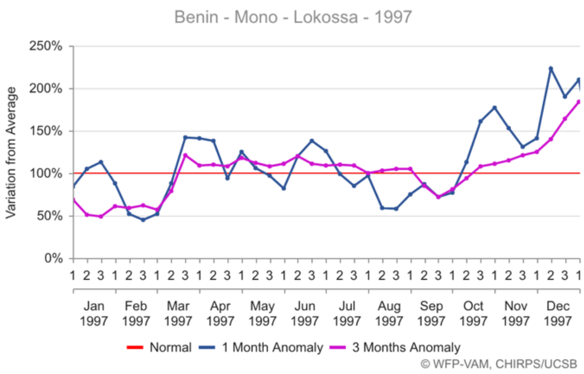


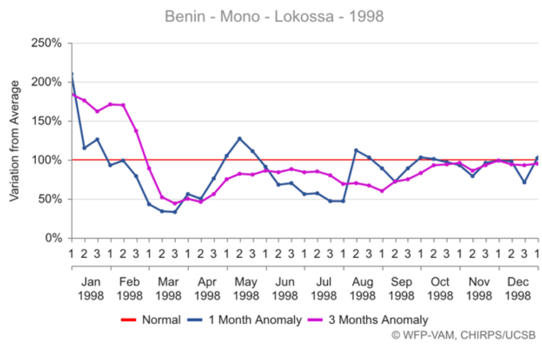

Benin - Mono - Lokossa - 1993
Variation from Average
Jan 1993 Feb 1993 Mar 1993 Apr 1993 May 1993 Jun 1993 Jul 1993 Aug 1993 Sep 1993 Oct 1993 Nov 1993 Dec 1993
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

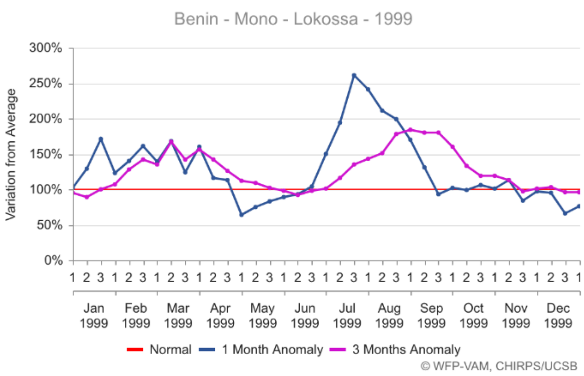

Benin - Mono - Lokossa - 1994
Variation from Average
Jan 1994 Feb 1994 Mar 1994 Apr 1994 May 1994 Jun 1994 Jul 1994 Aug 1994 Sep 1994 Oct 1994 Nov 1994 Dec 1994
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

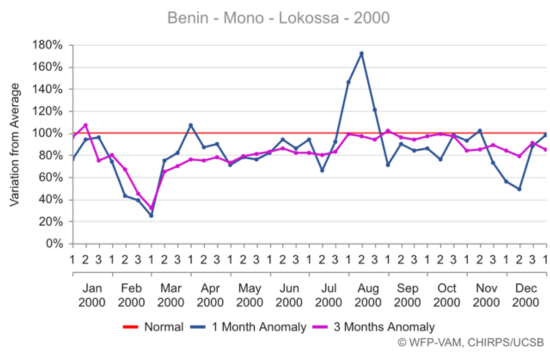

Benin - Mono - Lokossa - 1995
Variation from Average
Jan 1995 Feb 1995 Mar 1995 Apr 1995 May 1995 Jun 1995 Jul 1995 Aug 1995 Sep 1995 Oct 1995 Nov 1995 Dec 1995
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

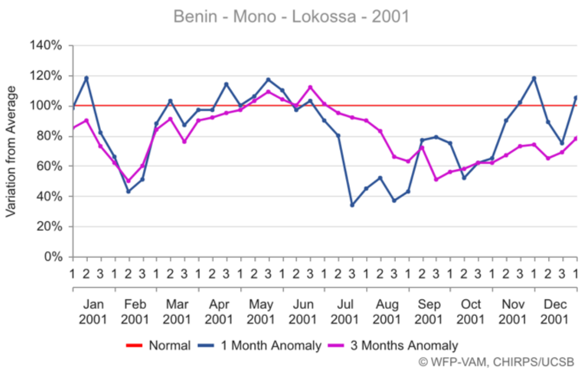

Benin - Mono - Lokossa - 1996
Variation from Average
Jan 1996 Feb 1996 Mar 1996 Apr 1996 May 1996 Jun 1996 Jul 1996 Aug 1996 Sep 1996 Oct 1996 Nov 1996 Dec 1996
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

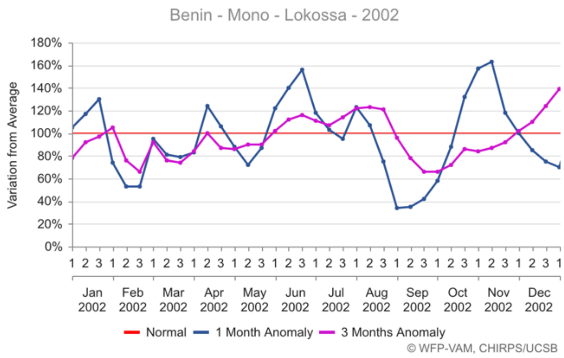

Benin - Mono - Lokossa - 1997
Variation from Average
Jan 1997 Feb 1997 Mar 1997 Apr 1997 May 1997 Jun 1997 Jul 1997 Aug 1997 Sep 1997 Oct 1997 Nov 1997 Dec 1997
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

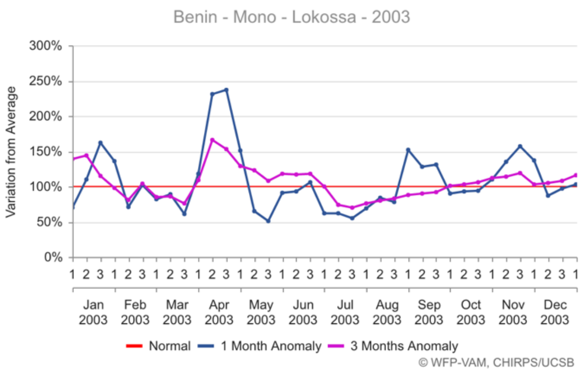

Benin - Mono - Lokossa - 1998
Variation from Average
Jan 1998 Feb 1998 Mar 1998 Apr 1998 May 1998 Jun 1998 Jul 1998 Aug 1998 Sep 1998 Oct 1998 Nov 1998 Dec 1998
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

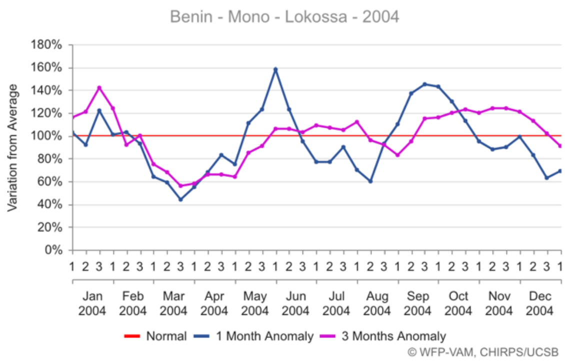

Benin - Mono - Lokossa - 1999
Variation from Average
Jan 1999 Feb 1999 Mar 1999 Apr 1999 May 1999 Jun 1999 Jul 1999 Aug 1999 Sep 1999 Oct 1999 Nov 1999 Dec 1999
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

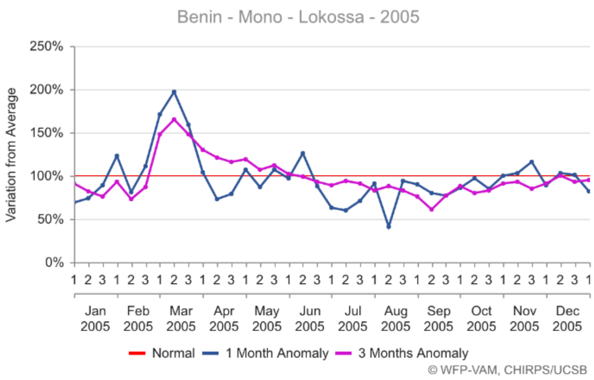

Benin - Mono - Lokossa - 2000
Variation from Average
Jan 2000 Feb 2000 Mar 2000 Apr 2000 May 2000 Jun 2000 Jul 2000 Aug 2000 Sep 2000 Oct 2000 Nov 2000 Dec 2000
Normal 1 Month Anomaly 3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

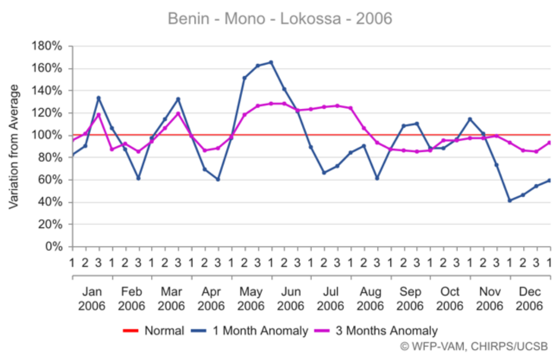

Benin - Mono - Lokossa - 2001
Variation from Average
Jan 2001 Feb 2001 Mar 2001 Apr 2001 May 2001 Jun 2001 Jul 2001 Aug 2001 Sep 2001 Oct 2001 Nov 2001 Dec 2001
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

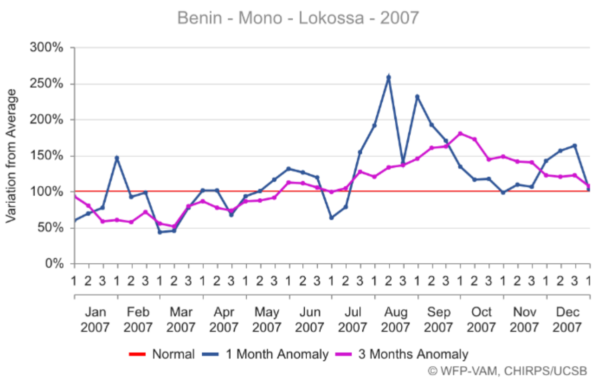

Benin - Mono - Lokossa - 2002
Variation from Average
Jan 2002 Feb 2002 Mar 2002 Apr 2002 May 2002 Jun 2002 Jul 2002 Aug 2002 Sep 2002 Oct 2002 Nov 2002 Dec 2002
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

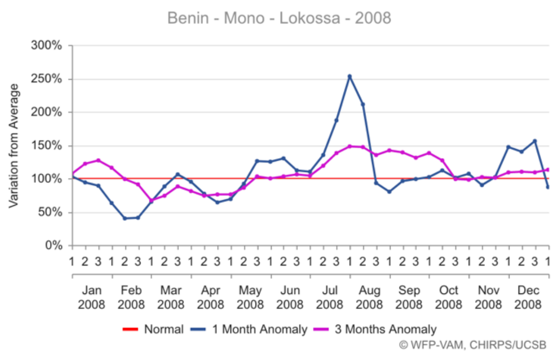

Benin - Mono - Lokossa - 2003
Variation from Average
Jan 2003 Feb 2003 Mar 2003 Apr 2003 May 2003 Jun 2003 Jul 2003 Aug 2003 Sep 2003 Oct 2003 Nov 2003 Dec 2003
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

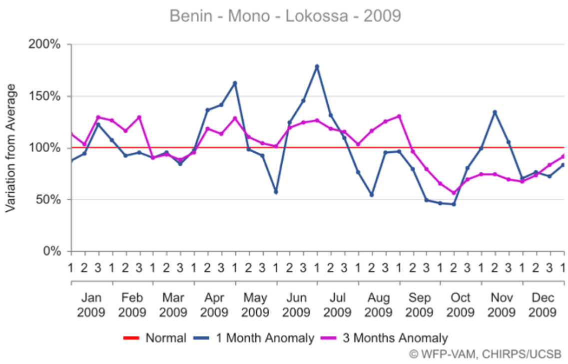

Benin - Mono - Lokossa - 2004
Variation from Average
Jan 2004 Feb 2004 Mar 2004 Apr 2004 May 2004 Jun 2004 Jul 2004 Aug 2004 Sep 2004 Oct 2004 Nov 2004 Dec 2004
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

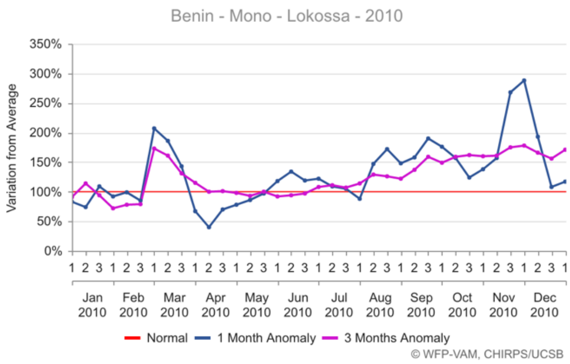

Benin - Mono - Lokossa - 2005
Variation from Average
Jan 2005 Feb 2005 Mar 2005 Apr 2005 May 2005 Jun 2005 Jul 2005 Aug 2005 Sep 2005 Oct 2005 Nov 2005 Dec 2005
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

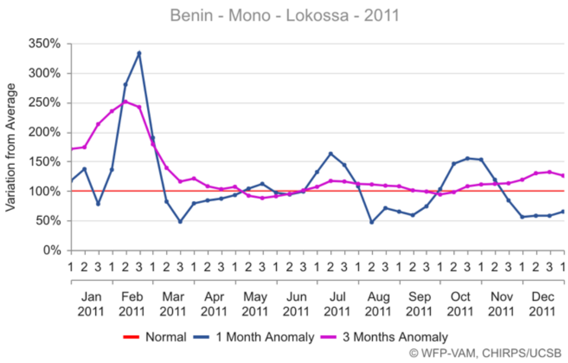

Benin - Mono - Lokossa - 2006
Variation from Average
Jan 2006 Feb 2006 Mar 2006 Apr 2006 May 2006 Jun 2006 Jul 2006 Aug 2006 Sep 2006 Oct 2006 Nov 2006 Dec 2006
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

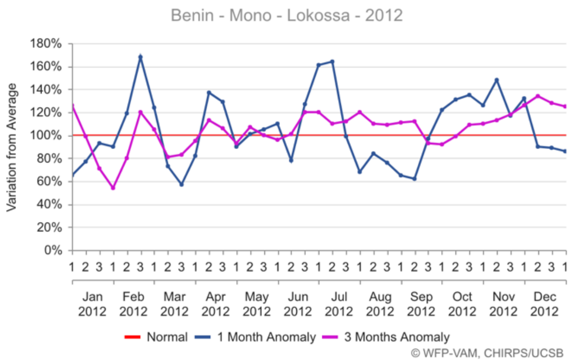

Benin - Mono - Lokossa - 2007
Variation from Average
Jan 2007 Feb 2007 Mar 2007 Apr 2007 May 2007 Jun 2007 Jul 2007 Aug 2007 Sep 2007 Oct 2007 Nov 2007 Dec 2007
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

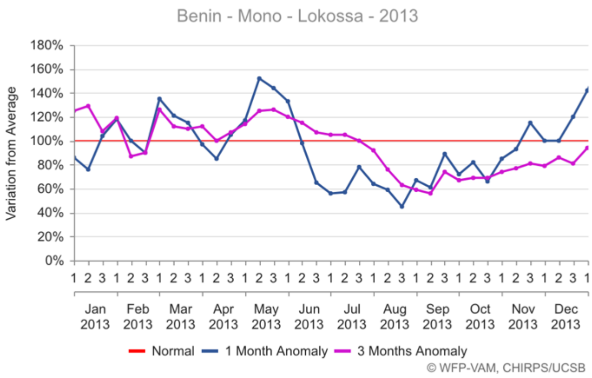

Benin - Mono - Lokossa - 2008
Variation from Average
Jan 2008 Feb 2008 Mar 2008 Apr 2008 May 2008 Jun 2008 Jul 2008 Aug 2008 Sep 2008 Oct 2008 Nov 2008 Dec 2008
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

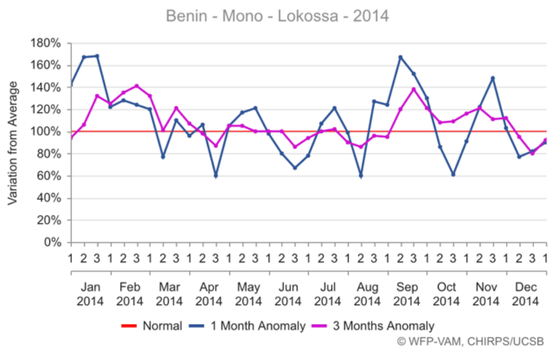

Benin - Mono - Lokossa - 2009
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

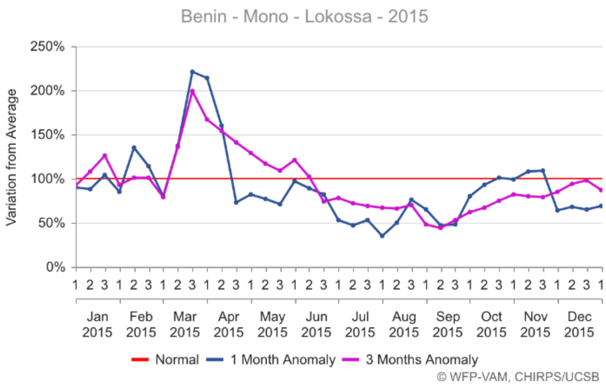

Benin - Mono - Lokossa - 2010
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB


Benin - Mono - Lokossa - 2011
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB


Benin - Mono - Lokossa - 2012
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB


Benin - Mono - Lokossa - 2013
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB


Benin - Mono - Lokossa - 2014
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB


Benin - Mono - Lokossa - 2015
Variation from Average
Normal
1 Month Anomaly
3 Months Anomaly
© WFP-VAM, CHIRPS/UCSB

Appendix v: Meanning of variables

COMCOL	Commune de collecte des donnees
COZ.VAR	Causes of the variations in catch quantities
CZ.CHNG	Likely causes of the changes
DST.LIV	Living district
DURETC	Working time in the workplace
EDUC	Education level
ENGPECHE	Engins de pêche
ETHNY	Ethnicity of the respondent
GENDER	Gender of the respondent
HRC.PST	Hierarchical position in the household
MANIFREQ	Frequent Manifestations
MAR.ST	Marital status
MESURES	The mesures to support the likely crise
MTH.ICM	Monthly income
NBR.CHL	Number of children in household
NDS.SUP	Support the needs of your family
NM.SURN	Nom& prenom (s) de l'enquete
NMSTRU	Structure name's
PROF	Profession
RZN.BCC	Reasons of their presence before
SEC.ACT	Secondary activities
SECTACTS	Secteurs d'activites de la structure
SIT.EVO	Situation evolution at the lac level
SPC.ACC	Species after manifestations
SPC.BCC	Species before manifestations
SPC.CTC	Species caught
SPC.PDS	Species in the ponds
STR.SUP	Public structures support or NGOs
TM.OBS	Time of the observation
YRS.FFM	Year passed in fish farming
YRS.FSH	Year passed in fishing
YRS.PSD	Number of year living in the municipality

Appendix vi: Recap of field variables analyzed with R packages

```
## 'data.frame':    95 obs. of  24 variables:
##  $ HRC.PST: Factor w/ 3 levels "Child contibutor",..: 3 3 3 3 3 3 3 3 3 1 ...
##  $ GENDER : Factor w/ 1 level "Male": 1 1 1 1 1 1 1 1 1 1 ...
##  $ MAR.ST : Factor w/ 4 levels "Divorced","Married",..: 2 2 2 2 2 2 2 2 1 3 ...
##  $ AGE    : int  55 53 65 28 30 30 37 68 65 24 ...
##  $ NBR.CHL: int  3 3 20 NA 4 3 5 10 2 8 ...
##  $ MTH.ICM: Factor w/ 5 levels "0 to 50000","100001 to 150000",..: 4 4 2 4 4 4 1 1 4 1 ...
##  $ ETHNY  : Factor w/ 5 levels "Adja","Fon","Haoussa",..: 3 4 5 5 5 1 1 5 5 4 ...
##  $ EDUC   : Factor w/ 4 levels "Advanced or Ordinary level",..: 3 3 1 1 2 3 3 2 2 1 ...
##  $ PROF   : Factor w/ 9 levels "Artisan","Carpenter",..: 5 5 5 5 1 5 1 5 5 2 ...
##  $ SECACT1: Factor w/ 2 levels "No","Yes": 2 2 2 1 2 2 2 1 1 2 ...
##  $ SECACT2: Factor w/ 6 levels "Breeder","Farmer",..: 2 1 2 NA 3 2 3 NA NA 3 ...
##  $ YRS.PSD: Factor w/ 5 levels "10 et 20 ans",..: 3 3 3 2 1 2 3 3 3 2 ...
##  $ YRS.FSH: Factor w/ 5 levels "10 et 20 ans",..: 3 3 3 1 4 2 2 3 3 1 ...
##  $ CC.KNW : Factor w/ 1 level "Yes": 1 1 1 1 1 1 1 1 1 1 ...
##  $ TM.OBS : int  5 5 30 5 7 12 10 10 10 10 ...
##  $ CC.PER : Factor w/ 3 levels "Every decade",..: 3 3 3 3 3 3 3 3 3 3 ...
##  $ BCC.QT : int  20 20 50 15 25 25 16 30 22 20 ...
##  $ ACC.QT : int  6 6 13 5 5 4 7 15 15 10 ...
##  $ RZN.BCC: Factor w/ 6 levels " Lower population density",..: 3 3 3 3 3 3 3 3 3 3 ...
##  $ COZ.VAR: Factor w/ 2 levels "Increase in water level",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ SIT.EVO: Factor w/ 1 level "Yes": 1 1 1 1 1 1 1 1 1 1 ...
##  $ NDS.SUP: Factor w/ 10 levels "Conversion in artisan",..: 5 5 2 5 5 5 8 5 5 2 ...
##  $ STR.SUP: Factor w/ 1 level "No": 1 1 1 1 1 1 1 1 1 1 ...
##  $ MESURES: Factor w/ 6 levels " ","Change fishing gears",..: 3 4 6 NA 5 NA 5 5 5 6 ...
##  [1] "HRC.PST" "GENDER"  "MAR.ST"  "AGE"     "NBR.CHL" "MTH.ICM" "ETHNY"
##  [8] "EDUC"    "PROF"    "SECACT1" "SECACT2" "YRS.PSD" "YRS.FSH" "CC.KNW"
## [15] "TM.OBS"  "CC.PER"  "BCC.QT"  "ACC.QT"  "RZN.BCC" "COZ.VAR" "SIT.EVO"
## [22] "NDS.SUP" "STR.SUP" "MESURES"
```

Appendix vii: Contingency tables for meeting family needs

- **"ETHNY"**

MT$NDS.SUP

MT$ETHNY	Conversion in artisan	Conversion in breeder	Conversion in designer
Sahoue	0	20	1
Adja	1	6	0
Fon	0	3	0
Haoussa	0	0	0
Kotafon	0	2	0
<NA>	0	0	0

MT$NDS.SUP

MT$ETHNY	Conversion in driver	Conversion in farmer	Conversion in hunter
Sahoue	2	27	1
Adja	0	21	0
Fon	0	1	0
Haoussa	0	1	0
Kotafon	0	7	0
<NA>	0	0	0

MT$NDS.SUP

MT$ETHNY	Conversion in masonry	Conversion in trader	<NA>
Sahoue	0	0	0
Adja	1	1	0
Fon	0	0	0
Haoussa	0	0	0
Kotafon	0	0	0
<NA>	0	0	0

MT$NDS.SUP

MT$ETHNY	Conversion in artisan	Conversion in breeder	Conversion in designer
Sahoue	0.00000000	0.39215686	0.01960784
Adja	0.03333333	0.20000000	0.00000000
Fon	0.00000000	0.75000000	0.00000000
Haoussa	0.00000000	0.00000000	0.00000000
Kotafon	0.00000000	0.22222222	0.00000000
<NA>			

MT$NDS.SUP

MT$ETHNY	Conversion in driver	Conversion in farmer	Conversion in hunter
Sahoue	0.03921569	0.52941176	0.01960784
Adja	0.00000000	0.70000000	0.00000000
Fon	0.00000000	0.25000000	0.00000000
Haoussa	0.00000000	1.00000000	0.00000000
Kotafon	0.00000000	0.77777778	0.00000000
<NA>			

MT$NDS.SUP

MT$ETHNY	Conversion in masonry	Conversion in trader	<NA>
Sahoue	0.00000000	0.00000000	0.00000000
Adja	0.03333333	0.03333333	0.00000000
Fon	0.00000000	0.00000000	0.00000000
Haoussa	0.00000000	0.00000000	0.00000000
Kotafon	0.00000000	0.00000000	0.00000000
<NA>			

- **"AGE"**

MT$NDS.SUP

MT$AGE.B	Conversion in artisan	Conversion in breeder	Conversion in designer
0	1	12	1
1	0	19	0
<NA>	0	0	0

MT$NDS.SUP

```
MT$AGE.B Conversion in driver Conversion in farmer Conversion in hunter
    0                     0                   24                    0
    1                     2                   33                    1
    <NA>                  0                    0                    0
        MT$NDS.SUP
MT$AGE.B Conversion in masonry Conversion in trader <NA>
    0                      0                    0    0
    1                      1                    1    0
    <NA>                   0                    0    0

        MT$NDS.SUP
MT$AGE.B Conversion in artisan Conversion in breeder Conversion in designer
    0                      1                    12                      1
    1                      0                    19                      0
    <NA>                   0                     0                      0
        MT$NDS.SUP
MT$AGE.B Conversion in driver Conversion in farmer Conversion in hunter
    0                     0                   24                    0
    1                     2                   33                    1
    <NA>                  0                    0                    0
        MT$NDS.SUP
MT$AGE.B Conversion in masonry Conversion in trader <NA>
    0                      0                    0    0
    1                      1                    1    0
    <NA>                   0                    0    0
        MT$NDS.SUP
MT$AGE.B Conversion in artisan Conversion in breeder Conversion in designer
    0              0.02631579            0.31578947             0.02631579
    1              0.00000000            0.33333333             0.00000000
    <NA>
        MT$NDS.SUP
MT$AGE.B Conversion in driver Conversion in farmer Conversion in hunter
    0             0.00000000           0.63157895           0.00000000
    1             0.03508772           0.57894737           0.01754386
    <NA>
        MT$NDS.SUP
MT$AGE.B Conversion in masonry Conversion in trader       <NA>
    0              0.00000000           0.00000000 0.00000000
    1              0.01754386           0.01754386 0.00000000
    <NA>
```

- **"EDUC"**

```
                            MT$NDS.SUP
MT$EDUC                      Conversion in artisan Conversion in breeder
  University                                     0                     0
  Advanced or Ordinary level                     1                    10
  Non-literate                                   0                    10
  Primary school                                 0                    11
  <NA>                                           0                     0
                            MT$NDS.SUP
MT$EDUC                      Conversion in designer Conversion in driver
  University                                      0                    0
  Advanced or Ordinary level                      0                    0
  Non-literate                                    0                    1
  Primary school                                  1                    1
  <NA>                                            0                    0
                            MT$NDS.SUP
MT$EDUC                      Conversion in farmer Conversion in hunter
  University                                    2                    0
  Advanced or Ordinary level                   18                    0
  Non-literate                                 14                    0
  Primary school                               23                    1
  <NA>                                          0                    0
```

```
                         MT$NDS.SUP
MT$EDUC                     Conversion in masonry Conversion in trader <NA>
  University                                    0                    0    0
  Advanced or Ordinary level                    0                    1    0
  Non-literate                                  0                    0    0
  Primary school                                1                    0    0
  <NA>                                          0                    0    0

                        MT$NDS.SUP
MT$EDUC                     Conversion in artisan Conversion in breeder
  University                                    0                     0
  Advanced or Ordinary level                    1                    10
  Non-literate                                  0                    10
  Primary school                                0                    11
  <NA>                                          0                     0
                         MT$NDS.SUP
MT$EDUC                     Conversion in designer Conversion in driver
  University                                     0                    0
  Advanced or Ordinary level                     0                    0
  Non-literate                                   0                    1
  Primary school                                 1                    1
  <NA>                                           0                    0
                         MT$NDS.SUP
MT$EDUC                     Conversion in farmer Conversion in hunter
  University                                   2                    0
  Advanced or Ordinary level                  18                    0
  Non-literate                                14                    0
  Primary school                              23                    1
  <NA>                                         0                    0
                         MT$NDS.SUP
MT$EDUC                     Conversion in masonry Conversion in trader <NA>
  University                                    0                    0    0
  Advanced or Ordinary level                    0                    1    0
  Non-literate                                  0                    0    0
  Primary school                                1                    0    0
  <NA>                                          0                    0    0

                         MT$NDS.SUP
MT$EDUC                     Conversion in artisan Conversion in breeder
  University                           0.00000000            0.00000000
  Advanced or Ordinary level           0.03333333            0.33333333
  Non-literate                         0.00000000            0.40000000
  Primary school                       0.00000000            0.28947368
  <NA>
                         MT$NDS.SUP
MT$EDUC                     Conversion in designer Conversion in driver
  University                            0.00000000           0.00000000
  Advanced or Ordinary level            0.00000000           0.00000000
  Non-literate                          0.00000000           0.04000000
  Primary school                        0.02631579           0.02631579
  <NA>
                         MT$NDS.SUP
MT$EDUC                     Conversion in farmer Conversion in hunter
  University                          1.00000000           0.00000000
  Advanced or Ordinary level          0.60000000           0.00000000
  Non-literate                        0.56000000           0.00000000
  Primary school                      0.60526316           0.02631579
  <NA>
                         MT$NDS.SUP
MT$EDUC                     Conversion in masonry Conversion in trader
  University                           0.00000000           0.00000000
  Advanced or Ordinary level           0.00000000           0.03333333
  Non-literate                         0.00000000           0.00000000
  Primary school                       0.02631579           0.00000000
```

```
  <NA>
                            MT$NDS.SUP
MT$EDUC                              <NA>
  University                   0.00000000
  Advanced or Ordinary level 0.00000000
  Non-literate                 0.00000000
  Primary school               0.00000000
  <NA>
```

- **"PROF"**

```
                                  MT$NDS.SUP
MT$PROF           Conversion in artisan Conversion in breeder
  Fisherman                           0                    16
  Artisan                             1                     7
  Carpenter                           0                     1
  Cook                                0                     0
  Farmer                              0                     2
  P.Worker                            0                     2
  Student                             0                     2
  Taxi driver                         0                     0
  Tradi.Med.Pract                     0                     1
  <NA>                                0                     0
                 MT$NDS.SUP
MT$PROF           Conversion in designer Conversion in driver
  Fisherman                            0                    0
  Artisan                              1                    1
  Carpenter                            0                    0
  Cook                                 0                    0
  Farmer                               0                    0
  P.Worker                             0                    0
  Student                              0                    0
  Taxi driver                          0                    1
  Tradi.Med.Pract                      0                    0
  <NA>                                 0                    0
                 MT$NDS.SUP
MT$PROF           Conversion in farmer Conversion in hunter
  Fisherman                         42                    1
  Artisan                            1                    0
  Carpenter                          1                    0
  Cook                               1                    0
  Farmer                             9                    0
  P.Worker                           0                    0
  Student                            0                    0
  Taxi driver                        3                    0
  Tradi.Med.Pract                    0                    0
  <NA>                               0                    0
                 MT$NDS.SUP
MT$PROF           Conversion in masonry Conversion in trader <NA>
  Fisherman                           0                    1    0
  Artisan                             1                    0    0
  Carpenter                           0                    0    0
  Cook                                0                    0    0
  Farmer                              0                    0    0
  P.Worker                            0                    0    0
  Student                             0                    0    0
  Taxi driver                         0                    0    0
  Tradi.Med.Pract                     0                    0    0
  <NA>                                0                    0    0
                 MT$NDS.SUP
MT$PROF           Conversion in artisan Conversion in breeder
  Fisherman                  0.00000000            0.26666667
  Artisan                    0.08333333            0.58333333
  Carpenter                  0.00000000            0.50000000
```

```
  Cook                     0.00000000            0.00000000
  Farmer                   0.00000000            0.18181818
  P.Worker                 0.00000000            1.00000000
  Student                  0.00000000            1.00000000
  Taxi driver              0.00000000            0.00000000
  Tradi.Med.Pract          0.00000000            1.00000000
  <NA>
               MT$NDS.SUP
MT$PROF          Conversion in designer Conversion in driver
  Fisherman                 0.00000000           0.00000000
  Artisan                   0.08333333           0.08333333
  Carpenter                 0.00000000           0.00000000
  Cook                      0.00000000           0.00000000
  Farmer                    0.00000000           0.00000000
  P.Worker                  0.00000000           0.00000000
  Student                   0.00000000           0.00000000
  Taxi driver               0.00000000           0.25000000
  Tradi.Med.Pract           0.00000000           0.00000000
  <NA>
               MT$NDS.SUP
MT$PROF          Conversion in farmer Conversion in hunter
  Fisherman               0.70000000           0.01666667
  Artisan                 0.08333333           0.00000000
  Carpenter               0.50000000           0.00000000
  Cook                    1.00000000           0.00000000
  Farmer                  0.81818182           0.00000000
  P.Worker                0.00000000           0.00000000
  Student                 0.00000000           0.00000000
  Taxi driver             0.75000000           0.00000000
  Tradi.Med.Pract         0.00000000           0.00000000
  <NA>
               MT$NDS.SUP
MT$PROF          Conversion in masonry Conversion in trader       <NA>
  Fisherman                0.00000000           0.01666667 0.00000000
  Artisan                  0.08333333           0.00000000 0.00000000
  Carpenter                0.00000000           0.00000000 0.00000000
  Cook                     0.00000000           0.00000000 0.00000000
  Farmer                   0.00000000           0.00000000 0.00000000
  P.Worker                 0.00000000           0.00000000 0.00000000
  Student                  0.00000000           0.00000000 0.00000000
  Taxi driver              0.00000000           0.00000000 0.00000000
  Tradi.Med.Pract          0.00000000           0.00000000 0.00000000
  <NA>
```

- **"YRS.FSH"**

```
          MT$NDS.SUP
MT$YRS.FSH.B Conversion in artisan Conversion in breeder Conversion in designer
        0                       1                    20                      1
        1                       0                    11                      0
        <NA>                    0                     0                      0
           MT$NDS.SUP
MT$YRS.FSH.B Conversion in driver Conversion in farmer Conversion in hunter
        0                      1                   32                    0
        1                      1                   25                    1
        <NA>                   0                    0                    0
           MT$NDS.SUP
MT$YRS.FSH.B Conversion in masonry Conversion in trader <NA>
        0                       1                    1    0
        1                       0                    0    0
        <NA>                    0                    0    0
           MT$NDS.SUP
MT$YRS.FSH.B Conversion in artisan Conversion in breeder Conversion in designer
        0              0.01754386            0.35087719             0.01754386
```

```
       1              0.00000000           0.28947368            0.00000000
       <NA>
           MT$NDS.SUP
MT$YRS.FSH.B Conversion in driver Conversion in farmer Conversion in hunter
       0             0.01754386           0.56140351           0.00000000
       1             0.02631579           0.65789474           0.02631579
       <NA>
           MT$NDS.SUP
MT$YRS.FSH.B Conversion in masonry Conversion in trader       <NA>
       0              0.01754386           0.01754386 0.00000000
       1              0.00000000           0.00000000 0.00000000
       <NA>
```

Appendix viii: Contingency tables for measures proposed

- **"ETHNY"**

```
                 MT$MESURES
MT$ETHNY  Change fishing gears Prayer  Ritual practices Ritual practices
  Sahoue                    13      0                1               12
  Adja                      16      2                0                6
  Fon                        0      0                0                1
  Haoussa                    0      1                0                0
  Kotafon                    3      1                2                1
  <NA>                       0      0                0                0
        MT$MESURES
MT$ETHNY  Suggest fish farming  <NA>
  Sahoue                    25    0
  Adja                       6    0
  Fon                        3    0
  Haoussa                    0    0
  Kotafon                    2    0
  <NA>                       0    0
        MT$MESURES
MT$ETHNY  Change fishing gears    Prayer  Ritual practices Ritual practices
  Sahoue            0.25490196 0.00000000       0.01960784       0.23529412
  Adja              0.53333333 0.06666667       0.00000000       0.20000000
  Fon               0.00000000 0.00000000       0.00000000       0.25000000
  Haoussa           0.00000000 1.00000000       0.00000000       0.00000000
  Kotafon           0.33333333 0.11111111       0.22222222       0.11111111
  <NA>
        MT$MESURES
MT$ETHNY  Suggest fish farming       <NA>
  Sahoue            0.49019608 0.00000000
  Adja              0.20000000 0.00000000
  Fon               0.75000000 0.00000000
  Haoussa           0.00000000 0.00000000
  Kotafon           0.22222222 0.00000000
  <NA>
```

- **"AGE"**

```
              MT$MESURES
MT$AGE.B Change fishing gears Prayer  Ritual practices Ritual practices
    0                      20      1                0                3
    1                      12      3                3               17
    <NA>                    0      0                0                0
       MT$MESURES
MT$AGE.B Suggest fish farming  <NA>
    0                      14    0
    1                      22    0
    <NA>                    0    0
```

```
        MT$MESURES
MT$AGE.B Change fishing gears    Prayer  Ritual practices Ritual practices
    0              0.52631579 0.02631579       0.00000000        0.07894737
    1              0.21052632 0.05263158       0.05263158        0.29824561
    <NA>
        MT$MESURES
MT$AGE.B Suggest fish farming        <NA>
    0               0.36842105 0.00000000
    1               0.38596491 0.00000000
    <NA>
```

- **“EDUC”**

```
                           MT$MESURES
MT$EDUC                      Change fishing gears Prayer  Ritual practices
  University                                    1      0                 0
  Advanced or Ordinary level                   12      1                 0
  Non-literate                                  6      0                 1
  Primary school                               13      3                 2
  <NA>                                          0      0                 0
                            MT$MESURES
MT$EDUC                      Ritual practices  Suggest fish farming  <NA>
  University                                0                     1    0
  Advanced or Ordinary level                5                    12    0
  Non-literate                              8                    10    0
  Primary school                            7                    13    0
  <NA>                                      0                     0    0
                            MT$MESURES
MT$EDUC                      Change fishing gears    Prayer  Ritual practices
  University                          0.50000000 0.00000000       0.00000000
  Advanced or Ordinary level          0.40000000 0.03333333       0.00000000
  Non-literate                        0.24000000 0.00000000       0.04000000
  Primary school                      0.34210526 0.07894737       0.05263158
  <NA>
                            MT$MESURES
MT$EDUC                      Ritual practices  Suggest fish farming       <NA>
  University                       0.00000000            0.50000000 0.00000000
  Advanced or Ordinary level       0.16666667            0.40000000 0.00000000
  Non-literate                     0.32000000            0.40000000 0.00000000
  Primary school                   0.18421053            0.34210526 0.00000000
  <NA>
```

- **“PROF”**

```
                 MT$MESURES
MT$PROF           Change fishing gears Prayer  Ritual practices
  Fisherman                         23      4                 3
  Artisan                            2      0                 0
  Carpenter                          0      0                 0
  Cook                               0      0                 0
  Farmer                             5      0                 0
  P.Worker                           0      0                 0
  Student                            1      0                 0
  Taxi driver                        1      0                 0
  Tradi.Med.Pract                    0      0                 0
  <NA>                               0      0                 0
                 MT$MESURES
MT$PROF           Ritual practices  Suggest fish farming  <NA>
  Fisherman                     10                    20    0
  Artisan                        3                     7    0
  Carpenter                      1                     1    0
  Cook                           0                     1    0
  Farmer                         2                     4    0
```

```
  P.Worker                0                     2    0
  Student                 0                     1    0
  Taxi driver             3                     0    0
  Tradi.Med.Pract         1                     0    0
  <NA>                    0                     0    0
                MT$MESURES
MT$PROF          Change fishing gears    Prayer  Ritual practices
  Fisherman                0.38333333 0.06666667       0.05000000
  Artisan                  0.16666667 0.00000000       0.00000000
  Carpenter                0.00000000 0.00000000       0.00000000
  Cook                     0.00000000 0.00000000       0.00000000
  Farmer                   0.45454545 0.00000000       0.00000000
  P.Worker                 0.00000000 0.00000000       0.00000000
  Student                  0.50000000 0.00000000       0.00000000
  Taxi driver              0.25000000 0.00000000       0.00000000
  Tradi.Med.Pract          0.00000000 0.00000000       0.00000000
  <NA>
                MT$MESURES
MT$PROF          Ritual practices  Suggest fish farming        <NA>
  Fisherman            0.16666667            0.33333333 0.00000000
  Artisan              0.25000000            0.58333333 0.00000000
  Carpenter            0.50000000            0.50000000 0.00000000
  Cook                 0.00000000            1.00000000 0.00000000
  Farmer               0.18181818            0.36363636 0.00000000
  P.Worker             0.00000000            1.00000000 0.00000000
  Student              0.00000000            0.50000000 0.00000000
  Taxi driver          0.75000000            0.00000000 0.00000000
  Tradi.Med.Pract      1.00000000            0.00000000 0.00000000
  <NA>
```

- **"YRS.FSH"**

```
                       MT$MESURES
MT$YRS.FSH.B Change fishing gears Prayer  Ritual practices Ritual practices
        0                     25      1                0                8
        1                      7      3                3               12
        <NA>                   0      0                0                0
            MT$MESURES
MT$YRS.FSH.B Suggest fish farming  <NA>
        0                     23    0
        1                     13    0
        <NA>                   0    0
            MT$MESURES
MT$YRS.FSH.B Change fishing gears    Prayer  Ritual practices Ritual practices
        0              0.43859649 0.01754386       0.00000000       0.14035088
        1              0.18421053 0.07894737       0.07894737       0.31578947
        <NA>
            MT$MESURES
MT$YRS.FSH.B Suggest fish farming        <NA>
        0               0.40350877 0.00000000
        1               0.34210526 0.00000000
        <NA>
```

Appendix ix: Questionnaire for fishermen & fish farmers (EN)

Appendix x: Questionnaire for fishermen & Fish farmers (FR)

Questionnare adresse aux Pecheurs_Pisciculteurs

Avril 2020 - PAUWES_WASCAL

Ce questionnaire est concu dans le cadre de la redaction d'un memoire de Master en Gouvernance des ressources en Eau en Afrique. Le theme de la presente etude est intitule 'Impacts des changements climatiques sur les rendements de la peche et de la pisciculture dans le bassin du Mono: cas du lac Toho. Elle a pour objet de collecter des donnees sociodemographiques, economiques ainsi les perceptions des acteurs du sous secteur.

Section 0: Identification

L'enqueteur a le devoir de decliner son identite

1. Quels sont vos nom et prenom(s) (enqueteur)?

La réponse est obligatoire.

2. Quel est votre numero de telephone?

Au cas ou l'enquete n'a pas de numero entrer le chiffre "999"

3. Date de l'interview

La réponse est obligatoire.

4. Heure de debut de l'interview

La réponse est obligatoire.

5. Preciser la Commune de collecte des donnees?

☐ 1. Athieme ☐ 2. Houyogbe ☐ 3. Lokossa ☐ 4. Autre

La réponse est obligatoire.
Terminer le questionnaire si COMCOL = "Autre"

Section 1: Profil socio-economique

6. Quels sont vos nom et prénom(s)?

La réponse est obligatoire.

7. Quel est votre age?

La réponse doit être comprise entre 20 et 99.

8. Quel est votre sexe?

☐ 1. Masculin ☐ 2. Feminin

Par observation directe

9. Quelle est votre situation matrimoniale?

☐ 1. Celibataire ☐ 2. Marie(e) ☐ 3. Divorce(e) ☐ 4. Veuf(ve) ☐ 5. Autre

La réponse est obligatoire.

10. Si 'Autre', précisez :

11. Quelle est votre ethnie?

La réponse est obligatoire.

12. Quel est votre niveau d'instruction?

☐ 1. Universite ☐ 2. Secondaire ou Lycee ☐ 3. Primaire ☐ 4. Alphabetise(e) ☐ 5. Non alphabetise(e) ☐ 6. Autre

La réponse est obligatoire.

13. Si 'Autre', précisez :

14. Quelle est votre profession?

☐ 1. Agriculteur ☐ 2. Pecheur ☐ 3. Eleveur ☐ 4. Commercant ☐ 5. Chasseur ☐ 6. Artisan
☐ 7. Fonctionnaire ☐ 8. Autre

La réponse est obligatoire.
Terminer le questionnaire si PROF # "Pecheur" ou PROF # "Eleveur" et ACTSEC1 = "Non"

15. Si 'Autre', précisez :

16. Faites-vous des activites secondaires?

☐ 1. Oui ☐ 2. Non

La réponse est obligatoire.

17. Pouvez-vous nous preciser la/les quelle(s)?

☐ 1. Agriculture ☐ 2. Peche ☐ 3. Elevage ☐ 4. Commerce ☐ 5. Chasse ☐ 6. Artisan
☐ 7. Fonctionnaire ☐ 8. Autre

Vous pouvez cocher plusieurs cases (3 au maximum).
La réponse est obligatoire.
Terminer le questionnaire si ACTSEC2 # "Peche" ou ACTSEC2 # "Elevage"

18. Activites elevage a preciser

☐ 1. Pisciculture ☐ 2. Autre

Lorsque l'enquete choisit la modalite de reponse "Elevage" avoir la presence de lui demander s'il fait de la pisciculture au niveau de cette collecte de reponse

19. Quelle(s) espece(s) elevez-vous dans vos etangs?

La question n'est pertinente que si ELVPISC = "Pisciculture"

20. Quelle(s) sont la/les espece(s) fréquentes dans vos prises?

La question n'est pertinente que si PROF = "Pecheur" ou ACTSEC2 = "Peche"

21. Dans quel arrondissement demeurez-vous?

La réponse est obligatoire.

22. Position hierachique dans le menage

☐ 1. Mari chef menage ☐ 2. Femme chef menage ☐ 3. Femme au foyer ☐ 4. Enfant en charge
☐ 5. Enfant contributeur ☐ 6. Autre

La réponse est obligatoire.

23. Si 'Autre', précisez :

24. Nombre d'enfant dans le menage

La réponse est obligatoire.

25. Revenu mensuel de l'enquete

☐ 1. 0 a 50000 ☐ 2. 50001 a 100000 ☐ 3. 100001 a 150000 ☐ 4. 150001 a 200000 ☐ 5. Plus de 200000

Section 2: Etude des mutations climatiques le long du lac

26. Depuis combien de temps residez-vous dans la commune?

☐ 1. Moins de 5 ans ☐ 2. 5 a 10 ans ☐ 3. 10 et 20 ans ☐ 4. 20 a 30 ans ☐ 5. 30 et plus

La réponse est obligatoire.

27. Depuis combien de temps pratiquez-vous la peche?

☐ 1. Moins de 5 ans ☐ 2. 5 a 10 ans ☐ 3. 10 et 20 ans ☐ 4. 20 a 30 ans ☐ 5. 30 et plus

La réponse est obligatoire.

28. Depuis combien de temps pratiquez-vous la pisciculture?

☐ 1. Moins de 5 ans ☐ 2. 5 a 10 ans ☐ 3. 10 et 20 ans ☐ 4. 20 a 30 ans ☐ 5. 30 et plus

La réponse est obligatoire.

29. Avez-vous connaissance des changements climatiques?

☐ 1. Oui ☐ 2. Non

La réponse est obligatoire.

30. Quelles sont les manifestations des changements climatiques dont vous avez connaissance?

☐ 1. Pluies irregulieres ☐ 2. Pluies abondantes(inondations) ☐ 3. Pluies insuffisantes
☐ 4. Pluies tardives ☐ 5. Arrets précoces des pluies ☐ 6. Temperatures plus elevees
☐ 7. Temperatures plus basses ☐ 8. Harmattan plus intense ☐ 9. Harmattan moins intense
☐ 10. secheresse ☐ 11. Autres

Laisser l'enquete faire des propositions de reponses puis lui faire des suggestions afin de completer la liste.

31. Si 'Autres', précisez :

32. Quelles sont les manifestations des changements climatiques dont vous avez connaissance?

☐ 1. Pluies irregulieres ☐ 2. Pluies abondantes(inondations) ☐ 3. Pluies insuffisantes
☐ 4. Pluies tardives ☐ 5. Arrets précoces des pluies ☐ 6. Temperatures plus elevees
☐ 7. Temperatures plus basses ☐ 8. Harmattan plus intense ☐ 9. Harmattan moins intense
☐ 10. secheresse ☐ 11. Autre

Laisser l'enquete faire des propositions de reponses puis lui faire des suggestions afin de completer la liste.

33. Si 'Autre', précisez :

34. Depuis quand observez-vous ces changements?

La réponse est obligatoire.

35. Quelle est leur periodicite?

☐ 1. Chaque saison ☐ 2. Chaque annee ☐ 3. Chaque decennie ☐ 4. Tous les 30 ans

La réponse est obligatoire.

36. Autre precision sur la periodicite des changements.

37. Quelles sont les causes probables de ces changements?

☐ 1. Colere des dieux ☐ 2. Deforestations ☐ 3. Emission des gaz dans l'atmosphere
☐ 4. Cycle naturel du climat ☐ 5. Autre

Vous pouvez cocher plusieurs cases.
La réponse est obligatoire.

38. Si 'Autre', précisez :

Section 3: Etude des impacts sur les communautes de pecheurs le long du lac

39. Avant que vous ne ressentiez les manifestations precedemment enumerees, quelles etaient les quantites de vos prises ? (Kg)

La réponse est obligatoire.

40. Quelles sont les especes que vous retrouviez dans vos prises avant les manifestations de changement du climat

La réponse est obligatoire.

41. Pouvez-vous nous donner des raisons pour lesquelles ces especes etaient frequentes dans vos prises?

La réponse est obligatoire.

42. Apres que vous ayez ressentis les manifestations precedemment enumerees, quelles etaient les quantites de vos prises? (Kg)

La réponse est obligatoire.

43. Quelles sont les especes que vous retrouviez dans vos prises apres les manifestations de changement du climat

Expliquer l'etat actuel des prises

44. Quelles seraient les causes des probables variations dans les quantites de prises?

- ☐ 1. Baisse du niveau de l'eau
- ☐ 2. Augmentation du niveau de l'eau
- ☐ 3. Baisse du niveau de la temperature de l'eau
- ☐ 4. Augmentation de la temperature de l'eau
- ☐ 5. Autre

Vous pouvez cocher plusieurs cases (3 au maximum).
La réponse est obligatoire.

45. Si 'Autre', précisez :

46. Pensez-vous que la situation actuel va continuer de s'aggraver?

☐ 1. Oui ☐ 2. Non

La réponse est obligatoire.

47. Si Non; Pourquoi?

48. Si oui; Comment allez-vous faire pour subvenir a vos besoins et celle de votre famille?

La réponse est obligatoire.

49. Dans le secteur de la peche et de la pisciculture, beneficiez-vous de l'accompagnement des structures etatiques ou des ONGs; etc?

☐ 1. Oui ☐ 2. Non

La réponse est obligatoire.

50. Si 'Oui', précisez :

51. Quelles sont les mesures que vous prenez pour faire face a la situation de changement du climat?

La réponse est obligatoire.

Section finale

52. Numero de telephone de l'enquete

Au cas ou l'enquete n'a pas de numero entrer le chiffre "999"

53. Heure de cloture de l'interview

La réponse est obligatoire.

Questionnare adresse aux Pecheurs_Pisciculteurs

Avril 2020 - PAUWES_WASCAL

Cette questionnaire est concu dans le cadre de la redaction d'un memoire de Master en Gouvernance des ressources en Eau en Afrique. Le theme de la presente etude est intitule 'Impacts des changements climatiques sur les rendements de la peche et de la pisciculture dans le bassin du Mono: cas du lac Toho. Elle a pour objet de collecter des donnees sociodemographiques, economiques ainsi les perceptions des acteurs du sous secteur.

Section 0: Identification

L'enqueteur a le devoir de decliner son identite

1. Quels sont vos nom et prenom(s) (enqueteur)?

La réponse est obligatoire.

2. Quel est votre numero de telephone?

Au cas ou l'enquete n'a pas de numero entrer le chiffre "999"

3. Date de l'interview

La réponse est obligatoire.

4. Heure de debut de l'interview

La réponse est obligatoire.

5. Preciser la Commune de collecte des donnees?

☐ 1. Athieme ☐ 2. Houyogbe ☐ 3. Lokossa ☐ 4. Autre

La réponse est obligatoire.
Terminer le questionnaire si COMCOL = "Autre"

Section 1: Profil de l'enquete

6. Quelle est le nom de votre structure?

La réponse est obligatoire.

7. Quels sont vos nom et prenom(s) (enquete)?

La réponse est obligatoire.

8. Position hierachique dans le menage

La réponse est obligatoire.

9. Depuis combien de temps travaillez-vous dans la commune?

☐ 1. Moins de 5 ans ☐ 2. 5 a 10 ans ☐ 3. 10 et 20 ans ☐ 4. 20 a 30 ans ☐ 5. 30 et plus

La réponse est obligatoire.

10. Quelles sont les secteurs d'activites de votre structure?

☐ 1. Peche ☐ 2. Pisciculture ☐ 3. Autre

Vous pouvez cocher plusieurs cases.
La réponse est obligatoire.

11. Si 'Autre', précisez :

12. Depuis combien de temps la structure exerce t-elle dans le secteur?

☐ 1. Moins de 5 ans ☐ 2. 5 a 10 ans ☐ 3. 10 et 20 ans ☐ 4. 20 a 30 ans ☐ 5. 30 et plus

La réponse est obligatoire.

13. Quelle(s) sont la/les espece(s) fréquentes dans vos prises?

14. Dans quel arrondissement demeurez-vous?

La réponse est obligatoire.

Section 2: Etude des mutations climatiques le long du lac

15. Avez-vous connaissance des changements climatiques?

☐ 1. Oui ☐ 2. Non

La réponse est obligatoire.

16. Quelles sont les manifestations des changements climatiques dont vous avez connaissance?

☐ 1. Pluies irregulieres ☐ 2. Pluies abondantes(inondations) ☐ 3. Pluies insuffisantes
☐ 4. Pluies tardives ☐ 5. Arrets précoces des pluies ☐ 6. Temperatures plus elevees
☐ 7. Temperatures plus basses ☐ 8. Harmattan plus intense ☐ 9. Harmattan moins intense
☐ 10. secheresse ☐ 11. Autres

Laisser l'enquete faire des propositions de reponses puis lui faire des suggestions afin de completer la liste.

17. Si 'Autres', précisez :

18. Quelles sont les manifestations des changements climatiques dont vous avez connaissance?

☐ 1. Pluies irregulieres ☐ 2. Pluies abondantes(inondations) ☐ 3. Pluies insuffisantes
☐ 4. Pluies tardives ☐ 5. Arrets précoces des pluies ☐ 6. Temperatures plus elevees
☐ 7. Temperatures plus basses ☐ 8. Harmattan plus intense ☐ 9. Harmattan moins intense
☐ 10. secheresse ☐ 11. Autre

Laisser l'enquete faire des propositions de reponses puis lui faire des suggestions afin de completer la liste.

19. Si 'Autre', précisez :

20. Depuis quand observez-vous ces changements?

La réponse est obligatoire.

21. Quelle est leur periodicite?

☐ 1. Chaque saison ☐ 2. Chaque annee ☐ 3. Chaque decennie ☐ 4. Tous les 30 ans

La réponse est obligatoire.

22. Autre precision sur la periodicite des changements.

23. Quelles sont les causes probables de ces changements?

☐ 1. Colere des dieux ☐ 2. Deforestations ☐ 3. Emission des gaz dans l'atmosphere
☐ 4. Cycle naturel du climat ☐ 5. Autre

Vous pouvez cocher plusieurs cases.
La réponse est obligatoire.

24. Si 'Autre', précisez :

Section 3: Etude des impacts sur les communautes de pecheurs le long du lac

25. Avant que vous ne ressentiez les manifestations precedemment enumerees, quelles etaient les quantites des prises ? (Kg)

La réponse est obligatoire.

26. Quelles sont les especes que vous retrouviez dans les prises avant les manifestations de changement du climat

La réponse est obligatoire.

27. Pouvez-vous nous donner des raisons pour lesquelles ces especes etaient frequentes dans vos prises?

La réponse est obligatoire.

28. Apres que vous ayez ressentis les manifestations precedemment enumerees, quelles etaient les quantites de vos prises? (Kg)

La réponse est obligatoire.

29. Quelles sont les especes que vous retrouviez dans vos prises apres les manifestations de changement du climat

Expliquer l'etat actuel des prises

30. Quelles seraient les causes des probables variations dans les quantites de prises?

- ☐ 1. Baisse du niveau de l'eau
- ☐ 2. Augmentation du niveau de l'eau
- ☐ 3. Baisse du niveau de la temperature de l'eau
- ☐ 4. Augmentation de la temperature de l'eau
- ☐ 5. Autre

Vous pouvez cocher plusieurs cases (3 au maximum).
La réponse est obligatoire.

31. Si 'Autre', précisez :

32. Pensez-vous que la situation actuel va continuer de s'aggraver?

☐ 1. Oui ☐ 2. Non

La réponse est obligatoire.

33. Si Non; Pourquoi?

34. Si oui; Comment allez-vous faire pour subvenir a vos besoins et celle de votre famille?

La réponse est obligatoire.

35. Dans le secteur de la peche et de la pisciculture, les communautes pratiquantes beneficient elle de l'accompagnement de votre structures etatiques ou des ONGs; etc?

☐ 1. Oui ☐ 2. Non

La réponse est obligatoire.

36. Si 'Oui', précisez :

37. Quelles sont les mesures que vous prenez pour faire face a la situation de changement du climat?

La réponse est obligatoire.

Section finale

38. Numero de telephone de l'enquete

Au cas ou l'enquete n'a pas de numero entrer le chiffre "999"

39. Heure de cloture de l'interview

La réponse est obligatoire.