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Rural Livelihood under a Changing Climate Pattern in the Zio District of Togo, West Africa

Thesis N° ....

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CONTENTS

ABBREVIATIONS/ ACRONYMS

AMED: Approche des Moyens d'Existence Durables

BLRM: Binary Logistic Regression Model

CARE: Cooperative for Assistance and Relief Everywhere

CENETI: Centre National d'Etude et de Traitements Informatiques

DDI: Département de Développement International

DFID: Department For International Development

DGSCN: Direction Générale de la Statistique et de la Comptabilité Nationale

DNM : Direction Nationale de la Météorologie

DSID: Direction de la Statistique agricole de l'Informatique et de la Documentation

DRDAT: Direction Régionale du Développement et de L'Aménagement du Territoire

FAO: United Nations Food and Agriculture Organization

FGD: Focus Group Discussion

GDP: Gross Domestic Product

GIS: Geographical Information System

ICAT : Institut de Conseil et d'Appui Technique

IFAD: International Fund for Agricultural Development

IGN: Institut Géographique National

IPCC: Intergovernmental Panel on Climate Change

MED: Moyens d'Existence Durable

NAPA: National Climate Change and Variability Adaptation Program of Action

NGO: Non-Governmental Organisation

ODEF: Office de Développement et d'Exploitation des Forêts

RGPH: Recensement Général de la Population et de l'Habitat

SLA: Sustainable Livelihood Approach

SLF: Sustainable Livelihood Framework

TRC: Togo Red Cross

UN: United Nations

UNDP: United Nations Development Programme

WFP: World Food Program

ILLUSTRATIONS

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

ABSTRACT

This study was carried out to assess the situation of households' livelihood under a changing climate pattern in the Zio district of Togo, West Africa. The study examined three important aspects: (i) assessment of households' livelihood situation under a changing climate pattern, (ii) farmers' perception and understanding of local climate change, (iii) determinants of adaption strategies' undertaken in cropping pattern to climate change. To this end, secondary sources of data, and survey data collected from 235 farmers in four villages in the study area were used. Adapted conceptual framework from Sustainable Livelihood Framework of DFID, two steps Binary Logistic Regression Model and descriptive statistics were used in this study as methodological approaches. Based on Sustainable Livelihood Approach (SLA), various factors revolving around the livelihoods of the rural community were grouped into social, natural, physical, human, and financial capital. Thus the study came up that households' livelihood situation represented by the overall livelihood index in the study area (34%) is below the standard average households' livelihood security index (50%). The natural capital was found as the poorest asset (13%) and this will severely affect the sustainability of livelihood in the long run. The result from descriptive statistics and the first step regression (selection model) indicated that most of the farmers in the study area have clear understanding of climate change even though they do not have any idea about greenhouse gases as the main cause behind the issue. From the second step regression (output model) result, education, farming experience, access to credit, access to extension services, cropland size, membership of a social group, distance to the nearest input market, were found to be the significant determinants of adaptation measures undertaken in cropping pattern by farmers in the study area. Based on the result of this study, recommendations are made to farmers, policy makers, institutions and development service providers in order to better target interventions which build, promote or facilitate the adoption of adaptation measures with potential to build resilience to climate change and then improve rural livelihood.

Keywords: climate change, rural livelihood, cropping pattern, adaptation, Zio District.

RESUME

Cette étude a évalué la situation des moyens de subsistance des ménages ruraux dans un climat en plein changement dans la préfecture du Zio au Togo, Afrique de l'Ouest. L'étude a analysé trois principaux aspects: (i) la situation des moyens de subsistance des ménages agricoles dans un climat en plein changement, (ii) la perception et la compréhension du changement climatique par les agriculteurs, (iii) les déterminants des stratégies d'adaptation adoptées dans les system de cultures par les agriculteurs. À cette fin, les données secondaires, ainsi que les données du sondage collectées auprès de 235 agriculteurs dans quatre villages de la zone d'étude, ont été utilisées. Le cadre conceptuel adapté du concept de Moyens d'Existence Durable (MED) du DDI, le Modèle de Régression Logistique à deux étapes et la statistique descriptive ont été utilisés comme méthodes. Se basant sur l'Approche des Moyens d'Existence Durables (AMED), les facteurs qui déterminent les moyens de subsistance de cette communauté rurale ont été regroupés en capital social, naturel, physique, humain, et financier. Ainsi, cette étude a révélé que l'indice global des moyens d'existence dans la préfecture de Zio (34%), représentant la situation des moyens de subsistance des ménages agricoles, est inférieur à la norme moyenne (50%). Un très faible niveau du capital naturel (13%) a été observé, indiquant la non durabilité des moyens de vie de cette communauté à long terme. Les résultats de la statistique descriptive et de la première étape de régression (modèle de sélection) ont indiqué que la majorité des agriculteurs de la zone d'étude ont une bonne compréhension du changement climatique même s'ils ne disposent pas d'information sur les gaz à effet de serre comme étant la cause principale du phénomène. Le résultat de la seconde étape de régression (modèle de sortie) a montré que l'éducation, l'expérience agricole, l'accès au crédit, l'appartenance à un groupe social, accès aux services agricole, la distance par rapport au marché le plus proche des intrants agricoles et la superficie de terre détenue sont d'une manière importante liés aux stratégies d'adaptation adoptées dans le system de culture par les agriculteurs dans la zone d'étude. Se basant sur les résultats de cette étude, des recommandations ont été faites à l'endroit des paysans, des décideurs politiques et les organisations et institutions de développement afin de mieux cibler les interventions qui construisent, favorisent ou facilitent l'adoption des mesures d'adaptation afin de renforcer la résilience au changement climatique et ainsi améliorer les moyens de subsistance en milieu rural.

Mots clés: changement climatique, moyens d'existence ruraux, système de culture, adaptation, préfecture de Zio.

Chapter 1: INTRODUCTION

1.1 Problem Statement

Rural livelihood in developing countries depends on agriculture and natural resources, and their availability will vary in a changing climate (IPCC, 2014a). This will have effects on human security and well-being (Kumssa and Jones, 2010). Furthermore, the largest known economic impact of climate change is upon agriculture because of the size and sensitivity of the sector, particularly in the developing world (IPCC, 2014a). Thus it has been shown that weather events and climate affect the lives and livelihood of millions of poor people (Field *et al.*, 2012). Climate change, climate variability and extreme events interact with numerous aspects of people's livelihood. (IPCC, 2014b). Furthermore, Bryan *et al.*, (2013) realised that even minor changes in precipitation amount, temporal distribution, or short periods of extreme events can harm livelihood of rural communities.

As strategy in response to climate change and climate variability and their stresses, farmers undertake some measures, including changes in cropping pattern to cope with and adapt (Manandhar *et al*, 2011). In other words, farmers have changed their cropping pattern per climatic adjustments (Bhandari, 2013). For example, changing crop varieties, planting date, amount or area of land under cultivation, diversifying crops, introducing new crops (IPCC, 20014a). However, the livelihood assets are the basis for understanding how people will respond to climate induced vulnerabilities, they are the basis for the development of adaptation strategies (Kebede and Adane, 2011).

In Togo, agriculture accounts for 40% of GDP and 20% of the export revenue, and employs 96% of rural households with nearly 54% of the active population (MAEP, 2013). However, according to ITRA (2009), most of the agricultural production in Togo is rainfed, a situation which makes it more vulnerable to climate change and variability. IFAD in it project for agricultural development in the maritime region with Zio District as one of the targeted areas realised that climate change is one of the main constraints to agricultural production that led to the abandonment of the second crop cycle (IFAD, 2010).

Several studies over the past (Kebede and Adane, 2011; Simatele, *et al*., 2012; Dube and Phiri, 2013; Kangalawe *et al.*, 2013; etc.) attempted to understand the impact of climate change on rural livelihood in many other countries but a little effort has been devoted to examine the five components of rural livelihood as a whole under climate change in Togo. This research, therefore, seeks to assess the situation of households' livelihood under a changing climate pattern in the Zio district, Togo.

1.2 Objectives of the Study

The general objective of this study is to assess the situation of rural livelihood under a changing climate pattern in the study area.

The specific objectives of the study consist in:

- ✓ Assessing the situation of households' livelihood under a changing climate pattern.
- ✓ Assessing farmers' perception and understanding of local climate change.
- ✓ Analysing the determinants of adaptation strategies undertaken in cropping pattern to climate change.

1.3 Research Questions

To achieve these objectives some questions of interest were asked:

- ✓ What is the situation of households' livelihood under a changing climate pattern?
- ✓ How do farmers perceive and understand local climate change?
- ✓ What are the determinants of adaptation strategies undertaken in cropping pattern to climate change?

1.4 Thesis Structure

This study is organised in five chapters. The introductory chapter includes the problem statement, objectives and research questions. The second chapter deals with literature review. This section focusses on concepts and relevant findings related to this topic and the method used. The third chapter discusses the materials and methods used for this study; i.e., the conceptual and theoretical framework on which the present work is based and the steps followed in order to reach the goal of this study. Chapter four examines the main findings of this study and their discussions. The last chapter concludes this work and presents the recommendations based on the results.

Chapter 2: LITERATURE REVIEW

2.1 Agriculture, Climate Change and Rural Livelihood.

Agriculture is the source of livelihood to an overwhelming majority of the Togolese population and the basis of the national economy (World Bank, 2010). This sector accounts for 40% of the GDP and 20% of the export revenue and employs 96% of rural households with nearly 54% of the active population (MAEP, 2013). In Togo, agriculture is heavily dependent on natural rainfall, with irrigation agriculture accounting for less than 2% of the country's total cultivated land (Mikémina**,** 2013). The same source revealed that agriculture will remain the mainstay of economic growth for the foreseeable future.

Crops are very sensitive to climate change because any change in temperature, humidity, solar radiation and precipitation which are important climatic factors for crops can lead to failure of crops and subsequent low crop production (Bhandari, 2013). In other words, "*climate is the primary determinant of agricultural productivity*" (Apata *et al*., 2009, p.2). According to the National Adaptation Program of Action (NAPA-Togo), the country is highly vulnerable to climate variations and the first sectors that will be most affected by climate change is agriculture (MERF, 2009). In the same line, *"the largest known economic impact of climate change is upon agriculture because of the size and sensitivity of the sector, particularly in the developing world"* (IPCC, 2014a, p.16). A recent mapping of vulnerability and poverty in Africa (Orindi *et al*., 2006; Stige *et al*., 2006) put Togo as one of the most vulnerable countries to climate change with the least capacity to respond.

Climate change erodes social and cultural asset as climatic stressors and changing trends disrupt informal social networks of the poorest, elderly, women, headed households, preventing mobilization of labour and reciprocal gifts (Osbahr *et al.*, 2008; Buechler, 2009) as well as formal social networks, including social assistance programs (Douglas *et al.*, 2008). Weather events and climate also erode farming livelihoods, via declining crop yields (Hassan and Nhemachena, 2008; Apata *et al.*, 2009; Li *et al.*, 2013), at times compounded by increased pathogens, insect attacks, and parasitic weeds (Byg and Salick, 2009). Moreover, projections of near and long-term climate change impacts on livelihood assets highlight the erosion of financial assets as a result of increased food prices (Jacoby *et al.*, 2011), human assets due to decline in nutritional status (Liu *et al.*, 2008), and natural assets due to lower agricultural productivity (Skoufias *et al.*, 2011). The fifth assessment report of Intergovernmental Panel on Climate Change (IPCC, 2014b) argued that the observed impacts of weather events and climate on livelihood and poverty and impacts projected from the sub-national to the global level suggest that livelihood well-being is already undermined and will continue to be eroded into the future (*high confidence*).

2.2 Review of Meteorological Approaches and Findings

2.2.1 Sustainable Livelihood Concept and its Application

Robert Chambers and G. R. Conway (1992) provided the first elaborated definition of the concept of sustainable livelihood. Later, DFID adapted the version of Chambers Conway's definition of livelihood: *"A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base."* (DFID, 1999).

The Sustainable Livelihood Framework of DFID (1999) is a useful operationalization of the livelihood concept which captures the complexities of rural livelihood in the context of external influences. It assumes that livelihood resources comprised of five different capitals or assets, namely, human, natural, financial, social and physical asset and each asset can be represented by a number of factors affecting livelihood. The concept of livelihood is about individuals, households, or groups making a living, attempting to meet their various consumption and economic necessities, coping with uncertainties, and responding to new opportunities (De Haan and Zoomers, 2003). Livelihood goals include the priorities and aims of the affected people themselves, for example, acquiring a sense of control over their life, as well as food and income security (Young et al., 2005). Furthermore, livelihood is the core of development and it is impacted by different internal and external forces (IPCC, 2007). Therefore, understanding the diverse and dynamic rural livelihood strategies help to identify appropriate strategies for intervention to introduce new livelihood strategies and for improved livelihood outcomes (Scoones, 1998).

Recent concepts addressing poverty are mainly based on income or consumption criteria assessment (Farrington et al, 1999). Investigations of rural livelihood tend to focus on income sources. However, this aspect of the Sustainable Livelihood framework goes well beyond income, and it is important not to neglect other considerations (DFID, 2000). Although poor people have limited income, they have assets and capabilities that can be strengthened to reduce their vulnerability to climate change (Kebede and Adane 2011). Thus, the Sustainable Livelihood Framework (SLF) developed by DFID is widely used or adapted by researchers (Kebede and Adane 2011; Pensuk and Shrestha 2007; Salisbury and Schmink 2007; Soini 2005; etc.) and institutions (UNDP, FAO, FIDA, WFP, CARE, etc.) around the world in order to assess people's livelihood. For instance, Kebede and Adane (2011) used Sustainable Livelihood Approach to assess climate change adaptations and induced farming livelihood in Ethiopia. The result indicated that livelihood strategies are the determinants of how people respond to climate-induced vulnerabilities.

2.2.2 Empirical Studies on Farmers' Perceptions and Adaptations to Climate Change

Fosu-Mensah, Vlek, and Manscheadi (2010) conducted a survey about 180 farmers in Sekyedumase District in the Ashanti Region of Ghana. The study applied the Binomial Logit Model to investigate how they perceive long-term changes in temperature, rainfall and vegetation cover over the past twenty years, and how they adapt. The major finding was that land tenure, soil fertility levels, access to extension services, access to credit and the community in which the farmers lived were found to be the significant determinants of their choice of adaptation measures. Similarly, Apata et al (2009) applied the Binomial Logit Model to analyse arable food crop farmers' perceptions about climate change and adaptation strategies in Nigeria and the result indicated that farmers perceived a significant increase in temperature, violent rain and hailstorms, delayed rainfall and early cessation. Acquah-de Graft and Onumah (2011) applied the Binomial Probit analysis to analyse farmers' perceptions and adaptation to climate change, and the barriers to adaptation options. As findings, the farmers identified lack of information on climate change impacts and adaptation options, lack of access to credit, access to water, high cost of adaptation, insecure property rights and lack of access to sufficient farm inputs as the main barriers to the adoption of any adaptation measure. The probit analysis indicated that the significant determinants of adaptation to climate change are age, gender, education, number of years of farming experience, own farm land and other income generating activities. In Osun State, Nigeria, Sofoluwe *et al.* (2011) used the Multinomial Logit Model to analyse the factors that determine farmers' perception and adoption of various adaptation measures toward climate change. The results show that more than 75% of the respondents were aware of increase in temperature and precipitation in the region, lack of information about climate change impacts, access to credit, labour shortages, shortage in land and poor potential for irrigation, are the barriers to adaptations. Furthermore, Nhemachena and Hassan (2007) used the Multinomial Logit Model to examine farmers' adaptation strategies in South Africa, Zambia, and Zimbabwe. The results indicated that using different crop varieties, crop diversification, changing planting dates were the main adaptation measures employed by farmers in these countries. It means that changes in cropping pattern are considered as adaptation strategy to climate change and then a strategy for better livelihood outcome.

Chapter 3: MATERIALS AND METHODS

This chapter presents the study area, the materials and methods used for this study. The conceptual and theoretical framework, sampling technique and steps followed in order to achieve the goal of this study are also discussed.

3.1 Study Area

Zio District is located between 0°54' and 1 ° 24' East longitude and between 6°10' and 6.50' North latitude. It is found in the Maritime Region of Togo with an area of 3,200km^2, and has approximately 276,456 inhabitants (RGPH, 2010).

Zio district is bounded on North by Haho district; South by the Gulf district; East by the district of Vo and Yoto; West by the Avé district.

The relief of the Zio district is monotonous and very little contrast with descending altitudes from north to south. We can distinguish two main types of soil, namely, sandy soils representing 25% of cultivated land and waterlogged clay soils that cover about 75% of exploited farmland (DRDATM, 2009). The vegetation of Zio district is tropical (bush land, wooded, grassy, with some oil palm, baobab and divers grasses). Two major water bodies namely, the Zio and the Lili rivers are found in the study area. The climate is Sudano-Guinean, hot and humid with an average annual temperature of 26 ° C, the area is characterized by four seasons: the great rainy season (March to July), small dry season (August), the small rainy season (September to November) and the long dry season (December to March), figure 1. However, it must be noted that this climate pattern is changing overtime and became irregular and more unpredictable.

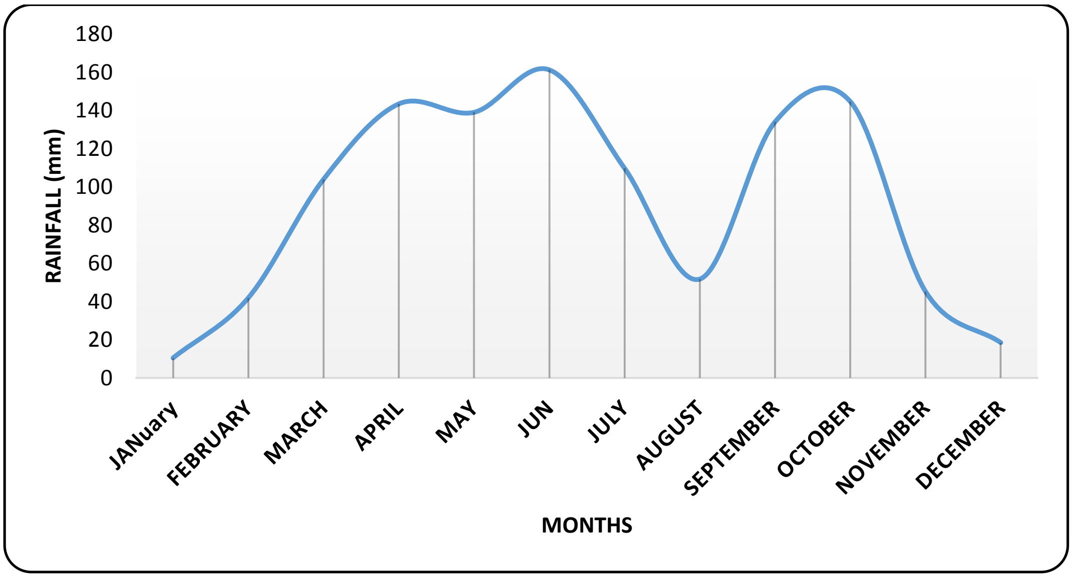


Figure 1: Average Monthly Rainfall (1983-2012)

Source of Data: DNM, 2015

The population of Zio district is predominantly agricultural; this agriculture is threatened by climate hazards and depletion of arable land (Adokpe, 2013). The area is considered as the basket of food and cash crops (UNDP, 2012), implying the major role of agriculture in the livelihood of population in the study zone. However, according to FAO (2012), rainfall in the area is affected by climate change resulting in less rainfall and disturbance in their frequency. In addition, a non-governmental organization named Treasures of Africa (ASTRAF) in its project called fertilization of soils and food security in 10 villages of Zio district mentioned that agriculture sector in Zio district is threatened by a multitude of problems, including uncontrolled grabbing agricultural lands by individuals, private and public structure, rural exodus, depletion of soil and climate change. (http://www.africatreasuretg.org/#fragment-4). Furthermore, Zio district is usually threatened by frequent flood event (UNDP, 2012). Therefore, this zone has been chosen because of its importance in agriculture in Togo and the problem it faces in terms of climate change stresses and consequences.

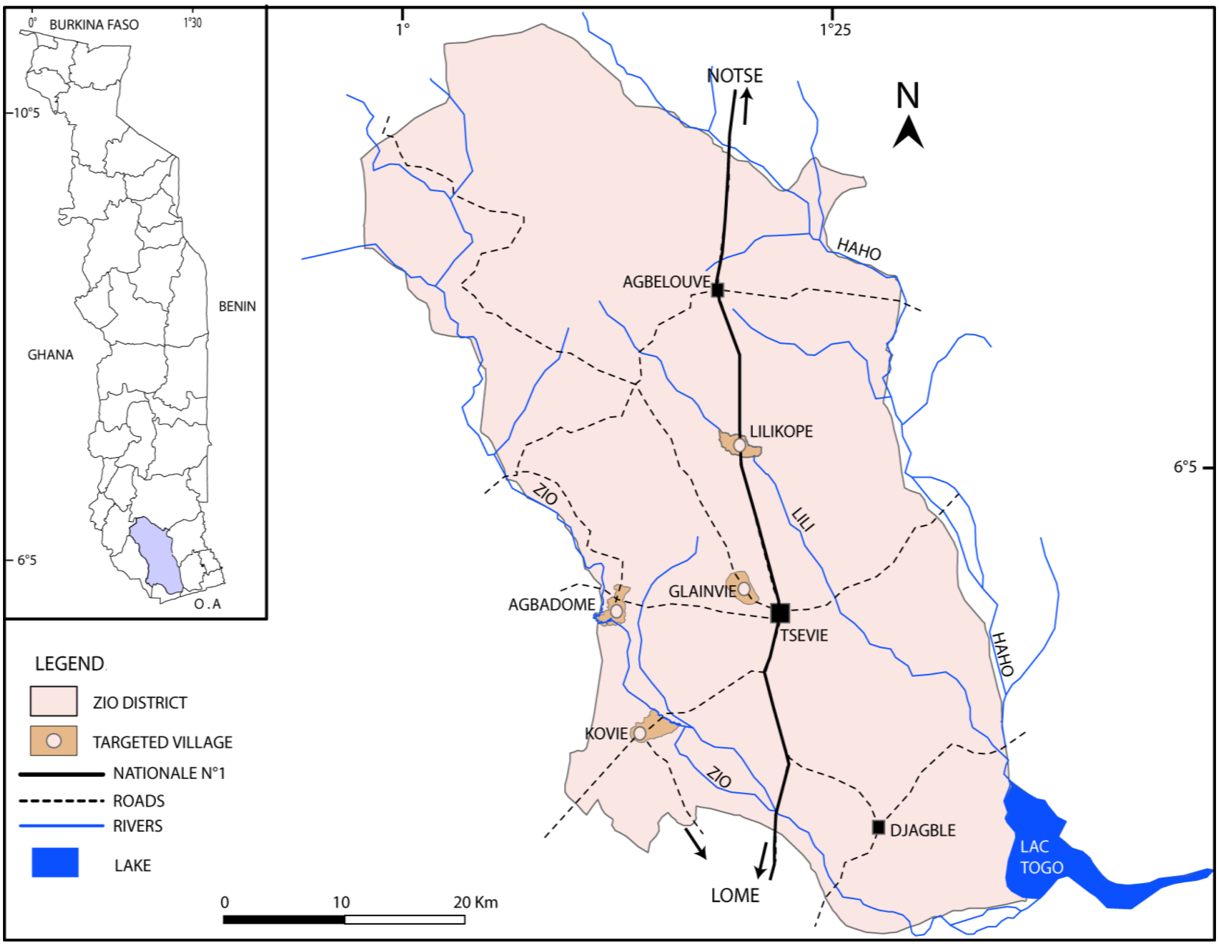


Figure 2: Map of the Study Area Showing the Targeted Villages

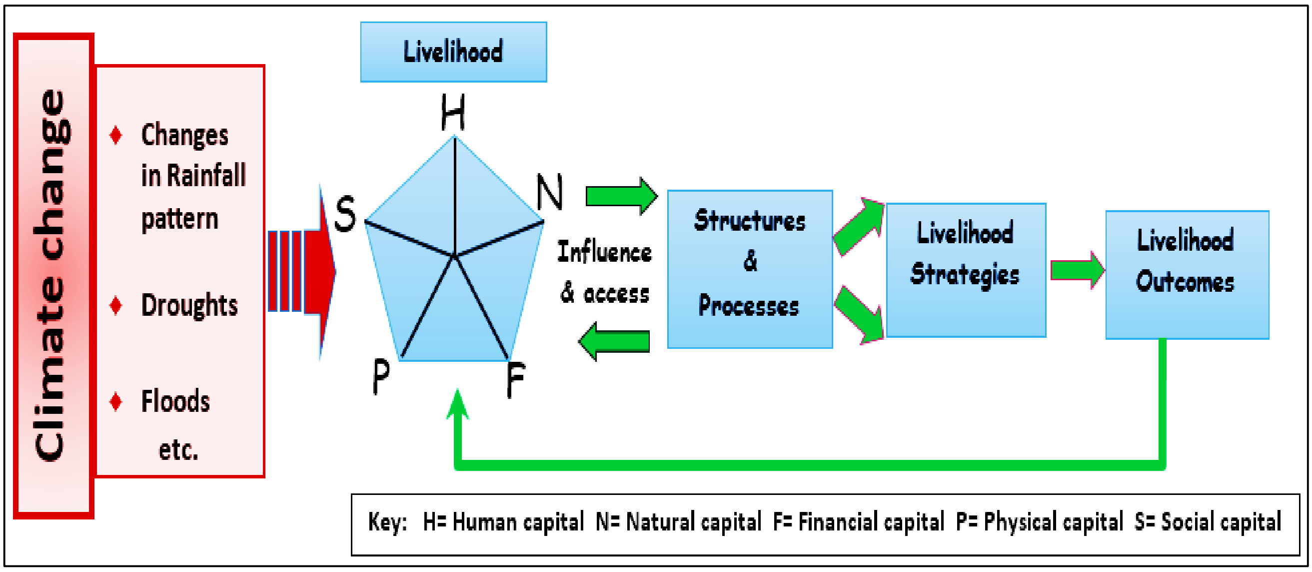
Source : IGN Togo/Field Survey, 2015

3.2 Methods

3.2.1 Households' Livelihood Assessment

3.2.1.1 Conceptual Framework

This study is based on Sustainable Livelihood Approach (SLA) of United Kingdom Department for International Development (DFID). However, this study did not look at the reciprocal effect of livelihood assets, structures and processes, on the factor that create the vulnerability (climate change) due to data unavailability and time constraint. Then, the adapted framework of SLA presented in schematic form below, was applied in this study in order to assess the situation of households' livelihood under a changing climate pattern in the study area. The figure 3 below shows the main components of SLA and how they are linked.



Source: Adapted from DFID Sustainable Livelihood Framework (1999)

Figure 3: Sustainable Livelihood Framework

- <u>**Components of Sustainable Livelihood Framework**</u>

In this study, climate change and its stresses and consequences such as changes in rainfall pattern, increase frequency of drought and flood, etc., are considered as external shocks that affect people's livelihoods. In other words, climate change is the factors that create, influence and perpetuate the vulnerability of households' livelihood.

Livelihood assets: according to SLA, livelihood resources consist of five different capitals or assets (human asset, natural asset, financial asset, social asset and physical asset) and each asset can be represented by a number of factors affecting livelihood (DFID, 1999).

- ✓ **Human capital**: it represents the skills, knowledge, ability to labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood objectives (DFID, 1999). It was derived from the percentage of people that have agriculture as the main occupation per household, the percentage of farm workers per household and knowledge on local signs to predict seasons.

- ✓ **Social capital**: in the context of the sustainable livelihood framework, social capital is taken to mean the social resources upon which people draw in pursuit of their livelihood objectives (DFID, 1999). Social assets are networks and connections, memberships of a social groups or networks and relationships of trust (de Sherbinin, *et al*, 2007). The social capital was derived from membership of a social group/network and assistance from family.
- ✓ **Natural capital**: according to Scoones (1998), natural asset can be considered as the natural stocks (land, soil, water, air, genetic, etc.) and environmental services (hydrological cycle, pollution sinks, etc.). The natural capital was derived from three indicators, namely water accessibility for irrigation, soil fertility status as perceived by farmers, and cropland holding size.
- ✓ **Physical capital**: it comprises the basic infrastructure and producer goods needed to support livelihood; e.g. roads, buildings, and energy supplies, production equipment and technologies, etc (DFID, 1999). The physical capital was mainly assessed using accessibility to market (distance to the nearest market), and access to modern equipment and technologies for farming activities such as insecticide sprayer, tractor, cultivator, etc.
- ✓ **Financial capital:** it denotes the financial resources that people use to achieve their livelihood objectives like income, cash, credit, savings, and other economic assets (DFID, 1999). The financial capital was assessed based on farm-income status overtime, saving and access to credit or loan.

Structures can be described as the “hardware” (private and public organisations) that set and implement policy and legislation, deliver services, purchase, trade and perform all manner of other functions that affect livelihood (DFID, 2000). Complementary to structures, **processes** constitute the “software” determining the way in which structures and individuals operate and interact. Important processes for livelihood are, for instance, policies, legislation and institutions, but also culture and power relations (Kollmair and Gamper, 2002).

Livelihood strategies consist of a range of activities that people engage themselves in so as to achieve their livelihood goals. Access to assets can have a major influence on choice of livelihood strategies (DFID, 1999). People choose different types of livelihood strategies, depending on the livelihood assets they have and the structures and processes that impact them under a given vulnerability context (Kebede and Adane, 2011). Adaptation to climate change thought changes in cropping pattern such as changes in planting dates and planting new crop varieties are considered in this study as a livelihood strategy.

Livelihood outcomes are the achievements or outputs of livelihood strategies, including more income, increased well-being, reduced vulnerability, improved food security, ecosystem sustainability (DFID, 2000).

3.2.1.2 Livelihood Indicators Development

Based on literature review (DFID, 1999; Scoones 1998; Soini 2005; Pensuk and Shrestha, 2007; Salisbury and Schmink, 2007; Kebede and Adane, 2011, etc.) and various discussions undertaken during the field work, indicators were developed to represent the five livelihood assets. The most relevant indicators developed taking into account the main factors that determine farmers' livelihood in the study area are presented in table 1 below.

Table 1: Indicators Developed for Livelihood Assets Assessment and their Measurements

Livelihood Capitals	Indicators	Description	Measurement
Human Capital	Knowledge on local indicators to predict seasons	Whether the farmer has any knowledge of local signs to predict seasons	Yes = 1 No = 0
	Farm workers in the household	Number of people who participate in farming activities in the household	(Continued)
	Agriculture as main occupation	Number of people who have agriculture as main occupation in the household	(Continued)
Natural Capital	Water accessibility for irrigation	Whether the farmer has access to water for irrigation or not.	Yes = 1 No = 0
	Soil fertility status	Farmers' perception of soil fertility status referring to the past 20 years	0 = Decrease 1 = Increase
	Cropland holding size	Total acreage allocated to crop in	Ha
Financial Capital	State of farm income	Farm income status compared to 20 years ago:	Decrease = 0 No change = 0.5 Increase =1
	Saving	Whether the farmer saves some money or not	Yes =1 No = 0
	Access to Credit	Whether the farmer has access to credit or not	Yes =1 No = 0
Social Capital	Networks	Whether the farmer is a member of any social group, network, association, etc.	Yes =1 No = 0
	Assistance from family (different from household members)	Whether the farmer receives assistance from family for farming activities.	Yes =1 No = 0
Physical Capital	Access to the nearest market	Distance to the nearest market	d > 10 km, = 0 ; 3<d<10 km = 0.5 d < 3 km = 1
	Modern equipment and technologies for farming.	Accessibility to modern equipment and technologies (such as tractor, plough, irrigation equipment, insecticide sprayer, etc)	No = 0 Medium = 0.5 (eg. insecticide sprayer) High =1 (eg. Tractor)

3.2.2 Farmers' Perception of Climate Change and Determinants of Adaptation Strategies

3.2.2.1 Analytical Framework: Binary Logistic Regression Model

In this study, Logistic Regression Model is used in order to understand farmers' perception about climate change, and the factors that determine the adaptation strategies u in cropping pattern to the negative effect of climate change. So the dependent variables are binary in nature, taking the value 1 or 0. For such dichotomous nature of the dependent variables, the use of linear probability models is a major problem (Ndambiri, *et al.* 2012). This is because the predicted value can fall outside the relevant range of zero to one probability value. Therefore, to overcome the problem associated with the linear probability model, logit and Probit models have been recommended (Gujarati, 2004). These models, which use Maximum Likelihood Estimation (MLE) procedures, ensure that the probabilities are bound between 0 and 1 (Uddin, *et al*. 2014). However, Probit models are often seen as better suited for experimental data (Rahm. et al, 1984). The logistic model considers the relationship between a binary dependent variable (Y) and a set of independent variables (X), whether binary or continuous. It is based on the cumulative standard logistic distribution. The independent or predictor variables in logistic regression can take any form. Thus Logistic regression does not make any assumptions of normality, linearity, and homogeneity of variance for the independent variables (Kebede and Adane, 2011).

Following Kalyebara (1999), the general form of the logit model to be estimated is as follows:

$$\text{Prob}\ (Y_i = 1) = F(\beta X) = \frac{e^{\beta X}}{1 + e^{\beta X}}$$

Equation 1: *Logistic Cumulative Probability Function*

$$\text{Prob}\ (Y_i = 0) = F(\beta\, X) = 1 - \left(\frac{e^{\beta X}}{1 + e^{\beta X}}\right) = \frac{1}{1 + e^{\beta X}}$$

Equation 2: Probability Function of Failure

Where Y_i is the observed response for the i^{th} observation of the response variable Y.

Y_i is a dummy dependent variable, $Y_i = 1$ if event happens (first category or success), $Y_i = 0$ if event doesn't happen (second category or failure).

X_i is the vector of explanatory variables that influence the i^{th} observation of the dependent variable.

$$P_i = prob\left[Y_i = 1 \mid X_i\right] = \frac{1}{1+e^{-Yi}}$$

Equation 3: Probability of Success

Where P_i is the probability that the i^{th} person will be in the first category ($Y_i = 1$),

$$Y_i = \beta_0 + \beta_i X_i$$

Equation 4: Linear Probability Function

β_0 the intercept of the model (constant term);

β_i are the model parameters to be estimated (Regression co-efficient);

X_i Represent the i[th] independent variables.

e denotes the base of natural logarithms, which is approximately equal to 2.718.

$$P_i = \frac{1}{1+e^{-Yi}} \leftrightarrow (1 + e^{-Y_i})P_i = 1 \leftrightarrow e^{Y_i} = \frac{P_i}{1-P_i}$$ *Equation 6: Odds Ratio of a Logit Model*

$$e^{Y_i} = \frac{P_i}{1-P_i} \leftrightarrow \ln(e^{Y_i}) = ln\left(\frac{P_i}{1-P_i}\right) = Y_i$$ *Equation 5: Logistic Probability Model*

- **Marginal Effects**

The marginal effects or marginal probabilities are functions of the probability itself and measure of the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Green, 2000). The marginal effects can also be computed to show the change in the probability when there is a unit change in the independent variables. The marginal effects are computed as follows:

$$\frac{\partial P}{\partial X_i} = \frac{\beta_i(1+e^{-Y_i})}{(1+e^{-Y_i})^2}$$ *Equation 7: Marginal Effect*

3.2.2.2 Empirical Model: Two Steps Binary Logistic Regression Model

In this study, two steps Binary Logistic regression Model are used. There are two dependent variables (Y_i) and (Y_j').

- Y_i: farmers' perception of climate change, which is a binary variable indicating whether or not a farmer has perceived climate change.
- Yj': adaptation to climate change, indicating whether or not the farmer tried to adapt to climate change.

Independent variables include a set of relevant explanatory variables (X) and (X') whose choice is based on a literature review of factors affecting the awareness and adaptation strategies of farmers to climate change (Uddin, *et al*. (2014); Ishaya and Abaje, 2008 ; Deressa et al., 2009 ; Okonya et al,2013 ; Isham, 2012 ; Ndambiri *et al*., 2012 ; Gbetibouo *et al*, 2009 ; Tilahun, *et al*, 2014 ; Madison, 2006 ; Ndambiri, *et al*., 2012). The explanatory variables include different socio-demographic and economic factors such as age, gender, education of the household head, local knowledge to predict seasons, household size, farming experience, cropland size, membership of a social group, farm and nonfarm income; institutional factors such as access to extension services on crop production, access to information on climate, access to credit, distance to nearest input market; and natural factors such as soil fertility status, access to water for irrigation.

The binary logistic regression models are specified as:

$$Y_i = \beta X_i + \varepsilon \qquad \textit{Equation 8: Perception Model}$$

$$Y'_{j\,(j=i \wedge Y_i=1)} = \beta' X'_j + \mu \qquad \textit{Equation 9: Adaptation Model}$$

Where:

Y_i = the perception by the (i^{th}) farmer about climate change.

$Y_j^{'}$ = the adaptation by the (j^{th}) farmer to climate change.

X_i = the vector of explanatory variables influencing the probability of perceiving climate change by the (i^{th}) farmer.

$X^{'}_{j}$ = the vector of explanatory variables influencing the probability of adapting to climate change by the (j^{th}) farmer.

β and β'= the vectors of the parameters estimates of the repressors hypothesized to influence respectively the probability of farmer (i_s) perception to climate change and the probability of farmer (j_s) adaptation to climate change.

μ and ε are the error terms.

Consequently, the empirical specification of the logistic regression model are:

*Equation 10: Empirical Specification for Perception Model (*First step)

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \varepsilon$$

*Equation 11: Empirical Specification for Adaptation Model (*Second step)

$$Y'_{j\,(j=i \wedge Y_i=1)} = \beta'_0 + \beta'_1 X'_1 + \beta'_2 X'_2 + \beta'_3 X'_3 + \beta'_4 X'_4 + \beta'_5 X'_5 + \beta'_6 X'_6 + \beta'_7 X'_7 + \beta'_8 X'_8 + \beta'_9 X'_9 + \beta'_{10} X'_{10} + \beta'_{11} X'_{11} + \beta'_{12} X'_{12} + \beta'_{13} X'_{13} + \beta'_{14} X'_{14} + \mu$$

Where,

$X_1 = X'_1$ = Gender

$X_2 = X'_2$ = Education

$X_3 = X'_3$ = Farming experience

$X_5 = X'_5$ = Access to Credit

$X_6 = X'_6$ = Soil fertility status

$X_7 = X'_7$ = Membership of a social group

$X_4 = X'_4$ = Off-farm income in total income

$X_9 = X'_9$ = Access to extension services

$X_{10} = X'_{10}$ = Access to climate information

X_{11} = Age

X_{12} = Farm income in total income

$X_8 = X'_8$ = Local Knowledge to predict seasons

X'_{11} = Household size

X'_{12} = Cropland size

X'_{13} = Access to water for irrigation

X'_{14} = Distance to the nearest inputs market

β'_0 and β_0 are the Constant terms

$\beta'_1, \ldots, \beta_n$ are the Regression Coefficients.

Description of Variables

♦ Dependent variables

For the first step of the regression (selection model), the binary dependent variable takes the value 1 if the farmer has perceived climate change and 0 otherwise. This was to distinguish between farmers who perceived climate change and those who did not in the study area. However, a farmer is considered to have perceived climate change when they perceived change in the general climate, increase in temperature pattern and has also noticed an irregularity or disturbances in rainfall pattern overtime. It means that a farmer that met the three conditions was coded as 1, otherwise 0.

The second step is conditional on the first step and represent the outcome model (Deressa *et al*., 2008). A farmer who indicated that they have taken adaptive measures in response to negative effects of climate change was given a value of 1 and a value of 0 for farmers who did not engage in any adaptive measures. Based on literature review, the information from individual survey and focus group discussion, this study considered a farmer to have adapted when he has at least changed the planting date (plant earlier or plant later) and has also changed crop varieties (plant short-cycle varieties, crop new varieties, plant drought tolerant crops). Thus, the dependent variables used in this study were constructed from other variables in order to have more consistence in the model.

♦ Independent Variables

Based on literature review and focus group discussions as mentioned earlier, this current research considered the variables described in table 2 below as potential factors affecting farmers' perception and adaptation to climate change.

Table 2: Variables Hypothesized to Affect Farmers' Perception and Adaptation to Climate change

Variables	Description	Measurement	Expected sign
Socio demographic and economic characteristics			
Age	Age of the head of the household	in year (continuous)	+
Gender	Gender of the head of the household	1=male , 0 = female	+ or -
Education of household head	Number of years of formal schooling attained by the head of the household	in years (continuous)	+
Local knowledge to predict seasons	Whether the farmer has any knowledge on local indicators to predict seasons or not	1= yes, 0 = No	+
Household size	Number of people living in the household	Number (continuous)	+ or -
Farming experience	Number of years of farming experience for the household head	in years (continuous)	+
Farm size	Total cropland area	Hectare (continuous)	+ or -
Social group	Whether the farmer belong to any social group or network	1= yes, 0 = No	+
Farm income	Percentage of farm income in the total income.	%	+
Off-farm income	Percentage of off-farm income in the total income	%	+ or -
Institutional factors			
Extension services	Whether the farmer has access to Extension services on crop production or not	1=access, 0 = otherwise	+ or -
Climate information	Whether the farmer has access to climate information or not	1= access, 0 = otherwise	+
Access to Credit	Whether the farmer has access to credit or not	1=access, 0 = otherwise	+ or -
Distance to the nearest input market	How far the farmer resides from the nearest market	(continuous)	+
Natural and climatic factors			
Soil fertility status	Whether the soil fertility has decreased or increased over time	0 = Decrease 1= Increase	-
Access to irrigation water	Whether the farmer has access to water for irrigation or not.	1= access, 0 = otherwise	+ or -

3.3 Data Collection and Analysis

3.3.1 Sampling Method

A sample is "a smaller (but hopefully representative) collection of units from a population used to determine truths about that population" (Field, 2005). A two stage sampling technique was used in selecting the respondents. The first stage was purposeful sampling of four representative villages belonging to the Zio district. This was done with the support of agricultural extension officers and prefectural coach of Togo Red Cross (TRC) following the criteria of the relevance of the subject for the villages. Then four (4) villages belonging to different canton, namely, Agbadomé, Gblainvié, Kovié and Lilikopé were selected for this study. The second stage of sampling involved the selection of farming households in the four villages. Data on population were taken from General Direction of Statistics and National Accounting of Togo. A total of 235 questionnaires including additional margin of 10% were produced. This sample size was determined, using following the equation proposed by Arkin and Colton (1963).

$$n = \frac{NZ^2\, p(1-p)}{Nd^2+Z^2\, p(1-p)}$$

Equation 12: Sample size

Where:

n = Sample size, N = Total number of households (1,806)

Z = Confidence level (95%), P = Estimated proportion of the population (80%)

d = Error limit (5%)

3.3.2 Data Collection

3.3.2.1 Primary data

In this study different methods and techniques were used to collect qualitative and quantitative data from primary sources. Primary data sources included structured and semi-structured interviews for households and key informants respectively, participatory assessments and physical observation. Participatory methods included focus group discussions, key informant interviews and transect walk at village level.

- ✓ Focus Group Discussions

Focus group discussions were used in each village to discuss farmers' perceptions of climate change, its impacts on farming and livelihood and how they respond to the issue. A checklist was used to guide the discussions and it helped to further balance information collected by other methods, including the household survey. The focus group discussion also discussed the relevance of climate change compared to other problems in the villages. This helped capture the changes in cropping pattern and the extent of community vulnerability to climate change. The focus group discussion consisted of 6 to 9 people in each village. An effort was made to ensure that the focus group discussions were as representative as possible of the different stakeholders. A particular attention was paid to gender representation and age differences in the focus groups.

✓ Semi-structured Interview

A semi-structured interview is a “technique designed to elicit a vivid picture of the participant's perspective on the research topic” (Mack and Woodsong, 2005). A total of 11 individual interviews were conducted with elderly people, women leaders, local chiefs in the respective villages and also from an ICAT agent and Red Cross coach at the district level. A checklists was developed to guide the key informant interviews.

✓ Structured Interview

Household interviews were conducted using structured questions to complement the qualitative information from participatory assessment and from documentary sources. The survey questionnaire designed were composed of both open-ended and closed questions categorized as basic household information such as demography and socio economic characteristics, perceptions and understanding about climate change, cropping pattern characteristics and livelihood implication of the changes induced by climate change by following the indicators developed for the five assets of Sustainable Livelihood. A one day pre-test of the questionnaire was conducted before commencing the proper field data collection.

✓ Transect Walk and Physical Observation

A transect walk is a participatory approach that enables the gathering of data, and is normally conducted by a group of local people and visiting professionals (Van Staden et al, 2006). Furthermore, a transect walk is a tool for describing and showing the location and distribution of resources, features, landscape, main land uses along a given transect (World Bank, 2013). According to CARE (2002), transects can help identify and locate major household food and livelihood security problems and opportunities. In this study, the purpose of the transect walk was, first, to describe the prevailing physical, social and economic environment in each village; and second, to identify the challenges and opportunities in the environment that can affect the livelihood of farmers. It helped become familiar with the physical surroundings of the community.

The participants were groups of men with whom we decided a route to be followed in order to cover the full geographical variation and socioeconomic components of the villages. The team in each village paid a particular attention to land use/land cover, soil, vegetation, crops, housing and general state of the environment as problems and opportunities present in the community. During the walk, we took notes of relevant features observed and got GPS coordinates of special terrain features resources along the way. With the participants, we discussed and sought clarifications about the observations, the problems and opportunities. After the walk, we gathered the participants to discuss notes and involved them in drafting of a transect diagram.

Physical observations was also made in the field to capture and crosscheck issues raised in the focus group discussions and key informant interviews, such as crop production, socio economic situations in the respective areas. Pictures were taken as a part of the observation process.
Transect diagrams and pictures from the study area are presented in Annex 2 (figures 16 - 23).

3.3.2.2 Secondary Data

Secondary data such as agricultural statistics were collected from DSID, census and demographic information were obtained from CENETI/ DGSCN. Relevant reports of government, non-governmental organizations and institutions such as FAO, UNDP, IFAD and others were reviewed and used as secondary source data. Climate data records such as temperature and rainfall were obtained from the Meteorological service of Togo and used in this study.

3.3.3 Data Analysis

3.3.3.1 Household Livelihood Analysis

Information collected on socioeconomic characteristics, climate change and cropping pattern and livelihood in general was used to assess the livelihood status of the four villages under a changing climate pattern in the study area by applying Sustainable Livelihood Approach (SLA) of DFID. The collected data on livelihood indicators were analysed using Statistical Package for the Social Sciences (SPSS). The indicators representing those five livelihood assets varied in terms of their characteristics, scales and measurement units. Hence, it was necessary to standardize them before computing livelihood indices. To do this, this study identified the functional relationship between the indicators and the livelihood index. It was observed that there is positive functional relationship between the indicators and the livelihood index. The methodology used in UNDP's

Human Development Index (UNDP, 2006), as shown in the following equations, was used for the standardization.

$$Xi = \frac{Ri - Rmin}{Rmax - Rmin}$$ *Equation 13: Normalisation Formula*

Where: Xi = Computed or normalized value, Ri = Raw value to be normalized

Rmin and Rmax = Actual minimum and maximum values of the variables respectively.

In this study, each indicator or dimension was judged to be roughly equal in importance (Vincent 2007), so the assets, and the indicators were equally weighted. The scores obtained from all indicators in each asset were averaged in order to generate the livelihood asset index which represent the livelihood situation of the selected households in the study area.

3.3.3.2 Analysis of Farmers' Perception of Climate Change and Determinants of Adaptation Strategies

Qualitative data analysis was done through triangulation of narratives from focus group discussion, key informant interview and evidence from field observations, while quantitative data were coded, processed and analysed using Statistic Package for Social Science (SPSS) version 20.0 and Stata version 13.1. Along with the econometric models analysis, descriptive statistics tools were employed to have a clear picture of household socio-demographic, economic and farm characteristics, and perception and adaptation to climate change. Climatic data from meteorological services such as rainfall and temperature were analysed using Excel 2013, Veusz and XLSTAT-2015 for trends and compared with villagers' accounts of climatic changes over the years.

Chapter 4: RESULTS AND DISCUSSIONS

4.1 Household Characteristics

4.1.1 Age and Gender Structures of the Respondents

In the study area, the youngest household head farmer interviewed was 20 years old while the oldest was 85. Based on age, studied population was grouped in three categories: less than or equal to 40 years old, 41- 59 and greater or equal to 60. The largest proportion of household members was in the 41- 59 years age category (42.13%) in all four villages while the smallest age category (≥ 60 years old) was 16.6 % (figure 4, b). This shows that the majority of household heads interviewed belong to the working age group and have good experience in farming activities. Regarding the gender aspect, 42.13% of the respondents were female, while 57.87% were male indicating a high involvement of women in agriculture in the study area and a good gender balance in this study (figure 4, a). The graphs below show age and gender structure in the study area.

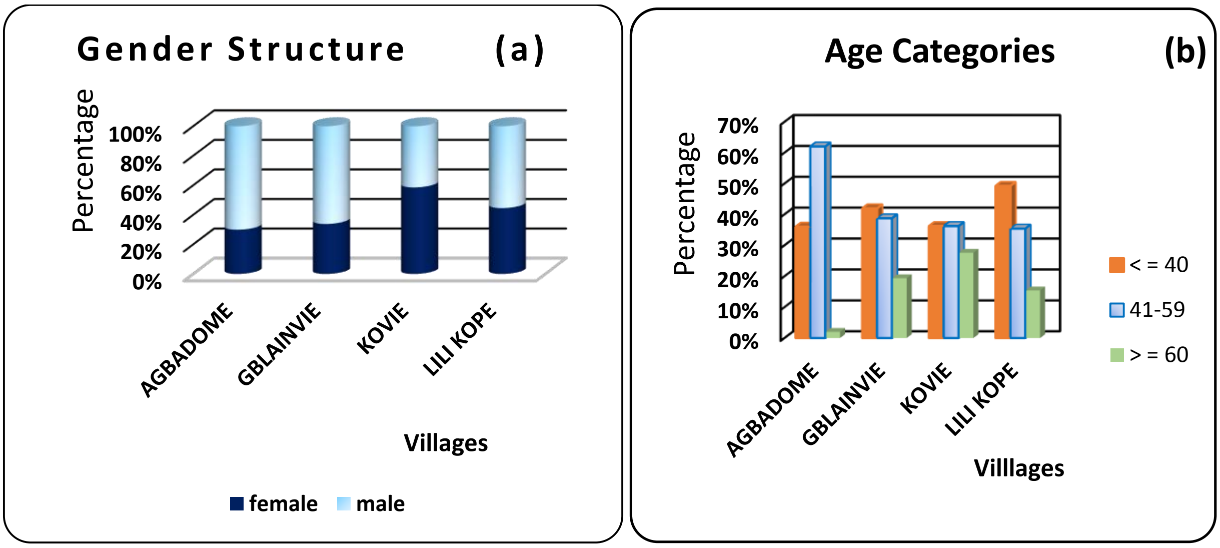


Figure 4: Age Category (b) and Gender Structure (a) of the Respondents in the Study Area.

4.1.2 Household Size and Marital Status of the Respondents

The average size of the surveyed households was 5.23 members per household. Gblainvié village had the largest household size (5.61 members/ household) and the smallest household size was found at Lilikopé (4.98 members/ household). Table 3 indicates that the minimum household size of the whole study area was 1 and the maximum was 13 members per household. Regarding the marital status distribution in the study area, most respondents were married (83%), implying the importance of their responsibility and role for the survival of their households. The pie chart below (figure 5) presents the marital status structure of the respondents in the study area.

Table 3: Surveyed Household Size Statistics by Village

Villages	N	Mean	Min	Max
	Descriptive Statistics			
GBLAINVIE	62	5.61	1	11
LILIKOPE	65	4.98	1	12
KOVIE	58	5.19	1	13
AGBADOME	50	5.10	1	12
Total	235	5.23	1	13

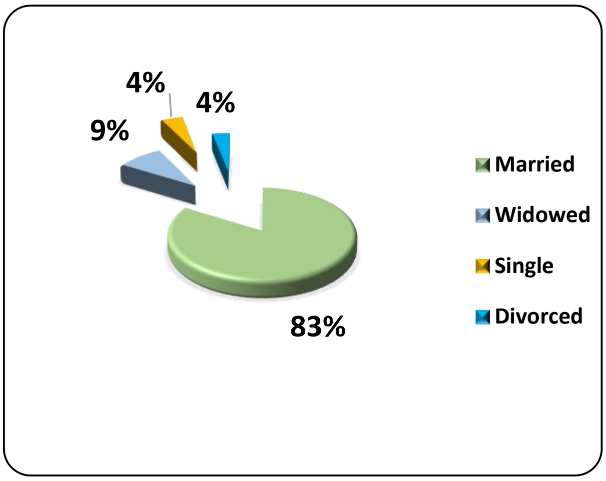


Figure 5: Marital Status Structure of the Respondents

4.1.3 Educational Attainment of the Surveyed Household Heads

The education attainment of surveyed households is presented in five categories, namely, illiterate, primary school, secondary school, high school and university in Table 4. The illiterate category was found as the highest proportion (40.9%) for the whole study area, followed by the category of primary school level (33.2%) and secondary school level (24.7%) of education. Only 0.9% and 0.4 % of the respondent have attained respectively high school and college. The number of illiterate in Kovié and Lilikopé was higher than Agbadomé and Gblainvié. However, the surveyed population that reached high school and college was found only in Lilikopé. For the overall study area, we realised that the level of education was low.

Table 4: Education Level of the Respondents by Village

Level of Education	AGBADOME	GBLAINVIE	KOVIE	LILIKOPE	Total
ILLITERATE	34%	30.6%	56.9%	41.5%	**40.9%**
PRIMARY SCHOOL	28%	45.2%	24.1%	33.8%	**33.2%**
SECONDARY SCHOOL	38%	24.2%	19.0%	20.0%	**24.7%**
HIGH SCHOOL	0%	0%	0%	3.1%	**0.9%**
UNIVERSITY (college)	0%	0%	0%	1.5%	**0.4%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**

4.1.4 Occupational Structure of the Respondents

In the study area, agriculture was the major occupation of the surveyed population as all the respondents were engaged in this occupation. About 65% of the surveyed population have agriculture as main and unique occupation, while the remaining have one or two secondary income sources apart from agriculture. Those secondary activities are mainly trading, livestock, craft industry and others (figure 6).

At the household level for the whole study area, about 45.86% of the household member has agriculture as main occupation while 30.84% are farm workers (those who participate in farming activities), (Table 5). All the surveyed households are involved in crop production as main activity for their livelihood. This suggests that when such activity is affected by climate change it may have serious consequence on household livelihood.

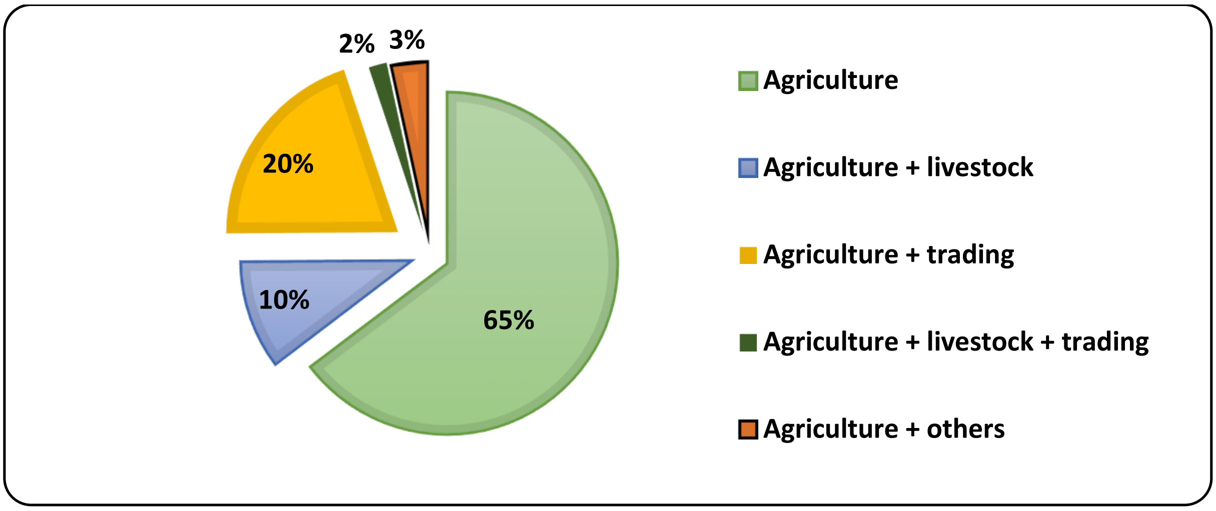


Figure 6: Occupational structure of the Respondents by Village

Table 5: Household Occupational Structure

	Agriculture as main occupation	Farm workers	**TOTAL**
AGBADOME	45.94%	25.28%	**71.22%**
GBLAINVIE	42.09%	38.64%	**80.73%**
KOVIE	48.34%	31.37%	**79.72%**
LILIKOPE	47.08%	28.07%	**75.14%**
TOTAL	**45.86%**	**30.84%**	**76.70%**

4.1.5 Land Holding Size and Land Tenure

For the whole study area (figure 7), the surveyed households own their land either by inheritance (48.9%), purchasing (5.53%) or donation (12.77%).

An average land holding size of the study area was 1.21 ha per farmer surveyed (table 14, annex 1). In table 6, we realised that the majority (58%) of the respondents belonged to the small category with less or equal to 1 ha land, 40% in medium category (1-3 ha) and only 2% belonged to the large category (>3 ha). The smallest land holding size was 0.03 ha found in Kovie village while the largest was found in Lilikope (8 ha).

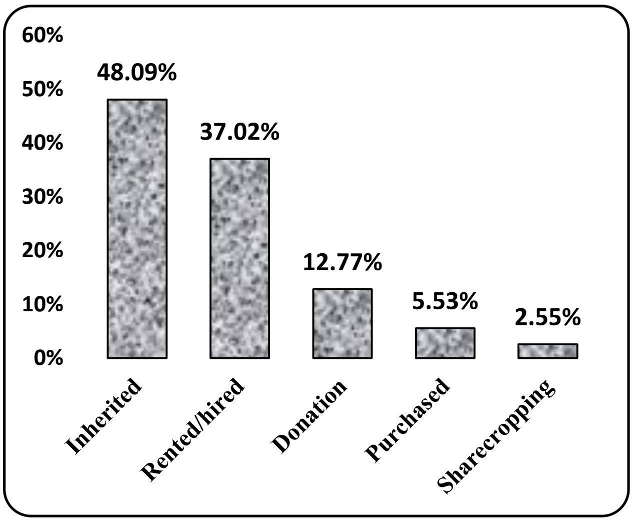


Figure 7: Land Tenureship of the Respondents

Table 6: Land Holding Size in Categories by Village

Villages	Land holding size in Category		
	Large (>3 ha)	Medium]1-3] ha	Small ≤ 1 ha
AGBADOME	2.00%	40.00%	58.00%
GBLAINVIE	1.61%	9.68%	88.71%
KOVIE	5.17%	24.14%	70.69%
LILIKOPE	10.77%	43.08%	46.15%
Total	**5.11%**	**28.94%**	**65.96%**

4.2 Households' Livelihood Situation

The livelihood assets in interaction with structures and processes determine how livelihood works and in particular is the basis for understanding how people will respond to climate induced vulnerabilities. They are the basis for the development of adaptation strategies (Kebede and Adane, 2011). Table 7 presents the detailed computed score for each indicator under each livelihood capital. The overall livelihood index, which is an average index value for the whole study area, was 34% which is below the standard average of households' livelihood security index (50%). With regard to overall livelihood capital index for each village, it was observed that Agbadomé has relatively better livelihood as shown by the higher index (0.41), compared to Gblainvié, Kovié and Lilikopé which have 0.31, 0.28 and 0.35, respectively, indicating poor situation of livelihood assets in general for all the villages. For the study area, the physical capital index was computed to be the highest (0.65) among the five livelihood capitals, followed by the human (0.43), social (0.24), financial (0.23) and the lowest was natural capital (0.13). Spiral diagram in figure 8 represent the livelihood situation for the whole study area.

Table 7: Summary of Livelihood Indicator Scores in the Study Area.

	AGBADOME		GBLAINVIE		KOVIE		LILI KOPE		**STUDY AREA**	
LIVELIHOOD INDICATORS	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Human Capital										
Farm workers (% / HH)	.25	.24	.39	.23	.28	.22	.31	.21	.31	.23
Local knowledge to predict seasons	.86	.35	.47	.50	.40	.49	.40	.49	.51	.50
Agriculture as main occupation (%/HH)	.46	.24	.42	.21	.47	.27	.48	.24	.46	.24
Human Capital Index	**.52**	.15	**.42**	.17	**.38**	.20	**.40**	.19	**.43**	.18
Natural Capital										
Access to water for irrigation	.22	.42	.34	.48	.19	.40	.17	.38	.23	.42
Soil fertility Status	.04	.20	.00	.00	.07	.26	.00	.00	.03	.16
Cropland land size	.15	.10	.09	.09	.13	.16	.21	.22	.15	.16
Natural Capital Index	**.14**	.15	**.14**	.16	**.13**	.18	**.13**	.13	**.13**	.16
Financial Capital										
Farm income	.50	.49	.15	.36	.10	.29	.23	.42	.24	.42
Saving	.20	.40	.34	.48	.14	.35	.22	.41	.23	.42
Access to credit	.22	.42	.15	.36	.22	.42	.28	.45	.22	.41
Financial Capital Index	**.31**	.29	**.21**	.27	**.16**	.24	**.24**	.29	**.23**	.27
Social Capital										
Assistance from family	.22	.42	.19	.40	.16	.37	.23	.42	.20	.40
Membership of a social group	.54	.50	.15	.36	.10	.31	.35	.48	.28	.45
Social Capital Index	**.38**	.31	**.17**	.24	**.13**	.24	**.29**	.34	**.24**	.30
Physical Capital										
Access to market	1.00	0.00	0.98	0.09	0.85	0.23	0.99	0.06	0.96	0.14
Access to farming modern equipment	0.41	0.19	0.26	0.25	0.34	0.32	0.39	0.23	0.35	0.26
Physical Capital Index	**0.71**	0.10	**0.62**	0.13	**0.59**	0.20	**0.69**	0.11	**0.65**	0.15
Overall Livelihood score	**0.41**	0.13	**0.31**	0.11	**0.28**	0.13	**0.35**	0.12	**0.34**	0.13

- ✓ **Natural capital**

Natural resources are among the most significant means of livelihood for the poorest and most vulnerable of the world especially for the rural community (Kebede and Adane, 2011). The natural asset in the study area was assessed through three indicators, including soil fertility status, land holding size and access to water for irrigation. The result indicates that natural asset which is one of the important assets of rural livelihood was below 25% for all the villages indicating a very low and poor natural capital situation and this will severely affect the sustainability of livelihood in the long run. As presented in table 13, about 66% of the household heads have less or equal to 1ha and farmers in Lilikopé have relatively larger land holdings compared to the other villages. From the various focus group discussions, especially in Gblainvié and Kovié, it is was pointed out that the reasons of small land size holding are mainly the uncontrolled sale of land that prevails in the study area and population growth that induces fragmentation by inheritance. In addition, People indicated in Gblainvié village that Development Forest Management Office of Togo have taken more than 400 Ha from them. Regarding soil fertility status, about 97% perceived decrease or degrading state of their soils. As water resources in the study area, we realised that only 23% have access to water for irrigation. The main source of irrigation water for Agbadomé and Kovié is river Zio while it is river Lili for Lilikopé village.
As realised Solomon et al., (2009) have pointed out, the most extreme form of erosion of natural assets is the complete disappearance of people's land on islands exacerbating livelihood.

- ✓ **Financial capital**

The financial asset was assessed mainly through the status of farm income, saving and access to credit. Overall financial asset of the study area was about 23%. Referring to the past 20 years, about 75% of the respondents perceived that their farm incomes were decreasing, 2% have relatively stable farm-income, while about 23% perceived increase in their farm-income. Focus group discussion in all the four villages revealed that disturbances in rainfall pattern and its consequences have reduced considerably their income from farming activities. Despite the retreating state of their income, about 71% of the surveyed farmers reported that they save some money in order to satisfy some needs like school fees for children, for funeral and also to solve other issues. However, it should be noted that the amount of saving has decreased as the farm-income is decreasing. Regarding access to credit, it was observed that only 21.7% of the respondents have access to credit. The issue of credit was serious in the study area, it was revealed that cash crop farmers are preferred for credit granting to the detriment of food crop farmers especially in Lilikopé and Kovié where people were not happy about that because they observed that it is only those who produce cotton and rice who have access to credit. As explained by Gblainvié focus group discussion participants,

"*By the past farming activities were profitable you can crop tree times in the year and the output of all of them will be good. If so, you can get a loan or credit and pay it back at the end of seasons but nowadays, you should pray before having at least what you need for consumption, under this condition, how will you pay the loan backif actually you have taken? This is also a reason why the credit institutions are reluchant to loan us money*."

As explained by Lilikopé FGD participants*, "In the past, our market functioned based on agricultural product and people from different places used to come. The market is the only place where our wives used to go to operate small income generating activities so that the household can survive but now, since we farmers don't get a good output how will the market operate well?"*

This result concurs with the finding of Hassan and Nhemachena, (2008) who stated that climatic stressors erode financial assets due to losses of farm income and jobs.

- ✓ **Social capital**

Targeting social networks also helps to enhance "social capital", something that is critical for building the resilience to cope with and adapt to changes brought about by adapting to climate change (Rowson et al., 2010). The social capital of the respondents was assessed through two important indicators: membership of a social group and assistance from family. The overall score of social capital in the study area was 24%. The results indicate that about 69% of the respondents were not members of any social group, while 31% belonged to social group. Agbadomé has the highest score for social index (0.38), compared to the other village the score of which is very low, this is due to the actual presence of Red Cross in that village. In fact, the village of Agbadomé is well organised in terms of social group with special reference to the one named "mothers club" established by Togolese Red Cross. The president of the group reported that the group is a platform where they share information, knowledge and skills, thanks to the group, many women have got some credit to start a small business and improve their farming activities. Concerning the assistance from family, the survey revealed that only 20% of the respondents have assistance from their family member. Key informants interviewed at the village level revealed that in the years 1980-1990 when you cropped on 1/3 ha you could not harvest it with just your small family, so usually farmers got assistance from family members and reciprocally but with changes in the rainfall pattern and individualism that prevails, each individual takes care of their own activities. In addition, focus group discussion in Lilikopé and Kovié revealed that mutual assistance among farmers has disappeared because of the drop in productivity that induces disgust in agriculture. Farmers have also indicated that prevalence of robbery has been increasing partly because of the food and income shortage induced by climate change. This result is in line with other studies that concluded that weather events and climate also erode social and cultural assets. Climatic stressors and changing trends disrupt informal social networks of the poorest, elderly, women, and women headed households, preventing the mobilisation of labour and reciprocal assistance (Osbahr et al., 2008; Buechler, 2009).

- ✓ **Human capital**

Human capital was derived from three human asset indicators, namely percentage of people who have agriculture as main occupation by household, percentage of people who participate in farming activities by household (farm workers) and knowledge of local indicators to predict seasons. It was observed that an average of 45.8% have agriculture as main occupation and 31.1% participate in farming activities by household in the whole study area. Even though the farmers have stated during the focus group discussion that some of their siblings and relatives have abandoned farming activities and start "moto taxi" and others have migrated to the capital Lomé for job, the study shows that the index of human asset is about 43% for the whole study area. Regarding their knowledge, we observed that more than 51.5% of the respondents know some local indicators to predict seasons. Those local indicators include mainly the movement of birds, clouds, wind, ants and also the position of the moon, while others look at the state of mango trees or flowers, the intensity and duration of the first rainfall, etc. This indicates a good level of endogenous knowledge on rainfall and seasons prediction in the study area. Gentle and Maraseni, (2012) also realised that climate change damages human assets of rural household livelihood.

- ✓ **Physical Capital**

The physical capital is assess through two indicators: access to market and access to modern equipment for farming activities such as insecticide sprayer, plough, tractor, cultivator, irrigation equipment, etc. Physical capital has the highest score (0.65) compared to the other livelihood assets. The result indicates that 91.5% of the respondents have market located less than 3 km while for others, the market is located at 3 to 10 km. It means that the majority of the respondents have access to market. As modern equipment, 66% of the respondents have access to modern insecticide sprayer while only 1% have access to tractor and cultivator. Tractor and cultivator were observed in Kovié and this with rice farmers. Douglas *et al.*, (2008) equally found that floods attributed to climate change have severely damaged physical capitals in many large city in Africa.

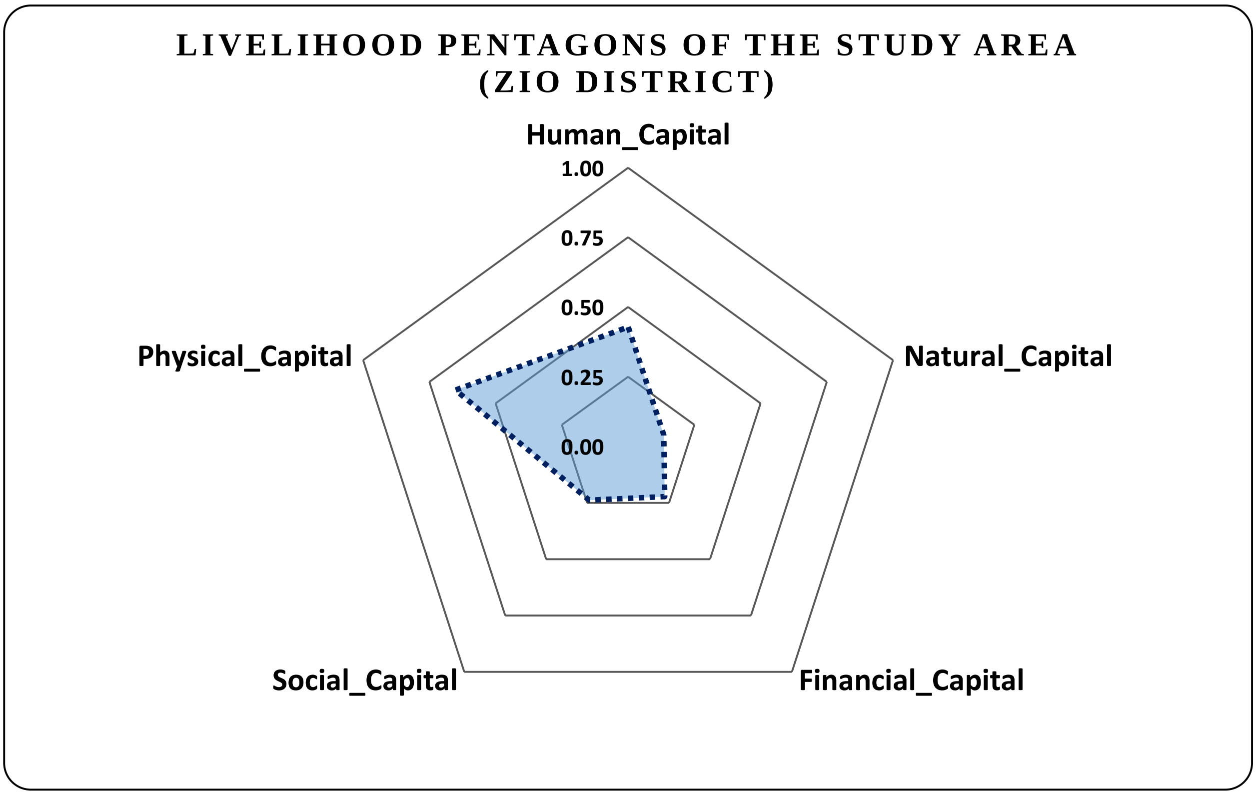


Figure 8: Livelihood Pentagons of the Study Area (Zio District)

Spiral diagram in figure 9 represents the livelihood situation for each of the 4 villages surveyed. With regards to the livelihood status of the villages, we observed that Agbadomé has relatively better livelihood as shown by the larger area of livelihood assets compared to the other villages. This can be explained by the fact that Agbadomé is often flooded due to its proximity to river Zio, and usually assisted by Togolese Red Cross which help them people to build resilience and increase their response capacity to climate risks. As shown in figure 9, Lilikopé and Glainvié have similar livelihood asset pattern. Lilikopé has a creek and Glainvié doesn't have any water body, then those two villages are likely to have a similar response capacity to climate risks. However, there is low cooperation or association among people in Glainvié due to the fact that some people are no more interested in agricultural activity because of climate change, and its closeness to the town of the district (Tsévié). Kovié has the lowest capacity compared to other villages. This can be explained by the fact that only rice farmers who are a minority in this village have access to some social groups and networks, and assets like credit, equipment, etc.

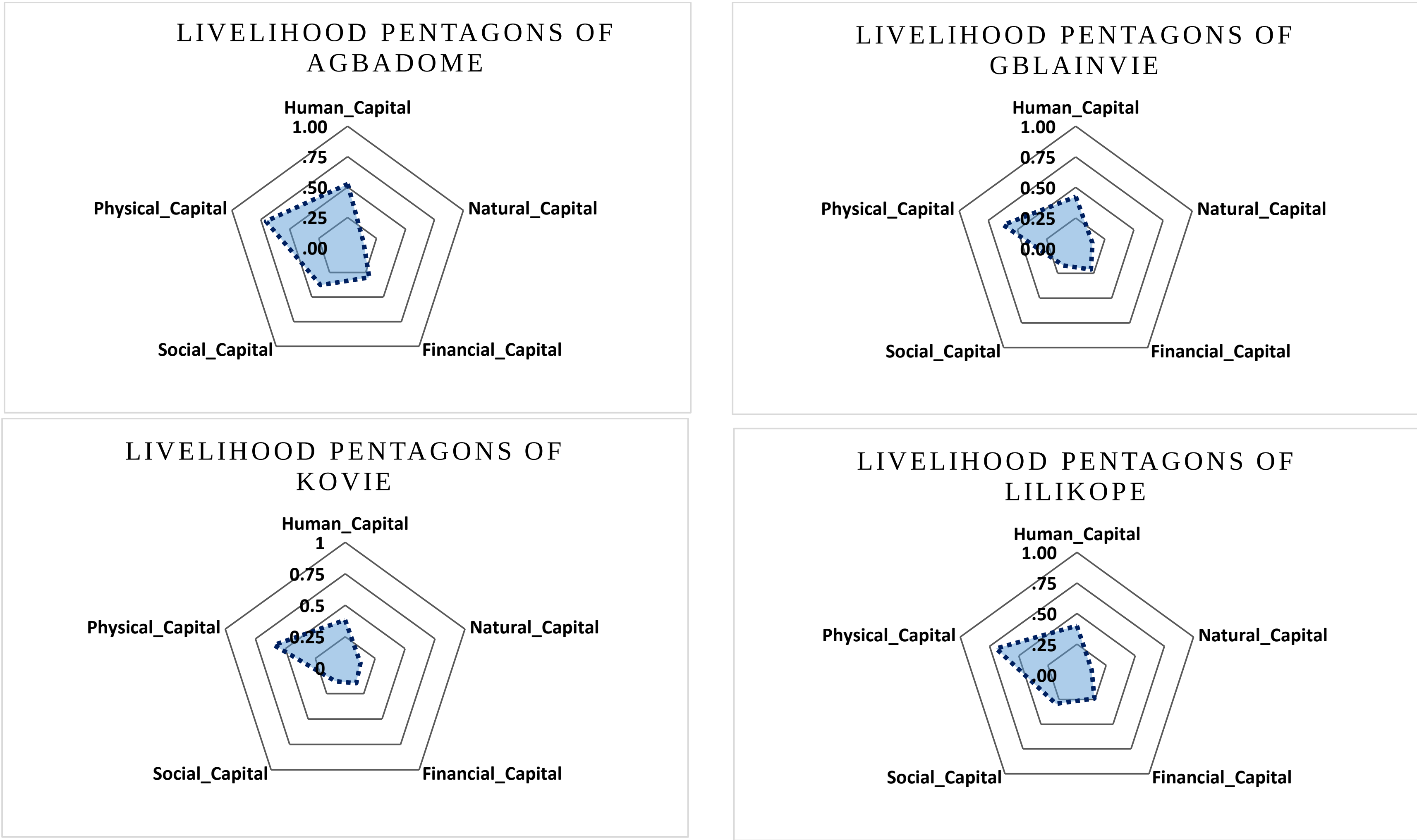


Figure 9: Livelihood Pentagon for Each Village

4.3 Descriptive Analysis: Farmers' Understanding and Perception of Climate Change

Farmers' perceptions and understanding of climate change are significant when it comes to livelihood adjustments and adaptations to climate change (Kebede and Adane, 2011). Recognizing this importance, perception and understanding of climate change by farmers was set as the second specific objective of this study. Results from this study indicate that communities have a clear understanding of climate change. At district and village levels, climate change is perceived through irregularity and disturbance in rainfall patterns, increase in temperature, and increase in the frequency of some weather extreme events such as flood, drought, storms and heavy rain.

4.3.1 Precipitation Pattern

In all villages surveyed, there was a general feeling that rainfall pattern has changed over the last 20 years as expressed by 98.72% of the respondents (table 14, annex 1). The table 8 below shows that more than 80 % of the respondents noticed that the rainfall has been coming late in the seasons, while 45.53% opined that the rainfall is coming too early in the seasons. In addition, about 44.68% of the respondents highlighted the unpredictability status of the seasons and 40.85% reported shortened growing seasons. Moreover, 44.68% perceived a decrease in the amount of rainfall, while others noticed increase in rainfall amount (15.32%), increase in rainfall intensity (17.87%), and presence of dry spells (12.77%).

Table 8: Changes Noticed by the Respondents in Rainfall Pattern

Changes in Rainfall Pattern	Percentage
Rainfall coming late in the season	80.43%
Rainfall coming too early in the season	45.53%
Decreased rainfall amount	44.68%
Unpredictability of the seasons	44.68%
Shortened growing seasons	40.85%
Increased rainfall intensity	17.87%
Increased rainfall amount	15.32%
Dry spell	12.77%

4.3.2 Temperature Pattern

It was generally acknowledged by the respondents in the whole study area that temperatures have increased over the past 20 years (figure 10). As reported by 88.74% of the respondents, the temperature has increased, while 11.26% have noticed the opposite, a decrease in temperature. The perception of decrease in temperature could be associated with the micro climate of some places that are near forest or water body. It can be also be attributed to little experience of the long term temperature patterns of the area, especially for the inhabitants who have settled in the study area only recently.

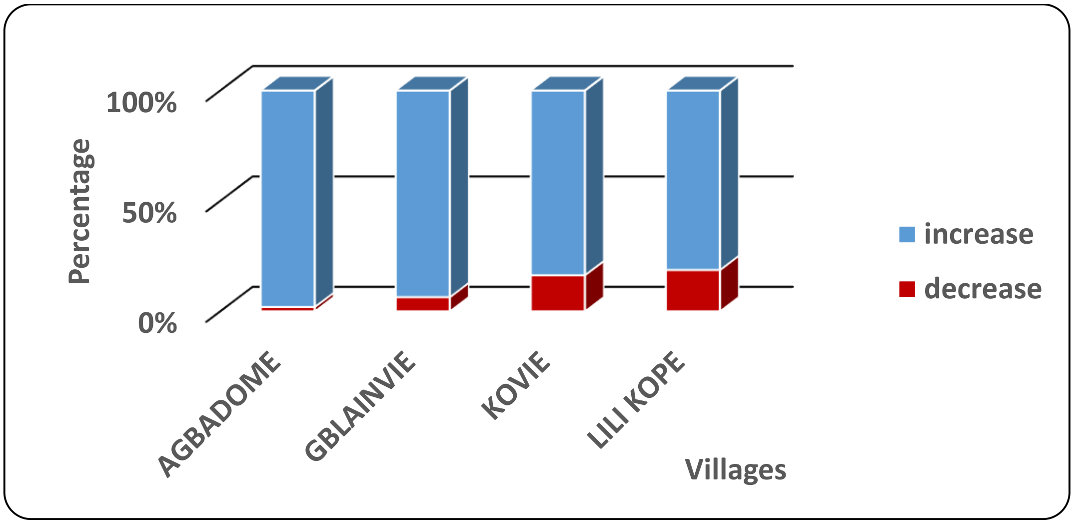


Figure 10: Perception on Temperature over the Last 20 years by the respondents

4.3.3 Weather Extreme Events

Rising frequency and serious extreme weather events over the last 20 years like flood, drought, storms and heavy rainfall were pointed out by farmers in the Zio district as a fact of climate change which challenge their lives and livelihood. The figure 11 below shows farmers' perception on the frequency of some extreme events.

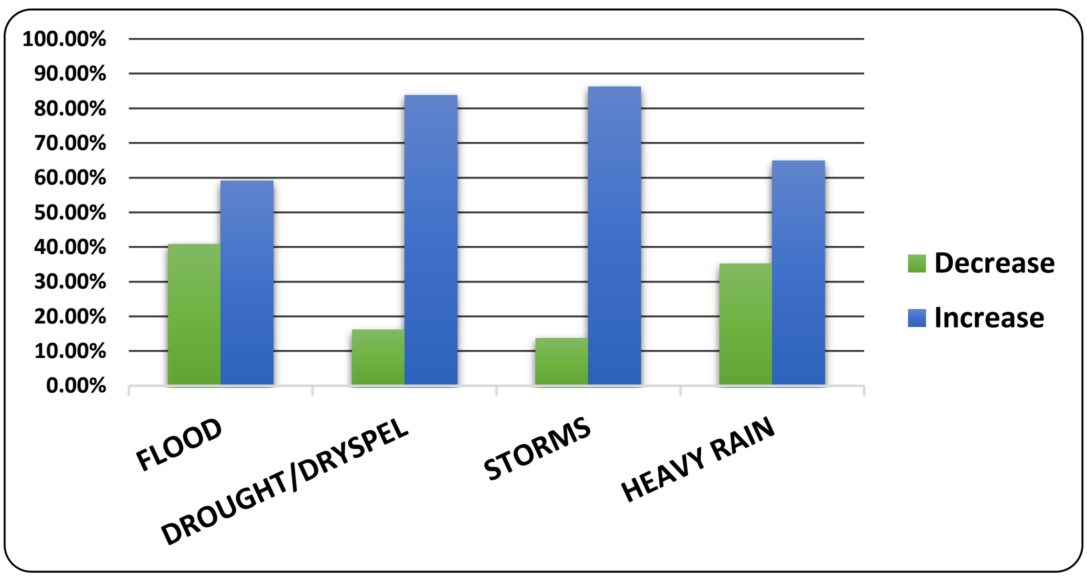


Figure 11: Frequency of Extreme Events as Perceived by Farmers

4.3.4 Causes of Perceived Changes in the Climate

The majority of the surveyed population (about 59.57%) attributed changes noticed in the climate to deforestation, while the remaining attributed the changes to other factors like nature, gods and sins. The table 9 below summarises the causes behind climate change as perceived by the farmers. It indicates that even though farmers did not have an idea about greenhouse gases, they recognised the regulating role of trees for their local climate.

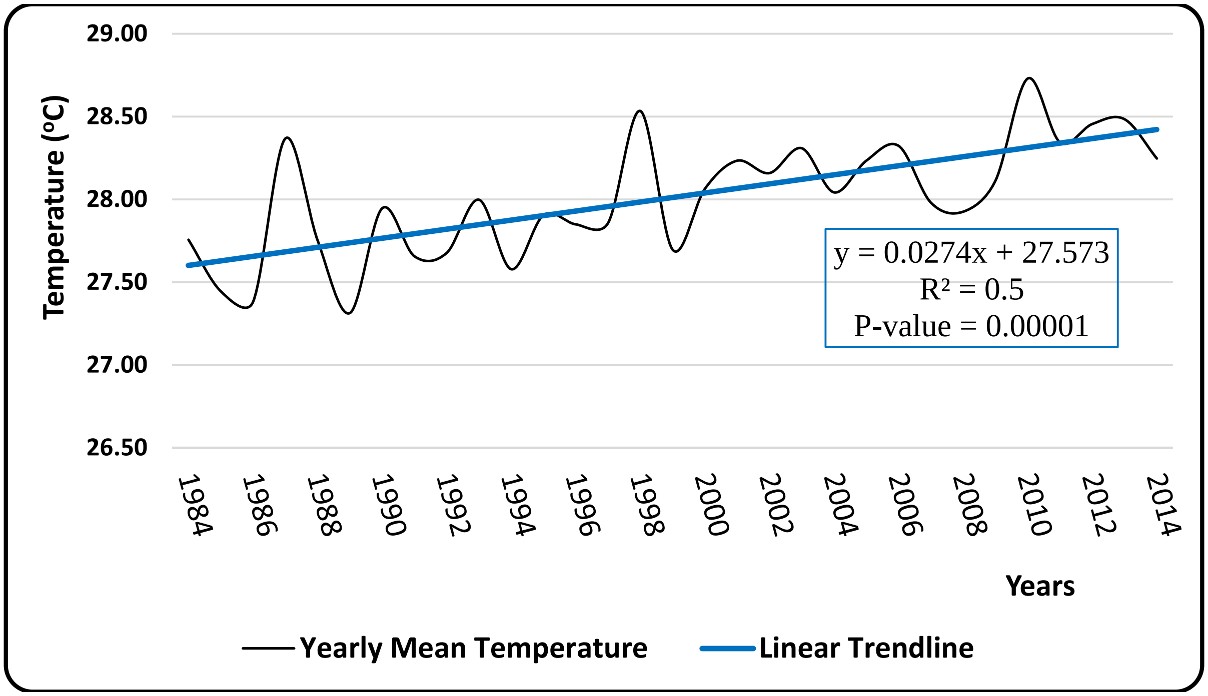
Table 9: Causes of Perceived Changes in the Climate by the Farmers

Causes of Climate Change	Percentage
Deforestation	59.57%
Natural	33.19%
Ancestor /gods	14.04%
Don't Know	11.49%
God	5.53%
Sins	3.83%

4.4 Meteorological Stations' Recorded Data of Climate in the Study Area

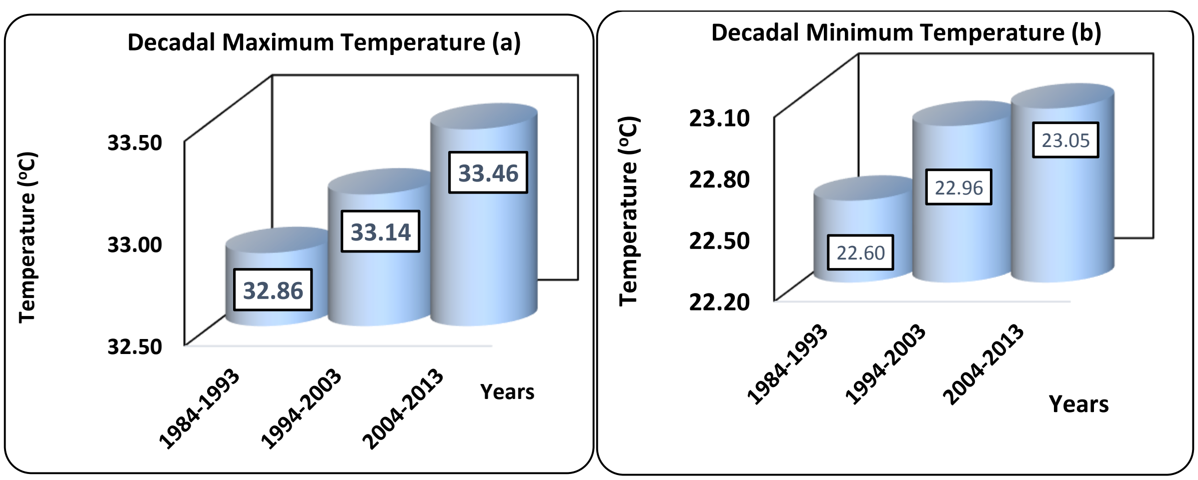
4.4.1 Temperature Pattern

We looked at how climate data recorded at national meteorological stations evolved over time (trends and variability). Temperature records of meteorological station for the study area show that there has been a significant linear trend at 0% of temperature increase ($y = 0.0274x + 27.573$, P-value = 0.00001) since 1984, (figure 12), which concurred with the majority of local perceptions. In the same line, decadal mean maximum and decadal mean minimum temperature as shown (in the figure13) below indicates that both mean maximum and mean minimum temperature have increased over the past three decades. This means that in the study area, both days and nights are becoming hotter compared to the previous decades.



Source of Data: DNM, 2015

Figure 12: Linear Trend of Temperature Over time (1984-2014)



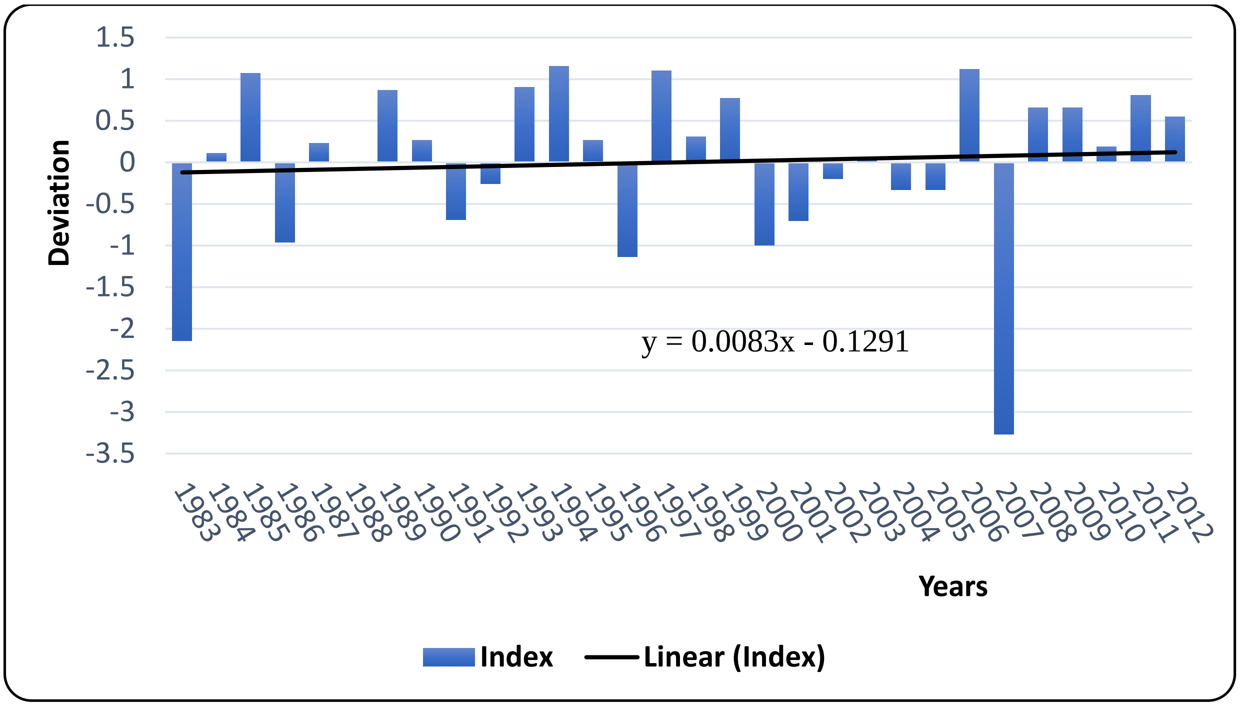
Source of Data: DNM, 2015

Figure *13:* Decadal Mean Maximum (**a**) and Minimum Temperature (**b**) (1984-2013)

4.4.2 Rainfall Pattern

An analysis of the rainfall data for Zio district over the past 30 years shows an interesting irregularity and disturbances in the rainfall pattern as shown in figures 14 and 15. Findings show that there is a slightly increasing trend (y = 0.0083x - 0.129) since 1983 in rainfall pattern. This trend is not significant (P-value = 0.700). However, it seems to support the concern of some of the respondents that rainfall is increasing.

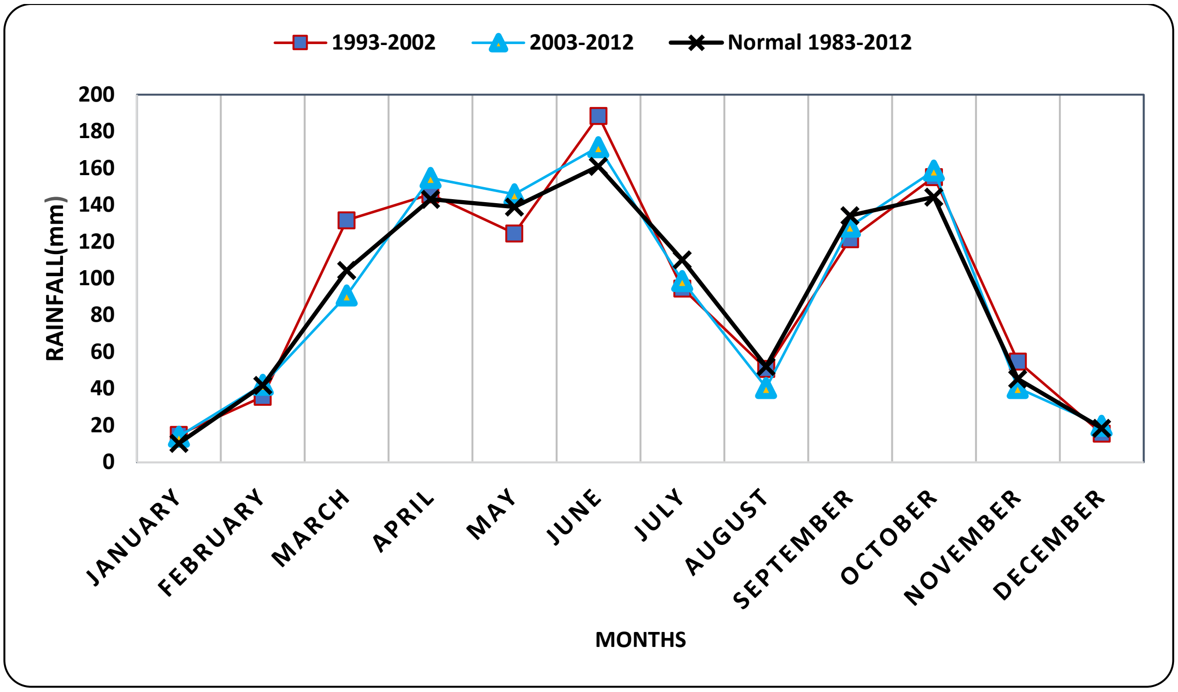
The cumulative deviation from mean of rainfall pattern as shown in (figure 14) indicates that apart from the years 1988 and 2003 which are almost normal years, there is in general, an alternation of dry and wet years. However, we can see that the period of 2000 -2005 were consecutively dry years while all the last five years (2008-2012) were consecutively wet years. Furthermore, the driest year over the last 30 years (1983-2012) was 2007. This seems to confirm the increasing frequency of flood and drought over the last decades as perceived by farmers.



Source of Data: DNM, 2015

Figure 14: Annual Rainfall Cumulative Deviation.

In the same line as the previous figure, figure 15 shows a monthly variability of rainfall pattern for the last two decades (1993-2002) and (2003-2012) from the normal (1983-2012). It shows that for the last two decades, the two highest peaks of the rainy seasons respectively in June and October were above the normal, while the peaks are below the normal in small dry season (August). This confirms once again the perceived increase in flood and drought in the study area as realised by farmers.



Source of Data: DNM, 2015

Figure 15: Monthly Rainfall Variation of the Last Two Decades from the Normal

4.5 Climate Change Impacts on Cropping Pattern and Adaptation Strategies Undertaken by Farmers

4.5.1 Climate Change Impacts on Cropping Pattern

Farmers in the study areas grow different crops for the pursuit of their livelihood. Many crops are grown in the study area but the main are maize, cassava, beans, tomato, groundnut, yam, pepper, rice, cotton and okra (table 10). Climate change affects farming activities in the study area in a number of ways, decrease in crop production, destruction of crops, acceleration of land degradation, abandoned of crops, outbreak of insects and outbreak of plant disease, decrease in soil fertility (table 11). Regarding the cropping system in the area (table 15, annex 1), we realised that mono cropping came first with 52%, intercropping with 40% and crop rotation with 17%. However the focus group discussions revealed that in the past, most farmers were practicing intercropping. Farmers were asked to tell the main reason behind the use of their main cropping system. And the result shows that about 41% percent of those who practice mono cropping justified their choice by disturbances in rainfall pattern, which did not allow them to intercrop maize with something else, particularly beans. Those who practice intercropping justified their choice as lack or insufficiency of cropland, while crop rotation was 68% attributed to the improvement of soil fertility.

Table 10: Main Crops Grown in the Study Area

Crops	Percentage
Maize	97.45%
Cassava	51.06%
Tomato	22.98%
Beans	22.55%
Groundnut	12.77%
Yam	11.06%
Pepper	9.36%
Rice	7.66%
Cotton	7.66%
Okra	6.38%

Table 11: Climate Change Impacts on Farming Activities in the Study Area.

Impacts	Percentage
Decreased crop productivity	93.19%
Destruction /loss of crops	36.60%
Land degradation	44.68%
Croplands abandoned due to flooding	11.91%
Outbreak of insects	8.94%
Outbreak of plant diseases	8.09%
Decrease in soil fertility	3.01%

As one farmer put it in the focus group discussion in Agbadomé,

"Farming has become a game of chance. We don't have any calendar for when to sow, you can only try if you are lucky you get something otherwise you won't get anything at all. Nowadays planning for a cropping pattern is becoming impossible, given the nature of rainfall pattern."

To avoid crop losses due to frequent floods some farmers declared that they abandoned or reduced their croplands that are located in flood prone area.

Kovié participants highlighted that "*before you can harvest three times in a year, you grow maize in the great rainy season called Ada and before the maturity of the maize you can crop beans under the maize and you will still have sufficient rain for it grows. But nowadays you cannot crop beans under maize in the great rainy season because the rain will stop before its maturity and also outbreak of insects will destroy it. In addition, you must use fertilizer and pesticide to get something, otherwise you will not get anything. However, the issue about pesticide is that once we use it, we can no longer consume the leaves which is our normal cooking vegetable"*.

4.5.2 Adaptations Strategies to Climate Change

Farmers use different adaptive measures to adjust to climate change effects. Regardless of the strategies applied by any farmer, it is predicted that taking adaptive measures reduces the negative effects of climate change on farm production, household income and farmers' livelihood (Uddin, *et al*.2014). In the study area, adaptation strategies in the crop production livelihood system include: change in crop variety, change in planting date, crop diversification, use of irrigation, change the amount of land area under cultivation, etc. (table 12).

Table 12: Adaptation Strategies Adopted by Farmers in Response to Climate Change.

Adaptation strategies	**Percentage**
Change in planting date	
Planting earlier	67%
Planting later	32%
Change in Crop Varieties	
Plant short cycle varieties	14%
Planting new crop varieties	6%
Planting drought tolerant crop	1%
Other Strategies	
Changing land size under cultivation	38%
Planting in lowland	17%
Irrigation	15%
Nothing	15%
Others	13%
Abandoning some crops	1%

4.6 Econometric Analysis

Before running the logit model, the explanatory variables were checked for the existence of multi-colinearity, using a contingency coefficient test to omit independent variables that are highly and strongly correlated to each other (Table 13). Absolute value of correlation coefficient of pairwise correlation that is greater than or equal to 0.7 threshold collinearity is considered as high and can severely distort model estimation and subsequent prediction (Anderson, *et al*., 1990; Fielding and Haworth, 1995; Dormann, *et al.*, 2012*)*. Multi-colinearity was observed between farming experience and age, farm income in the total income and off-farm income in the total income. As a matter of fact, the model was run with age and farm income omitted as their econometric estimates in those simulations were found not to have significant effect on the dependent variable.

The Hosmer Lemeshow test for logistic regression is widely used to answer the question "How well does my model fit the data?" (Archer, 2006). For both perception and adaptation regression in this study, we realised that Hosmer Lemeshow tests are respectively 0.163 and

0.369 which are greater than 5% level of significance. Then we reject the null hypothesis of Hosmer Lemeshow that is significant lack of fit between the fitted model and the expected data, and we conclude that our model fits well the data (table 18, annex1). In addition, the Omnibus Tests of Model Coefficients for the two steps regression are significant at 1%, indicating that the new models (with explanatory variables included) is an improvement over the baseline models (with only constant included), (table 18, annex 1).

Table 13: Correlations Matrix for the Two Stage Logistic Regression Models

Independent Variables	Age	Gender	Education	Farming experience	Household Size	Farm income	Off-farm income	Cropland Area	Access to Credit	Access to water for irrigation	Soil fertility status	Membership of a social group	Local Knowledge	Access to extension services	Access to climate information	Distance to the nearest input market
Age	1															
Gender (0/1)	.063	1														
Education (in year)	-.199	.489	1													
Farming experience (in Year)	.711**	.127	-.158	1												
Household Size	-.030	.004	.033	.055	1											
Farm income in total income (%)	-.032	.083	-.086	.027	-.100	1										
Off-farm income in total income (%)	.032	-.083	.086	-.027	.100	-1.000**	1									
Cropland Area	-.035	.165	.180	.032	.294	-.073	.073	1								
Access to Credit (0/1)	.044	.031	.051	-.014	.041	.158	-.158	.168*	1							
Access to water for irrigation	-.095	.142	-.040	.029	-.057	.310	-.310	-.084	.165	1						
Soil fertility status (0/1)	.044	.048	-.028	.045	-.077	.104	-.104	.011	.151	.121	1					
Membership of a social group (0/1)	.044	.144	.199	.064	.062	-.037	.037	.257	.182	.104	.099	1				
Local knowledge to predict seasons(0/1)	.105	.024	-.001	.106	-.051	.155	-.155	-.032	.155	.059	.068	.204	1			
Access to extension services (0/1)	-.008	.190	.173	.091	.201	-.080	.080	.259	.212	.032	.116	.366	.039	1		
Access to climate information (0/1)	.037	-.004	.058	.118	.006	.159	-.159	-.050	.014	.091	.133	-.005	.135	.012	1	
Distance to the nearest input market	.045	-.142	-.123	-.059	-.054	-.106	.106	.202	.128	-.141	-.045	.142	.043	-.090	-.392	1

** High co-linearity between the two variables

4.6.1 Farmers' Perceptions of Climate Change

The results from the regression indicate that most of the explanatory variables affect the probability of perceiving climate change by farmers. Education, farming experience, access to climate information, access to extension services, off-farm income, local knowledge to predict seasons, membership in a social group have positive impact on the climate change perception, while gender, access to credit, soil fertility status have negative relationships with the perception on climate change. The model results, along with the marginal impacts, is presented in (table 16, annex 1).

Education: Education of the respondents has a positive and significant influence on climate change perception (**β** = .0089538, p < 5%). A unit increase in number of years of schooling corresponds to 17.8% increase in the *odds* that a farmer perceives changes in climate change. This result is in line with Ayanwuyi *et al.,* (2010), Ndambiri *et al* (2012) who reported that education level of households had positive and strong relationship with perception of climate change. However, Gbetibouo *et al* (2009) have found that education seems to decrease the probability that the farmer will perceive long-term changes in rainfall.

Gender of the head of household*:* Unlike to prior expectations, the result indicates that gender has negative and significant influence on climate change perception (**β** = -.0588715, p < 5%). Male-headed households in the study area were 68% less likely to perceive changes in climate than female headed households. It means that female-headed households are more likely to perceive changes in climate than male-headed households. This is probably due, on the one hand, to the considerable proportion of female farmers (42.13%) involved in farming activities in the study area and, on the other hand, to the high presence of women in social groups, in places like markets, water sources which are considered as a platform where rural people especially women share information on different issues.

With respect to farming experience, the study found out that more experienced farmers were also more likely to perceive climate change than farmers with low farming experience (**β** = .0021909, p < 5%). One year increase in the farming experience increase by 4.1% the odds of a farmer to perceive changes in the climate. This is because experienced farmers have high skills in farming activities and therefore are able to detect any change in climatic conditions or changes in crop production levels resulting from variability in climate. This result is similar to the work of Gbetibouo *et al* (2009), Ndambiri *et al* 2012. Moreover, studies indicated that experienced farmers have a higher probability of perceiving climate change as they are exposed to past and present climatic conditions over the longer perspective of their life span (Maddison, 2006; Ishaya and Abaje, 2008, Deressa et al., 2009).

Off-farm income in total income: With regard to the off-farm income, the study results showed a positive relationship between off-farm incomes and the probability of farmers to perceive climate change (**β** = 0013202, $p < 1\%$). As pointed out by the farmers in focus group discussion, agriculture was the only main source of income for the village but since farming is no longer profitable, many people have added a second source of income, especially livestock and trading. This is probably the reason why one unit increase of the percentage of off-farm income in the total income increases the chance of a farmer to perceive climate change by 2.4%. The result is similar to Okonya, et al (2013) and (Isham, 2012) who concluded that higher non-farm income positively influence farmers' perception of climate change. However Ndambiri, *et al* 2012 found the copposite.

Access to credit: The result revealed an inverse relationship between farmers' perception to climate change and their access to credit. It was established that farmers with access to credit were less likely to perceive climate change than farmers without access to credit (**β** = -.1153074, $p < 10\%$). This is probably because the lack of credit access enhances the vulnerability of farmers to risks associated with climate change and hence their probability to perceive that climatic conditions are changing. This finding concurs with findings by Gbetibouo *et al* (2009) and Ndambiri *et al* (2012).

Soil fertility status: Perceiving climate change is negatively and significantly influenced by the perception of the farmer on soil fertility status (**β** = -.6080396, $p < 5\%$). The chance of farmer that perceived increase in the soil fertility status to perceive that the climate has changed is about 2.8%. The probable reason for the negative relationship between soil fertility status and climate change perception could be explained by the fact that most people who perceived decrease in the soil fertility attributed this to the increase in temperature and prolonged drought period (focus group discussion in Agbadome, Kovie and Lilikopé). In addition, the result is in line with Gbetibouo, *et al* (2009).

Membership in a social group: It impacts positively and significantly climate change perception (**β** = .0605094, $p < 10\%$)**.** This result is probably due to the fact that social group is considered as a platform where farmers share information as revealed by Focus Group Discussion Participants in Agbadomé.

Local Knowledge to predict seasons: Local knowledge to predict seasons influenced positively and significantly the ability of farmers to perceive changes in the climate (**β** = .0605094, p < 10%). Farmer who have local knowledge of seasons prediction have 2.875 times the odds to perceive climate change than farmers without endogenous knowledge to predict season. Okonya, et al (2013) have also found the similar relationship between local knowledge to predict seasons and climate change perception.

Extension services*:* it is expected, access to crop extension services has a positive and significant effect on the likelihood of perceiving climate change (**β** = .0666373, p < 5%). This result implies the important role of agricultural institutional support in improving farmers' awareness and understanding about climate change. Having access to extension services increases 3.765 times the chance of perceiving changes in climate. Gbetibouo, *et al* (2009) have found the similar result and stated that farmers who have access to extension services are more likely to be aware of changing climatic conditions.

Access to climate information*:* information on climate has a significant and positive impact on the likelihood of perceiving climate change by farmers (**β** = .068816, p < 10%). It increases 2.939 times the odds of a farmer to perceive climate change. This finding is similar to the work of Tilahun, *et al* (2014) who realised that access to information on climate change increases the probability of perceiving the occurrence of change in climate. In addition, access to climate change information is an important precondition for farmers to take up adaptation measures (Madison, 2006), Ndambiri *et al* (2012).

Farmers in the study area have a clear understanding of climate change even though they do not have an idea about the increase of greenhouse gases concentration in the atmosphere which is the main cause behind the issue. The analysis showed that farmers' perceptions of climate change are in line with the climatic data records. This result concurred with the conclusion of Juana, et al (2013) who stated that most farmers in sub-Sahara Africa are aware of the impact of climate change, especially changes in temperature and precipitation.

4.6.2 Determinants of Adaptation Strategies Undertaken in Cropping Pattern to Climate Change

Understanding the likely adaptive responses of farmers to anticipated climate change represents serious challenges for researcher. (Gbetibuo, 2009). Adaptation to climate change requires that farmers first notice that the climate has changed, and then identify useful adaptations and implement them (Maddison 2006). In other words, perceiving climate change is prerequisite for adaptation of climate change (Benedicta, *et al. 2010).* The logit result (table 17, annex 1) indicates the reasons underlying the response of those who perceived changes in the climate. The findings of the logistic regression shows that education, farming experience, access to credit, cropland size, membership in a social group and the distance to input market have significant effect on the adaptation measure undertaken in cropping pattern to climate change.

- ✓ **Education**

In relation to the education level, it was established from the study that adaptation to climate change has a positive relationship with education farmers (**β** = .0130303, p < 5%). The likelihood of more educated farmers to adapt to climate change was higher than that of less educated. This is because higher education was more likely to expose farmers to available information on climate change (Ndambiri H. K. *et al*, 2012). This result is in support of the findings of Deressa et *al* (2009) who established a positive relationship between education and adaptation to climate change.

- ✓ **Farming Experience**

A positive relationship was found between the experience of the farmer and the adoption of adaptation measures (**β** = .0020427, p < 10%). It means that highly experienced farmers tend to have more information about changes in climatic conditions and the relevant response measures to take. Studies by Maddison (2006) and Nhemachena and Hassan (2007) also indicated that experience in farming increases the probability of uptake of adaptation measures to climate change, as experienced farmers have better knowledge and information on changes in climatic conditions and crop and management practices than less experienced farmers.

- ✓ **Access to credit**

Access to credit*:* access to credit allows higher chances of adapting to changing climatic conditions (Deresa *et al*, 2008). It increases financial resources of farmers and their ability to meet transaction costs associated with adaptation strategies (Kebede and Adane, 2011). It was found that access to credit has positive and significant impact on farmers' decision to adopt an adaptation strategies (**β** = .1344495, p < 5%). This result is in line with Caviglia-Harris (2002) and Gbetibouo (2009) who concluded that access to credit is associated with a positive effect on adaptation behaviour. Furthermore, Fosu-Mensah et *al* (2010) found that access to credit is critical in helping farmers to adapt to climate change in Africa.

- ✓ **Cropland Size**

Cropland area represents the total land area devoted to cropping activities by a farm household and may be taken as a proxy for farm household wealth (Scheffran et al., 2015). The results indicated that the cropland area has positive and significant impacts on adaptation strategies considered. (**β** = .0275837, $p < 5\%$). This is probably because farmers with larger land size have higher level of well-being and then can adapt, compared to farmer with small land size. This result concurs with the finding of Scheffran et al., (2015).

- ✓ **<u>Membership in a Social group</u>**

Membership in a social group and adaptation to climate change are positively related and significant (**β** = .1132801, $p < 5\%$). We can interpret this observation as an indication that membership and engagement in a social group encourages farmers to engage in adaptation strategies to face climate change. Uddin *et al*, (2014) found that farmers involved in cooperatives share knowledge and innovation ideas, discuss problems and challenges with others, and engage in collaborative decision-making. This finding is in tandem with the research report of Apata *et al.* (2009) and Anyoha *et al.* (2013) in Nigeria.

- ✓ **<u>Access to Extension Services</u>**

The study revealed that farmers' access to extension services on crop production had a higher likelihood of influencing the farmer to adapt to climate change (**β** = .0832974, $p < 10\%$).This is because access to extension services increases the awareness and exposes the farmer to new technologies. A number of studies confirm these results such as those by Gbetibouo (2009), Maddison (2006) and Nhemachena and Hassan (2007).

- ✓ **<u>Distance to input market</u>**

There is a negative yet significant (**β** = -.0042387, $p < 10\%$) relationship between distance to input market and adaptation to climate change effects. The results show that increasing distance of input market from the farmer decreases the likelihood of farmers' adoption of adaptive strategies to climate change. The nearest input (fertiliser, seed of different variety, pesticide, etc) market being the town of the district (Tsévié), the study results means that farmers residing further away from Tsévié were less likely to adapt to the changing climate than farmers residing shorter distances to Tsévié. This result confirms the work of Ndambiri H. K. *et al* (2012) who found that farmers residing further away from the nearest input market were less likely to adapt to the changing climate than farmers residing shorter distances to the nearest input market.

Chapter 5: CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

In the study area, households' livelihood is mainly dependent on farming activities. Changes in climate are considered as the major issue affecting the lives and livelihood of farmers. This study has assessed the capacities, resources, skills, knowledge affected and available for undertaking an adaptation measures, especially in cropping pattern. Its result has revealed that the overall livelihood index (34%) in the Zio district is below the standard average of households' livelihood security index (50%) with natural capital being the poorest (13%). This will severely affect the sustainability of livelihood in the long run.

Farmers in the study area have clear understanding of climate change, even though they do not have an idea about the increase of greenhouse gases concentration in the atmosphere which is the main cause behind the issue. They mentioned the increasing trend of temperature, they also noted disturbances and irregularities in the rainfall pattern and realised an increasing frequency in some extreme events like flood, drought, storms and heavy rain referring to the past 20 years. The analysis showed that farmers' perceptions of climate change are in line with meteorological climatic data recorded. As such, most farmers had undertaken some adaptation measures mainly in their cropping pattern to counter the adverse effects of climate change. The study has also showed that education, experience in farming, access to extension services, access to credit, cropland size, membership of a social group and distance to the nearest input market are the determinants of adaptation strategies undertaken by farmers in the study area. Based on the state of households' livelihood index and the determinants of adaptation measures obtained, farmers in the Zio district have low capacity to undertake adaptation strategies necessary to the pursuit and improvement of their well-being.

Because this work was conducted in only one district of Maritime region, it is difficult to make generalization for the whole region based on the results. There are other problems that affect different aspects of rural livelihood, so it was difficult to single out the contribution of climate change to existing problems based on the methods used. Future research works on rural livelihood under climate change in Togo at deeper and larger scale are needed.

5.2 RECOMMENDATIONS

Agriculture in a changing climate needs more and better interventions on resource accessibility and the reforming of policies, institutions, and processes in order to build, promote or facilitate the adoption of adaptation measures by making the livelihood assets of the poor more resilient to climate change. Livelihood assets are disappearing with climate change, urgent adaptation measures must be driven by key stakeholders in agriculture sector.

- The status of households' natural capital, as revealed in this study, points to the need to be strengthened by farmers themselves; government and development institutions support farmers to ensure sustainability of their livelihoods.
    - Development of land security policies to secure land and reduce the uncontrolled sale of land that prevails in the Zio district. Thus young people to possess enough land and take up farming as their main occupation.
    - Promote and adopt sustainable land management approaches in order to restore, conserve and improve the quality of soil fertility status in the study area.
- Education, extension services and access to climate information increase the awareness of farmers on climate and reduce their vulnerability to the adverse effect of climate change. The government and development service providers at all level must support farmers' education through various policies:
    - ✓ Intensify and provide adult literacy to local farmers at affordable charges.
    - ✓ More schools and better education facilities should be provided in rural areas.
    - ✓ Specialised education on climate change and the agriculture sector can help increase farmers' knowledge and help them better adapt to climate change.
- Based on the determinants of farmers' decisions to adapt as observed in this study, the following suggestions should be taken into account:
    - ✓ Government and development service providers' at all level need to produce and provide new crop varieties, physically and economically accessible to farmers.
    - ✓ More Social groups and cooperatives in the Zio district are needed to enable farmers to share knowledge, innovative ideas, and discuss problems and challenges, are very important need to be encouraged and promoted by government and non-governmental institutions.
    - ✓ Rural micro finance institutions to support farmers' adaptation to climate change. Agricultural finance institutions should be allocated more resources to expand their

services to reach rural areas by introducing affordable lines of credit. An increase in affordable credit is important in adapting to climate change, with more income, they will be able to buy fertilisers and early yielding crop seeds.

  - ✓ Provision and development of input market closer to farmers to increase their decision to adapt.

- Encourage humanitarian organization like Red Cross for disaster risk reduction and management in the study area.

REFERENCES

Abaje, I.B and Ishaya, S. (2008). "Indigenous people's perception of climate change and adaptation strategies in Jema's local government area of Kaduna State, Nigeria". *Journal of Geography and Regional Planning*, 1 (18), pp. 138-143.

Acquah-de Graft, H., & Onumah, E. (2011). ''Farmers' perceptions and adaptations to climate change: An estimation of willingness to pay''. *Agris, 3*(4), 31-39.

Adokpe M. Tokouda (2013). *Enjeux et perspectives de développement durable à travers les organisations caritatives nationales dans les communautés de base de la préfecture de Zio au Togo,* Thèse de doctorat à l'Université de Lomé, Faculté des Lettres et Sciences Humaines (FLESH) – Département de Sociologie, No 429. P.54.

Anderson, D.R., Sweeney, D.J., Williams, T.A., (1990). *An Introduction to Management Science: A Quantitative Approach to Decision Making* Lincoln, LIN, United Kingdom.

Anyoha NO, FN Nnadi, J Chikaire, JA Echetama, CO Utazi, RA Ihenacho (2013). Socio-economic factors influencing climate change adaptation among crop farmers in Umuahia South Area of Abia State, Nigeria. Net J. Agric. Sci. 1(2): 42-47.

Apata, T. G., Samuel, K. D., & Adeola, A. O. (2009). Analysis of climate change perceptions and adaptation among arable food crop farmers in South Western Nigeria. *Contributed paper presented at 23rd Conference of International Association of Agricultural Economists, Beijing, China*, August 16-22.

Archer J. K. (2006): "Goodness-of-fit test for a logistic regression model fitted using survey sample data". *The Stata Journal, Number 1, pp. 97–105*

Arkin, H. and Colton, R. (1963). *Table for statistics*, New York. Barnes and Noble.

Ayanwuyi, E. Kuponiyi., F.A. Ogunlade., and Oyetoro, J., (2010). "Farmers Perception of Impact of Climate Changes on Food Crop Production in Ogbomosho Agricultural Zone of Oyo State, Nigeria". *Global Journal of Human Social Science,* **10** (7): 33-39.

Bashir, Masarra Ahmed Adam (2012**):** "The Impact of Land-Use Change on the Livelihoods of Rural Communities: A case-Study in Edd Al-Furssan Locality, South Darfur State, Sudan", Dissertation for awarding the academic degree, Doctor of Natural Science, Technical University of Dresden, Faculty of Environmental Sciences, page 118.

Bhandari, G. (*2013):* "Assessment of Climate Change Impacts and Adaptation Measures in the Kapilbastu District of Nepal*", Applied Ecology and Environmental Sciences, Vol. 1, No. 5, 75-83* Available online at http://pubs.sciepub.com/aees/1/5/2

Buechler, S., 2009: Gender, water, and climate change in Sonora, Mexico: implications for policies and programmes on agricultural income-generation. *Gender & Development,* 17(1), 51-66.

Bureau Central du Recensement au Togo (2011): Quatrième Recensement General de la Population et de l'Habitat (RGPH) du novembre 2010, résultats provisoires.

Bryan, E., C. Ringler, B. Okoba, C. Roncoli, S. Silvestri, and M. Herrero, 2013: "Adapting agriculture to climate change in Kenya: Household strategies and determinants". *Journal of Environmental Management,* 114, 26-35.

Byg, A. and J. Salick,(2009). "Local perspectives on a global phenomenon--Climate change in Eastern Tibetan villages". *Global Environmental Change,* 19(2), 156- 166.

CARE (2002). *Household Livelihood Security Assessments: A Toolkit for Practitioners*, Prepared for the PHLS Unit by: TANGO International Inc., Tucson, Arizona, ¨page 24.

Caviglia-Harris, J. (2002). Sustainable Agricultural Practices in Rondônia, Brazil: Do Local Farmer Organizations Impact Adoption Rates? Department of Economics and Finance, Salisbury University.

Chambers, R. (1987) 'Sustainable livelihoods, environment and development: Putting poor rural people first'. IDS Discussion Paper. No. 240. Brighton: IDS.

Department for International Development DFID (1999). Sustainable Livelihoods Guidance Sheets. Department of International Development. Retrieved 21/02/ 2015 from http://www.livelihoods.org/info/info_guidancesheets.html

Department for International Development DFID (2000): Sustainable Livelihoods Guidance Sheets. Department for International Development. http://www.livelihoods.org/info/info_guidancesheets.html (accessed: 02.05.2015).

Deressa T.T, R.M. Hassan C. Ringler, T. Alemu and M. Yesuf (2009). "Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia". *Global Environmental Change* 19 (2009) 248–255.

Direction Régionale du Développement et de l'Aménagement du Territoire Région Maritime (DRDATM), 2009 : Monographie de la Préfecture du Zio, page 4-6.

Dormann, *et al (2012):* Collinearity: a review of methods to deal with it and a simulation study evaluating their performance, Ecography 35: 001–020.

Douglas, I., K. Alam, M.A. Maghenda, Y. Mcdonnell, L. McLean, and J. Campbell, 2008: Unjust waters: climate change, flooding and the urban poor in Africa. *Environment and Urbanization,* 20(1), 187-205.

FAO, 1996, Agro-ecological zoning guidelines. FAO Soils Bulletin 73 (Rome: FAO).

FAO/UNEP (1999): *The Future of Our Land: Facing the Challenge. Rome.* 72p.

FAO (2012): *La démarche de qualité liée à l'origine du riz de Kovié, Togo.*

Farrington, J., Diana Carney, Caroline Ashley and Cathryn Turton (June 1999): " Sustainable Livelihoods In Practice: Early Applications of Concepts in Rural Areas", *Natural Resources perspectives*, Number 42, page 2. Available at: http://hdr.undp.org/hdr2006/statistics/

Field, A. (2005). *Discovering statistics using SPSS:* (2nd ed.). London: Sage publication.

Field, C.B., V. Barros, T.F. Stocker, D. Qin, D. Dokken, K. Ebi, M. Mastrandrea, K. Mach, G. Plattner, and S. Allen, (2012): Managing the risks of extreme events and disasters to advance climate change adaptation. *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, UK, and New York, NY, USA.*

Fielding, A. H. and P. F. Haworth. 1995. Testing the generality of bird-habitat models. Conservation Biology 9:1466-1481.

Fosu-Mensah, B., Vlek, P., & Manschadi, M. (2010). Farmers' Perceptions and Adaptations to Climate Change: A Case Study of Sekyedumase District in Ghana. *A contributed paper presented at World Food Systems Conference in Tropentag, Zurich: 14th -16 September.*

Gbetibouo, G. (2009). Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability, the Case of the Limpopo Basin, South Africa: *IFPRI Discussion paper 00849*.

Gentle, P. and T.N. Maraseni, 2012: Climate change, poverty and livelihoods: adaptation practices by rural mountain communities in Nepal. *Environmental Science & Policy*, **21**, 24-34. Green, W. H. 2000. *Econometric analysis*, 4th ed. Prentice Hall, Upper Saddle River, New Jersey: Prentice-Hall.

Gujarati, D.N.; Porter, D.C. *Basic Econometrics*, 5th ed.; McGraw-Hill: New York, NY, USA, 2009.

Haan, L., and. Zoomers A. (2003). "Development Geography at the Crossroads of Livelihood and Globalisation. Tijdschrift voor Economische '. *Sociale Geografie* 94(3):350–362.

Institut Togolais de Recherche Agronomique (ITRA, 2009): Le rapport annuel, page 7

Intergovernmental Panel on Climate Change, IPCC (2014a): WGIIAR5-Chap9: Rural Areas**,** FGD[DJD], page 8, 25.

Intergovernmental Panel on Climate Change, IPCC (2014b): WGIIAR5- Chapter 13. Livelihoods and Poverty, FGD[DJD], page 1-57.

Intergovernmental Panel on Climate Change IPCC (2007): Impacts, Adaptation and Vulnerability," Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge.

International Fund for Agricultural Development, IFAD (2010): Support Project for Agricultural Development in Togo.

Isham, J. (2002). "The Effect of Social on Fertiliser Adoption: Evidence from Rural Tanzania". *Journal of African Economies*, 11, pp. 39-60.

Jacoby, H., M. Rabassa, and E. Skouas, 2011: *Distributional implications of climate change in India*. World Bank, Washington DC, USA, pp. 1-56.

Juana1,J.S. Kahaka1, Z. and Okurut1, F. N. (2013) : "Farmers' Perceptions and Adaptations to Climate Change in Sub-Sahara Africa: A Synthesis of Empirical Studies and Implications for Public Policy in African Agriculture". *Journal of Agricultural Science*; Vol. 5, No. 4.

Kalyebara, R. (1999), *A comparison of factors affecting adoption of improved coffee management recommendations between small and larger farmers in Uganda*, Department of Agricultural, Environmental, and & Development Economics, The Ohio State University.

Kangalawe, R. Y. M., Lyimo, J. G. (2013): *Climate Change, Adaptive Strategies and Rural Livelihoods in Semiarid Tanzania. Natural Resources*, 4, 266-278 http://dx.doi.org/10.4236/nr.2013.43034 Published Online July 2013 (http://www.scirp.org/journal/nr)

Kebede Dawit and Adane Habtamu (2011): *Climate change adaptations and induced farming livelihoods*, The Drylands Coordination Group (DCG) Report No. 64.

Khanal RC J. (2009. "Climate change and organic agriculture". *Agric.Environ*.; 10(1):100-110.

Kollmair M. and Gamper St. (2002), *The Sustainable Livelihoods Approach*, Input Paper for the Integrated Training Course of NCCR North-South Aeschiried, Switzerland, Development Study Group, University of Zurich (IP6), p.8.

Kumssa, A. and J.F. Jones, 2010: "Climate change and human security in Africa". *International Journal of Sustainable Development and World Ecology*, 17(6), 453-461.

Kurukulasuriya, P. and Mendelsohn, R. (2008), ‘’A Ricardian analysis of the impact of climate change on Africa cropland, The wold bank, Washington, DC.d; policy research working paper 4305.

Li, Y., D. Conway, Y. Wu, Q. Gao, S. Rothausen, W. Xiong, H. Ju, and E. Lin, 2013: Rural livelihoods and climate variability in Ningxia, Northwest China. *Climatic Change*, (3-4), 1-14.

Liu, J., S. Fritz, C. Van Wesenbeeck, M. Fuchs, L. You, M. Obersteiner, and H. Yang, 2008: “A spatially explicit assessment of current and future hotspots of hunger in Sub-Saharan Africa in the context of global change”. *Global and Planetary Change*, 64 (3-4), 222-235.

Mack, N., and K. Woodsong. 2005. *Qualitative Research Methods: A Data Collector’s Field Guide, Family Health International*. Retrieved from http://www.fhi.org (retrieval date: 31-12-2013).

Maddison, D., (2006). The Perception of and Adaptation to Climate Change in Africa, CEEPA Discussion Paper No.10, Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Manandhar S, Schmidt VD, Perret S, Kazama F. Adapting cropping systems to climate change in Nepal: a cross-regional study of farmers' perception and practices Reg. Environ. Change; 2011. p. 335-348.

Mendelsohn, R., & Dinar, A. 1999. *Climate change, agriculture, and developing countries: Does adaptation matter?* World Bank Research Observer, 14(2), 277–293.

Mikémina, P. (2013). **“**Climate Change Impact on Togo’s Agriculture Performance: A ricardian analysis based on time series data “*Ethiopian Journal of Environmental Studies and Management Vol. 6 No.4, 392* org/info/guidance_sheets_pdfs/section2.pdf>.

Ministere de l’Agriculture, de l’Elevage et de la Pêche (MAEP, 2013) : Recensement National de l’agriculture: Aperçue général de l’Agriculture Togolaise à travers le Pré- Recensement 2012. Direction des Statistiques Agricoles, de L’informatique et De la Documentation (DSID). Volume 1, p.1-122.

Ministere de l’Environnement et des Ressources Forestieres (MERF, 2009) : National Climate Change and Variability Adaptation Program of Action, 1-113.

Ndambiri H. K. *et al* (2012): “Assessment of Farmers’ Adaptation to the Effects of Climate Change in Kenya: the Case of Kyuso District”. *Journal of Economics and Sustainable Development, Vol.3, No.12, 2012, retrived online 30/06/2015).*

Nhemachena, C., and R. Hassan. (2007). Micro-level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discussion Paper No. 00714. International Food Policy Research Institute, Washington, D.C.

Okonya, et al (2013), "Farmers' Perception of and Coping Strategies to Climate Change, Evidence From Six Agro-Ecological Zones of Uganda", *Journal of Agricultural Science*; Vol. 5, No. 8.

Orindi V., Ochieng A., Otiende B., Bhadwal S., Anantram K., Nair S., Kumar V. and Kelkar U. 2006. Mapping climate vulnerability and poverty in Africa. Report to the Department for International Development, ILRI, Nairobi, Kenya. Section 2. Department for International Development, London.

Osbahr, H., C. Twyman, W.N. Adger, and D.S.G. Thomas, 2010: Evaluating successful livelihood adaptation to climate variability and change in southern Africa. *Ecology and Society,* 15(2**)**, 27.

Pensuk A. and Shrestha R.P., 2007: *Effect of Land Use Change on Rural Livelihoods: A Case Study of Phatthalung Watershed, Southern Thailand.* GMSARN International Conference on Sustainable Development: Challenges and Opportunities for GMS 12-14.

Puhalla M. Janet (2009): "Land Use and Agricultural Intensification in Mugandu Wetland, Kabale District, Uganda", a dissertation presented to the graduate school of the University of Florida in partial fulfillment of the requirements for the degree of doctor of philosophy, University Of Florida.

Rahm, M.R.; Huffman, W.E. The adoption of reduced tillage: The role of Human capital and other variables. *Am. J. Agric. Econ.* 1984, *72*, 405–413.

Récensement Général de la Population au Togo (RGPH, 2010) : Direction Générale de la Statistique et de la Comptabilité Nationale (DGSCN).

Rowson, J., Broome, S., Jones, A. (2010). Connected Communities: How Social Networks Power and Sustain the Big Society. Royal Society of Arts, London.

Sakthivel.M, Baskaran.M, Vijayakumar.S, Murugesan.S, Wilmart Clark.U, (2013): "An Assessment of Spatio -Temporal Land Use/Land Cover Changes in Manachanallur Taluk Tiruchirapalli District, Tamilnadu –India. *Int. Journal of Advances in Remote Sensing and GIS*, Vol. 1, No. 4.

Salisbury, S.D. and Schmink, M., 2007. Cows versus rubber: Changing livelihoods among Amazonian extractivists. Geoforum 38, 1233-1249.

Scheffran J., M. Abid ; U. A. Schneider , and M. Ashfaq (*2015)*: **"**Farmers' perceptions of and adaptation strategies to climate change and their determinants: the case of Punjab province, Pakistan", *Earth Syst. Dynam., 6, 225–243.*

Scoones, (1998): Sustainable rural livelihoods- A framework for Analysis-IDS Workingpaper no. 72.

Shiferaw A. (2014): "Smallholder Farmers Adaptation Strategies to Climate Change in Ethiopia: Evidence from Adola Rede Woreda, Oromia Region", *Journal of Economics and Sustainable Development* Vol.5.

Simatele, Binns and Simatele (2012): Simatele D, Binns N. & Simatele M. (2012). "Sustaining livelihoods under a changing climate: the case of urban agriculture in Lusaka, Zambia", *Journal of Environmental Planning and Management*, Vol. 55, No. 9, 1175–1191.

Smithers, J., and B. Smit. 1997. "Human adaptation to climatic variability and change." *Global Environmental Change* 7:129–146.

Soepboer, W., 2001. *The conversion of Land Use and its Effects at Small regional extent CLUE-S: An application for Sibuyan Islam, The Philippines.* Laboratory of Soil Science and Geology, Environmental Science, Wageningen University.

Sofoluwe, N., Tijani, A., & Baruwa, O. (2011). "Farmers' Perception and Adaptations to Climate Change in Osun Satte, Nigeria". *African Journal of Agricultural Research, 6*(20), 4789-4794.

Soini, E. 2005. *Land use change patterns and livelihoods on the slopes of Mt.Kilimanjaro, Tanzania*. Agricultural Systems 85; 306-323.

Skoufias, E., M. Rabassa, S. Olivieri, and M. Brahmbhatt, 2011: "The poverty impacts of climate change". *Economic Premise,* (51), 1-5.

Solomon, S., G.K. Plattner, R. Knutti, and P. Friedlingstein, 2009: "Irreversible climate change due to carbon dioxide emissions". *Proceedings of the National Academy of Sciences,* 106(6), 1704.

Stige, L. C., J. Stave, K. Chan, et a*l*., (2006). "The effect of climate variation on agro-pastoral production in Africa. Proceedings of the National Academy of Sciences 103: 3049–3053. *Sustainable Development and World Ecology*, 17(6), 453-461.

Thulani Dube and Keith Phiri (2013): "Rural Livelihoods under Stress: The Impact of Climate Change on Livelihoods in South Western Zimbabwe", *American International Journal of Contemporary Research*, Vol. 3 No. 5.

Tilahun, *et al 2014: "*Farmers' Perceptions and Adaptations to Climate Change through Conservation Agriculture: The Case of Guto Gida and Sasiga Districts, Western Ethiopia"**,** *Journal of Economics and Sustainable Development* Vol.5, No.17, 45-46.

Uddin, *et al*. (2014): "Factors Affecting Farmers' Adaptation Strategies to Environmental Degradation and Climate Change Effects: A Farm Level Study in Bangladesh", *Climate*, 2, 223-241; doi:10.3390/cli2040223.

UNDP (2006): Human development report, United Nations Development Program.

UNDP (2012) : Carte des potentialités d'emplois des jeunes et des femmes dans les préfectures et Sous-préfectures de Togo. Retrive on 5th January 2015 from http://www.republicoftogo.com/content/download/19218/171520/file/Etude%20PNUD.pdf.

Van Staden D, Rogers E, Makaudi I, Winkler J, White J, Kangale M, Rudman N, Nkosi S, Dreyer Coetzer TR (2006). A transect Walk Undertaken in Itereleng Informal Settlement to Observe Community Vulnerability. Unpublished report. Pretoria: City of Tshwane Metropolitan Municipality Disaster Risk Management Centre.

Vincent (2007): Katharine Vincent. Uncertainty in adaptive capacity and the importance of scale. *Global Environmental Change*, 17(1):12 – 24, 2007. ISSN 0959-3780. doi: DOI: 10.1016/j.gloenvcha.2006.11.009.

World Bank, 2010. Project Information Document "Togo Agricultural Sector Support Project" Report: AB5799.

World Bank (2013), http://siteresources.worldbank.org/EXTTOPPSISOU/Resources/1424002 1185304794278/4026035-1185375653056/4028835 1185375678936/1_Transect_walk.pdf (Assessed Jun 12, 2015).

Young H., Osman A., Akliluy Y., Dale R., (2005) Darfur Livelihood under Siege, Feinstein International Famine Center, Tufts University.

ANNEXE:

ANNEX 1: Descriptive Statistics of Variables Used in the Study

Table 14: Summary Statistics of the Variables used for the Logistic Regression Model and Livelihood Capitals

Categorical Variables	Choices	Frequency	Percent
Gender (0/1)	female	99	42.1
	male	136	57.9
	Total	235	100.0
	no	184	78.3
Access to credit (0/1)	yes	51	21.7
	Total	235	100.0
Farm income Status	Decrease (0)	177	75.3
	Stable (0.5)	5	2.1
	Increase (1)	53	22.6
	Total	235	100.0
Saving (0/1)	0	182	77.4
	1	53	22.6
	Total	235	100.0
	Decrease	228	97.0
Soil fertility status (0/1)	Increase	7	3.0
	Total	235	100.0
	no	181	77.0
Access to water for irrigation	yes	54	23.0
	Total	235	100.0
	no	162	68.9
Membership in a social group (0/1)	yes	73	31.1
	Total	235	100.0
	0	188	80.0
Assistance from Family (0/1)	1	47	20.0
	Total	235	100.0
	no	113	48.1
Local Knowledge to predict seasons(0/1)	yes	122	51.9
	Total	235	100.0
	no	143	60.9
Access to extension services (0/1)	yes	92	39.1
	Total	235	100.0
Access to Climate Information (0/1)	no	86	36.6
	yes	149	63.4

	Total	235	100.0
Distance to the nearest Market (Km)	<3km (1)	215	91.5
	3-10 km(0.5)	20	8.5
	Total	235	100.0
Access to modern equipment	Nothing (0)	78	33.2
	insecticide sprayer (0.5)	151	64.3
	Tractor/ Cultivator (1)	6	2.6
	Total	235	100.0
Perception on Climate Over time (instrumental)	no change	33	14.0
	Change	202	86.0
	Total	235	100.0
Perception on Climate (Observation)	Change	235	100
	no change	0	0
	Total	235	100
Perception on temperature	decrease	30	12.8
	increase	205	87.2
	Total	235	100.0
Disturbances in rainfall	no	3	1.3
	yes	232	98.7
	Total	235	100.0
Adaptation	no	169	83.7
	yes	33	16.3
	Total	202	100.0

Continuous Variables	Observations	Min	Max	Mean	Std. Dev
Education (in Year)	235	0	15	3.72	3.667
Off-farm income (%)	235	0	75	49.43	29.246
Farming experience (in Year)	235	1	66	23.64	14.366
Household Size (continuous)	235	1	13	5.23	2.440
Cropland Size (Ha)	235	.03	8	1.21	1.26
Farm workers by household (%)	235	00	88.89	31.18	.23.02
Agriculture as main occupation by household (%)	235	00	100	45.09	24.01
Distance to the nearest input market (Km)	202	3	20	13.51	6.83

Table 15: Main cropping system in the study area

Main cropping system	Percentage	Main reason evocated
Mono cropping	52%	Rainfall Disturbances (41%)
Intercropping	40%	Lack of cropland (75%)
Crop rotation	17%	To Fertilize the land (68%)

Table 16: Results of the Logistic Regression Model of Farmers' Perception of Climate Change in Zio District

	Regression Model (perception on climate change)			**Marginal Effect**	
Explanatory Variables	Coefficient (B)	P-value	Exp(B)	Coefficient (B)	P-value
Gender (0/1)	-1.125**	.031	.324	-.0588715**	0.045
Education (in year)	.164**	.029	1.178	.0089538**	0.049
Farming experience (in Year)	.040**	.036	1.041	.0021909**	0.042
Off-farm income in total income (%)	.024***	.004	1.024	.0013202***	0.009
Access to Credit (0/1)	-1.429**	.011	.240	-.1153074*	0.063
Soil fertility status (0/1)	-3.560***	.006	.028	-.6080396**	0.025
Membership in a social group (0/1)	1.346*	.067	3.843	.0617254**	0.035
Local Knowledge to predict seasons (0/1)	1.056**	.042	2.875	.0605094*	0.059
Access to extension services (0/1)	1.326**	.044	3.765	.0666373**	0.033
Access to climate information (0/1)	1.078**	.028	2.939	.068816*	0.066
Constant	-1.062	.143	.346		

*Note: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.*

Table 17: Results of the Binary Logistic Regression Model of Farmers' Adaptation to Climate Change in Zio District.

	Regression Model (adaptation to climate change			**Marginal Effect**	
Explanatory Variables	Coefficient (B)	P-value	Exp(B)	Coefficient (B)	P-value
Gender (0/1)	-1.002	.145	.367	-.0687046	0.171
Household size (continuous)	-.073	.523	.930	-.0046135	0.520
Education (in year)	.206**	.017	1.229	.0130303**	0.015
Farming experience (in Year)	.032*	.082	1.033	.0020427*	0.083
Off-farm income in total income (%)	.015	.134	1.015	.0009406	0.129
Access to Credit (0/1)	1.460***	.007	4.307	.1344495**	0.043
Cropland Size (Ha)	.436**	.020	1.546	.0275837**	0.028
Soil fertility status (0/1)	-23.061	.999	.000	-	-
Membership in a social group (0/1)	1.415**	.018	4.116	.1132801**	0.047
Local Knowledge to predict seasons (0/1)	-.782	.141	.457	-.0516359	0.167
Access to extension services (0/1)	1.170**	.033	3.222	.0832974*	0.058
Access to Irrigation Water (0/1)	-.444	.476	.641	-.0255635	0.433
Access to climate information (0/1)	.755	.228	2.127	.0437992	0.216
Distance to the nearest input market (Km)	-.116**	.012	.891	-.0073393***	0.007
Constant	-4.172***	.002	.015		

*Note: *** significant at 1% level; ** significant at 5% level; * significant at 10% level*

Table 18: Tables of Statistical Test

Hosmer and Lemeshow Test of Perception Model

Step	Chi-square	df	Sig.
1	11.740	8	.163

Omnibus Tests of Perception Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	60.847	10	.000
	Block	60.847	10	.000
	Model	60.847	10	.000

Hosmer and Lemeshow Test of Adaptation Model

Step	Chi-square	df	Sig.
1	8.694	8	.369

Omnibus Tests of Adaptation Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	58.109	14	.000
	Block	58.109	14	.000
	Model	58.109	14	.000

Classification Table[a](perception model, only constant included)

	Observed		Predicted		
			Perception on climate overtime referring to the past 20 years		Percentage Correct
			no change	Change	
Step 0	Perception on climate over time referring to the past 20 years	no change	0	33	.0
		Change	0	202	100.0
	Overall Percentage				86.0

a.The cut value is .500

Classification Table[a] (Perception model, Explanatory variables included)

	Observed		Predicted		
			Perception on climate overtime referring to the past 20 years		Percentage Correct
			no change	Change	
Step 1	Perception on climate over time referring to the past 20 years	no change	13	20	39.4
		Change	4	198	98.0
	Overall Percentage				89.8

a. The cut value is .500

Classification Table[a,b] (adaptation model only constant included)

	Observed		Predicted		
			Whether the farmer adapt to climate change or not		Percentage Correct
			no	yes	
Step 0	Whether the farmer adapt to climate change or not	no	169	0	100.0
		yes	33	0	.0
	Overall Percentage				83.7

a. Constant is included in the model.

b. The cut value is .500

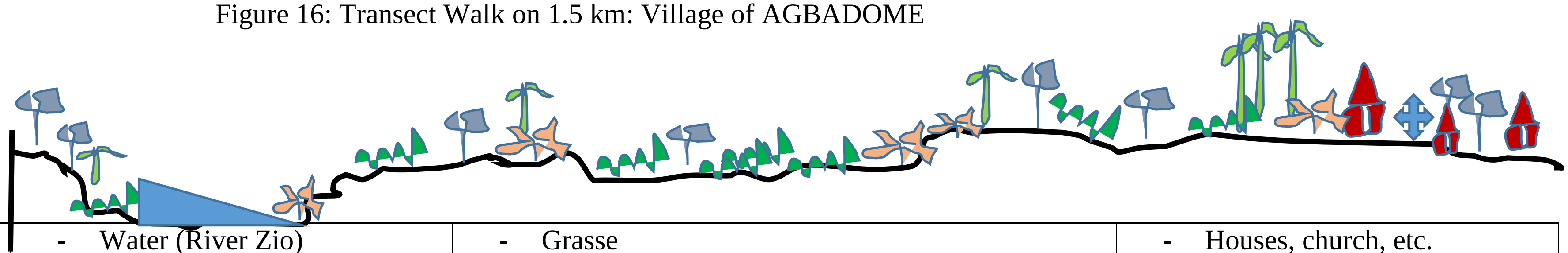
Classification Table[a] (adaptation model, Explanatory variables included)

	Observed		Predicted		
			Whether the farmer adapt to climate change or not		Percentage Correct
			no	yes	
Step 1	Whether the farmer adapt to climate change or not	no	163	6	96.4
		yes	21	12	36.4
	Overall Percentage				86.6

a. The cut value is .500

ANNEX 2: Transect Walks and Pictures

Figure 16: Transect Walk on 1.5 km: Village of AGBADOME



Land use/ Land cover	- Water (River Zio)	- Grasse - Water	- Houses, church, etc. - Farming
Soil & Soil quality	- Clayey soil	- Clay-sandy soil	- Sandy-clayey soil
Crops & Vegetation	Maize crops Trees (teak, oil palm, etc.)	- Fallow land abandoned due to frequent flood - Some palm tree dating back 38 years - Some trees like teak, mango tree, and others	Cocoa farm, maize crop, banana plantation,
Problems	Flood prone area	- High Flood risk	- Erosion, flood risk
Opportunities	Availability of irrigation water	- Availability of irrigation water - Very active social group and collaboration	- Water channel (water for domestic use and irrigation) - Access to latrine

Source: Author of the Study, 2015

Legend:

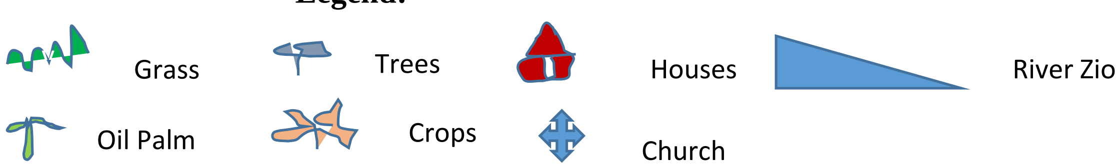
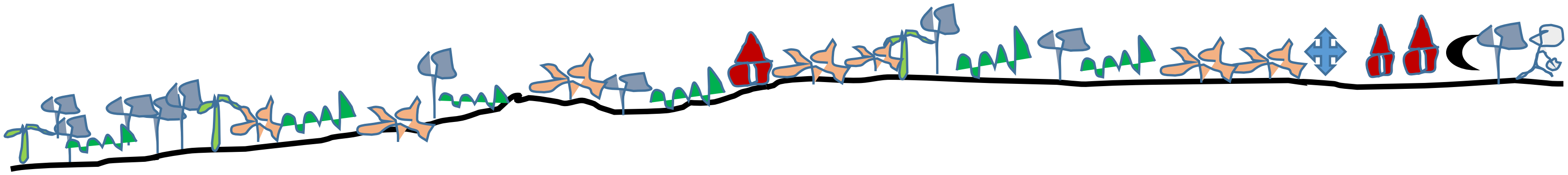


Figure 17: Some Pictures from Agbadomé Village

Figure 18: Transect Walk on 2.5 km: Village of GLAINVIE



Land use/ Land cover	- Farming	- Houses, church, etc. - School, Mosque, Church
Soil & Soil quality	- Ferruginous soil	- ferruginous leached soil, Sandy soil
Crops & Vegetation	Maize crops, tomato, cassava Orange tree, oil palm Trees (teak, eucalyptus, mango tree etc.), grasses -	Oil palm, orange trees, banana plantation. Grasses
Problems	- Soil degradation, conflict between Pastoralists and farmers.	- Soil degradation
Opportunities	Development and Forest Management Office by ODEF. -	- Closeness to Tsévié (for extension services, input, etc.) - Access to solar panel light

Legend:

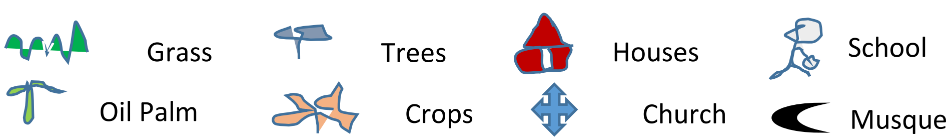
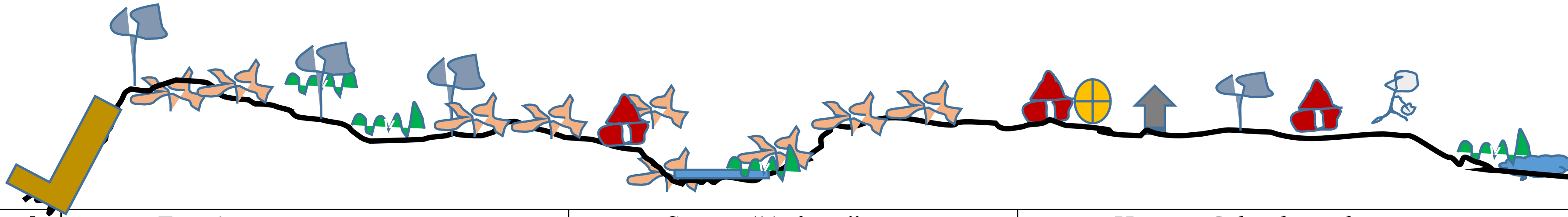


Figure 19: Some Pictures from GBLAINVIE Village

Figure 20: Transect Walk on 2 km: Village of LILIKOPE



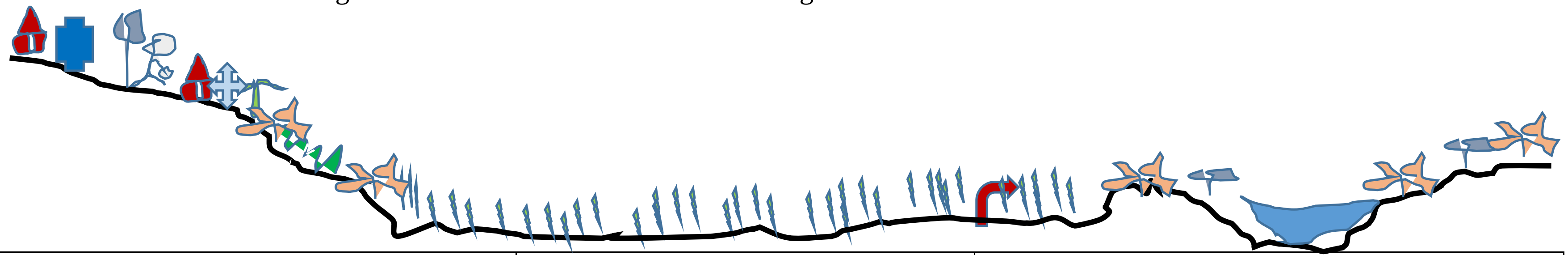
Land use/ Land cover	- Farming, - Gritting quarry -	- Stream “Agboto” - Houses - Farming	- Houses, School, market - Lili river - Main road
Soil & Soil quality	- Washed ferruginous soil	- Sandy clayey soil	- Sandy soil - Clayey-sandy soil
Crops & Vegetation	- Maize crops, oil palm, cassava, okra - Trees (Teak, Mango trees, Baobab Trees, etc.), Grasses	- Maize, Okra, cassava - Trees, grasses	- Orange trees, mango trees - Okra, Banana - Grasses
Problems	- Erosion - Strong noise, risk of shaking and other risks associated with blasting	- flood	- Flood
Opportunities	-	- Water for Irrigation	- Water for Irrigation - Market

Source: Author of the Study, 2015

Legend:

Figure 21: Some Pictures from LILIKOPE Village

Figure 22: Transect Walk on 2.5 km: Village of KOVIE



Land use/ Land cover	- Houses, Farming, School, Church, - Hospital -	- Rice plantation	- Zio river - Farming
Soil & Soil quality	- Washed ferruginous soil, Clayey-sandy soil	- Hydromorphic soil	- hydromorphic soil, Clayey soil, ferruginous soil
Crops & Vegetation	- Maize, oil palm, cassava, - Grasses - Teak, Trees, Orange trees, etc	- Rice plantation - Grasses	- Teak trees
Problems	- Erosion - Flood risk -	- Flood risk	- Flood risk
Opportunities	-	- Favourable to rice - Water for Irrigation	- Water for Irrigation

Source: Author of the Study, 2015

Legend:

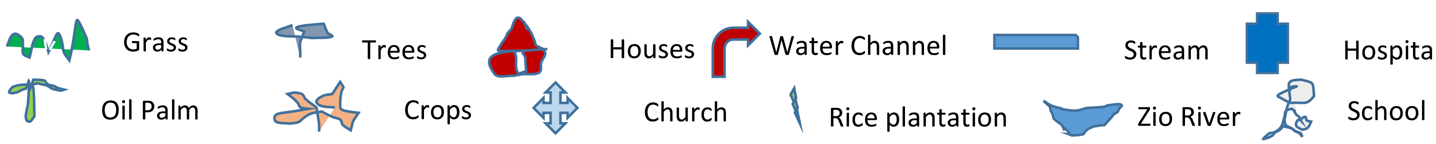


Figure 23: Some Pictures from KOVIE Village

ANNEX 3: Tools and Materials used for the Study

GUIDANCE SHEET FOR THE TRANSECT WALK

Land use/ Land cover			
Soil & Soil quality			
Crops & Vegetation			
Problems			
Opportunities			

Source: Author of the Study, 2015

GUIDE OF FOCUS GROUP DISCUSSIONS

Region: …………**Maritime**………………**.District**………**Zio**……… **Date ….……/………/………;**

Village …………………………………………………

Number of Participants: /……………………………………/ **Number of women /……………../**

Name of Animator/Facilitator……………………………………………………………………………

NOTES Taker……………………………………………………………………………………

Themes	Questions
Farmers' Perception on Climate Change	**1-** Have you noticed any disturbances in the climate/weather referring to the past 20 years in this village? What are the changes or disturbances you have noticed? (examples or occurrences of climate disturbances they experienced) **2-** In your point of view; what are causes behind this changes or disturbances in the climate/weather? **3-** How do the changes in the climate affect you in this village? **4-** What is the relevance of Climate change compared to other problems in the village?
Cropping Pattern and Adaptation	**1-** Have you noticed any change in your cropping system overtime (referring to the past 20years)? **2-** What was your normal distribution of seasons and your cropping activities calendar in this village? Has it changed overtimes? How? **3-** What are the reasons behind the changes you have noticed in your cropping system? **4-** How do you adapt to the disturbances? What are your difficulties in adapting?

Source: Author of the Study, 2015

SURVEY QUESTIONNAIRE

Name of the Interviewer: ____________________ ________Date: ____/___/___

Region:............**Maritime**.................. District: .....**Zio**........

Canton: ___________________________Village ____________________

Household Number /________________/

SECTION 1: SOCIO-DEMOGRAPHIC, ECONOMIC AND INSTITUTIONAL CHARACTERISTICS

1- Age: /…………………/

2- Gender: 0= Female ☐ 1= Male ☐

3- Marital Status: 1= Married ☐ 2= Widowed ☐ 3= Divorced ☐ 4= Single ☐

4- Have you been to school? 0= No ☐ 1= Yes ☐

If yes, level of education: (precise the number of year) 1 = Primary ☐ /_____/

2= Secondary ☐ /_____/ 3= High school ☐ /_____/ 4= University ☐ /_____/

5- Household Size (How many people live in this household?) /_______________________/

6- Number of people that have agriculture as main occupation in the household: / _______/

7- Number of people who participate in farming activities in the household: /_______________/

8- Are you native of the village? 0 = No ☐ 1= Yes ☐

If no, where are you from? ……………………………………….

And how many year have you being in this village? /__________________________/

9- Do you seasonally migrate somewhere for labour? 0= No ☐ 1= Yes ☐

If yes, where? ……………………………………………………………………….

10- What are your main income sources?

1= Agriculture ☐ 2= Livestock ☐ 3= Trading ☐

4 = Others ☐ (specify) ____

11- What is your farming experience (in years)? /_____________/

12- How much of your household's total income per year is generated by farming Activities (farm income)? 1= 25% ☐ 2= 50%☐ 3= 75% ☐ 4= 100% ☐ 5= Others ☐ ____

13- What do you think about your farm income when compared to 20 years ago?

1 =Increase☐, for how much? (A= 25% ☐ B= 50% ☐ B= 75% ☐ D= 100% ☐)

2 =Decrease☐, for how much? (A= 25% ☐ B= 50% ☐ B= 75% ☐ D= 100% ☐ **)**

3 =The Same ☐

14- Do you save any money? 0= No ☐ 1= Yes ☐

15- Do you have access to credit? 0= No ☐ 1= Yes ☐

If yes, from where**?** 1=Government institutions ☐ 2= Microfinances☐ 3= Individuals ☐

16- Have you received any credit or loan? 0= No ☐ 1= Yes ☐

17- Do you have access to modern equipment and technologies for farming such as plough, tractor, irrigation equipment, insecticide sprayer

1= Yes ☐ ☐ 3= No**,** **If** yes, please specify

A = Plough☐, B=Tractor ☐, C= Irrigation equipment ☐

D= Insecticide sprayer ☐ E = Others☐ (please specify)……………………………

18- Do you have access to extension services on crop production? 0= No ☐ 1=Yes ☐

19- Do you have access to Weather forecast and climate information? 0= No ☐ 1= Yes ☐

20- Do you receive any assistance / help from family for your activities?

0= No ☐ (Go to **b**) 1= Yes ☐ (Go to **a**)

a- If yes**,** how often did you receive assistance from family?

1 **=**Sometimes☐, 2 = Often ☐

And what kind of help? A= Financial ☐ (how much? ....) B = Labour ☐

b- If no, Why? ....

21- How often do you yourself provide help/assistance to your family members?

1 **=**Sometimes☐, 2 = Often ☐

And what kind of help/assisatance? A= Financial ☐ (how much? ....….) B = Labour ☐

If no, Why? ....

22- Are you a member of any social group, network, association etc.? 0 **=** No ☐ 1= Yes ☐

23- Do you receive any benefit/ help from outside for your farming activities?

0= No ☐ 1= Yes ☐ if yes, from who? ....

24- Do you have access to market? 0 = No ☐ 1= Yes ☐

25- How far is your house from the nearest market?

1 = < 3 km ☐ , 2 = 3-10 km ☐ , 3 = > 10 km ☐

26- How much of the product is sold at the markets? /__________ (in %)_/

And how often do you go to the market for buying food and other items?

1= Frequently☐ 2= Sometimes☐,

27- What is your main source of water?

1= Wells ☐ 2= Fontains ☐ 3= Rivers ☐ 4= Others ☐…………………

28- Do you have access to water? 0 = No ☐ 1= Yes ☐

29- How far is the nearest water source from your house?

1- < 3 km ☐, 2= 3-10 km ☐ , 3= > 10 km ☐

<u>SECTION 2</u>: PERCEPTION AND UNDERSTANDING ABOUT CLIMATE CHANGE

1- How will you appreciate the climate in this village overtime, referring to the past 20 years?

2- How will you appreciate the temperature in this village overtime, referring to the past 20 years? 0 = Decrease ☐ 1= Increase ☐

2- Have you noticed any disturbances in the precipitation pattern compared to the past 20 years? 0 = Yes ☐ 1= No ☐

If yes, what kind of disturbances have you noticed in the precipitation pattern?

1= Shortened growing seasons ☐ 5= Increased rainfall intensity ☐

2= Rainfall coming late in the season ☐ 6= decreased rainfall amount ☐

3= Rainfall coming too early in the season ☐ 7= Unpredictability of the seasons ☐

4= Increased rainfall amount ☐

8= Dry spell ☐ 9= Others ☐ (please specify) …………………………………

3- Have you noticed any of the following extreme event (hazard) in the local climate/weather over the last 20 years in this village?

1= Drought ☐ 2= Flood ☐ 3= Storm ☐ 4= Heavy rain ☐

5= Hot weather ☐ 6= Cold weather ☐ 7= Others ☐ (please specify) ……………

………………………………………………………………………………………..

4- How will you appreciate the frequency of the following events or hazards overtime referring to the past 20 years?

Flood	**Drought/ dry spell**	**Storm**	**Heavy rain**
0 = Decrease ☐	0 = Decrease ☐	0 = Decrease ☐	0 = Decrease ☐
1 = Increase ☐	1= Increase ☐	1= Increase ☐	1 = Increase ☐

5- In your opinion, what are the reasons behind those disturbances noticed in the climate?

1= Deforestation ☐ 2= Ancestor /gods ☐ 3= God ☐

4= Natural ☐ 5= Greenhouse gases ☐ 6= Don't know ☐

7= ☐ Others (please specify) ………………………………………………………………..

…………………………………………………………………………………………………

6- Do these disturbances in the climate/weather affect your farming activities?

0 = No ☐ 1= Yes ☐

If yes, how?

1= Decreased crop productivity ☐ 2= Destruction /loss of crops ☐

3= Land degradation ☐ 4 = Outbreak of plant diseases ☐

5= Outbreak of insects ☐ 6= Croplands abandoned due to flooding ☐

7 = Changes in cropping pattern ☐

8= ☐ Others (please specify) ……………………………………………………

7- Do you have any knowledge on local indicators to predict seasons? 0 = No ☐ 1= Yes ☐

If yes, what are these indicators? ……………………………………………………

Are you still applying this knowledge? 0 = Yes ☐ 1= No ☐

If yes, how far it helps to reduce your vulnerability to climate disturbances?

……………………………………………………………………………….

If no, why? . ...

8- Have you received any training or techniques to adapt to the disturbances observed in the seasons, climate/whether? 0 = Yes ☐ 1= No ☐

If yes, do you follow that technique(s)? 0 = Yes ☐ 1= No ☐ , if no, why? ………

…………………………………………………………………………………………..

SECTION 3: CROPPING PATTERN AND ADAPTATION

1- What is the total area of all the land you use for agricultural purposes?

Local units.............................. ha................................

2- What is/are the source of your cropland?

1= Purchased ☐ 2= Inherited ☐ 3= Rented/hired ☐

4= Sharecropping 5= Donation ☐ 6= Others ☐…………………………………

3- How many field/farm do you have for agricultural purposes? /................................/

4- Which crops do you grow?

1= Maize ☐ 2= Cassava ☐ 3= Rice ☐ 4= Beans ☐ 5= Tomato ☐ 6= Sorghum ☐

7= Groundnut ☐ 8= Cotton ☐ 9= Oil Palm ☐ 10= Yam ☐

11= Others ☐ (please specify) …………………………………………………………..

5- What are the most important crops do you grow?

Main Crop 1______________________ Main Crop 2______________________

Main Crop 3______________________ Main Crop 4______________________

6- How many time do you grow crops a year in 20 years ago?

1= One ☐ 2= Two ☐ 3=Three ☐

7- How many time do you grow crops a year nowadays?

1= One ☐ 2= Two ☐ 3=Three ☐

8- Did this household have any fallow land during the last agricultural year?

0= No ☐ 1= Yes ☐ If no, go to question n^{o} 10

If yes, How much? Ha.................... Local units............. …………….

9- How long is the fallow period usually? ________________Has it changed overtime?

0 = No ☐ 1= Yes If yes how many year? …………………

And Why? 1= Rainfall disturbances ☐ 2= Financial reasons ☐

3= Supply & demand ☐ 4= Flood ☐ 5= Drought ☐

6= Lack of cropland ☐ 7= Land degradation ☐

8= ☐ Others (please specify) ……………………………………..

10- What is your main cropping system?

1= Mono cropping 2= Intercropping ☐ 3= Crop Rotation ☐

4= ☐ Others…………………………………………………………………………

And why did you choose this kind of cropping system?

1= Rainfall disturbances ☐ 2= Drought ☐ 3 = Flood ☐

4= Lack of cropland ☐ 5= Land degradation ☐

6= Fertilizing the land 7= Others ☐ (specify)...

11- Did you apply any sustainable land management techniques such as

1= Irrigation ☐ 2= Manure ☐ 3= Minimum tillage ☐ 4 = Stone bunds☐,

5 = Nothing ☐ 6= Others ☐ (please specify)……………………………………

12- How did you change your cropping pattern in order to respond to climate disturbances?

1= plant earlier ☐, 2= plant later ☐, 3= plant in lowlands ☐ ,

4= Plant short-cycle varieties☐ 5= Irrigation☐ 6= Crop new varieties ☐

7= Plant drought tolerant crops ☐ 8= Abandon some crops ☐

9 = Nothing ☐ 10 = Others ☐ (please specify)…………………………………………

13- Is there any crop which you did not plant 20 years ago, planting now?

0= No ☐ 1= Yes ☐

If yes, which crops? ..../.......................................

....................................../……………………………/………………………………

And why? 1= Rainfall disturbances ☐ 2= Flood ☐ 3= Drought ☐

4= Supply & demand ☐ 5= Financial reasons ☐

6= Land degradation ☐ 7= Others reasons ☐ (please specify) ……………………

…………………………………………………………………………………

14- Are there any crops that had been abandoned?

0= No ☐ 1= Yes ☐ If yes, which crops?

1.........................../.2......................../.3................./.4.................../5……..........

And why? 1= Rainfall disturbances ☐ 2= Flood ☐ 3= Drought ☐

4= Supply & demand ☐ 5= Financial reasons ☐

6= Land degradation ☐ 7= Others reasons ☐ (please specify) ……………………

15- Is there any change in your total cropping area referring to the past 20 years?

0 = No ☐ 1= Yes ☐

✓ If yes, have you increased or decreased the total land under cultivation?

0= Decreased ☐ 1= Increased ☐

16- Have you increased or decreased the land area of the following main crops referring to the past 20 years?

Crops	Area (in Ha or local unit)
1-	0= Decrease ☐ 1= Increase ☐, from………….. to…………..
2-	0= Decrease ☐ 1= Increase ☐, from………….. to…………..
3-	0= Decrease ☐ 1= Increase ☐, from……………..to…………..
4-	0= Decrease ☐ 1= Increase ☐, from……………..to…………..

And why? ? 1= Rainfall disturbances ☐ 2= Flood ☐ 3= Drought ☐

4= Financial reasons ☐ 5 = Supply & demand ☐ 6 = Selling of land ☐

7= Parcelling up for inheritance ☐ 8= Land degradation ☐

9= Others reasons ☐ (please specify) ……………………………………………..

In case of different reasons, please specify by crop!

Crops	Reasons
1-	
2-	
3-	
4-	

17- Do you have access to water for irrigation? 0 = No ☐ 1= Yes ☐

If yes, from which source? 1= Rivers ☐ 2= Reservoirs ☐ 3= Dams ☐ 4= Wells ☐

5= Others ☐ ………………………………………………………………………

18- Do you practice irrigation? 0 = No ☐ 1= Yes ☐

19- Do you use farm inputs such as fertilizers and pesticides? 0 = No ☐ 1 = Yes ☐

20- What do you think about soil fertility status referring to the past 20 years?

0= Decrease ☐ 1= Increase ☐,

!!! <u>Please thank the interviewee for completing the survey</u>.

REMARKS BY INTERVIEWER

KEY INFORMANTS INTERVIEW GUIDE

1- How will you appreciate the climate/weather of this village referring to the past 30 years?

2- What are the signs or disturbances you have noticed in the local climate/weather of this village?

3- According to you, what are reasons behind these disturbances in the climate/weather?

4- How does this disturbances in the climate/weather affect you and your community?

5- What was your cropping systems 30 years ago?

6- Do these cropping systems have changed overtime? Why?

7- Is there any crop which you did not plant 30 years ago, planting now? If yes which crops?

8- Are there any crops that had been abandoned? If yes which crops?

9- Is there any change in your total cropping area in this village referring to the past 30 years? Why?

10- Facing all these problems, how do you adapt or cope in this village?