VULNERABILITY OF SMALLHOLDER MAIZE FARMING HOUSEHOLDS TO CLIMATE VARIABILITY IN THE EASTERN REGION OF GHANA

BY

MUSTAPHA ABUBAKAR SADIQ

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DECLARATION

I, Mustapha Abubakar Sadiq, the author of this thesis "**Vulnerability of Smallholder Maize Farming Households to Climate Variability in the Eastern Region of Ghana**", do hereby declare that apart from the references to other people's work which I have duly acknowledged and of which a plagiarism report is attached in appendix VII, the results presented in this thesis was done entirely by me. This work has never been presented in whole or in part for any other degree in this university or elsewhere.

....

Mustapha Abubakar Sadiq

(Student)

Date: ....

This thesis has been submitted with our approval as supervisors.

....	....
Prof. Ramatu M. Al-Hassan	Dr. John K.M. Kuwornu
(Major Supervisor)	(Co-Supervisor)
Date:	Date: ....

DEDICATION

I dedicate this work to my entire family and friends.

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ABSTRACT

Climate change and variability is one of the great challenges facing farming households in Ghana. The main objective of this study is to assess the vulnerability of smallholder maize farming households to climate variability in the Eastern region. Specifically, the study investigates the vulnerability of households to climate variability, the determinants of households' livelihood vulnerability level, the adoption level of adaptation strategies to climate variability and the determinants of the choice of those strategies and finally households' constraints to climate variability adaptation strategies in the Yilo Krobo Municipality and Ayensuano District in the Eastern Region of Ghana. Primary data was collected using structured questionnaires and focus group discussions whereas the Secondary data for climate were collected from the Meteorological Agency, Ghana. Fifteen (15) respondents each were sampled randomly from 10 communities making 150 respondents. The Livelihood Vulnerability Index (LVI) is used to analyze households' vulnerability to climate variability while Generalized Least Square is used to estimate the determinants of household vulnerability level. Multinomial Logistic regression model is employed for the determinants of the choice of adaptation strategies. The main software used is Stata (13). The results of the LVI score for Yilo Krobo is 0.363 and that of Ayensuano is 0.390 while the LVI-IPCC is 0.028 for Yilo Krobo and 0.031 for Ayensuano, all the two approaches indicating that households in Ayensuano are most vulnerable to the impacts of climate variability. Both Ayensuano and Yilo Krobo are most vulnerable in the natural disaster and climate variability component (0.528 for Ayensuano and 0.459 for Yilo Krobo) but least vulnerable in food component of the LVI (0.227 for Ayensuano and 0.202 for Yilo Krobo). The results of the GLS regression show gender, farm size, access to credit and temperature perception to be the factors that statistically influence household vulnerability in Yilo Krobo while farming experience, formal extension and hired labour are found to significantly influence vulnerability of households in Ayensuano district. The pooled sample show farming experience, access to credit, formal extension, temperature perception and hired labour to be the determinants of households' vulnerability level. The most adopted climate adaptation option in the area is found to be improved varieties and breeds strategies (38%) follow by recommended agricultural practice strategies (36%) with soil related strategies been the least adopted adaptation strategies (27%). The parameter estimates of the MNL regression model show rainfall perception, access to credit and farming experience to be influencing the choice of recommended agricultural practices while that of soil related strategies are gender and rainfall perception. Farming experience and rainfall perception are the factors that influenced the choice of improved varieties and breeds strategies. The empirical results of the Kendall's ranking show there is agreement among the ranking of constraints by the respondents. The most pressing constraints identified in the study area are inadequate and limited access to credit, inadequate drought tolerant varieties and low literacy. However, inadequate knowledge on climate related strategies and poor extension are the least ranked constraints in the study area. Water supply should be improved in Yilo Krobo municipality through the construction of potable water sources such as boreholes and wells in order to reduce the vulnerability of households to climate variability. Further, farmers in the region should be provided with improved varieties of maize that can withstand droughts. Ayensuano District Assembly should assist to establish community financial co-operative in order to promote savings and investment which can lead to a reduction in level of vulnerability financially and help to build social networks. Weather stations should be installed in the two districts to aid in the dissemination of information on any impending natural disasters to farmers.

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CDF	Cumulative Distribution Function
CIA	Central Intelligence Agency
CIMMYT	International Maize and Wheat Improvement Center
CRI	Crop Research Institute
CSIR	Centre for Scientific and Industrial Research
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GLS	Generalized Least Square
GSS	Ghana Statistical Service
IPCC	Intergovernmental Panel on Climate Change
LRDP	Lowland Rice Development Project
LVI	Livelihood Vulnerability Index
MiDA	Millennium Development Authority
MoFA	Ministry of Food and Agriculture
NGOs	Non-Governmental Organizations
IISD	International Institute for Sustainable Development
OLS	Ordinary Least Square
PHC	Population and Housing Census
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development

CHAPTER ONE

INTRODUCTION

1.1 Background

Climate is a component of an environment that basically consists of aggregates of temperature, rainfall, humidity and wind (Lama *et al.*, 2009). Climate change and climate variability are different entities and the distinction is often misunderstood. Climate change refers to a statistically significant variation in the mean state of the climate, persisting for an extended period of about 30 years (IPCC, 2001). This climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere (IPCC, 2012). Although an area's climate is always changing, the changes do not usually occur on a time scale that is immediately experienced. It is usually based on the weather in one locality averaged for at least 30 years.

United Nation Framework Convention on Climate Change, UNFCCC (2001) provided a definition of climate change which seems to be limiting the cause of the change in climate to human activities: UNFCCC defines climate change as one which occurs as a result of indirect or direct human activities that modify the composition of the universal atmosphere and natural climate variability observed over comparable time period of time.

However, climate variability is the way climate fluctuates yearly (short time) above or below a long term average value (IPCC, 2014). Variations (ups and downs) in climatic conditions on time scales ranges from months, years and decades. Main effect of climate variation includes droughts and floods which affect food production negatively in the immediate effect.

Every year in a specific time period, the climate of a location is different with some years below average, and some average, or above average. These variations in climate parameters are generally attributed to natural causes. However, because of changes in the earth's climate since the pre-industrial era, some of these changes are now considered attributable to human activities.

Scholze *et al.* (2006) assert that the lives of the entire world are progressively being endangered by the adverse effects of climate variability and change. Economic sectors that largely depend on climate related activities, most notably agriculture, are increasingly subject to the impacts of climate change and variability (IPCC, 2014). According to IPCC (2014), the effects of climate variability are already being experienced on every continent in the globe, and that the adverse impact of it on agricultural production will be massive in the tropics and subtropics, with sub-Saharan Africa (SSA) particularly vulnerable due to the range of projected impacts, multiple stresses and low adaptive capacity. Boko *et al*. (2007) also note that agricultural production and food security in many African countries and regions are likely to be severely compromised by climate change and variability.

World Bank (2010), posits that climate variability and change have been experienced in Ghana with three major physical impacts, namely change in rainfall, rise in sea level and temperature change. The report of the World Bank is supported by Owusu *et al*. (2008) who found that there has been a swing in the rainfall pattern in Ghana towards a longer dry season and vanishing short dry spells. High temperatures in Ghana have resulted in low yields of maize due to the reduction in growing period and increase in evapotranspiration rate (Daze, 2007).

In Ghana, EPA predicted an expected mean temperature increases of 0.6 °C, 2.0 °C and 3.9 °C by the years 2020, 2050 and 2080 respectively over the 1961-2000 mean value (EPA-Ghana, 2011).

Based on the same climate statistics, annual rainfall amounts are expected to decrease by 1.1% to 3.1% and 13.0% to 21.0% by the year 2020 and 2080 respectively across all ecological zones in Ghana (EPA, 2011). This prediction by EPA is a clear indication that climate change and variability is experienced in Ghana because the prediction takes its basis from an observed meteorological data between the years 1961 to 2000.

World Bank (2010) reported that the annual rainfall in Ghana is highly variable. The analysis showed that rainfall was mostly high in the 1960s, but significantly reduced in the latter part of the 1970s and early 1980s. A trend analysis showed an average decrease of 2.3 millimeters per annum of rainfall between 1960 and 2006. Kankam-Yeboah *et al*. (2011), also reported that climate in Ghana has changed significantly with 1ºC increase in temperature over 30-year period based on historical data. World Bank (2010) projected the temperature of Eastern Region to increase by 1.7ºC – 2.0ºC by the year 2050.

There are several climate related initiatives implemented in Ghana. Some of these initiatives include GLOWA Volta Project by the University of Bonn (2000-2009), The Economics of Adaptation to Climate change by World Bank (2007-2010) and Ghana natural resource and Environment governance-DPO by Government of Ghana (2010-2011). These initiatives are indication of the concern about climate change and variability in Ghana.

Agriculture must provide food for an additional 3.5 billion people for the next 50 years in order to combat the global food security (Borlaug, 2007). Farming is Africa's main livelihood: more than two-thirds of Africans depend on agriculture for their income. Most countries in the region have the natural and human resources needed for strong and sustainable agricultural development. Agriculture contributes immensely to the Ghanaian economy; employing more than half of the country's population and contributing about 16.9% to nominal GDP) (GSS, 2014). However, agricultural production is mainly rain fed with the arable lands under irrigation being less than 2% (GIDA, 2010; MoFA, 2013).

All plants have certain climatic requirements of temperature, sunshine, precipitation and humidity. Much of the literature report that some countries in Africa already face semi-arid conditions that make agriculture challenging, and climate change will likely reduce the length of growing seasons, as well as force large regions of marginal agricultural potential out of production ((Fischer *et al*., 2005), (Thornton *et al.*, 2006), and IPCC, 2007)). Fischer *et al*. (2005) posited that domestic food production has declined by 10% in several of the sub-saharan countries. IPCC (2007) predicted that reductions in crop yield, in some countries, would be as much as 50% by 2020, with small-scale farmers being the most affected.

All crops photosynthesized and any factor that affects the biochemical process of photosynthesis will therefore invariably impact on crop yields. Photosynthesis is influenced by some major atmospheric factors such as carbon dioxide, water, solar radiation and temperature. Kumar (1998) posited that the onset of the raining season directly affects farming management practices from sowing to the last stage of development of crops significantly affects crop yield and the probability of agricultural droughts. For sowing in particular, it is important to know whether the rains are continuous and sufficient to ensure enough soil moisture consistently during planting in order to avoid total crop failure (Walter, 1967). Over the past few years, climate related crop failure due to episodes of late rains for planting, variability in the pattern and levels of rainfall, and intermittent droughts and floods in Ghana have been a common phenomenon.

Agriculture in Ghana is also dominated by smallholder farmers. More than 70% of these farmers cultivate farmland of less than 3 hectares (Chamberlin *et al.*, 2007). This smallholder agriculture is characterized by reliance on rain fed conditions, limited use of improved seeds, fertilizer and mechanization for production, thereby making its productivity levels below potential Maize is among the world's leading crops with an estimated production of 1,016,740,000 tons in 2013 (FAO, 2015). It is one of the important staple food crops in most Sub-Saharan Africa countries; it plays key role in food security and generates income for most farmers (Hassan, 1998). Maize is one of Ghana's leading staple food crops with its domestic demand increasing. However, there has been a shortfall in the average supply of maize in Ghana by 11% in 2011 (MoFA, 2012).

In the Eastern Region, farmers are predominantly smallholder and usually involved in the cultivation of staple grains such as maize, rice, millet, soybean, cowpea and groundnut, and also engage in the rearing of small ruminants such as sheep and goats (MoFA, 2011).

According to Zhu & Zhou (2011), climate change and variability has become the foremost environmental problem distressing the survival and the development of mankind, and it has attracted global, governmental organizations and attention of the academic community. This amounts to a serious threat to food security and to the achievement of major developmental goals. The implications of climate change and variability on agriculture cannot therefore be overemphasized especially for agrarian economies such as Ghana (Boko *et al.*, 2007).

1.2 Problem Statement

Climate is a key factor influencing agricultural production as its fluctuations largely affect the status of food security in Africa. Climate variability has been described as a new security threat to

Africa. The Intergovernmental Panel on Climate Change (2014) predicts that, climate change will lead to decreasing crop yields in most tropical and sub-tropical regions owing to alterations in temperature and precipitation patterns (McCarthy, 2001), thereby negatively impacting on agricultural sectors and worsening the prevalence of hunger in developing countries. As well as inflicting these direct climatic impacts, climate change and variability will compound the existing vulnerabilities of smallholder farmers, as a result of their poverty status, sensitivity of their geographical locations, high dependence on natural resources and limited capacity to adopt new livelihood strategies (Schipper & Pelling, 2006).

It is well-understood that poor people in the poorest countries are the most vulnerable to the impacts of anthropogenic climate change and variability (Stern, 2007). Although smallholders have considerable experience in dealing with climate variability and possess local knowledge to cope during difficult periods, the unprecedented and sustained levels of variability associated with long-term climate change are outside the realm of what traditional coping strategies are able to manage (Pettengell, 2010). The Agricultural sector has the poorest occupational group in Ghana with food crop farmers being the worst group affected (MoFA, 2011). This is making the sector a major target for both food security and poverty reduction interventions in the country.

Models and information about climate variability are available at macro levels but little has been done at the micro level ((Novignon *et al.*, 2012; (Etwire *et al.*, 2013)). Yet, the impact of climate variability is felt at the household level and also increases the risk faced by farmers in producing maize in Ghana. Without the appropriate policies and /or adaptive strategies in place, the smallholder farmers will find it extremely difficult to practice sustainable agriculture in an environmentally unpredictable climatic condition (Nelson *et al*., 2007).

Maize is the main staple crop in Ghana and it forms a major component of several domestic diets. In addition, maize is a major ingredient in feed formulation for livestock and a possible substitute in the malt brewing industry (Rondon and Ashitey, 2011). Agricultural activities are rural-based in Eastern Region and the farmers are predominantly smallholder (MoFA, 2011). The rural agricultural households in the Eastern Region constitute 68.8% of all agricultural households in the region and the region is the second largest producer of maize in Ghana, where about 19% of the maize is grown (GSS, 2010). However, climate variability is expected to affect food production in the region where much of the population, especially the poor smallholder farmers, rely on local supply systems that are sensitive to climate variation (MoFA, 2011). Disruptions of the existing food system will have devastating implications for development and livelihoods and are expected to add to the challenges climate change and variation already pose for poverty eradication (IISD, 2007).

To contribute to the reduction in vulnerability of smallholder maize farmers in the region to climate variability, this study will attempt to find solutions to the problem by addressing the following questions:

1. How vulnerable are smallholder maize farming households to climate variability in the Eastern Region?
2. What are the determinants of household's vulnerability to climate variability?
3. What are the adaptation strategies adopted by smallholder maize farming households to climate variability?
4. What factors influence the choice of climate adaptation strategies?
5. What are the constraints to adapting to climate variability?

1.3 Research Objectives

The main research objective is to assess the vulnerability of smallholder maize farming households to climate variability in the Eastern region.

The specific objectives are:

1. To measure the vulnerability of smallholder maize farming households to climate variability.
2. To estimate the determinants of household's level of vulnerability to climate variability.
3. To identify the adaptation strategies adopted by smallholder maize farming households to climate variability.
4. To estimate the determinants of the choice of climate adaptation strategies.
5. To identify and rank the constraints to climate variability adaptation strategies.

1.4 Justification for the Study

This study would aid in better assessment of household's vulnerability to climate variability and the factors that influence the vulnerability of households to climate variability. To reduce the level of vulnerability, the study would provide insights into the adaptation of strategies to cope with climate related hazards and the constraints households face in adopting those strategies to mitigate climate extreme impacts in the region.

This research would also aid in policies that will enhance a sustainable agriculture in the region and the nation as a whole. It will again provide practical tool to understanding factors contributing to climate vulnerability at the district or community level. Potential areas in maize production can be identified for intervention. It will also guide researchers, extension agents, policy makers and organizations on how to design interventions to meet the needs of their target groups for effective participation.

1.6 Organization of the Thesis

This thesis is organized into five chapters with chapter one being the introduction. The introduction contains a brief background of the study, the problem statement, objectives of the study as well as the justification of the study. Chapter two reviews literature related to climate variability, vulnerability of smallholder maize farming households, maize production in Ghana, methods used for the study, climate adaptation strategies as well as constraints confronting farmers in adapting climate related strategies. The research methodology is presented in chapter three. This primarily covers the description of the study area, theoretical concepts, type of data, sampling procedure, tools for data analysis as well as the methods of data analysis for the study.

Chapter four presents the discussion of results in relation to vulnerability of smallholder maize producing households to climate variability and its determinants. The adaptation strategies adopted and the constraints to adoption of climate adaptation strategies are further discussed in this chapter. The final chapter which is five, winds up the entire study with the summary of findings, conclusions of the study and policy recommendations of the main findings of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents reviewed literature, terms and concepts related to climate variability, measurement of vulnerability, adaptation to climate extreme events, impacts and evidence of climate variability in Ghana. The review also covers features of smallholder maize farming households, adoption of adaptation strategies and constraints faced by farmers.

2.2 Concept of Vulnerability

Vulnerability has no commonly accepted definition because different institutions use the term in different perspective of their areas of concern (Kasperson *et al*., 2001). The word vulnerability ordinarily refers to capacity to be wounded, i.e. the degree to which a system is likely to experience harm due to hazardous exposure (Turner II *et al*., 2003). Timmermann (1981) posits that ‘‘vulnerability is a term of such broad use as to be almost useless for careful description at the present, except as a rhetorical indicator of areas of greatest concern’’. On the other hand, Liverman (1990) notes that vulnerability has been equated to concepts such as resilience, susceptibility and adaptability.

The IPCC (2007) defines vulnerability to climate extreme events as the level to which a system is incapable of surviving under adverse effects of climate change, including climate variability and extremes. The IPCC (2007) also concluded that vulnerability is a function of the character, extent and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Vulnerability to climate change and variability differs across space and time due to the numerous factors causing the variation (FAO, 2006).

The approach recommended in most literature such as Marshall et al. (2010), USAID (2007) and Turner (2003) covers the three main areas of the IPCC definition: exposure, sensitivity and adaptive capacity, as they collectively determine the level of vulnerability to climatic impacts.

Exposure: The extent to which a community comes into contact with climate events or specific climate impacts. Specifically, this includes areas of residency and resource use exposed to different climate events and impacts. For example, houses near the highwater mark may have high exposure to rising sea levels.

Sensitivity: The degree to which a community is negatively affected by changes in climate. Sensitivity is largely determined by the relationship of individuals, households, or a community to available resources impacted by climatic risks, and by the degree of dependency on those resources.

Adaptive capacity: The potential or capability of a community to adjust to impacts of changing climate. It may be influenced strongly by a few key characteristics, or by a wide range of social characteristics. A household that has diversified sources of income and supplementary livelihood options will have higher adaptive capacity to the impacts of climate variability than those that do not. Ford & Smith (2004) posit that international efforts at finding solutions to climatic hazards have recognized the role of adaptation as a policy option.

Adaptation to climate change occurs in different forms. These include anticipatory and reactive; autonomous or spontaneous and planned adaptations (UNEP, 2009). Anticipatory adaptation is the type of adaptation where the system changes before the adverse impacts of climate change and variability are detected (IPCC, 2007). However, reactive adaptation occurs after the change is made just at the beginning of the climatic impacts (IISD, 2003). Planned adaptation is the thoughtful policy decision, based on the awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state (IPCC, 2007) whereas autonomous adaptation varies from the planned adaptations because it is not a mindful response to climatic stimuli but activated by ecological changes in welfare of natural and human systems (IISD, 2003).

According to Damas and Israt (2004), many factors contribute to vulnerability, and these factors act to undermine capacity for self-protection, diminish access to social protection, or expose some groups to greater or more frequent hazards than other groups. Different groups in the same community may experience different levels of vulnerability to climatic shocks due to variation in socio-demographic, economic and institutional factors experienced. Demographically vulnerable people are those that, because of their particular socio-demographic characteristics, are more vulnerable than others in the broader community. According to IPCC, (2007) Africa is one of the most vulnerable continents to climate change and variability due to the over-reliance on rainfall for agriculture.

The factors influencing smallholder maize farming households' vulnerability to climate variability may include sex of household head, age of household head, formal education of household head, total farm size, farming experience of the household head, household size, hired labour, family labour, membership in a social group and access to formal credit, temperature and rainfall perception (K.R. Tiwari *et al.*, 2008). Climatic shocks are expected to disproportionately affect the poor, young, elderly, sick, and otherwise marginalized populations (Kasperson *et al.*, 2001).

2.3 Smallholder Agriculture in Ghana

Smallholder agriculture has long been the dominant economic activity in the sub-Saharan region, and it will remain enormously important for the foreseeable future by serving as the source of livelihoods (FAO, 2010). Almost all the agricultural workforce is employed in smallholder production systems rather than large-scale production. Smallholders are variously defined in literature in terms of the land area of the farm, the number of workers, the value of output, or the value of asset holdings of the farmer.

Size of farm holding is perhaps the most direct and easily introduced indicator of who smallholders are. According to Ekboir, Boa, Dankyi (2002), a small-scale farmer in any region of Ghana cultivates less than five (5) hectares of land. There is clear evidence of a widespread decline in land holding size per household in African (Lipton 2006). The small area of land available to many rural households for cultivation represents a significant hindrance to household welfare where livelihoods are highly dependent on agriculture because there is a strong positive relationship between access to land and household income (Jayne *et al.*, 2003).

Food security is a top priority for rural households in Ghana with most of the households willing to produce their own as far as possible. Smallholders are widely thought to be less engaged in producing crops for marketing when markets are inefficient, but rather plant their holdings to staple crops for home consumption (Pandey *et al*., 2006). Farmers in Ghana produce crops such as maize, rice, cassava, yam among others.

Smallholder farmers face various challenges that impede their ability to effectively contribute to food security. Some of the constraints they face include lack of access to land, poor physical and institutional infrastructure such as roads. Inaccessible roads, for example, limit the ability of rural farmers to transport inputs, produce and also access information in order to improve their livelihoods.

2.4 Maize Production in Ghana

Maize is a crop cultivated throughout the ecological zones of Ghana with Brong Ahafo, Eastern and Ashanti Regions being the leading growing regions of the crop in the country. It is grown by the vast majority of rural households (both males and females) in all parts of the country except for the Sudan savannah zone of the far north. The area annually planted to maize in Ghana currently averages about 650,000 hectares with more than 70 percent of the farms cultivated being three hectares or below. Maize in Ghana has attracted the attention of commercial farmers, although it never achieved the economic importance of traditional plantation crops such as oil palm and cocoa.

Total production has increased from 550,000 tonnes in 1990 to 1,900,000 tonnes in 2010 (Angelucci, 2012). Maize average yield in 2010 was 1.9 Mt/ha against an estimated achievable yield of around 2.5 to 4 Mt/ha (Ministry of Food and Agriculture, 2010).

Maize needs a regular supply of water and suffers badly in times of drought. It requires rainfall of about 600 – 1,200mm per annum particularly at the time of tasselling and must be well distributed throughout the year (Awuku *et al.*, 1991). Tweneboah (2000) posited that soil moisture deficiency that causes wilting for 1 -2 days during tasselling can reduce yield up to 20%, and 6 – 8 days of wilting at this stage can reduce yield by 50% which cannot be made up by later availability of soil moisture either by precipitation or irrigation. Maize tolerates a wide range of environmental conditions but it is essentially suited for warm climates with adequate moisture and a suitable temperature ranges of 21 – 30^0 C (Adjetey, 1994). Maize grows satisfactorily in a well-drained, deep loams with high to moderate organic matter and nutrient content and pH 5.5 – 8.0 (Tweneboah, 2000).

Among the important constraints to maize production are pests and diseases. Insect pests that affect maize crop include stem borer, jassid, grasshopper, grey weevil, hairy caterpillar, root worm and leaf miner. Common diseases that affect maize production in Ghana are rust, leaf blight, downy mildew, stalk and ear rots, leaf spot, and maize streak virus. Other constraints to maize production include the declining soil fertility, limited use of nitrogenous fertilizers, and periodic drought caused by erratic rainfall distribution patterns.

Maize accounts for about 55% of grain output followed by paddy rice (23%), sorghum (13%) and millet (9%) (Angelucci, 2012). Maize is an important component of human diet, poultry feed and to a lesser extent the livestock feed sector as well as a substitute for the brewing industry. Maize plays an important role in food security for many poor households in Ghana (MoFA, 2011) with a per capita consumption of over 100 kg while also serving as a cash crop (FAO, 2008).

2.5 Adoption and Diffusion of Technology

Diffusion of technology is about how technology is taken up in a population. There are several theories of technology and innovation adoption and the most widely used theoretical framework in the area of technology diffusion and adoption is Rogers' theory. Rogers defines *technology* as "a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome" (Rogers, 2003). Rogers (2003) again defines *adoption* as a decision of "full use of an innovation as the best course of action available", and *diffusion* as "the process in which an innovation is communicated through certain channels over time.

Diffusion is used to describe the spread of technology among communities, regions, nations, or even global. According to Rogers (2003), adoption of technology progresses overtime through five stages. These are as follows;

i. The target group must learn about the innovation (acquire knowledge);
ii. They must be persuaded on the value of the innovation. (Persuasion);
iii. They must decide to adopt it (Decision);
iv. The innovation must be implemented (implementation); and
v. The innovation must be reaffirmed or rejected (confirmation).

These stages in the diffusion process simply imply a time lag between awareness and adoption and it is usually measured from first knowledge until the decision is made whether to adopt or not. Hence, adoption is not a random behaviour, but is the result of sequence of events passing through these adoption stages (Rogers, 1983). Perceived ease of use of innovation also plays a prominent role in the adoption of that technology. In his work, Rogers states that adopters of a new innovation can be categorized into five groups on the basis of the time it takes to go through the process of deciding to adopt or not to adopt. These categories are: Innovators, early adaptors, early majority, late majority, and the last group are the laggards.

Mann, (1978) and Byerlee and Hesse de Polanco, (1986) argue that farmers do not adopt technologies as a package, but rather adopt a single or few components of the technologies that are suitable to them. This is supported by the findings of Nagy and Sanders (1990) and Leather and Smale (1991), who concluded that farmers choose to adopt inputs sequentially.

According to consumer behavior theory, the needs of individuals form the basis for comparing the benefits of an innovation to the pre-existing practice (Berezovskaya, 2004). The theory asserts that individuals only adopt a technology which is useful to them.

Research has shown that many factors influence farmer's decision to adopt improved technologies. Jatoe *et al* (2005) in their analysis of factors affecting the adoption of technology, identify farmer based factors and characteristics of the innovation in the farmers own environment as the factors that influence the decision to adopt a technology. Among the factors identified are farmers' educational level, age of the farmer, available family labour, non-farm income, farmers' perception about the innovation, farm size, frequency of extension visits and accessibility of the new technology.

A comprehensive survey by Feder *et al.* (1985) and Feder and Umali (1993) also found that farm size, risk, human capital, labour availability, access to credit and land tenure systems were the most important factors influencing farmers' decision of technology adoption.

2.6 Climate Adaptation Strategies Adopted in Ghana

Adaptation to climate change and variability is a complex and multidimensional process (Bryan and Behrman, 2013). According to R. Heltberg *et al.* (2009), climate related adaptation process is in terms of type, scale, timing, and outcome of the responses, as well as the factors that influence adaptation. Adaptation to climate change and variability involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability as well as longer-term climate change (Smit, 1993).

Climate extreme events introduce numerous uncertainties over the livelihoods of smallholder farming households that depend heavily on the weather and climate (Al-Hassan and Poulton, 2009). These farmers have therefore been modifying their practices to better adapt to the changing climate. Several technologies and practices such as high yielding varieties, early maturing varieties, conservation agriculture and drought tolerant varieties, are available for smallholder farmers largely developed by the Council for Scientific and Industrial Research (CSIR) and the universities in Ghana to enable them better adapt to the effects of climate change and variability.

Strategies for adapting to climate change and variability can be grouped into two, namely autonomous and planned adaptation strategies. Autonomous adaptation strategies involve actions taken by non-state agencies such as farmers, communities or organizations and /or firms in response to climatic shocks while planned adaptation involves actions taken by local, regional and or national government to provide infrastructure and institutions to reduce the negative impact of climate change and variability. According to Sathaye and Christensen (1998), one can adopt strategies before climate hazards (anticipatory strategies) or after (proactive strategies).

Bruin (2011) also identifies strategies such as switching crops, shifting crop calendar, engaging new management practices for a specific climate regime, changing irrigation system and selecting different cropping technologies as adaptation strategies.

Among the strategies adopted in Ghana include high yielding varieties, inorganic fertilizers, harrowing, planting of trees, early maturing varieties, compost, conservation agriculture, irrigation, drought tolerant varieties, herbicides, planting during recommended period, reduce farm size and planting in rows.

2.7 Constraints to Climatic Related Adaptation Strategies

Many frameworks and approaches have been developed to understand the barriers to climate adaptations in sub-Saharan Africa. Barriers to climate related adaptation strategies are defined as factors, conditions or obstacles that reduce the effectiveness of those adaptation strategies (Huang *et al*., 2011). Constraints to climate adaptation strategies can be grouped into financial, socio-cultural, institutional, informational and technological barriers.

Bryan *et al*. (2009) reported that financial barriers due to lack of credit facilities are important obstacles hindering the implementation of climate adaptation strategies by farmers in Ethiopia. This finding is consistent with that of Antwi-Agyei *et al*. (2013) who reported that financial constraint is a key barrier faced by smallholder farming households in Sub-Saharan Africa of which Ghana is inclusive to climatic shock adaptation. Farmers in the Eastern Region during this study report of inability to purchase improved varieties of maize seeds introduced by MoFA due to financial constraints.

Socio-cultural constraints such as beliefs, cultural practices and the worldviews of individuals or groups, greatly influence the way farmers perceive climate change, and their subsequent adaptation strategies. Moser and Ekstrom (2010) assert that people's response to risk might be greatly influenced by their pre-existing belief, values, and norms regarding that event. This means that people who live in the same community with different cultural backgrounds may respond differently to risks related to the impacts of climate variability.

According to Seitz *et al*. (2011), institutions play a key role in enhancing the ability of communities to cope with climate variability which can help to shape the social and individual interactions within the society. It can be concluded from literatures that institutional barriers are a key restriction on publications of adaptation strategies. Weak institutional capacity coupled with lack of policies on food security and lack of climate adaptation information, place food security in Ghana and in many other communities across Sub-Saharan Africa, under considerable threat.

Access to information on climate extreme event is a powerful tool that can be used to enhance the adoption and implementation of adaptation strategies by households in Ghana (Antwi-Agyei *et al*., 2013). However, lack of appropriate climatic data has resulted in few climatic projections in the country. This has resulted in households relying on their own agro-ecological knowledge, based on past experience. This knowledge allowed farmers to form complex mental models of the climate which can affect their farming operations negatively.

Improvement in technology, for example, the development of improved crop varieties as well as establishing irrigation techniques, are very crucial to climate change and variability adaptation but limited availability of these technologies makes farmers rely on their own indigenous technology in reducing the impacts of climate change and variability on their livelihoods (Antwi-Agyei *et. al*., 2014).

2.8 Measurement of Vulnerability

Vulnerability in general can be measured using two approaches, namely the indicator approach and the econometric approach. The indicator approach involves the selection of variables that a researcher considers to contribute to climate related vulnerability while the econometric technique involves the application of economic, mathematical and statistical methods in analyzing climate vulnerability. Both techniques have setbacks. The indicator approach has some level of subjectivity in selecting the various variables that may be accounting for vulnerability whereas the econometric approach has the possibility of violating an econometric assumption.

There are several methods of measuring vulnerability using the indicator approach. United Nations General Assembly (1997) used Sustainable Livelihoods Approach to design development programming at the community level by looking at five types of household assets—natural, social, financial, physical, and human capital. The approach has proven useful for assessing the ability of households to withstand shocks such as civil conflict but climate change adds complexity to household livelihood security. The Sustainable Livelihoods Approach addresses the issues of sensitivity and adaptive capacity to climate change and variability, but fails to integrate climate exposures to it (Hahn *et al.*, 2009).

Due to the limitation of the Sustainable Livelihoods approach, Hahn *et al*. (2009) employed two techniques to assess households' vulnerability levels to climate change and variability in Mozambique. The first technique expresses the LVI as a composite index comprised of seven major components (socio-demographic profile, livelihood strategies, social networks, health, and access to food, access to water, and natural disasters and climate change) while the second aggregates the seven into IPCC's three contributing factors to vulnerability (exposure, sensitivity, and adaptive capacity). Etwire *et al*. (2013) employed the LVI technique developed by Hahn *et al.* (2009) to assess households' vulnerability to climate change and variability in Northern Ghana.

Christiaensen and Boisvert (2000) employed the econometric technique to measure households' food vulnerability in Northern Mali using panel data with 1997-98 as the reference period.

The approach employed in this study is the two approaches employed by Hahn *et al.* (2009) in assessing households' vulnerability levels in Mozambique to climate change and variability. This approach uses primary data from household surveys and secondary data from the Meteorological Agency to construct the index. It also presents a framework for grouping and aggregating indicators on district level, which can be critical for development planning. By using primary household data, this approach helps reduce the pitfalls associated with using only secondary data; it also reduces dependence on climate models.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

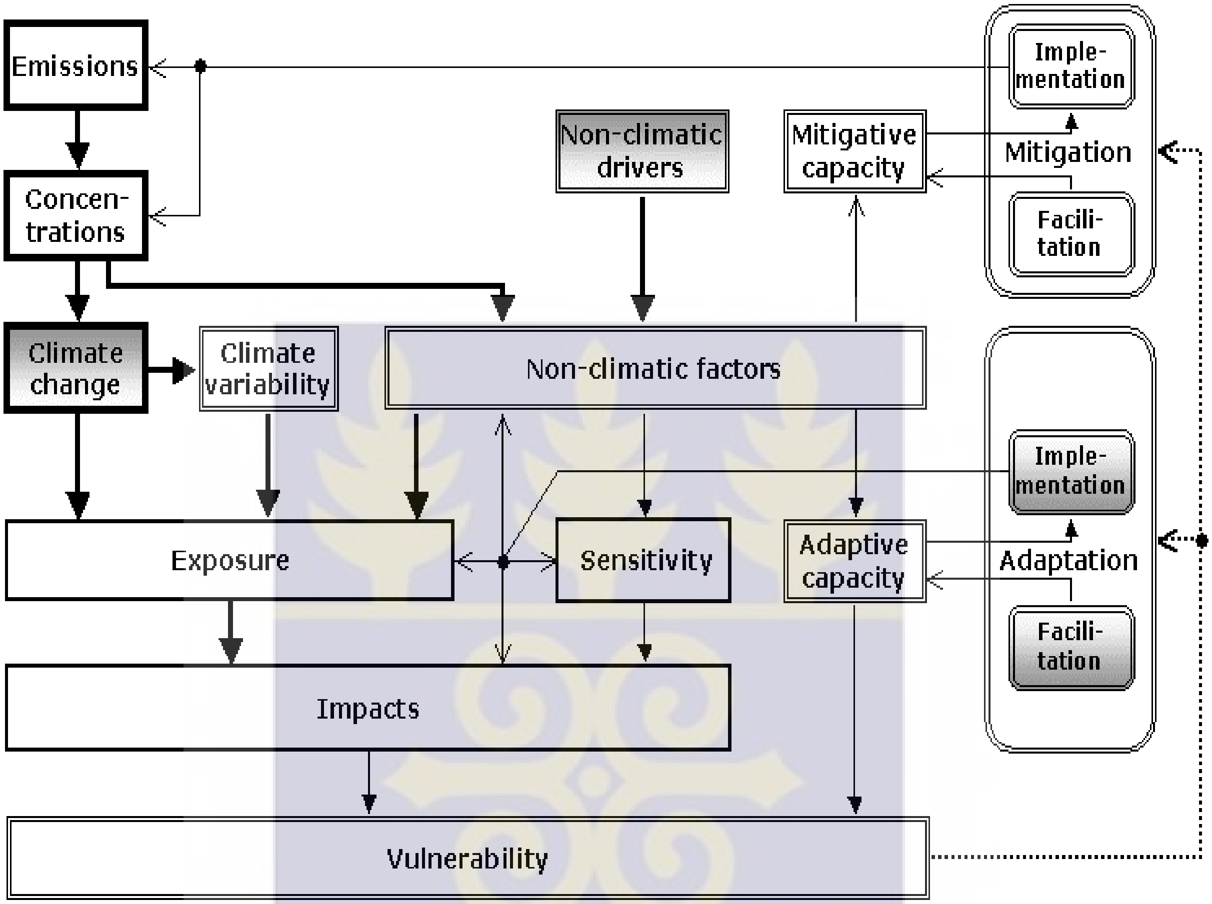
This chapter presents the methodology applied in this study, including the conceptual framework, key concepts, methods of data collection and analysis. The chapter also describes the geographical and socio-economic nature of the study area.

3.2 Conceptual Framework

The measure of vulnerability to climate change and variability takes as its starting point the IPCC working definition of vulnerability as a function of exposure, sensitivity, and adaptive capacity (IPCC, 2001). Thus vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. Vulnerability in agriculture to climate change can, for example, be described in terms of exposure to an increase in temperatures, the sensitivity of crop yields to the high temperature and the ability of the farmers to adapt to the effects of this exposure and sensitivity by, for example, planting crop varieties that are more heat- tolerant.

The index of vulnerability was constructed as the simple average of those three sub-indices: exposure, sensitivity, and adaptive capacity, as done by Fussel (2010). This is shown in figure 3.1. According to Smit and Wandel (2006), a system is vulnerable if it is exposed and sensitive to the effects of climate variability and at the same time has only limited capacity to adapt to the impacts of climate variability. On the contrary, a system is less vulnerable if it is less exposed, less sensitive or has a strong adaptive capacity.

Figure 3.1: Conceptual framework of vulnerability to climate change and variability



Source: Adapted from Fussel, 2010

Exposure as defined by IPCC in 2007, is the magnitude and duration to which the population is exposed to disaster. Thus, exposure as a component of vulnerability is not only the extent to which a system is subjected to variations in climatic condition, but also the degree and duration of these variations.

Although climate variability can alter and increase the future exposure of a system, exposure to natural climate variability is independent of future changes in climate (Lavell *et al.*, 2012).

Sensitivity of a system to climate variability is the "degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise)" (IPCC, 2007).

Exposure and sensitivity as shown in figure 3.1 above, together describe the potential impact that climate variability can have on a system but it does not necessarily mean a system is vulnerable. This is because the adaptive capacity of a system is what affects its vulnerability to climate variability by modulating exposure and sensitivity (Adger *et al*., 2007).

Adaptive capacity is the potential of a system to adjust successfully to climate change and variability to moderate potential damages, to take advantage of opportunities and/or to cope with the consequences (IPCC, 2007). Adaptive capacity can basically be shaped by human actions in order to influence both the biophysical and social elements of a system (IPCC, 2012).

3.3 Methods of Data Analysis

3.3.1 Measuring the vulnerability of households to climate variability using Livelihood Vulnerability Index

A. LVI

The Livelihood Vulnerability framework is particularly relevant to understand vulnerability to climate variability because it provides a framework for analyzing both the key components that make up livelihoods and the contextual factors that influence them.

The livelihood vulnerability would be derived from all the districts selected for the study, taking into account the Intergovernmental Panel on Climate Change, IPCC definition of vulnerable climatic impacts developed by Hahn *et al*. (2009). It makes use of seven major components namely socio-demographic profile, livelihood strategies, social networks, health, and access to food, access to water, and natural disasters and climate change. Each component is made up of several sub-components, each of which is measured on a different scale; it is therefore necessary to standardize each as an index using equation (1).

$$index_{sd} = \frac{s_d - s_{\min}}{s_{\max} - s_{\min}} \tag{1}$$

Where S_d is the observed sub-component indicator for household, and S_{min} and S_{max} are the minimum and maximum values respectively. After each is standardized, the sub-component indicators are averaged using equation (2) to obtain the index of each major component:

$$M_d = \frac{\sum_{i=1}^{n} index_{s_{di}}}{n} \tag{2}$$

Where M_d is one of the seven major components [Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Network (SN), Health (H), Food (F), Water (W), or Natural Disaster and Climate Variability (NDCV)] for household d; $index_{s_{di}}$ represents the sub-components, indexed by i , that make up each major component, and n is the number of sub-components in each major component. Once values for each of the seven major components for a household are calculated, they are averaged using Equation (3) to obtain the district-level LVI:

$$LVI_d = \frac{\sum_{i=1}^{7} W_{Mi} M_{di}}{\sum_{i=1}^{7} W_{Mi}} \tag{3}$$

This can also be expressed as

$$LVI_d = \frac{W_{SDP}SDP_d + W_{LS}LS_d + W_{SN}SN_d + W_F F_d + W_H H_d + W_W W_d + W_{NDCV}NDCV_d}{W_{SDP} + W_{LS} + W_{SN} + W_F + W_H + W_W + W_{NDCV}} \quad (4)$$

The weights of each major component, WMi, were determined by the number of sub-components of each major component. Thereby, ensuring that the overall LVI is the result of equal contribution of sub-components. In this study, the LVI is scaled from 0 (minimum of vulnerability) to 1 (maximum of vulnerability). The summary of the LVI is also presented in a spider diagram.

The description of the major components and sub-components of the LVI developed for the study area is presented in appendix III.

B. Computation of (LVI-IPCC Approach)

From equations (1)-(3), Hahn *et al*. (2009) calculated a new variable, LVI-IPCC. This takes into consideration IPCC definition of vulnerability. The LVI-IPCC diverges from the LVI when the major components are combined. Rather than merge the major components into the LVI in equation (3), the major components are first combined according to three categories namely exposure, adaptive capacity and sensitivity using the following equation:

$$CF_d = \frac{\sum_{i=1}^{n} W_{Mi} M_{di}}{\sum_{i=1}^{n} W_{Mi}} \quad (5)$$

Where CF_d, is an IPCC-defined contributing factor (exposure, sensitivity, or adaptation capacity) for district d, M_{di} are the major components for district indexed by i, $w_{Mi}$is the weight of each major component, and n is the number of major components in each contributing factor.

Table 3.1: IPCC contributing factors to vulnerability

Major Components	Sub-components
Exposure	Natural disasters and climate variability
Sensitivity	Health Food Water
Adaptive capacity	Socio-demographic profile Livelihood strategies Social networks

Source: Hahn *et al*. (2009)

Once exposure, adaptive capacity and sensitivity are calculated, the three contributing factors are combined using equation;

$$LVI - IPCC_d = (e_d - a_d) * S_d \qquad (6)$$

The LVI-IPCC is on a scale of -1 (least vulnerable) to 1 (most vulnerable) and the result is presented in a vulnerability triangle. For the purpose of illustration, a detailed example of calculating the LVI-IPCC contributing factors for one of the districts in the study areas is presented in Appendix III.

Microsoft Office excel 2013 was employed in estimating the livelihood vulnerability index of households.

3.3.2 Identifying the determinants of households Livelihood Vulnerability to climate variability

To model the determinants of livelihood vulnerability to climate variability, the Generalized Least Square model was employed, which, in its general form, can be written as:

$$y = X\beta_i + \varepsilon \quad (7)$$

where y is the dependent variable, X is the explanatory variable(s), β is coefficient of the explanatory variable(s) and ε is the error term. i is a positive integer: (i = 1,...,n), where n is the number of observations in the dataset.

Generalized Least Squares (GLS) was introduced by Aitken (1935) and it is designed to produce an optimal unbiased estimator of β for situations with heterogeneous variance (0.0003 for Yilo Krobo and 0.0002 for Ayensuano). In such cases, OLS estimates are unbiased and consistent but inefficient.

The regression parameter of the betas is given by:

$$\beta_{GLS} = (X'\Omega^{-1}X)^{-1}X'\Omega^{-1}Y \quad (8)$$

and the standard errors of the beta also given as:

$$V(\beta_{GLS}) = (X'\Omega^{-1}X)^{-1} \quad (9)$$

where Ω is the variance matrix and it is given as

$$\Omega = \sigma^2 I \quad (10)$$

I is the identity matrix of the model.

GLS has the following desirable properties:

1. The GLS estimator is unbiased

2. The GLS estimator is efficient.

3. The GLS estimator is the maximum likelihood estimator.

4. The variance-covariance matrix of estimates is correct, and therefore the estimates of the standard errors are unbiased and consistent.

5. Hypothesis tests are valid.

Empirically, the pooled model is specified as:

LVI_i =f(Age, Gender, F. Labour, Farm size, F. Exp, Access to Credit, F. Ext, Temp. Perception, H. Labour, Marital Status, D. Yilo) (11)

$LVI_i = \alpha + \beta_1(\text{Age}) + \beta_2(\text{Gender}) + \beta_3(\text{F. Labour}) + \beta_4(\text{Farmsize}) + \beta_5(\text{F. Exp.}) + \beta_6(\text{Credit}) + \beta_7(\text{F.Ext.}) + \beta_8(\text{Temp. Perception}) + \beta_9(\text{H. Labour}) + \beta_{10}(\text{Marital}) + \beta_{11}(\text{D. Yilo}) + \varepsilon_i$ (12)

Where LVI_i is the vulnerability index of i^{th} district (dependent variable) α is the intercept (constant), β_1 to β_{11} are the parameters to be estimated for the explanatory variables and ε_i is the error term which is independent, identical, normally distributed with zero (0) mean and constant variance.

Table 3.2: Description of explanatory variables used for the GLS analysis

Variable	Description	Measurement	*A priori* expectation
LVI	Livelihood vulnerability Index	0 < LVI < 1	
Age	Age of household head	Years	+/-
Gender	Gender of household head	0=Male and 1=Female	+
F.Labour	Family labour	1=Yes 0=No	-
Farmsize	Farm size of household	Hectares	+/-
F.Exp.	Farming experience of household head	Years	-
Credit	Access to credit	1=Yes 0=No	-
F.Ext.	Formal extension contact	1=Yes 0=No	-
Temp.Perception	Temperature perception by household head	1=Perceived changes 0=No Change	-
H.Labour	Hired labour	Hours/Hectare	-
Marital	Marital status of household head	1=Married 0=otherwise	-
D.Yilo	Households in Yilo Krobo	1=Yes 0=No	+/-
D.Ayensuano	Households in Ayensuano	1=Yes 0=No	+/-

Source: Field Survey, 2016.

The justification for choice of each of the explanatory variables follows.

Age of household head

Age of household head may have both positive and negative effects on livelihood vulnerability according to the literature. Whereas Deressa *et al.* (2010) report that age has a positive influence on the choice of an adaptation strategy by farmers to reduce their vulnerability to climate variability, Adesina & Zinnah (1993) posit that farmers are less able to adopt new strategies to adapt to climate extreme events as they grow older, hence they become vulnerable.

Gender of household head

Abaje *et al.* (2014) note that women have limited access to information, land and other resources thereby making them vulnerable to climate variability. Agrawa (1997) who also asserts that in response to climate shocks, men are more likely to migrate and leave behind their families in search of secondary employment while women are more likely to stay home trying to deal with the situation.

Family labour

Peterman *et al.* (2010) report that the use of family labour on staple crops cultivation will increase the productivity of the crops. This is because the farmer would not incur additional cost of hiring a labour during the production season, hence giving the farmer an opportunity to adopt new and better agronomic practices with less cost. This would then have a positive impact on vulnerability during an extreme climatic event. This study also hypothesizes a negative relationship between the use of family labour on farm and vulnerability to climate variability.

Farm size

The effect of farm size on vulnerability is mixed in literature. Deressa *et al.* (2010) posit that wealthier farmers are more likely to have larger farm holdings and they can depend on their investments for living during an extreme climatic shock. Gbetibouo (2009) also indicates that large farmers are more likely to adopt adaptation strategies since they have the capital and resources to do so.

Farming experience of household heads

The study hypothesizes a negative relationship between farming experience and vulnerability to climate variability. The longer farmers grow a crop, the more knowledgeable they are about the climate and the weather requirements of the crops; this puts them in a better position to adapt to climate extreme events. This is supported by Deressa *et al*. (2009).

Access to credit

Credit is often regarded as a major factor in agricultural production. According to Adegeye and Dittoh (1985) "credit is the process of obtaining control over the use of money, goods and services in the present in exchange for a promise to repay at a future date". Access to credit is often found to increase the probability of adoption of new strategies (Liane *et al.*, 2007). This will help farmers to be less vulnerable since they can adopt new strategies to curb the situation of climate extreme events even if it comes with cost.

Formal extension contact

Extension contact is expected to reduce vulnerability of households to climate variability. Extension is key in the dissemination of new agricultural practices in Ghana because it serves as an important source of information on climate variability as well as adaptation options for farming households. This claim is in accordance with the findings of Nhemachena and Hassan (2007), that farmers who have contact with extension agents are more likely to be aware of climate variability and available adaptation strategies, and subsequently adopt these options to be less vulnerable.

Temperature perception

Deressa *et al.* (2010), report a positive relationship between temperature perception and adoption of climate related strategies. This study also expects farmers who perceive that there have been changes in temperature to adopt climate related techniques that will render them less vulnerable.

Hired labour

Most literature argue that hired labour increases productivity ((Adebayo and Adewumi (2008), Ajibefun and Abdulkadri (2004)). The services of hired labour is key in carrying out labour intensive adaptation strategies which are beyond the capability of the farming household. This study therefore hypothesizes a negative relationship between hired labour and vulnerability.

Marital status

Household heads who are married are more likely to have larger household sizes that can serve as proxy for family labour during production. This study expects a negative relationship between marital status and vulnerability to climate variability.

Locational difference

Location difference variable is introduced in the pooled regression analysis to capture differences in levels of vulnerability of household in the different districts of the study area. It is important because farmers in different agro ecological zones are likely to experience different impact of climate variability and probably would be adopting different adaptation strategies. Morris *et al.* (1999) assert that the level of adoption of improved technologies varies across different agro-ecological jurisdiction.

Based on the explanatory variables considered for this analysis, the following hypotheses would be tested using a t-test:

1. **Age of household head and farm size**

   Ho: Age of the household head and farm size has no significant effect on vulnerability to climate variability.

   Ha: The effect of age of the household head and farm size on climate variability are indeterminate.

2. **Gender of household head**

   Ho: The gender of the household head has no significant effect on vulnerability to climate variability.

   Ha: The gender of the household head has a positive effect on vulnerability to climate variability.

3. **Family labour, hired labour, farming experience, access to credit, temperature perception, formal extension, marital status and location difference**

   Ho: Family labour, hired labour, farming experience, access to credit, temperature perception, formal extension, marital status and location difference has no significant effect on vulnerability to climate Variability.

   Ha: Family labour, hired labour, farming experience, access to credit, temperature perception, formal extension, marital status and location difference has a negative effect on vulnerability to climate variability.

The t-statistic is specified as

$$t = \frac{\beta_i}{SE(\beta_i)} \qquad (13)$$

where SE is the standard error of the estimated coefficients.

The decision rule is that reject the null hypothesis if tcal>tcrit, otherwise do not reject the null hypothesis.

3.3.3 Identifying Climate Related Adaptation Strategies Adopted by Smallholder Maize Farming Households

Farmers adopt different strategies to adapt to climate variability. The effects of the adaptation strategies are influenced by the socioeconomic characteristics of the farmers. Irrespective of the strategies applied by any farmer, it is predicted that taking adaptive measures reduces the negative effects of climate variability on farm production as well as farmers livelihoods. Each farmer adopts more than one adaptation strategy but the dominant strategies would be analyzed.

3.3.4 Estimating the Determinants of Adoption of Adaptation Strategies to Climate Variability

In determining the econometric model to employ in an adoption decision study involving more than two choices, two models traditionally utilized to evaluate qualitative dependent variables are considered. These models are multinomial probit (MNP) and multinomial logit (MNL). Both models are similar in their formulation but MNL is preferred because its cumulative distribution function (CDF) is logistic whereas that of MNP is normal distribution. MNP model also does not enable precision robustness as it fails to allow the modeler to adjust for covariates but MNL does.. Hence, the MNL model over MNP is chosen for this estimation.

Adaptation strategies, with four possibilities; no adaptation, improved varieties strategies, soil related strategies and recommended agricultural practice strategies was used as the dependent variable. In Multinomial Logit model (MNL), a baseline alternative is chosen because the options must always be in the respondents' choice set to be able to interpret the results in standard welfare economic terms (Hanley et al., 2001). The choice 'no adoption' was used as the baseline and compared with the other choice of adaptation strategies.

The functional form of the MNL model is specified as:

$$\text{Prob } (A_i = j) = \frac{e^{\beta'_j X_i}}{\sum_{k=0}^{J} e^{\beta'_k X_i}} \tag{14}$$

Where A_i is the probability of farmer i choosing alternative j, J is the adaptation strategies (0=no adaptation, 1=recommended agricultural practice, 2=improved varieties strategies and 3=soil related strategies), X_i is the independent variables and β is a vector of coefficients on each of the independent variables X.

Equation (14) can be normalized to remove indeterminacy in the model. This is achieve by assuming that $\beta_0 = 0$:

$$\text{Prob } (A_i = j|x_i) = \frac{e^{\beta'_j X_i}}{1 + \sum_{k=1}^{J} e^{\beta'_k X_i}} \tag{15}$$

If k=0, then equation (15) yields the J log-odds ratios of the form:

$$\text{In}\left(\frac{P_{ij}}{P_{ik}}\right) = X'_i \, (\beta_j - \beta_k) = X'_i \beta_j \tag{16}$$

β_0 = Constant term, $\beta_1, \ldots, \beta_n$ = Regression co-efficient, μ= Error term

The MNL coefficients are difficult to interpret, and associating the β_j with the jth outcome is misleading. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived as (Greene, 2003):

$$\delta = \frac{\partial P_j}{\partial X_i} = P_j(\beta_j - \bar{\beta}) \quad (17)$$

Empirically, the model is specified as:

$$Y_i = \text{In}\ (P_{ij}/\ P_{ik}) = \beta_0 + \beta_1(\text{Age}) + \beta_2(\text{Gender}) + \beta_3(\text{Farmsize}) + \beta_4(\text{F. Exp.}) + \beta_5(\text{Rainfall Perception.}) + \beta_6(\text{Credit}) + \mu_i \quad (18)$$

Where Y_i is the probability of ith farming household choosing a specific option (i=positive integer).

A major condition that has to be satisfied in MNL is the Independence from Irrelevant Alternatives (IIA). The IIA Property requires that the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives in the model (Hausman *et al*., 1984). The IIA test was carried out to ascertain that condition.

The explanatory variables used for the regression analysis are described in the table below.

Table 3.3: Explanatory variables and their expected sign

Variable	Description	Expected sign	Reason
Age	Age of household head (years)	-	As farmers grow older, they become weak in strength to undertake any intensive farming activity.
Gender	Gender of household head (1=female, 0=male)	-	Female heads have less access to resources for adaptation.
Farmsize	Current farm size of household (hectare)	+/-	Smaller farm size are easily managed than bigger ones. However, wealthier farmers are those who can own bigger farms for cultivation and thus can adopt adaptation strategy to increase yield.
F.Exp.	Years of farming by household head (years)	+	More years of farming favours adaptation of a strategy due to knowledge of weather as well as the crop being cultivated.
Rainfall Perception	Perceived changes in amount of rainfall (1=yes, 0=no)	+	Household who perceived a change in rainfall amount are better able to adapt.
Credit	Households with access to credit (1=yes, 0=no)	+	Access to credit enable households adapt to climate hazards even if it is costly.

Source: Field Survey, 2016.

Based on the explanatory variables described above, the following hypotheses would be tested:

1. Age

Ho: Age has no significant effect on adoption of adaptation strategies.

Ha: Age has a positive significant effect on adoption of adaptation strategies.

2. **Gender**

   Ho: There is no significant difference between male and female in the adoption of adaptation strategies.

   Ha: Female-headed households are more likely to adopt climate adaptation strategies than their male counterparts.

3. **Farm size**

   Ho: Farm size has no significant effect on adoption of adaptation strategies.

   Ha: Effect of farm size on adoption of adaptation strategies is indeterminate.

4. **F. Exp. (Farming experience)**

   Ho: Farming experience has no significant effect on adoption of adaptation strategies.

   Ha: Experienced farmers are more likely to adopt an adaptation strategy than inexperienced farmers.

5. **Rainfall Perception**

   Ho: Households who perceive a change in rainfall do not adapt to climatic hazards.

   Ha: Households who perceive a change in rainfall do adapt to climatic related hazards.

6. **Credit (Access to Credit)**

   Ho: Access to credit does not enhance adaptability of households to climate variability.

   Ha: Access to credit enhance the adaptability of households to climate variability.

3.3.5 Identification and ranking of constraints to climate variability adaptation strategies

This was achieved by reviewing related literatures to identify the constraints. The constraints identified were then presented to the respondents for ranking. Simple ranking technique was used by scoring the most pressing constraint 1 while the less constraints is scored 9. Numeric value was assigned for the ranking. The total score of each respondent was calculated and the constraints with the lowest score was ranked the most pressing whereas the highest score was ranked least constraint.

The Kendall's coefficient of concordance (W) was used to measure the degree of agreement among the rankings of the constraints by the respondents using the rank scores. It was one when the ranks assigned by each farmer is the same as those assigned by other farmers and zero when there is a maximum disagreement among the farmers. Given that T represents the sum of ranks of each factor being ranked, the variance of the sum is given by;

$$Var_T = \frac{\sum T^2 - \left(\sum T^2\right) / n}{n} \tag{19}$$

The maximum variance of T is then given by $\frac{m^2\left(n^2-1\right)}{9}$ (20)

Where, m = Number of sets of ranking by the farmers and n = the number of specific constraints being ranked.

The coefficient concordance (W) is therefore given as,

$$W = \frac{\left[\sum T^2 - \left(\sum T^2\right) / n\right] / n}{m^2\left(n^2-1\right) / 9} \tag{21}$$

Chi-square test was used to assess the hypothesis and significance of the ranking as follows:

H_o: There is no agreement among the rankings of the constraints by the farmers.

H_a: There is agreement among the rankings of the constraints by the farmers.

If $\text{Chi-square}_{cal} > \text{Chi-square}_{cri}$ the null hypothesis is rejected, otherwise do not reject the null.

3.4 Data and Data Sources

3.4.1 Data

Both primary and secondary data are used in this study. Primary data at household level in the two selected districts were solicited using questionnaire, semi-structured interview and focus group discussions. These instruments were used to ensure thorough examination and understanding of the phenomenon. A questionnaire covering 34 key variables such as household composition and resources, institutional setting, perception about changes in temperature among others, was designed, tested and administered at the household level and applied to calculate LVI and other components of the research.

Secondary data on rainfall and temperature were obtained from the National Meteorological Department of Ghana. The reference period for the climate events data was selected from 2006 to 2015. Relevant literature from secondary sources were reviewed to support or refute arguments and conclusions about the subject matter. Such secondary sources included journals, publications and the internet.

Excel (2010) was employed during data entry and management. The pivot tables were also created using the Excel.

Both the multinomial regression of the determinants of choice of adaptation strategies as well as the determinants of the vulnerability of households to climate variability were analyzed using Stata (13.0).

3.4.2 Sampling Procedure and Sample Size

Multi-stage sampling technique was employed to sample households. Purposive sampling of the Region was done due to its level of maize output in the country: it is the second largest producer of maize in 2010 (MoFA, 2011). The two districts, Yilo Krobo and Ayensuano were also purposively selected because their households are highly agrarian and they have small farm holdings. Also, there has been little research in the two districts.

Simple random sampling (picking from a list) was used to select five communities from each district making a total of ten communities for the research. Fifteen household heads were selected randomly from each community for a sample size of 150.

Table 3.4: Sample size of communities selected for the study

Districts/Municipal		Communities	Sample size
Yilo Krobo Municipal	1.	Agogo	15
	2.	Akwapem	15
	3.	Trawa	15
	4.	Ocansere	15
	5.	Brukum	15
Ayensuano District	1.	Sakra	15
	2.	Anum Apapam	15
	3.	Mfranor	15
	4.	Amanase	15
	5.	Kofi Pare	15
TOTAL			**150**

Source: Field Survey, 2016.

The interview and administration of questionnaire was done in January, 2016.

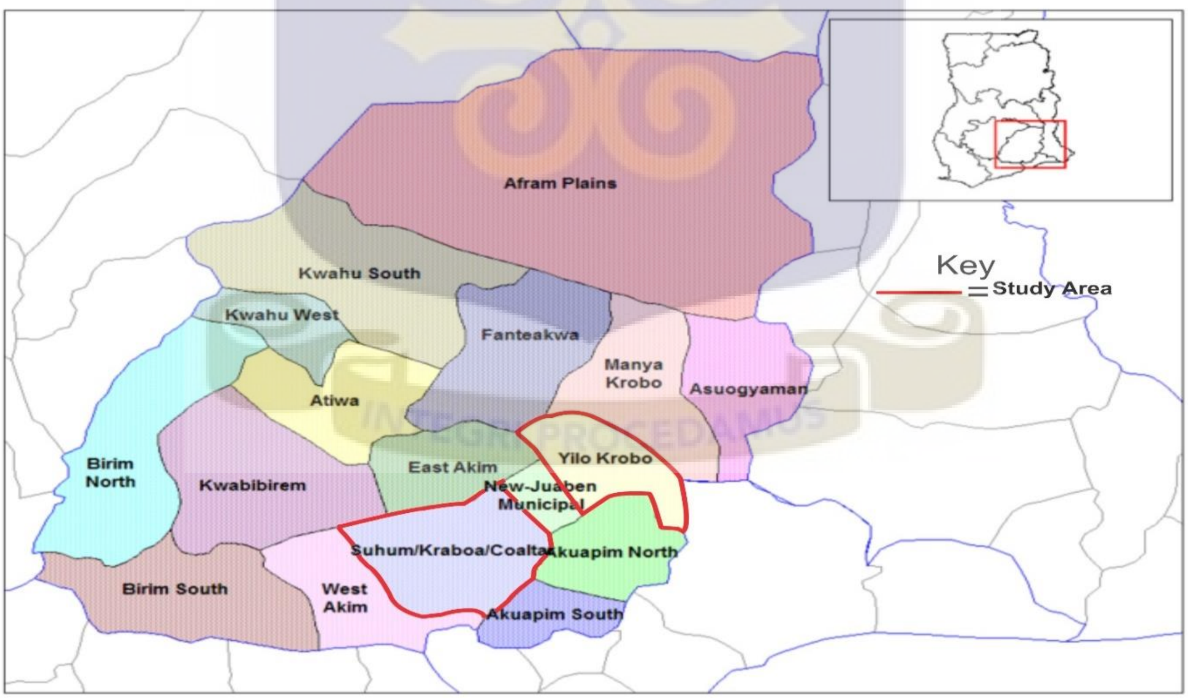
3.5 Study Area

The study was conducted in the Eastern Region of Ghana. The region has land area of 19,323 square kilometers and it is the sixth largest region of the country. Eastern Region is the third most populous region after Ashanti and Greater Accra with a population of 2,106,696 in 2010.

The main occupations of the economically active population in the region are Agriculture and related work (54.8%), Sales (14.3%), Transport, Production and Equipment work (14.0%), Services (5.0%) with Professional and Technical work accounting for 6.9% (GSS, 2010).

The region lies within the wet semi-equatorial zone characterized by dual rainy season. The temperature ranges between 24 ^{0}C and 36 ^{0}C.

Figure 3.2. Map of Eastern Region



Source: GhanaDistricts.com

3.5.1 Yilo Krobo Municipal

Yilo Krobo Municipality is one of the 26 administrative Districts in the Eastern Region of Ghana. It lies approximately between latitude 60.00'N and 00.30'N and between longitude 00.30'W and 10 .00'W.The Municipality shares common boundaries with Lower and Upper Manya Krobo Districts to the North and East respectively. To the South, the Municipality shares boundary with Dangme West and Akwapim North Districts. In addition, the Municipality shares boundaries with New Juaben and East Akim in the South-west and finally with Fanteakwa in the West. The Municipality covers an estimated area of about 805 square kilometres, representing about 4.2 percent of the total area of the Eastern Region.

The Municipality is within the dry equatorial climatic zone which experiences substantial amount of precipitation. It experiences a bi-modal rainy season, which reaches its maximum during the two peak periods of May - June and September - October. The annual rainfall is between 750 mm in the Southeast and 1600 mm on the slopes of the Akwapim ranges in the Northwest. Temperature ranges between a minimum of 24.9 ^{0}C and a maximum of 29.9 ^{0}C. The Municipality lies within the semi-deciduous rain forest and the coastal savanna zone of the country with a relative humidity of 60-93%.

The results of the 2010 Population and Housing Census (2010 PHC) shows that the population of the Municipality is 87,847 with 48.2% being males while the remaining 51.8% are female. Further, 56.5% of the population are between 15 to 64 years, thus the population is economically active in nature. A higher proportion of the population (41.9%) is engaged in agriculture with service and sales taking 21.7% of the population (GSS, 2010).

3.5.2 Ayensuano District

The District lies within Latitudes 5^0 45^1N and 6^0 5^1 N and Longitudes 0^0 15^1W and 0^0 45^1W. It shares boundaries with Suhum Municipality to the North; Nsawam Adoagyiri Municipality to the South; Akwapem South District to the East and Upper West Akim District and West Akim Municipality to the West. With a total land area of 499km^2, Ayensuano District occupies 2.3 percent of the total land area of the Eastern Region (19, 323 km^2).

The population of Ayensuano District, according to the 2010 Population and Housing Census, is 77,193 representing 2.9% of the region's total population. Males constitute 49.8% and females represent 50.2 %. More than ninety percent (93. %) of the population is rural. The population of the district is youthful (40.5%) depicting a larger working force for the district.

About 80.8% of households in the district are engaged in agriculture. In the rural setting, 81.4% of the households are engaged in agriculture while that of the urban localities is 72.8%. Most households in the district (96.6%) are involved in crop farming with Poultry (chicken) being the dominant animal reared in the district.

The climatic condition is tropical where average temperatures are usually high throughout the year, ranging from 24 ^{0}C to 29 ^{0}C. The hottest months are March and April while the coolest months are December and January. Relative humidity, especially in the rainy season (April to November) is between 87 and 91 percent. In the dry season, it is between 48 and 52 %.

The District was originally covered by a semi deciduous forest but human activity such as cultivation and lumbering has considerably reduced the land covered by the original vegetation to an insignificant level and is now covered mostly by re-growth thickets and secondary forests. The

District has very suitable soil conditions for the development of agriculture and the lumber industry.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter discusses the study results. The socio-demographic characteristics as well as the occupational and production characteristics of the sample are presented. Also, the results of the vulnerability of households to climate variability and the factors influencing the vulnerability are discussed. Furthermore, the adaptation strategies adopted by the respondents and the determinants of the choice of those strategies are discussed. Finally, the factors militating against the adoption of various adaptation strategies are presented.

4.2 Socio-demographic and Occupational Characteristics of Respondents

4.2.1 Gender of Respondents

Males are more involved in maize production than females. Group discussion with the farmers revealed that the role of females in maize production is mainly sowing, harvesting and processing whilst the males owned and prepared the land for cultivation of the crop. This is in line with what Lowland Rice Development Project (LRDP) in 2001 found; 6.7% of LRDP beneficiaries were women, most of them owning plots for the first time (Jenin and Awuni, 2001).

Table 4.1: Gender distribution

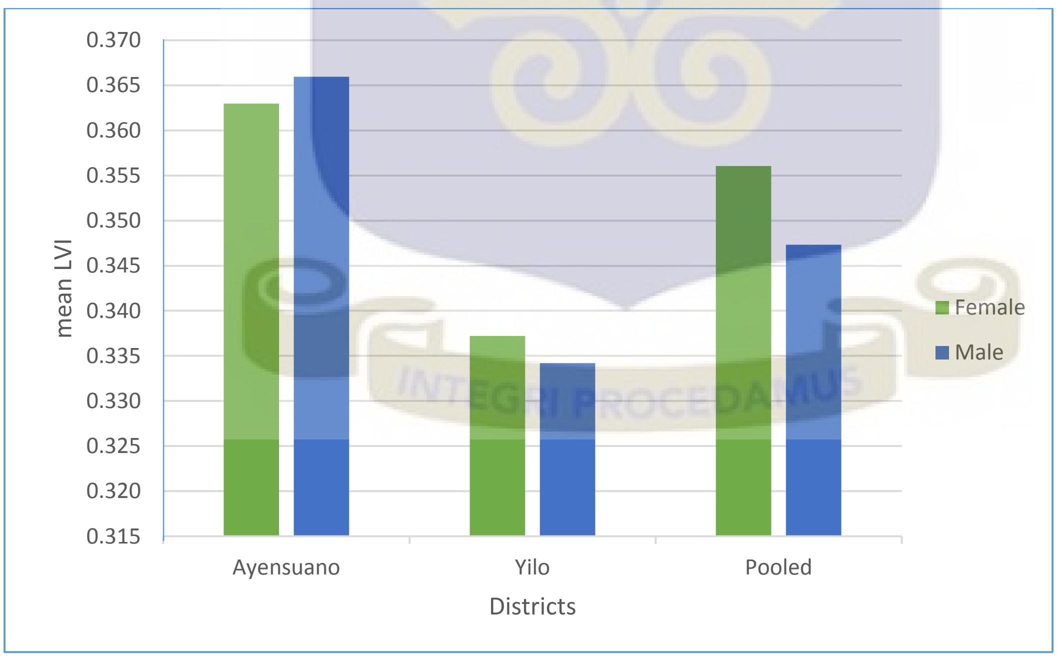
Districts	Males		Females	
	Frequency	%	Frequency	%
Yilo	64	85.33	11	14.67
Ayensuano	45	60.00	30	40.00
Pooled	109	72.67	41	27.33

Source: Field Survey, 2016.

The data suggests that female headed households are more vulnerable in Yilo Krobo Municipality than their male counterparts.

The overall mean value of the females' LVI is higher than that of the male (0.019**).

Figure 4.1: Mean LVI by Gender



Source: Field Survey, 2016.

4.2.2 Age of Respondents

Among the respondents, the aged are less involved in agriculture. This could be attributed to the fact that, agriculture is labour intensive. The youth constitutes about 15% while that of the adult is 82% of the total population of the respondents. Thus, the workforce of the study area is high and this serves as an opportunity for the agricultural sector.

Table 4.2: Age Distribution

Age Group	Ayensuano		Yilo		Pooled	
	Frequency	%	Frequency	%	Frequency	%
<35	10	13.33	12	16.00	22	14.67
35-64	61	81.33	62	82.67	123	82.00
>65	4	5.33	1	1.33	5	3.33

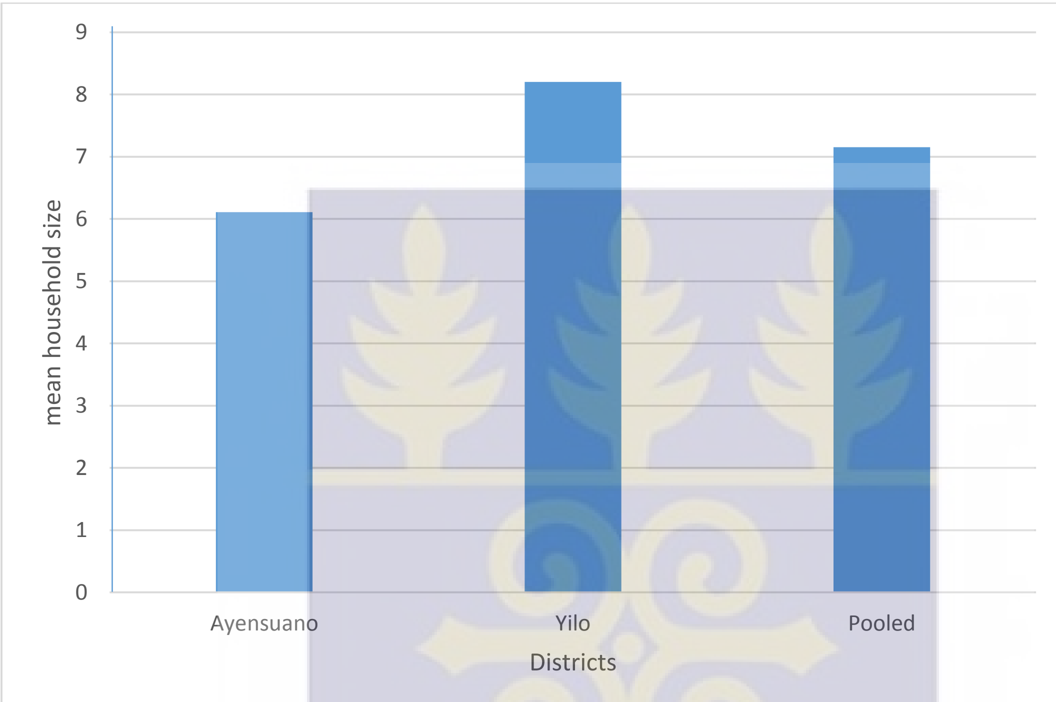
Source: Field Survey, 2016.

The average age of both males and females in the study area is 45 years. The mean age of female respondents in Ayensuano and Yilo Krobo districts are 45 and 48 years respectively whilst that of the males are 47 and 44 years respectively in those districts.

4.2.3 Household size of Respondents

Household according to the 2010 PHC is defined as a person or a group of persons, who share the same housing unit or compound and share the same house-keeping arrangements and constitute a single consumption unit. The mean household size for Ayensuano and Yilo Krobo districts are 6 and 8 respectively. The average household per house for the districts according to the 2010 census are 4 for Ayensuano and 4 for Yilo compared with 4 for the region. This differences could be attributed to the fact, that unemployment is increasing and therefore the head of the household has more people to take care of.

Figure 4.2: Mean Household Size

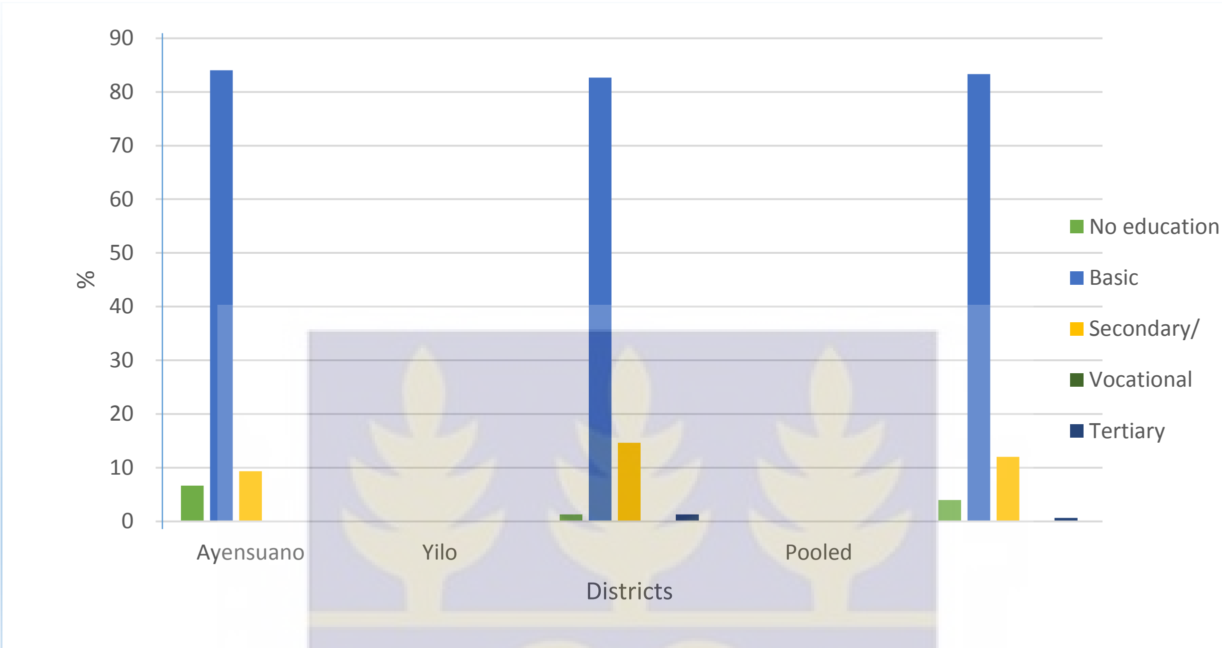


Source: Field Survey, 2016.

4.2.4 Educational Status

It was observed that 4% of the farmers interviewed had no formal education. Also 83%, 12% and 1% of the farmers had Basic, Secondary and Tertiary education respectively. Tertiary here, refers to polytechnics and universities. None of the respondents attended training college. This educational status is consistent with the regional report of the PHC (2010) which says that majority of the population (60%) had basic education.

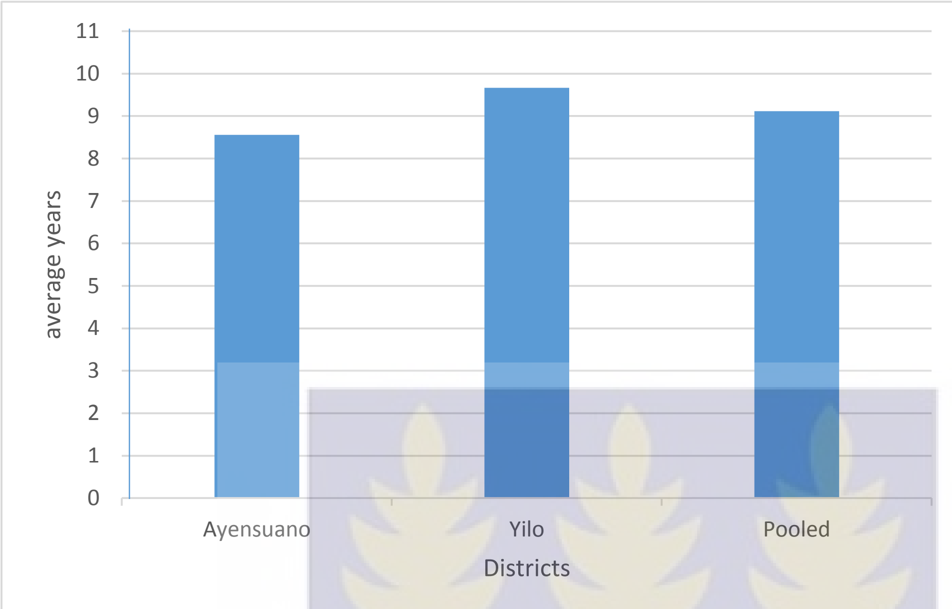
Figure 4.3: Level of Education



Source: Field Survey, 2016.

The average years of schooling in Yilo is more than that of Ayensuano. The average years are 10 and 9 for Yilo and Ayensuano districts respectively. The average years of formal education for the pooled is 9. Hence, generally each respondent had attained basic education.

Figure 4.4: Average years of education



Source: Field Survey, 2016.

4.2.5 Experience in Maize Farming

The field survey data analyzed revealed that majority of the farmers sampled are fairly experienced in maize farming with an average of 19 years. Males are relatively experienced than females in Ayensuano districts whereas in Yilo, the females are more experienced than their male's counterpart.

Table 4.3: Mean years of farming experience of respondents

	Average Years of Farming Maize	
Districts	**Female (years)**	**Male (years)**
Ayensuano	21	22
Yilo	17	16
Pooled	**20**	**19**

Source: Field Survey, 2016.

4.2.6 Size of Farm Holding

The size of the respondent's maize farm ranges from 0.2 to 4.0 hectares with an average of 1.3 hectares. From the analysis of the field data, on the average in terms of farm holding, Yilo has the least 1.1 hectares while Ayensuano has 1.5 hectares. The small size of farm holding could be attributed to the practice of dividing land among family members through inheritance and also high cost of acquisition of lands in the study area.

It was also realized from the analysis that farmers with smaller farm size tend to be less vulnerable to climate variability. This can be seen from the table below.

Table 4.4: LVI against farm size

Districts	Average LVI	Average farm size(ha)
Ayensuano	0.365	1.493
Yilo	0.335	1.083
Pooled	0.350	1.288

Source: Field Survey, 2016.

4.2.7 Land Acquisition

Land for maize production is acquired through rent/lease, self-owned, spouse, spouses' family and inheritance. The farmers pay for rented land in kind or in cash before or after harvesting of produce. Majority of the farmers interviewed who have rented lands for production pay in kind after harvesting, on the average of 2 bags (50kg bag) per acre.

Percentage of land acquisition differs from district to district. 47 % of the respondents owned their farming lands. The least method of land acquisition is through spouse and spouses' family (1 %).

Table 4.5: Method of land holdings

Districts	Owned land (%)	Spouse (%)	Spouses' family (%)	Inheritance/family (%)	Rent/Lease (%)
Ayensuano	45.33	0.00	1.33	22.67	30.67
Yilo	49.33	1.33	0.00	26.67	22.67
Pooled	**47.33**	**0.67**	**0.67**	**24.67**	**26.67**

Source: Field Survey, 2016.

4.2.8 Type of Labour Employed

Different types of labour are used for farm operation in the study area. About 41% of the respondents used both self, family and hired types of labour for farming during the previous season. Self-labour is the least of all types used (4%), while 17% and 39% uses hired labour and family labour respectively. From the table below, it can be deduced that the spirit of group labour that existed in rural communities is gradually disappearing since the respondents no longer use group labour for farming. This could be as a result of social changes that are taken place in our rural communities.

Table 4.6: Type of labour used by the respondents

Districts	Self (%)	Family (%)	Hired (%)	All (%)
Ayensuano	2.67	33.33	18.67	45.33
Yilo	5.33	44.00	14.67	36.00
Pooled	**4.00**	**38.67**	**16.67**	**40.67**

Source: Field Survey, 2016.

Most of the respondents in Ayensuano used all three types of labour while in Yilo, family labour was mostly used.

4.2.9 Occupational Distribution of the Respondents

About 88% of the respondents have agriculture as their main occupation whiles petty trading, salaried work (formal sector) and others (craftsmanship, herbalist and driving) constitute 3% and 6% and 3% respectively. This is consistent with the regional findings of the PHC (2010) which reported that majority of those with low levels of educational attainment are in occupations that do not require high skills.

Table 4.7: Occupational distribution

Districts	**Agriculture (%)**	**Petty trading (%)**	**Salaried work (%)**	**Others (%)**
Ayensuano	90.67	5.33	4.00	0.00
Yilo	85.33	1.33	8.00	5.33
Pooled	88.00	3.33	6.00	2.67

Source: Field Survey, 2016.

It can be seen from the table above that Yilo has more salaried workers than Ayensuano.

4.2.10 Extension Service

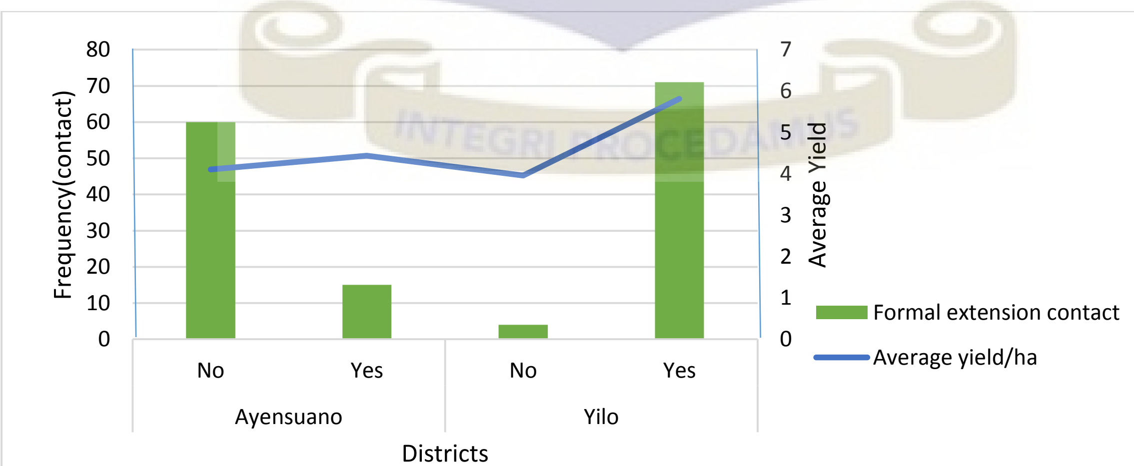
Access to extension services is critical to improving the productivity of farmers. This is no exception from this study. Respondents who have access to extension service during the last farming season had higher yields than those who did not get such access. Respondents with extension access had an average of 6 bags/ha (100 kg bag) compared with 5 bags/ha (100 kg bag) for those without access. There is more extension contact in Yilo than Ayensuano.

Table 4.8: Access to extension service and Maize Yield

Districts	Formal extension contact			
	No (%)	Average Yield (100kg/ha)	Yes (%)	Average Yield (100kg/ha)
Ayensuano	80.00	4.10	20.00	4.43
Yilo	5.33	3.96	94.67	5.81
Pooled	42.67	4.09	57.33	5.57

Source: Field Survey, 2016.

Figure 4.5: Access to Formal Extension



Source: Field Survey, 2016.

Maize yield of respondents with access to extension is higher than those who do not have access to. Extension service is an important source of information on climate variability as well as adaptation options hence farmers who have contact with extension agents are more likely to adopt suitable strategies to cope with the climate variability which will subsequently increase their yield (Nhemachena and Hassan, 2007.).

4.2.11 Rainfall Perception

Respondents were asked about their perceptions on rainfall for the past 10 years and table 4.9 gives the summary of their responses. From the data analyzed, 67% of respondents in Ayensuano perceived a decreased in amount of rainfall, 4% perceived an increased, 25% perceived an unpredictable rainfall and 4% perceived consistent amount of rainfall.

For Yilo Krobo, 57% perceived a decreased, 17% perceived consistent, 25% perceived an unpredictable amount of rainfall but no one perceived an increased in the amount of rainfall for the past 10 years. The results of the pooled data is no exception, 62%, 2%, 11% and 25% perceived a decreased, an increased, consistent and unpredictable amount of rainfall respectively.

Table 4.9: Respondent's perceptions on rainfall

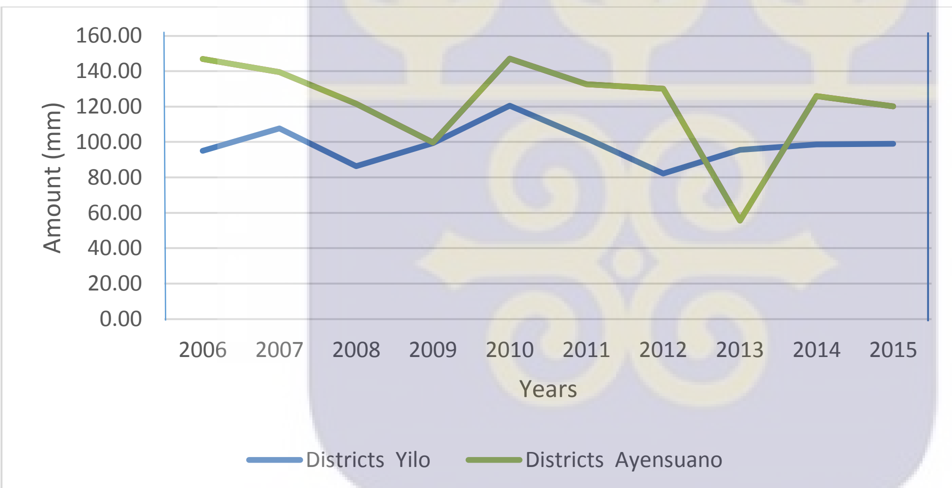
Districts	Unpredictable		No change		Decreased		Increased	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Ayensuano	19	25.33	3	4.00	50	66.67	3	4.00
Yilo	19	25.33	13	17.33	43	57.33	0	0.00
Pooled	38	25.30	16	10.70	93	62.00	3	2.00

Source: Field Survey, 2016.

The responses from the respondents is supported by the findings of Kankam-Yeboah *et al.* (2011) who report that there is climate change as a result of climate variability in Ghana. Fosu-Mensah *et al*. (2012) also report that majority of their respondents perceived a decrease in the amount of rainfall over the years.

Respondents have different perceptions about the amount of rainfall for the past 10 years. This is consistent with the data from the Ghana Meteorological Department, from the year 2006 to 2015 as depicted in the graph below.

Figure 4.6: Mean annual rainfall



Source: Ghana Meteorological Department, 2016.

4.2.12 Temperature Perception

Respondents gave different responses when asked about their perception on temperature for the past 10 years. In Ayensuano, 85% of respondents perceived an increased in temperature, 5% and 9% perceived consistent and unpredictable temperature respectively. However, no respondent perceived a decreased in temperature.

In Yilo Krobo, 23%, 17% and 60% of respondents perceived that temperature is unpredictable, consistent and increased respectively from 2006 to 2015 with no respondent perceiving a decreased in the temperature.

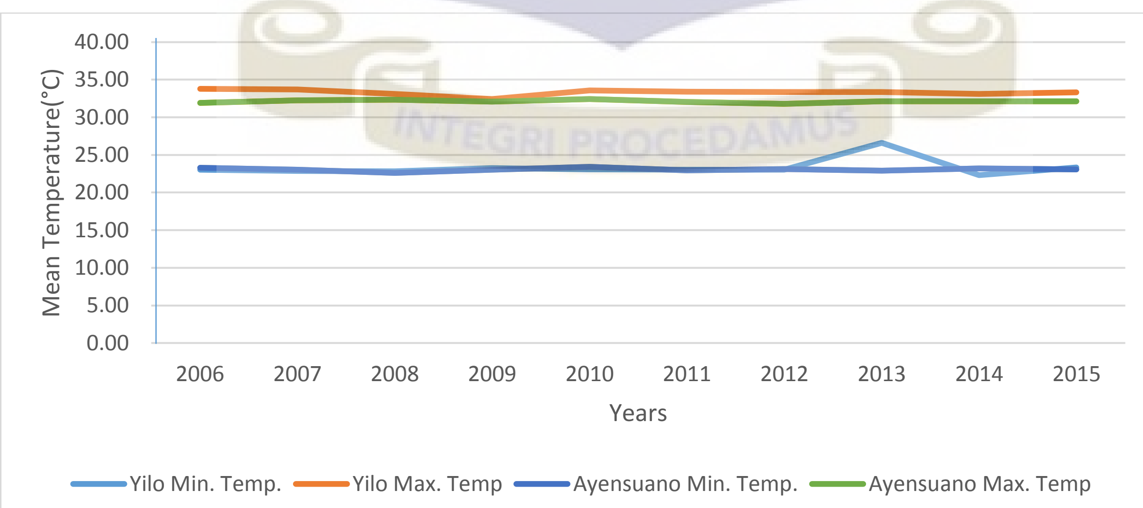
The result of the sampled data is consistent with Fosu-Mensah *et al*. (2012) which reported that majority of its respondents perceived an increase in the temperature.

Table 4.10: Respondent's perceptions on temperature

Districts	**Unpredictable**		**No change**		**Decreased**		**Increased**	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Ayensuano	7	9.33	4	5.33	0	0.00	64	85.33
Yilo	17	22.67	13	17.33	0	0.00	45	60.00
Pooled	24	16.00	17	11.30	0	0.00	109	72.70

Source: Field Survey, 2016.

Figure 4.7: Minimum and Maximum Temperatures



Source: Ghana Meteorological Department, 2016.

It is seen in the graph that variations in the temperatures is minimal but in 2013, there was a sharp rise in the minimum temperature of Yilo Krobo but decreased again in 2014. This could be attributed to the fact that in 2014, the amount of rainfall was high.

4.2.13 Household Annual Income

Household income here refers to the income from maize farm for last two growing seasons (thus the major and minor seasons). From the pooled data, the minimum annual income is GH₵ 125.00 whiles the maximum is GH₵ 2250.00. The average income is GH₵ 739.00

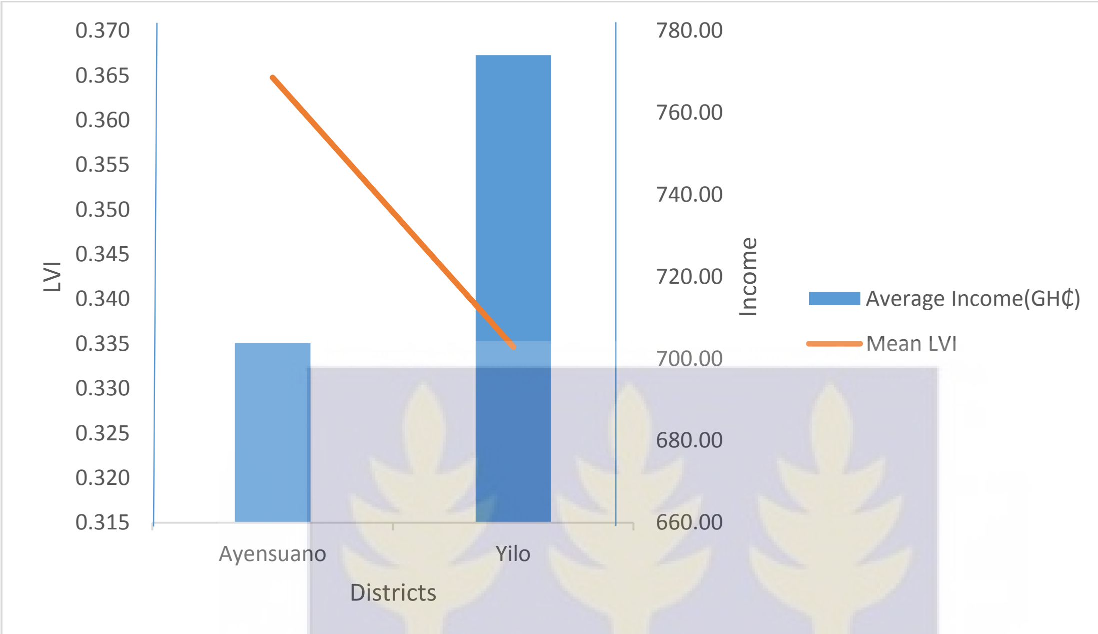
Table 4.11: Income distribution against LVI

Districts	Average Income(GH₵)	Mean LVI
Ayensuano	703.93	0.365
Yilo	774.07	0.335
Pooled	**739.00**	**0.350**

Source: Field Survey, 2016.

From the table, the district with high income is less vulnerable (t-test is -20.068***). Yilo Krobo has a higher income than Ayensuano on the average and hence its mean LVI is the least.

Figure 4.8: Income against LVI



Source: Field Survey, 2016.

Table 4.12: Summary of socio-economic characteristics

Parameters	Yilo				Ayensuano			
	Mean	Std. Dev.	Max	Min	Mean	Std. Dev.	Max	Min
Age (years)	44.45	9.09	73.00	25.00	45.87	10.14	74.00	24.00
No. Strategies (#)	2.72	1.31	8.00	1.00	2.69	1.33	7.00	1.00
YIELD (100kg/ha)	5.71	2.66	15.00	0.71	4.17	2.59	12.50	0.83
Education (years)	9.67	1.85	16.00	0.00	8.56	3.05	15	0.00
Farm size (ha)	1.08	0.48	2.80	0.40	1.49	0.91	4.00	0.40
Annual Income (GH₵)	774.07	415.71	2250.00	250.00	703.93	477.97	2080.00	125.00
Time to health (mins)	53.80	29.93	170.00	5.00	27.93	18.34	70.00	5.00
Time to water (mins)	12.61	6.63	30.00	2.00	9.23	5.71	35.00	2.00
Members Employed (#)	1.47	0.72	4.00	1.00	1.47	0.62	3.00	1.00

Source: Field Survey, 2016.

4.3 Vulnerability of Smallholder Maize Farming Households to Climate Variability

In assessing the vulnerability of households, thirty (30) key variables were collected and grouped as sub-components for the seven major blocks on the basis of their contributions towards the calculation of the LVI as developed by Hahn *et al*. (2009). The LVI was computed for both Yilo Krobo Municipal and Ayensuano District (see appendix IV). The assessment of the individual major components along with their respective sub-components of the LVI value indicates the level of vulnerability of various blocks.

Results of major components of the LVI for each district are presented in table 4.13. Ayensuano has higher percentage of female headed household (39%) than Yilo Krobo (15%). This would make Ayensuano more vulnerable in terms of gender because literature shows that females are more vulnerable to climate variability than their male counterparts. This may be attributed not only to women's limited physical capacity but also to their overwhelming family burdens. This findings is consistent with that of Hahn *et al*. (2009), that respondents in Mabote are more vulnerable due to the high number of female-headed households. Heads of household without formal education is higher in Ayensuano (0.067) than in Yilo Krobo (0.013) but both dependency ratio and percentage of orphans in households are higher in Yilo Krobo than in Ayensuano. However, Ayensuano is more vulnerable (0.362) in socio-demographic profile than Yilo Krobo (0.327).

Households that depend solely on agriculture as source of livelihood are more vulnerable to extreme climatic events (Hahn *et al*., 2009). This is similar to the finding in this study: Ayensuano is more vulnerable (0.502) in terms of livelihood strategies than Yilo Krobo (0.413), because households in Ayensuano are more dependent on rain fed agriculture as source of income. For this reason, any shock in climate variability has more impacts on the district. Also, burden of loans by households tends to make them vulnerable to climate event when the crops fail to grow well as a result of unfavourable climatic condition. LVI value from the burden of loans is higher in Ayensuano (0.400) than in Yilo Krobo (0.293).

Table 4.13: Summary of the major LVI components

Major components	Yilo	Ayensuano	t-test	Prob.	Pooled
Socio-demographic Profile	0.327	0.362	-12.972***	0.000	0.344
Livelihood Strategies	0.413	0.502	-85.548***	0.000	0.458
Health	0.209	0.252	-16.267***	0.000	0.231
Social Network	0.387	0.431	-11.390***	0.000	0.409
Food	0.202	0.227	-54.259***	0.000	0.215
Water	0.519	0.402	4.912***	0.000	0.460
Natural disaster and climate variability	0.459	0.528	-55.760***	0.000	0.493
OVERALL VULNERABILITY	**0.363**	**0.390**	**11.8533*****	**0.000**	**0.377**

Source: Field Survey, 2016.

The third major component of the LVI is health. The LVI value on health is generally low (0.209 for Yilo Krobo and 0.252 for Ayensuano). This could be as a result of better health facilities accessible to all in the study area. Etwire *et al.* (2013) found that, limited access to quality health services increases the vulnerability of smallholder farmers to extreme climatic events due to a decrease in their health status. However, the block with the most households that reported members suffering from chronic illness was Ayensuano (0.187). Ayensuano again tends to be more vulnerable in terms of availability of toilet facilities at the residence with an LVI value of 0.307 compared with 0.267 value for Yilo Krobo. Average Malaria Exposure and Prevention Index was low for both districts (0.167 for Yilo Krobo and 0.163 for Ayensuano). This could be attributed to the sensitization campaigns and free distribution of mosquito nets by the Ministry of Health in the study communities.

The fourth component is the Social Network. It consists of three sub-components computed for both districts. Good social relationships among members of a community mostly reduces the impact of climatic stresses on individual households. In both districts, no respondent applied to their local government for assistance to their households for the past twelve months. This makes the LVI value of this component to be extremely high (1.00). This is consistent with the findings of Etwire *et al.* (2013), who report that households who have less access to emergency cash loan/aid are likely to be more vulnerable. Access to emergency loans/aid in times of need are important assets for the households' livelihoods. Ayensuano is more vulnerable in terms of LVI value for average borrow to lend ratio (0.133) than Yilo Krobo (0.040). The overall vulnerability of Ayensuano is higher (0.431) than that of Yilo Krobo (0.387).

Climate variability may affect agriculture and food security by altering the spatial distribution of rainfall and the availability of water. It may heighten uncertainties throughout the food chain, from farm to fork and yield to trade dynamics (Hanjra and Qureshi, 2010.). This makes the food component of the LVI an important component in the analysis. It is computed using five key sub-components and indices show Ayensuano to be more vulnerable than Yilo Krobo. The LVI value for households who use only forest-based energy for cooking purposes is the same for both districts (0.973). This value means that the use of petroleum products for cooking has not gained much popularity in the study area. Households in Yilo Krobo do not struggle to find food but about 6% of the respondents in Ayensuano struggle to find food for home consumption. About 99% of respondents grow one additional crop to the maize, hence the LVI value on average crop diversity index is low, (0.011 for Yilo Krobo and 0.014 for Ayensuano). Ayensuano is more vulnerable (0.040) on the food component of the LVI than Yilo Krobo (0.010).

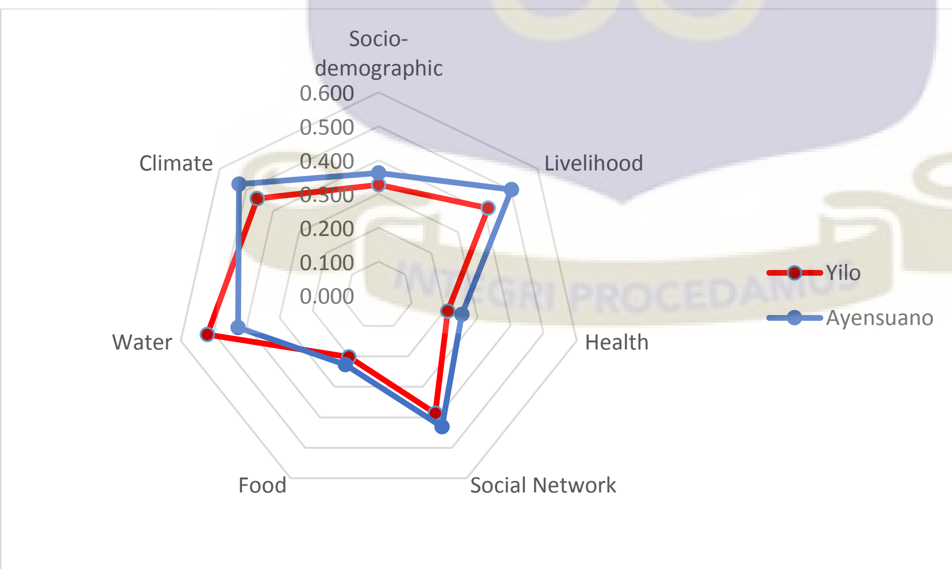
The sixth major component of the LVI is water and it consists of five sub-components. After aggregating the sub-components, the indices show that Yilo Krobo is more vulnerable (0.202) than Ayensuano (0.227). This is because majority of the respondents in Yilo Krobo (89%) reported to have inconsistent water supply due to inadequate water sources such as boreholes and wells. Ayensuano showed lesser vulnerability value of 0.219 in terms of the average time to water sources than Yilo which showed 0.379. This result is supported by the findings of Hahn *et al.* (2009), who report a lower vulnerability score (0.099) for respondents in Mabote because of consistent and easy access to potable water. The average volume of water stored in the study area is 306 litres daily with Yilo Krobo storing about 340 litres per household whiles households in Ayensuano stores 272 litres daily. In both districts, women and children are mostly those who fetch water for the households. This is very common in Ghanaian culture. Yilo Krobo showed higher vulnerability value (0.320) in conflict over water but that of Ayensuano is lesser (0.240).

The last component of the LVI is natural disasters and climate variability. Six components were aggregated for this major component. The result shows that Ayensuano was more vulnerable (0.773) than Yilo Krobo (0.253) in the reported cases of floods and droughts. About 7% of households in Ayensuano sustained an injury for the past ten years as a result of an occurrence of floods and droughts but no household in Yilo Krobo was reported to have sustained an injury for that same period. Adaptation is an ongoing planning process and adjustment required to respond to an evolving context and risks. To do this effectively requires availability of appropriate, timely and locally relevant climate information such as weather forecasts, seasonal forecasts and early warnings for pending climate related hazards. Publicity about pending climate disaster was low in

Yilo Krobo; about 5% of the respondents were reported to have received warning about pending natural disaster. This means Yilo Krobo was more vulnerable (0.947) than Ayensuano (0.813) in terms of this information dissemination. This is consistent with the findings of Etwire *et al.* (2013) and Hahn *et al.* (2009). The LVI value of Ayensuano is lower for both mean standard deviation of average maximum temperature and mean standard deviation of average rainfall than that of Yilo Krobo recorded for the past ten years. Thus, Yilo Krobo is more vulnerable in mean standard deviation of average maximum temperature (0.684) and mean standard deviation of average rainfall (0557) than that of Ayensuano (0.663 for mean standard deviation of average maximum temperature and 0.504 for that of average rainfall).

After aggregating for the seven major components of the LVI, Ayensuano was found to be more vulnerable (0.390) than Yilo Krobo (0.363). For the pooled, the LVI value was 0.377. The major vulnerability components are presented in the figure below.

Figure 4.9: Vulnerability Spider diagram



Source: Field Survey, 2016.

The spider diagram provides information on household characteristics that contribute most to climate variable vulnerability in the study area. The closer the major component to the centre of the diagram, the least vulnerable is that component. The contribution of food component to the LVI is the least amongst the other components for both districts with natural disaster and climate variability having greatest impact on the vulnerability level.

A two-tailed t-test was conducted to test the statistical difference in the mean LVI of the districts. The difference in mean LVI between the two districts is significant at 1% (Table 4.14).

Table 4.14: Results of Two-Tailed T-Test for Differences in Mean LVI

Variable	Count	Mean	Std. Dev.	Std.Err. of Mean	t-test value	Prob	df
Ayensuano	75	0.3648	0.0153	0.0028			
Yilo Krobo	75	0.3347	0.0158	0.0018	11.8533***	0.000	148
Pooled	150	0.3500	0.0216	0.0018			

Source: Field Survey, 2016.

The results of the LVI-IPCC show Ayensuano to be again more vulnerable (0.031) than Yilo Krobo (0.028). The LVI-IPCC values range from -1 (least vulnerable) and +1 (highly vulnerable). This result is depicted in table 4.15 showing the sub-components of the major components.

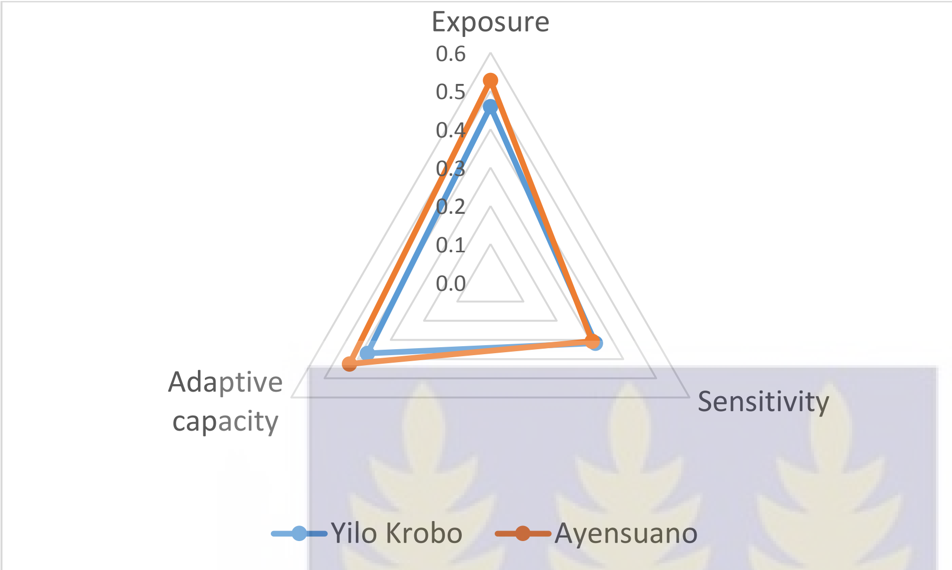
Table 4.15: LVI-IPCC contributing factors

Major components	Sub-components	Yilo Krobo	Ayensuano
Exposure	Natural disasters and climate variability	0.459	0.528
	Sub-LVI	**0.459**	**0.528**
Sensitivity	Health	0.209	0.252
	Food	0.202	0.227
	Water	0.519	0.426
	Sub-LVI	**0.317**	**0.305**
Adaptive capacity	Socio-demographic profile	0.327	0.362
	Livelihood strategies	0.413	0.502
	Social networks	0.387	0.431
	Sub-LVI	**0.371**	**0.425**
Overall LVI-IPCC		**0.028**	**0.031**

Source: Field Survey, 2016.

Yilo Krobo is least exposed (LVI value of 0.459) to climate variability than Ayensuano (0.528), but in terms of sensitivity, Yilo Krobo is more vulnerable (0.317) than Ayensuano (0.239). Ayensuano is found to be less adaptive to the shocks of climate variability: LVI value for Ayensuano is 0.425 while that of Yilo Krobo is 0.371. Figure 4.10 summarizes the LVI-IPCC contributing factors.

Figure 4.10: Vulnerability Triangle of LVI-IPCC for Ayensuano and Yilo Krobo



Source: Field Survey, 2016.

A two-tailed t-test was used to assess the statistical significance of the difference in the mean LVI of the districts and the hypothesis is rejected at 1% level of significance.

Table 4.16: Results of Two-Tailed T-Test for Differences in Mean LVI

Variable	Count	Mean	Std. Dev.	Std.Err.of Mean	t-test value	Prob	df
Ayensuano	75	0.0278	0.0105	0.0012			
Yilo Krobo	75	0.0210	0.0026	0.0003	5.4348***	0.000	148
Pooled	150	0.0244	0.0083	0.0007			

Source: Field Survey, 2016.

4.4 Determinants of Household Vulnerability

Before the data analysis, the contingency coefficient test was applied to test for correlation among the independent variables. An r value of less than 0.5 is weakly correlated, between 0.5 and 0.9 is strongly correlated and 1 is perfectly correlated. The explanatory variables were found to be weakly correlated and the results are presented in appendix V.

Farming experience, access to credit, formal extension, temperature perception, hired labour and dummy Ayensuano are the factors that influence the livelihood vulnerability index of households using the pooled data. These results are presented below.

Table 4.17: GLS regression results of the factors influencing household vulnerability index

Variables	Yilo Krobo		Ayensuano		Pooled	
	Coefficients	P>|Z|	Coefficients	P>|Z|	Coefficients	P>|Z|
Constant	0.340***	0.000	0.384***	0.000	-0.653***	0.000
Age	0.000	0.973	0.000	0.574	0.000	0.445
Gender	0.011*	0.075	-0.003	0.506	0.002	0.567
Family labour	0.000	0.952	0.001	0.237	0.001	0.238
Farm size	0.009*	0.071	0.000	0.833	0.001	0.550
Farming experience	0.000	0.261	-0.001**	0.039	0.000*	0.061
Access to credit	-0.012***	0.004	-0.002	0.312	-0.003**	0.021
Formal extension	-0.007	0.436	-0.007*	0.092	-0.007*	0.057
Temperature perception	-0.010**	0.043	-0.012	0.125	-0.012***	0.002
Hired labour	0.000	0.501	0.000**	0.033	0.000*	0.070
Marital status	0.009	0.159	-0.004	0.453	0.001	0.771
Dummy Ayensuano					1.029***	0.000
Diagnostic statistics						
No. of observation	**75**		**75**		**150**	
Deviance	**0.014**		**0.012**		**0.028**	
Log likelihood	**215.799**		**220.479**		**430.124**	
Pearson statistic	**0.000**		**0.000**		**0.000**	

Source: Field Survey, 2016.

For Yilo Krobo municipality, the factors that determines the vulnerability index of households are gender, farm size, access to credit and temperature perception. In the Ayensuano district, farming experience, formal extension and hired labour are statistically significant.

Female headed households in Yilo Krobo are more vulnerable to the impact of climate variability. This is because females are less able to adapt to the negative impact of climate variation as a result of its intensive nature. This result is supported by the findings of Hassan and Nhemachena, (2008) Deressa *et al*. (2010) and Lambrou & Piana (2006), who all argue that male headed households have more access and control over resources than their female counterpart, which make the males more likely to adopt adaptation strategies to minimize the effect of climate variability.

Additional land allocated for farming in Yilo Krobo increases the vulnerability of households to climate variation marginally. This could be due to the fact that much work needs to be done as farm size increases and adaptation that comes with cost tend to increase the cost of production. This result is consistent with the findings of Deininger *et al.* (2013).

Credit aids in the purchasing of farm inputs for agricultural production and also increases the opportunity of households to adapt to climate variation which is likely to reduce the vulnerability of smallholder farmers to climate variation. Access to credit in Yilo Krobo and the pooled is statistically significant and the sign is negative. This is consistent with the *a priori* expectation and also supported by the findings of Fosu-Mensah *et al.* (2012).

Respondents who perceived a change in temperature in Yilo Krobo are about 1% less vulnerable to climate variability, as they are able to adapt to the impacts of climate shocks. This findings is consistent with that of Deressa *et al.* (2009), who report a positive relationship between temperature perception and adoption of adaptation measures.

Hired labour is positively significant in Ayensuano district and the pooled. This is contrary to the *a priori* expectation although the coefficients are negligible, but it is expected that hired labour is used by wealthier famers and for that matter would have their vulnerability reduced. Adapting wrong strategies from a perceived climate variation to overcome the negative shocks of the climate could account for the positive relationship between hired labour and vulnerability.

A smallholder maize farming household that had contact with an extension agent is about 1% less vulnerable to the negative impact of climate variation in Ayensuano district. Agricultural extension agents are the main linkages between agricultural researchers and farmers, hence smallholder farmers who have access to the services of these agricultural extension officers are more likely to adopt effective climate related strategies. This empirical result is supported by the finding of Nhemachena and Hassan (2007). Extension agent to farmer extension has been reported also by Deressa *et al*. (2010) to have a positive influence on the adoption of adaptation technologies in response to climate variability which would subsequently reduce the vulnerability of households to extreme climatic events.

As maize farmers in Ayensuano become more experience, their vulnerability reduces marginally. More years of farming may endow the farmers with the requisite experience that will enable them make better assessment of the risks involved in climatic extreme adaptation investment decisions. This is consistent with the finding of Enete *et al.* (2002), who report that older farmers have more experience and are able to take healthier production decisions than younger ones. On the contrary, farming experience for the pooled data significantly increases vulnerability by 10%. This could be due to the fact that experienced farmers are usually older in age and are more likely to be risk averse, especially to matters regarding climate variability than younger ones. It could also be due to the fact that farmers with long years of experience are used to obsolete methods of farming and traditional tools which will reduce output.

4.5 Identified Climate Related Adaptation Strategies

Farmers in the study area adopt different climate adaptation strategies. Maize farming is solely rain fed so all farmers rely on the rainfall before planting. Irrigation is not practiced by the respondents and hence timing of rain is not considered as an adaptation strategy for this study. Thirteen (13) different strategies were identified; 90% of the sample adopt about three of the identified strategies averagely making a sum of 339 adaptation strategies and the remaining 10% of the sampled population not adopting any of those strategies. Planting in rows is the most widely (24%) adopted climate adaptation strategies in the study area followed by mixed cropping (15.63%) with land rotation and tree planting been the least adopted (2% each) strategies. The summary of the adaptation strategies for the pooled data is presented in table below. Based on literature, the various strategies are grouped into soil related strategies, recommended agricultural practice strategies and improved varieties strategies.

Table 4.18: Identified strategies adopted by respondents

Soil related strategies		Recommended agricultural practice strategies		Improved varieties strategies	
Sub-strategies	%	Sub-strategies	%	Sub-strategies	%
Mounds/ridges	5.60	Land rotation	1.77	Mixed cropping	15.63
Manure/compost	5.60	Spacing	8.55	Livestock rearing	5.60
Inorganic fertilizer application	6.78	Planting in rows	23.64	High yielding varieties	6.19
				Drought tolerant varieties	7.67
Insecticides	8.55	Tree planting	1.77	Early maturing varieties	2.65
Total	**26.53**	**Total**	**35.73**	**Total**	**37.74**

Source: Field Survey, 2016.

Farming households in the communities surveyed uses wide range of adaptation measures in response to climate variability. Improved varieties strategies is the dominant (38%) strategy in the study area. Several improved maize varieties such as Okomasa, Obatanpa and Dadaba with different maturity periods have been developed and released to farmers by the CSIR- Crops Research Institute (CSIR-CRI) of Ghana to meet the needs of growers in the different ecological zones of Ghana (Twumasi – Afriyie *et al.*, 1997). These strategies guard against crop failure as the farmer cultivates different crops with different climatic requirements as well as varieties that can withstand climatic shocks. The strategies also aid to bridge the “hunger gap” before the longer maturing plants are harvested.

The percentage of recommended agricultural practices such as spacing, planting of trees and planting in rows is about 37% in the study area. The recommended spacing for maize cultivation is 90cm apart and 40cm between plants, and 75cm x 40cm depending on the variety (Awuku *et al.* 1991). All plants require a certain amount of nutrients, water and space for better growth and development. If the space needed for their development is to some extent occupied by weeds that rob the cultivated plants of nutrients, moisture and sunlight, the plant cannot thrive well and then the returns from the crop would be correspondingly less.

Soil related strategies play important role in climate adaptation strategies by rendering the adopters of those strategies less vulnerable. These strategies constitute about 27% of the total strategies adopted in the study area with insecticides (9%) been the most practiced technique used to control insects and other predators on the farm. The best soils for maize are normally deep, medium – textured, well – drained, loamy soils rich in humus with a high water – holding capacity (Baffour, 1990). Availability of soil moisture at the time of tasseling is essential for the production of high yields and that one is achieved through manure and mounds construction. According to Awuku *et al.* (1991) farmers can use organic or chemical fertilizer on continuously or previously used land in southern Ghana. According to Lafitte (2000) and Birch *et al.* (2003), if water and temperature conditions are satisfied for the development of maize, then productivity can only be limited by non-availability of nitrogen in the soil. This makes it necessary for nitrogen fertilizers to be applied in order to enhance productivity.

4.6 Determinants of Choice of Adaptation Strategies

A household is considered as adopting a particular strategy if it adopt at least one of the sub-strategy under a major strategy. The marginal effects of the factors that influence the choice of climate adaptation related strategies by smallholder maize farming households in the Eastern Region are presented in the table below.

Table 4.19: Results of the multinomial logistic regressions of the factors that influence the choice of adaptation strategies

Variables	Recommended agricultural practice		Improved varieties strategies		Soil related strategies	
	dy/dx	P>|Z|	dy/dx	P>|Z|	dy/dx	P>|Z|
AGE	-0.002	0.299	-0.011	0.117	0.012	0.281
GENDER	-0.078	0.712	-0.042	0.536	-0.131*	0.074
FARMSIZE	-0.039	0.251	-0.002	0.128	-0.0542	0.132
F.EXP.	0.001**	0.046	0.010**	0.010	0.008	0.528
RAIN. PERCEP.	0.129***	0.000	0.076***	0.000	0.039***	0.000
A. CREDIT	0.050*	0.093	0.026	0.151	0.002	0.161
Diagnostic statistics						
Number of observation	150					
Log pseudolikelihood	-173.755					

*, ** and *** Statistical significance at 10%, 5% and 1% respectively.

Source: Field survey, 2016.

This analysis uses *no adaptation* as the base category and evaluates the other choices as alternative to this option. The Hausman test was carried out to determine the assumption of IIA. All choices gave a positive P-value. Hence, the assumption of MNL model been correctly specified was not violated. Results of the IIA test are presented in appendix VI. Also, Spearman's rank correlation coefficient test was run to test for correlation among the independent variables before the model estimation. Some variables (years of education, temperature perception and formal extension) were found to be highly correlated and were omitted from the model. The final variables used were free from correlation. Result of the test is presented in appendix V.

Farming experience, rainfall perception and access to credit are the factors that influence the choice of recommended agricultural practice strategies whilst rainfall perception and farming experience also influence the choice of improved varieties. The choice of soil related strategies is determined by gender of household head and rainfall perception.

Better access to credit is found to promote the use of recommended agricultural practices than not adapting to curb the negative influence of climatic events. Factor endowment (i.e. access to credit) at the disposal of farming households enable farmers to make use of all their available information to change their management practices in response to climate change and variability. This is supported by several studies such as the findings of Kandlinkar & Risbey, (2000) and Tizale, (2007).

As expected, the study revealed a positive relationship between perceived changes in rainfall and the adaptation by faming households. That is, farmers who noted a change in rainfall amount are more likely to adapt a strategy than not adapting compared to those farmers who did not perceive a change in rainfall amount. The possible reason for this positive relationship is that farming in the Region is already rainfall-based and therefore, decreased precipitation in such an area is likely to constrain farm production and hence the need to adapt to the changing climate. The findings of Gbetibouo (2009) also agrees with these result.

Female headed household is found to be statistically and negatively significant determinant of soil related strategies. Study conducted by Nhemachena and Hassan, (2007) found male headed household to be positively significant factor in determining the adoption decision of climate related strategies. The findings of this study is contrary to what Bekele & Drake, (2003) found: they found that household gender was not a significant factor influencing farmers' decisions to adopt climate adaptation strategies.

Years of farming is hypothesized to positively influence the choice of adaptation strategies and the results of this study is consistent with the a priori expectation. More years of farming improves the awareness of potential benefits of adopting measures to manage natural resources and conservation activities. According to Maddison, (2006) experienced farmers are expected to have more knowledge and information about climate change and agronomic practices that they can use to reduce the negative effect of climate variability. Farming experience influenced both recommended agricultural practices and improved varieties strategies.

4.7 Constraints to Climate Variability Adaptation Strategies

Farmers adapt to climate variability differently. In the process of adopting strategies to cope with the impact of extreme climate events, farmers encounter several challenges all the way from personal to institutional constraints. Based on literature and focus group interaction with the respondents, nine constraints were identified, pre-tested and finally presented to the farmers for ranking using a simple ranking technique. The result of the ranking is presented in table 4.21.

From the result of the ranking, farmers in Yilo Krobo rank inadequate and limited access to credit, low literacy and high cost of labour as the most pressing constraints. This empirical result is consistent with the finding of Deresa *et al*. (2008) who reported that lack of finance hinders farmers from getting the necessary resources and technologies that would facilitate the adoption of climate related adaptation strategies. Ravi Shankar *et al.* (2013) also found that lower education level limits access of climate related information available from various sources and poor understanding of it increases the vulnerability of these farmers to climate extreme events. The hypothesis that there is no agreement among the ranking of constraints by the respondents is rejected at 5% significance level.

Table 4.20: Ranking of constraints to climate adaptation strategies by respondents

Constraints	Yilo Krobo		Ayensuano		Pooled	
	Mean score	Rank	Mean score	Rank	Mean score	Rank
Inadequate and limited access to credit	2.86	1st	3.18	1st	3.02	1st
Inadequate drought tolerant varieties	5.25	5th	3.42	2nd	4.31	2nd
Low literacy	4.59	2nd	4.45	3rd	4.52	3rd
High cost of labour	4.65	3rd	5.21	4th	4.94	4th
Inaccessible and high cost of input	5.49	7th	5.24	5th	5.36	5th
Poor access to meteorological information	5.40	6th	5.45	6th	5.43	6th
Land tenure	5.09	4th	5.92	7th	5.52	7th
Inadequate knowledge of climate related strategies	5.70	8th	5.97	8th	5.84	8th
Poor extension	5.96	9th	6.16	9th	6.06	9th
Diagnostic statistics						
Number of observation	**59**		**62**		**121**	
Kendall's W	**0.113**		**0.159**		**0.117**	
Chi-Square calculated	**53.291**		**79.011**		**113.522**	
Chi-Square critical	**15.507**		**15.507**		**15.507**	
Degree of freedom	**8**		**8**		**8**	
Asymptotic Significance	**0.000**		**0.000**		**0.000**	

Source: Field survey, 2016.

The ranking of constraints in Ayensuano is same as for the pooled. Inadequate and limited access to credit, inadequate drought tolerant varieties and low literacy are ranked the most pressing constraints by respondents in the Ayensuano district. The use of drought tolerant varieties is another adaptation measure which farmers can adopt to reduce the risk of climate vulnerabilities. However, this strategy requires additional amount of inputs and credit because it comes with a cost. The agreement among the rankings of the respondents is about 16% for Ayensuano and 12% for the pooled. Though the percentage of agreement is low, the null hypothesis that there is no agreement is rejected at 5% significance level.

Some of the farmers opined that poor access to meteorological information and its low reliability are major obstacles to practice adaptability measures to minimize the shocks of climate variability. The study again shows that farmers in the study area lack the technical knowledge on climate variability, its consequences and adaptation strategies to curb the negative impacts of climate related disaster. Respondents expressed that small landholdings due to extended families sharing the lands (land fragmentation) and low annual income were another constraints to adapt various coping measures like soil and water conservation measures, cultivating drought tolerant varieties, etc. The findings are in conformity with the findings of Idrisa *et al.* (2012) who noticed that absence of location specific climate forecasts, poor reliability and failure of the climate forecasts, coupled with poor extension service on climate prediction, were major problems confronting farmers in Borno State, Nigeria.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

The summary, conclusion and key findings of the study are presented in this chapter. Policy recommendations based on the findings of the study and direction for future research are also outlined.

5.2 Summary of the Study

The study was conducted to assess the vulnerability of smallholder maize farming households to climate variability. Climate is seen as an environmental aggregate that consists of factors such as temperature, precipitation, humidity and air. The tendency to become adversely affected by the variation in climate, regardless the contribution of individuals and communities to that variations is simply known as vulnerability to climate variability. Vulnerability according to IPCC, (2007) is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. Impacts of climate variation do not affect all people and communities at the same time, and at same degree because people are exposed at different rates.

The study was conducted in two districts of the Eastern Region of Ghana with 75 respondents randomly selected from each districts. A total of 150 smallholder maize farming households were interviewed using a structured questionnaire. Thirty variables were used in assessing the LVI of both districts as well as individual's households. Two approaches of calculating LVI were used: LVI by Hahn *et al*. and LVI-IPCC. Both methods uses weighted average approach where each sub- component contributes equally to the overall index of each households.

5.3 Key Findings of the Study

Households in Ayensuano are more vulnerable to the impact of climate variability than those in Yilo Krobo with Livelihood Strategies, Social Network and Natural Disaster and Climate Variability components being the most vulnerable components.

The GLS results of the determinants of household's LVI reveal gender, farm size, access to credit and temperature perception as the factors that determined the vulnerability level of households in Yilo Krobo whilst farming experience, formal extension and hired labour were statistically significant in Ayensuano. Women in the study area were mostly affected by the negative impact of climate variability and change.

Three major climate related adaptation strategies are identified; these are soil related strategies, recommended agricultural practice strategies and improved varieties strategies. The most widely used strategy in the study area is improved varieties and breeds strategies, followed by recommended agricultural practices with the least adopted strategy being soil related strategies.

Farmers in the study area are adopting more than one adaptation strategies in response to the impacts of climate variability. A large proportion (41%) of the households interviewed adopt both improved varieties strategies and recommended agricultural strategies, 30% for improved varieties and breeds strategies and soil related strategies, 35% for soil related and recommended agricultural practice with 23% adopting all the three major strategies. The choice of improved varieties strategies is influenced by rainfall perception and farming experience of the household head. The adoption of recommended agricultural practice strategies is determined by farming experience, rainfall perception and access to credit whereas gender and rainfall perception are the determinants of soil related strategies in the study area.

The study identifies nine constraints faced by the respondents in the study area. The three most pressing constraints in Yilo Krobo are inadequate and limited access to credit, low literacy and high cost of labour whereas that of Ayensuano and the pooled are inadequate and limited access to credit, inadequate drought tolerant varieties and low literacy. Inadequate knowledge of climate related strategies and poor extension are the least ranked constraints in the study area.

5.4 Conclusion

Households in Ayensuano district are more vulnerable to climate variability than households in Yilo Krobo municipal. This implies that, households in Ayensuano are sensitive to modest variation in climate and their ability to adapt is severely constrained. This makes the vulnerable households at risk of becoming food insecure or malnourished.

The overall vulnerability index of households in Yilo Krobo is reduced as a result of their access to credit and temperature perception. Formal extension visits and experience of the household heads make households in Ayensuano less vulnerable since they are equipped with new and improved agricultural practices. The pooled data shows that access to credit, formal extension contacts and temperature perception are factors that reduce the vulnerability of households in the study area.

The main adaptation practices actually employed by farmers are mostly taken in combination with other measures and not alone. The different combinations of adaptation practices are grouped into three major adaptation options: soil related strategies, improved varieties and breeds strategies and recommended agricultural practice strategies.

Combining farming experience and access to credit ensures that farmers have the information for decision making and the means to take up adaptation measures. Other enabling factors that have significant potential for promoting climate adaptation strategies, which are usually capital and labour intensives are rainfall perception and gender of household heads. Women were found to be less likely to adopt soil related strategies such as inorganic fertilizer application, construction of ridges and mounds among others.

Many of the barriers identified in the study communities relate to those mentioned in the literature review on constraints to climate variability adaptations. Some of the constraints include inadequate and limited access to credit, low literacy, high cost of labour, inadequate drought tolerant varieties, poor access to meteorological information and low literacy.

5.5 Policy Recommendation of the Study

From the findings of the study, the following recommendations are provided:

1. Water supply should be improved in Yilo Krobo districts in order to reduce the vulnerability of households to climate variability. This can be achieved through the extension of pipe borne water projects to more deprived communities as well as the construction of potable water sources such as boreholes and wells.
2. Urgent intervention in Ayensuano is necessary to enhance financial and social capitals of households. Along with this, intervention is required to enhance human, physical and social capitals. The district assembly should assist to establish community financial co-operative in order to promote savings and investment in the district. This has the tendency of reducing the vulnerability of households financially and help to build social networks.

3. Farmers in the study area should be provided with improved varieties of maize that can withstand drought. This would reduce to probability of losing crops to climate variability and hence render the respondents less vulnerable.
4. Weather stations should be installed in all settlements of the country which are significantly different in geography and socio- economy. This is because climate research in Ghana suffers from lack of weather data of specific site. Scientifically recorded weather data give prime location specific information of climate variability of a particular place. This will aid in the dissemination of information on any impending natural disasters to farmers.
5. For long term solution to over-reliance on rainfall for agriculture in all wards of the region, it is suggested that dam should be constructed at vantage sites to provide irrigation services to the farmers. This would ensure an all year round farming and can raise the financial standings of farmers in the region.
6. Promotion of informal and non-formal education via information centres and classes for adult farmers is essential for making farmers in the study communities aware of the problems facing them and its consequences, and develop self-confidence that would make them ready to act for community's development.
7. Agricultural extension services should be revamped by resourcing the institution and employing more agents. This will make agricultural extension services widely available to smallholder farmers in the study area in order to boost the adoption strategies that will make them less vulnerable to climate shocks.
8. Government should revamp financial institutions by assisting to bring financial services to the largely unbanked population. This would make credit more accessible to farmers in the study area. It would again encourage households to diversify their agricultural activities by

practicing mixed farming to enable the smallholder farming households become resilient to climatic shocks.

5.6 Direction for Future Research

1. It is suggested that in the future, climate related research should be conducted in regions of sharp climatic and socio-economic differences in order to make best assessment of climatic impacts on the livelihood of farmers in the country.
2. A more econometric approach for assessing the vulnerability of households to climate variability is encouraged because both LVI and LVI-IPCC lacks methodological uniformity.

REFERENCES

Abaje I, Sawa B, Ati A. (2014). Climate variability and change, impacts and adaptation strategies in Dutsin-Ma local government area of Katsina State. *Bello University*, Nigeria

Adebayo, F. A., & Adewumi, M. O., (2008). Profitability and technical efficiency of sweet potato production in Nigeria. *Journal of Rural development, 31(5), 105-120.*

Adegeye, A.J. and Dittoh, J.S. (1985) Essentials of Agricultural Economics. *Impact Publishers Nigeria Ltd,* Ibadan, Nigeria.

Adesina, A. A., & Zinnah, M. M. (1993). Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. *Agricultural Economics, 9(4), 297-311.*

Adger WN, Huq S, Brown K, Conway D, Hulme M (2003). Adaptation to Climate Change in the Developing World. *Programme Development Studies. 3(3):179-195.*

Adjetey, J. A. (1994). Maize physiology and growth requirements. *Crops Research Institute (CRI) Management Guide 19. Kumasi. Page 22.*

Ajibefun, I. A., & Abdulkadri, A. O. (2004). Impact of size of farm operation on resource use efficiency in small scale farming: Evidence from southwestern Nigeria. *Journal of Food Agriculture and Environment, 2, 359-364.*

Al-Hassan R, Poulton C (2009). Agriculture and Social Protection in Ghana. *Future Agricultures. Working Paper No. 009.*

Al-Hassan R. M, Kuwornu J. K. M, Etwire PM, Osei-Owusu Y (2013). Determinants of choice. *Environmental Climate Change, Volume 3 (2), pp. 172-187*.

Angelucci F., (2012). Analysis of incentives and disincentives for maize in Ghana. *Technical notes series, MAFAP,* FAO, Rome.

Antwi-Agyei, P., Dougill, A. J., Fraser, E. D., & Stringer, L. C. (2013). Characterising the nature of household vulnerability to climate variability: empirical evidence from two regions of Ghana. *Environment, Development and Sustainability*, 15(4), 903-926.

Awuku, K.A., Brese, G.K., Ofosu, G.K. and Baiden, S.O. (1991). Senior Secondary School Agriculture and Environmental Studies, London: *Evans Brothers Ltd Pp.85-86.*

Baffour, J. H. F. (1990). "O" Level Agricultural Science. Accra: *Afram Publications Ghana Ltd., Pp. 55-56.*

Bekele, W & Drake, L, 2003. Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area. *Ecological Economics 46, 437–51.*

Berezovskaya, S., Yang, D., & Kane, D. L. (2004). Compatibility analysis of precipitation and runoff trends over the large Siberian watersheds. *Geophysical Research Letters, 31(21).*

Berezovskaya, S., Yang, D., & Kane, D. L. (2004). Compatibility analysis of precipitation and runoff trends over the large Siberian watersheds. *Geophysical Research Letters, 31(21).*

Birch, C. J., Robertson, M. J., Humphreys. E., Hutchins, N. (2003). Agronomy of maize in Australia-in review and prospects. In: CJ Birch. SR Wilson, eds. Versatile maize-Golden Oppoitunities: *5th Australian Maize Conference, City Golf Club, Toowoomba, 18-20*

Boko, M; Niang, A; Githeko. C. A; Medany, M; Osman-Elasha, B; Tabo, R; Yanda, p; (2007). Climate change 2007: Impacts, adaptation and vulnerability, Contribution of working group II. The fourth Assessment Report of the Intergovernmental Panel on Climate Change. *Climate change research, Global Environmental Change, 17, 155–167.*

Borlaug, N. (2007). Feeding a hungry world. *Science, 318(5849)*

Bruin, K. (2011). An Economic Analysis of Adaptation to climate Change under Uncertainty. Unpublished Doctoral Dissertation, University of Wageningen, the Netherlands.

Bryan, E., Deressa, T.T., Gbetibouo, G.A., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: Options and constraints. *Environmental Science & Policy, 12(4), 413–426*

Bryan, E., and Behrnan J., (2013). Community-based adaptation to climate change: A Theoretical Framework, Overview of Key Issues and Discussion of Gender Differentiated Priorities and Participation. *International Food Policy Research Institute,* CAPRi Working Paper No. 109. Washington D.C.

Byerlee, D., E.H. Polanco, (1986). Farmers' Stepwise Adoption of Technological Packages. Evidence from the Mexican Altiplano, *American Journal of Agricultural Economics*.

Chamberlin, J. (2008). It's Small World After All: Defining Smallholder Agriculture in Ghana: *International Food Policy Research Institute.*

Chamberlin, J., Diao X., Kolavalli, S. and Breisinger, C. (2007). Smallholder Agriculture in Ghana. *International Food Policy Research Institute (IFPRI). Ghana Strategy Support Program. IFPRI Discussion Brief 3*.

Christiaensen, L. J., & Boisvert, R. N. (2000). *On measuring household food vulnerability*: Case evidence from Northern Mali. Department of Agricultural, Resource, and Managerial Economics, Cornell University.

CIA World Factbook, (2013).

Damas, P., & Israt, R. (2004). Vulnerability and poverty: What are the causes and how are they related. *Center for Development Research*, University of Bonn.

Damas, P., & Israt, R. (2004). Vulnerability and poverty: What are the causes and how are they related.

Dazé, A. (2007). Climate change and poverty in Ghana. Unpublished report by CARE International Ghana.

Deininger, K., Ali, D. A., & Alemu, T. (2013). Productivity effects of land rental market operation in Ethiopia: evidence from a matched tenant–landlord sample. *Applied Economics, 45(25), 3531-3551.*

Deressa, T. T., Hassan, R. M., & Ringler, C. (2010). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *The Journal of Agricultural Science, 149(01), 23-31.*

Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change, 19(2), 248-255.*

Deressa, T., Hassan, R. M., & Ringler, C. (2008). Measuring Ethiopian farmers' vulnerability to climate change across regional states. *International Food Policy Research Institute.*

E. Bryan, and J. Behrman (2013). Community–based adaptation to climate change: A Theoretical Framework, Overview of Key Issues and Discussion of Gender Differentiated Priorities and Participation. *International Food Policy Research Institute, CAPRi Working Paper No. 109. Washington, D.C.: International Food Policy Research Institute.*

Ekboir, J., K. Boa, and A. A. Dankyi, (2002). Impacts of No-Till Technologies in Ghana. *Mexico D.F.: CIMMYT*

Enete, A. A., & Amusa, T. A. (2010). Challenges of agricultural adaptation to climate change in Nigeria: a synthesis from the literature. Field Actions Science Reports. *The journal of field actions, 4.*

EPA. (2009). National action programme to combat drought and desertification. Accra: *Environmental Protection Agency*, Ghana.

EPA. (2011). Annual Report 2011, Accra, Ghana.

Etwire PM, Al-Hassan RM, Kuwornu JKM, Osei-Owusu Y (2013). Application of the Livelihood Vulnerability Index in Assessing Vulnerability to Climate Change and Variability in Northern Ghana. *Journal on Environmental Earth Science 3(2):157-170.*

FAO Statistical Databases (2008). FAOSTAT: Agriculture Data. Available online: http://faostat.fao.org.

FAO. (2006). Global forest resources assessment 2005—progress towards sustainable forest management. *FAO Forestry Paper No. 147*. Rome.

FAO. (2007). Climate Change: Climate Change Impacts, Adaptation and Vulnerability. *IPCC Working Group II fourth Assessment Report.*

FAOSTAT. (2010). Food and Agricultural Organization of the United Nations (FAO), FAO *Statistical Database*, 2010. http://faostat.fao.org

Feder, G., R.E. Just and D. Zilberman, (1985). Adoption of Agricultural Innovations in Developing Countries: *A Survey, Economic Development and Cultural Change.*

Feder, G. and D.L. Umali, (1993). The Adoption of Agricultural Innovations: *A Review, Technological Forecasting and Social Change.*

Fischer G., M. Shah, F.N. Tubiello, H. van Velhuizen (2005). Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990-2080. *Philosophical Transactions of the Royal Society B-Biological Sciences, 360(1463).*

Food and Agriculture Organisation (FAO) (2009). Profile for Climate Change, Rome, Italy. P. 28.

Ford, J. D., & Smit, B. (2004). A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. *Arctic, 389-400.*

Fosu-Mensah, B. Y. (2012). "Modelling Impact of Climate Change on Maize (Zea mays L.) yield under Rainfed Condition in Sub-humid Ghana". Source: http://inra.unu.edu/d21/presentationunu%203.pdf Downloaded on 14.08.2012.

Füssel, H. M., (2007): Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change 17:155–167*

Fussel, H.M. & Klein, R.J.T. (2006:2010). Climate change vulnerability assessments: an evolution of conceptual thinking. *Climatic Change 75, 301–329.*

Gbetibouo AG (2009). Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa. IFPRI Discussion *Paper No. 00849. International Food Policy Research Institute*, Washington, D.C. P. 36.

Ghana Environmental Protection Agency (2007), Climate change and the Ghanaian economy. *Policy Advice Series Environmental Protection Agency, Ghana Government of Ghana, Accra, Ghana.,*

Ghana Meteorological Agency (2016) National office, Accra.

GhanaDistricts.com. Retrieved 15th January, 2013 on www.ghanadistricts.com.

GIDA (2010). National irrigation policy, strategies and regulatory measures. http://mofa.gov.gh/site/wpcontent/uploads/2011/07/GHANA IRRIGATION DEVELOPMENT POLICY1.pdf

Greene, W.H., (2000). Econometric Analysis. *5th Edition, Prentice Hall, New Jersey.*

GSS.(2010). Population and Housing Census, Analytical Report , Eastern Region.

Hanley, N., Mourato, S., and Wright, R. (2001). Choice Modeling Approaches, a Superior Alternative for Environmental Modeling*? Journal of Economic Surveys*; Vol 15, No. 3

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global Environmental Change, 19(1).*

Hanjra, M. A., and M. E. Qureshi. (2010). Global water crisis and future food security in an era of climate change. *Food Policy no. 35:365–377.*

Hassan, R. and C. Nhemachena, (2008). Determinants of African farmer's strategies for adapting to climate change: Multinomial choice analysis. *African Journal of Agric. Research, 2(1).*

Hassan, R. M. (1998). Maize technology development and transfer: a GIS application for research planning in Kenya: *Cab International*.

Hausman, J., and Mc-Fadden, D. (1984). Specification tests for Multinomial Logit Model. *Econometrica*, *52*, pp 1219-1240.

Huang, C., Vaneckova, P., Wang, X., Fitzgerald, G., Guo, Y., & Tong, S. (2011). Constraints and barriers to public health adaptation to climate change. *American Journal of Preventive Medicine.*

Idrisa Y L, Ogunbameru B O, Ibrahim A A, Bawa D B (2012). Analysis of awareness and adaptation to climate change among farmers in the Sahel savannah agro-ecological zone of Borno State, Nigeria. *African Journal of Agricultural Research*.

IISD. (2003). SEI: Livelihoods and Climate Change: Combining Disaster Risk Reduction. Natural Resource Management and Climate Change Adaptation in a New Approach to the Reduction of Vulnerability and Poverty. *International Institute for Sustainable Development*, Winnipeg, Canada.

IPCC. (2001).Climate Change 2001: Synthesis Report. Contribution of Working Groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. *Cambridge University Press*, Cambridge.

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

IPCC, (2007).Climate Change 2007: Synthesis Report. *Contribution of Working Groups I. II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press*, Cambridge, UK.

IPCC, (2009). Climate Change: Synthesis Report. *Contribution of Working Groups I. II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press*, Cambridge, UK.

IPCC, (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. *Contribution of Working Groups I and II of IPCC. Cambridge University Press*, Cambridge, UK.

IPCC. (2014). Climate Change 2007: Impacts, Adaptation, and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report. *Cambridge University Press*, Cambridge, UK.

Jatoe, J. B. D., Al-Hassan, R. M., & Abatania, L. N. (2005). Factors affecting the adoption of improved sorghum varieties among farm households in the northwest Ghana: a probit analysis. *Ghana Journal of Development Studies*.

Jayne, T., T. Yamano, M. Weber, D. Tschirley, R. Benfica, A. Chapoto and B. Zulu (2003). Smallholder Income and Land Distribution in Africa: Implications for Poverty Reduction Strategies. *Food Policy 28(3): 253-275*

Jenin L. and Awuni, J. (2001) Lowland rice Development Report: *Monitoring and Evaluation Mission 1 Report*, MoFA, AFD

K. R. Tiwari, B. K. Sitaula, I. P. Nyborg, and G.S. Paudel (2008). Determinants of Farmers' adoption of improved soil conservation technology in a Middle Mountain watershed of Central Nepal. *Environmental Management*.

Kandlinkar, M & Risbey, J, 2000. Agricultural impacts of climate change: If adaptation is the answer, what is the question*? Climatic Change* 45, 529–39.

Kankam-Yeboah, K., Adjei, K. A., Ren, L., Appiah-Adjei, E. K., & Agyapong, A. A. (2011). Validation of TRMM Data in the Black Volta Basin of Ghana. *Journal of Hydrologic Engineering*.

Kasperson, J.X., Kasperson, R.E., (2001). International workshop on vulnerability and global environmental change. SEI Risk and Vulnerability Programme Report 2001-01, *Stockholm Environment Institute*, Stockholm, Sweden.

Kumar, R. and Sampson, M. A. (1982). Review of stem borer research in Ghana. *Insect Science Application Volume 3 No 2 page 3.*

L. Sarina & D. Bhupendra, (2009). Vulnerability of Mountain Communities to Climate Change and Adaptation Strategies. The Journal of Agriculture and Environment.

Lafitte, H. R. (2000). Tropical maize physiology. In: Paliwal,R.L Granados.G.H.R Lafitte,.A.D Vlollc. (eds).Tropical Maize :Improvement and Production. *Food and Agriculture Organization of the United Nations* Rome.

Lambrou, Y., & Piana, G. (2006). Gender: The missing component of the response to climate change: *Food and Agriculture Organization of the United Nations* (FAO) Rome.

Lavell, A., Oppenheimer, M., Diop, C., Hess, J., Lempert, R., Li, J., Muir-Wood, R. & Myeong, S. (2012). Climate change: new dimensions in disaster risk, exposure, vulnerability, and resilience. In C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor & P.M. Midgleyeds. Managing the risks of extreme events and disasters to advance climate change adaptation, pp. 25–64. *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*. Cambridge, UK, and New York, USA, Cambridge University Press.

Liane, F (2007). Adoption of Water Conservation and Intensification Technologies in the Lowland Rice Production Systems of Northern Ghana. *Selected Paper prepared for presentation at the MEIDE conference*, Maastricht, Netherlands, May 30- June1, 2007.

Lipton M (2006) Can small farmers survive, prosper, or be the key channel to cut mass poverty? *Electronic Journal of Agricultural and Development Economics 3(1): 58-85*

Liverman, D.M., (1990). Vulnerability to global environmental change. In: Kasperson, R.E., Dow, K., Golding, D., Kasperson, J.X. (Eds.), Understanding Global Environmental Change: *The Contributions of Risk Analysis and Management. Clark University, Worcester, MA, pp. 27–44 (Chapter 26).*

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.

Mann, C.K., (1978). Packages of Practices: A step at a Time of Clusters, *studies in development.*

Marshall, N.A, Marshall, P.A., Tamelander, J., Obura, D.O., Mallaret-King, D. & Cinner, J.E. (2010). A Framework for Social Adaptation to Climate Change: *sustaining coastal communities and industries, p.36. Gland, Switzerland, IUCN*.

Manso, P. P.Osei-Yeboah, S. Apau, A. O. Mensah- Ansah,A. Haag, W.and Dzah, B. D. (1997). Development and release of three quality protein hybrid varieties. Dadaba, Mamaba and CIDA-ba in Ghana. Kumasi: *Crop Research Institute*.

McCarthy, J. J. (2001). Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change: *Cambridge University Press*.

MiDA. (2009). Investment Opportunity in Ghana; Maize, Soya and Rice. *Millennium Development Authority (MiDA) and United States Millennium Challenge Corporation*.

Ministry of Food and Agriculture, MoFA (2011). 2011 Annual Report. *Policy Planning Monitoring and Evaluation Directorate.* Accra, Ghana. P. 103.

Ministry of Food and Agriculture, MoFA (2011). Agriculture in Ghana: Facts and Figures (2010). *Accra, Ghana. P. 53.*

Morris ML, Tripp R, AA Dankyi (1999*). Adoption and Impacts of Improved Maize Production Technology:* A Case Study of the Ghana Grains Development Project. Economics Program Paper 99-01. Mexico, D.F.*: CIMMYT*.

Moser, S. C., & Ekstrom, J. A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences*.

Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to environmental change: contributions of a resilience framework. *Annual review of Environment and Resources*.

Nhemachena, C., & Hassan, R. (2007). Micro-level analysis of farmers adaption to climate change in Southern Africa. *International Food Policy Research Institute.*

Novignon J., Mussa, R., & Chiwaula, L. (2012). Health and Vulnerability to Poverty in Ghana: Evidence from the Ghana living standards survey round 5, *Health Economics Review 2: 11*. Available online http://www.healtheconomicsreview.com/content/2/1/11.

O'Brien, K. and Vogel C., Eds. 2003. Coping with Climate Variability: The Use of Seasonal Climate Forecasts in Southern Africa. *Ashgate Publishing,* Aldershot.

Owusu, K., Waylen, P., & Qiu, Y. (2008). Changing rainfall inputs in the Volta basin: implications for water sharing in Ghana. *GeoJournal*.

Pandey, S., N. Khiem, H. Waibel and T. Thien (2006). Upland Rice, Household Food Security and Commercialization of Upland Agriculture in Vietnam. Los Banos, Philippines, *International Rice Research Institute*.

Paudel P., Shrestha A. K. and Matsuoka A. (2009) Socio-economic Factors Influencing Adoption of Fertilizer for Maize Production in Nepal. *The 83rd Annual Conference of the Agricultural Economics Society,* Dublin Japan.

Peterman, A., Quisumbing, A., Behrman, J., & Nkonya, E. (2010). Understanding gender differences in agricultural productivity in Uganda and Nigeria: *Citeseer*.

Pettengell, C. (2010). Climate Change Adaptation: Enabling people living in poverty to adapt. *Oxfam Policy and Practice*: Climate Change and Resilience.

Philip Antwi-Agyei, Andrew J. Dougill & Lindsay C. Stringer (2014): *Barriers to climate change adaptation*: evidence from northeast Ghana in the context of a systematic literature review, *Climate and Development*.

R. Heltberg, P. B. Siegel, and S. L. Jorgensen. (2009). Addressing human vulnerability to climate change: Toward a 'no–regrets' approach. *Global Environmental Change*.

Ravi Shankar K, Nagasree K, Maruthi Sankar GR, Prasad M S, Raju B M K, Subbarao A V M, Venkateswarlu B. (2013). Farmers' Perception and Adaptation Measures Towards Changing Climate in South India and Role of Extension in Adaptation and Mitigation to Changing Climate. *Extension Bulletin No.03/2013. Central Research Institute for Dry land Agriculture, Hyderabad.*

Rogers, E.M (1962). Diffusion of innovation. *New York: free press*.

Rondon, M., & Ashitey, E. (2011). 2011 Grain and Feed Annual Report Ghana. USDA Foreign Agricultural Service. *Global Agricultural Information Network*.

Sathaye, J. A., & Christensen, J. (1998). Mitigation and Adaptation Cost Assessment: Methods and Approach Use. UNEP Collaborating Centre on Energy and Environment, *Riso National Laboratory*, Denmark.

Schipper, L., & Pelling, M. (2006). *Disaster risk, climate change and international development*: scope for, and challenges to, integration. Disasters.

Scholze, M., Knorr, W., Arnell, N. W., & Prentice, I. C. (2006). A climate change risk analysis for world ecosystems. *Proceedings of the National Academy of Sciences*.

Sietz, D., Boschütz, M., & Klein, R.J.T. (2011). *Mainstreaming climate adaptation into development assistance*: Rationale, institutional barriers and opportunities in Mozambique. *Environmental Science & Policy*.

Smit B, Wandel J (2006) Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*.

Stern, Nicholas. 2007. The Economics of Climate Change: *The Stern Review*. *Cambridge and New York: Cambridge University Press.*

Tizale, CY, (2007). The dynamics of soil degradation and incentives for optimal management in the Central Highlands of Ethiopia. PhD thesis, Department of Agricultural Economics, Extension and Rural Development, Faculty of Natural and Agricultural Sciences, *University of Pretoria*.

Timmermann, P., (1981). Vulnerability, resilience and the collapse of society. *Environmental Monograph, vol. 1. Institute for Environmental Studies*, University of Toronto, Toronto, Canada.

Thornton, P.K.; Jones, P.G.; Owiyo, T.M.; Kruska, R.L.; Herrero, M.; Kristjanson, P.; Notenbaert, A.; Bekele, N.; Orindi, V.; Otiende, B.; Ochieng, A.; Bhadwal, S.; Anantram, K.; Nair, S.;

Kumar, V.; Kulkar, U. (2006). Mapping Climate Vulnerability and Poverty in Africa. 200p. *Nairobi (Kenya), ILRI.*

Turner II, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A., (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences of the United States of America.*

Tweneboah, C. K (2000). Modern Agriculture in the Tropics, Food crops. *Co-wood Publishers.*

Twumasi-Afriyie, S. Sallah, P.Y.K. Ahenkora, K. Asiedu, E. Obeng-Antwi, S. Frimpong-Manso, P. P.Osei-Yeboah, S. Apau, A. O. Mensah- Ansah,A. Haag, W.and Dzah, B. D. (1997). *Development and release of three quality protein hybrid varieties. Dadaba, Mamaba and CIDAba in Ghana. Kumasi*: *Crop Research Institute*.

UNEP. (2009). *the defining Challenge of our age*: United Nations climate Change Conference; *United Nations Environment programme*; Copenhagen

UNFCCC. (2001), United Nations Framework Convention on Climate Change: *Text, Geneva, World Meteorological Organization and United Nations Environment Program.*

USAID (2007) Adapting to climate variability and change. *A guidance manual for development planning* http://www.usaid.gov.ourwork/environment/climate/docs.(cited on the 27th January 2010)

Walker, B., Gunderson, L., Kinzig, A., Folke, C., Carpenter, S. & Schultz, L. (2006). A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and Society*.

Walter Reuther, (1967). Anatomy, Physiology, Genetics and Reproduction. *University of California, USA.*

World Bank (2008). Biodiversity, Climate Change and Adaptation. *Nature-Based Solutions from the World Bank Portfolio*. 1818 H Street NW Washington DC, USA.

World Bank, (2010). Economic of Adaptation to Climate Change: *Social Synthesis Report, 1818* H Street NW Washington DC, USA.

Zhu, H., & Zhou, S. (2010). Vulnerability analysis of southern rice to climate change— Taking Jiangxi Province as an example. *Research Agr Modern.*

APPENDICES

APPENDIX I: Household Questionnaire

DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS

UNIVERSITY OF GHANA

This study is being carried out by Mustapha Abubakar Sadiq, an MPhil student of the University of Ghana, Legon on the topic "VULNERABILITY OF SMALLHOLDER MAIZE FARMERS TO CLIMATE VARIABILITY IN THE EASTERN REGION OF GHANA" in partial fulfilment of the award of master of philosophy degree in Agricultural Economics. All information gathered will be treated with much confidentiality and would solely be used for academic purposes. Your participation is completely voluntary and you have the right NOT to participate in this survey at all or stop participation at any point in time during the survey but your support and contribution would be very much appreciated.

For further enquiries, please contact me on sidiqson@rocketmail.com or call on 0546947414.

QUESTIONNAIRE FOR HOUSEHOLD SURVEY

Questionnaire ID:	Date:
Name of enumerator:	Phone Number:
District:	District code:
Community:	Community code:

A. **General Information**
1. Name of Respondent: […………………………………………………………..]
2. Gender: [………] 0=Male 1=Female
3. Age of Respondent: […………………….]

4. Highest level of formal education of respondent: […………..] 0=None 1=Basic (Primary/JHS/Middle) 2=Secondary (Secondary/Vocational), 3 = Post-secondary (Training college/Diploma program) 4 = Tertiary(polytechnic / University)
5. Number of years of education of respondent: [……………..]
6. Marital status of respondent: […………….]
   0=Single 1=Married 2=Divorced/Separated 3=Widowed
7. Years of farming experience of respondent: […………………….]

B. **<u>Household Composition</u>**

7. How many persons are in this household? Total [……] Males […...] Females [……]
8. How many are orphaned (<18 years & have lost 1 or both parents): [……………..]
9. Number of persons with age below 15 years: Total [..…] Males […...] Females [……]
10. Number of persons between ages 15 and 65 years. Total [...] Males [….] Females […]
11. Number of persons with age above 65 years: Total […..] Males […..] Females […...]

C. **<u>Household Income Sources</u>**

12. What is the main occupation of the Head of your Household: [………] 1 = Agriculture 2=Petty trading 3=Craftsmanship 4=Salaried work (formal sector) 5 = other (specify): [……………… ……………………………………………………………….…]
13. How many of your household members are employed? Total [...] Males […] Females […]
14. Are members of your household engaged in any off-farm income generating activities? […...] 1=Yes 0=No, If no, skip to 16.
15. If yes to (14), please provide the details below:

Activity	Males				Females			
	№	Qty	Price	Amount	№	Qty	Price	Amount
Petty trading								
Handicrafts making								
Rice processing								
Oil palm processing								

Pito brewing								
Butchering								
Gathering something from the wild or water body for sale								
Others (Specify):								

D. <u>Assets</u>

16. Which of these assets do your household own? Tick all applicable.
    Radio: [........] T.V: [........] Mobile phone: [.........] Bicycle: [........] Motor bike [……]
    Others (Specify)………………………………………..
17. Do you have access to tractors or animal power? [………] 1=Yes 2=No
18. What material is the floor of your house made of? [ ] 1=Earth 2=Cement
    3=Tiles 4 = Others (Specify)…………………………….
19. What is the material used in building the walls of your house? [ ]
    1=Earth/Mud 2=Wood/bamboo 3=Burned mud bricks 4=Cement/bricks 5=
    Others (Specify)[………………………………………….]
20. What is the roof of your house made of? [ ] 1=Grass/thatch 2=Mud
    3=Iron sheets/asbestos 4=others (Specify):[…………………………………….]
21. How much land does your family have?[ ] acre
22. How many rooms does this household have? [ ]

E. <u>Availability and Access to Infrastructure</u>

23. Do you have a household latrine in your house? 1 = Yes, 0 = No
24. Does any member of your household work outside this community? […..] 1=Yes 0=No

25. Where do you source water for drinking and other household chores? Tick all applicable?
    1. [ ] Pipe borne 2. [ ] Dam 3. [ ] Rain 4 [ ] River lake, stream 5 [ ] Wells 6. [ ] borehole
    7. [ ] other (specify): [……………………………….. ……………………………………]
26. How long (minutes) does it take to get to the water source?
    On foot [.........] / by bicycle [……..]
27. Has water availability been a problem? [………..] 1=Yes 0=No
28. How many buckets (size 34) of water do your household store per day? [……………]
    (Probe)
29. In the past, have you heard about any conflicts over water in this community?
    […..]1=Yes 0=No
30. How long (in minutes) does it take you to reach the nearest health facility? […….]
31. Do any of the household members have a chronic disease? [………] 1=Yes 0=No
32. Has any member of the household been very ill in the past 6 months that he/she had to miss work or school? [………] 1=Yes 0=No
33. How many months in a year is malaria particularly common? [………]
34. Name the months: [………………………………] 1 = Jan, 2 = Feb, ……., 12 = Dec
35. How many mosquito nets do your household own? [……………………]
36. What is the major source of energy for cooking/heating purpose in your house?1= Firewood
    2=Petroleum 3=Alternative (electricity, Solar)
37. What were the ages of family members who died in this house so far that you can remember?
    Member 1: Member2: Member3: Member4:

F. <u>Farm Characteristics</u>

38. What is your current farm size (hectares)? [……………..]
39. Who owns your farm land? [……] 1 = self-own, 2 = husband 3 = husband's family
    4 = my family 5 = Others (Specify): [……………………………………………….……]

40. What crops did you grow last season (2015)?	41. Size of Area cultivated (Hectares)	42. Harvest of this crop per planting season (100kg).	43. % consumed	44. % sold	45. Total value of crops sold (GH₵)
Maize					
Other crops:					

46. Do your family members assist you in your farm? [.....] 1 = Yes,) = No
47. If yes to (46), how many hours do they help you per season? [..........]
48. Do you engage hired labour in your farming activities?
49. If yes to (48), how many hours do you engage them in a season? [.........]
50. Does this household save seeds for cultivation in the next planting season/year? [....] 1=Yes 0=No
51. Does your household have adequate food throughout the year from own production and purchases?[ ] 1=Yes 0=No, If yes, skip to 54.
52. If no to (51), how many months in a year do this household experience food shortage? [..]
53. Name the months: [..................................] 1 = Jan, 2 = Feb, ..., 12 = Dec

G. Network/Relationships

54. Has any member of this household received any assistance from relatives or friends within the past 12 months? (E.g. remittances, care during sickness or medicines, sale of crops or livestock, baby-sitting etc.)? [...........] 1=Yes 0=No. If no, skip to 56.
55. If yes to (54), List the type of assistance received:

    (a) [..] (b) [..]

    (c) [..] (d) [..]

56. Has any member of this household give any assistance to relatives or friends within the past 12 months? (E.g. remittances, care during sickness or medicines, sale of crops or livestock, baby-sitting etc.)? [………..] 1=Yes 0=No.
57. If yes to (56), List the type of assistance given:
    (a) [……………………………………….] (b) [……………………..……………..]
    (c) [………………………………...…..] (d) [……………………………..…………..]
58. Did you borrow any money from relatives/friends in the past 12 months? [………....] 1=Yes 0=No, If no skip to 60.
59. If yes to (58), what did you use the money for? [………………..…]
    1 = Farming, 2 = Health care, 3 = Social activities, 4 = Children school fees,
    5 = Others (Specify): […………………………..…………………………………]
60. Did you borrow any money from formal credit sources in the past 12 months? […] 1=Yes 0=No. If no, skip to 62.
61. If yes to (60), what did you use the money for? [………………..…]
    1 = Farming, 2 = Health care, 3 = Social activities, 4 = Children school fees,
    5 = Others (Specify):[…………………………………………………………………]
62. Did you lend any money to relatives/friends in the past 12 months? […] 1=Yes 0=No
63. In the past 12 months, has any member of your household gone to your community leader for assistance (e.g., Chief, Assemblyman, Member of Parliament etc.)? […] 1=Yes 0=No
64. If yes to (63), specify the type of assistance received?
    [……………………………………………………………………………………..]
65. Are any of your family members affiliated with any NGO in local area? [ ]
    1=Yes 2=No

H. <u>Climate Variability</u>

66. Have you noticed any changes in the weather pattern in the past 10 years? [………] 1=Yes 0=No
67. If yes, what notable changes have been observed (Don't probe)
    (a): [………………………………………………………………………………]

(b): [……………….……………………………………………………..………….]

(c): [………..……………………………………………………………………..]

68. What changes have you observed on the rainfall pattern? [ ]

1=Unpredictable 2=No change 3=Decreased 4=Increased

69. What changes have you observed on the temperature pattern?

1=Unpredictable 2=No change 3=Decreased 4=Increased

70. Has your household suffered from any drought or flood since 2005? [……….]

1=Yes 0=No. If no skip to 76.

71. Did you receive any warning about the flood or drought before it occurred? [………]

1=Yes 0=No

72. Did any member of your household sustain any injury or lost the life as a result of the flood or drought? [……………] 1=Yes 0=No

73. If yes to (72), what number of persons was injured: […..] / lost their lives: […….]

74. Did you lose any crops as a result of the flood or drought? [……….] 1=Yes 0=No

75. How much did you lose? [ ]/50kg bag

76. Was there any loss in the value of your crops as a result of the flood or drought? [……]

1=Yes 0=No

77. Are you adopting strategies to adapt to the situation? [ ] 1=Yes 0=No

78. If yes, what adaptation strategy are you adopting?

Indigenous strategies adopted	Rank	Research-based strategies adopted	Rank
Crop Related Strategies		Improved variety Strategies	
Soil Related Strategies		Soil and Plant Health related strategies	
Cultural Practices Related Strategies		Recommended Agricultural Practices Strategies	
Other related strategies		Other Related Strategies	

Rank 1 as most effective

79. What constraints are you faced with in attempt to adopt an adaptation strategy?

Indigenous Adaptation Strategies			**Research-based Adaptation Strategies**		
S/№	Constraint	Rank	S/№	Constraint	Rank
1.			1.		
2.			2.		
3.			3.		
4.			4.		
5.			5.		
6.			6.		
7.			7.		

Rank: 1 = Most pressing constraint

I. Access to Agricultural Extension Services

80. Have you received any extension services from other farmers in the past 12 months? [....]
    1=Yes 0=No
81. If yes to (80), how many times? [………………..]

82. What are these extension services? Tick all applicable:

1 Establishment of demonstration farms [ ], 2 Organization of field days [ ],

3 Awareness creation [ ] 4. Facilitates access to inputs [ ], 5 Facilitates access to credit [ ],

6. Advice on crop management [ ] 7. Introduced new varieties [ ]

8. Others (Specify) [ ]: [..]

83. Have you received any formal agricultural extension services in the past 12 months?

[……..] 1=Yes 0=No

84. If yes to (83), how many times? [……………….]

85. What are these extension services? Tick all applicable:

1 Establishment of demonstration farms [ ], 2 Organisation of field days [ ],

3 Awareness creation [ ] 4. Facilitates access to inputs [ ], 5 Facilitates access to credit [ ], 6. Advice on crop management [ ] 7. Introduced new varieties [ ]

8. Others (Specify): [..]

86. Are you a member of any social group? 1 = Yes, 0 = No.

87. Are you consulted in decision making of the house or community? 1 = Yes, 0 = No

88. Any other information/comment

[……………………………………………………………...………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
…………………………………………………...…………………………………...]

Thank you for cooperating

End of discussion

APPENDIX II: Calculation of the food component of the LVI for Yilo Krobo Municipality

Sub-components	Value for sub-components	Max. value for the study population	Min. value for the study population	LVI for sub-components	LVI food component
Percentage of households who struggle to find food (F_1)	0.08	100.00	0.00	0.000	**0.202**
Percentage of households using only forest-based energy for cooking purposes (F_2)	97.33	100.00	0.00	0.973	
Average Crop Diversity Index (F_3)	65.33	100.00	0.00	0.012	
Percentage of households that do not save crops (F_4)	0.00	100.00	0.00	0.000	
Percentage of households that do not save seeds (F_5)	0.00	100.00	0.00	0.027	

STEPS

1. $F_1 = \frac{S_d - S_{min}}{S_{max} - S_{min}}$

$= \frac{0.08-0}{100-0} = 0.0008$

Repeat for all sub-component indicators

2. $M_d = \frac{\sum_{i=1}^{n} index_{s_{di}}}{n}$

$F = (F_1 + F_2 + F_3 + F_4 + F_5) / 5$

$F = (0.000 + 0.973 + 0.012 + 0.000 + 0.027) / 5$

$= 0.202$

APPENDIX III: Components of LVI

Major Components	Sub-components	Explanation of the Components and Measurement
SOCIO-DEMOGRAPHIC PROFILE	Percentage of female-headed households	Percentage of female-headed households. If a male head is away from home > 3 months per year, the female is counted as the head of the household
	Percentage of households where head of the household had not attended school	Percentage of households where the head of the household reported that they had not attended school
	Dependency level	Percentage of population below 15 and over 65 years of age
	Percent of households with orphans	Percentage of households that have at least 1 orphan living in their home.
LIVELIHOOD STRATEGIES	Percentage of households with family members working outside the community	Percentage of households that reported at least one family member who worked outside the community to earn a wage
	Percentage of households solely dependent on agriculture as source of income	Percentage of households that reported only agriculture as their source of income
	Average number of households who have burden of loan	Percentage of households who took a loan in the past 12 months
HEALTH	Percentage of households with family member suffering from chronic illness	Percentage of households that reported at least one member of their family suffering from chronic illness
	Average time to health facility(minutes)	Average time it takes the households to get to the nearest health facility.
	Average number of households receiving proper facilities for child delivery and immunisation	Percentage of households receiving proper facilities for child delivery and immunisation

Major Components	**Sub-components**	**Explanation of the Components and Measurement**
	Households that do not have toilet facilities	Percentage of households who do not have toilet facilities
	Average Malaria Exposure*Prevention Index (range:0–12)	Months reported exposure to malaria*Owning at least one bed net indicator (have bed net = 0.5 ,no bed net =1) (e.g., Respondent reported malaria is a problem from January–March and they do not own a bed net=3*1=3).
SOCIAL NETWORK	Average Receive : Give ratio (range:0–15)	Ratio of (the number of types of help received by a household in the past one year) to (the number of types of help given by a household to someone else in the past one year).
	Average Borrow : Lend Money ratio (range:0.5–2)	Ratio of a household borrowing money in the past 12 months to a household lending money in the past month, e.g., If a household borrowed money but did not lend money, the ratio = 2:1or2 and if they lent money but did not borrow any, the ratio = 1:2 or 0.5.
	Percentage of households that did not apply to their local government for assistance in the past 12 months	Percentage of households that reported they did not receive any assistance from their local government in the past 12 months
FOOD	Average number of households who struggle to find food	Percentage of households who struggle to obtain food for their family
	Percentage of households using only forest-based energy for cooking purposes	Percentage of households using only forest-based energy for cooking purposes
	Average Crop Diversity Index	Percentage of households who grow 1 additional crop
	Percentage of households that do not save crops	Percentage of households that do not save crops

Major Components	**Sub-components**	**Explanation of the Components and Measurement**
	Percentage of households that do not save seeds	Percentage of households that do not save seeds
WATER	Percentage of households reported conflicts over water	Percentage of households who heard about water conflicts in their community
	Percentage of households that utilise natural water source	Percentage of households who reported that they collected water from well, river, lake as their primary water source
	Percentage of households that do not have consistent water supply	Percentage of households that reported they cannot avail constant supply of water
	Average time to water source (minutes)	Average time it takes the households to travel to their primary water source.
	Inverse of the average number of liters of water stored per household(range: >0–1)	The inverse of (the average number of liters of water stored by each household +1).
NATURAL DISASTERS AND CLIMATE VARIABILITY	Percentage of household that reported the occurrence of floods and droughts in the past 10 years	Percentage of household that reported the occurrence of floods and droughts in the past 10 years
	Percentage of household members with an injury or death as a result of the most severe natural disaster in the past 10 years	Percentage of households that reported that their household members suffered from injury or death
	Percent of households that did not receive a warning about the pending natural disasters	Percentage of households that did not receive a warning about the most severe flood and drought event in the past 10 years.

Major Components	Sub-components	Explanation of the Components and Measurement
	Mean standard deviation of the daily average maximum temperature by month	Standard deviation of the average daily maximum temperature by month between 2006 and 2015 was averaged for each province
	Mean standard deviation of the daily average minimum temperature by month	Standard deviation of the average daily minimum temperature by month between 2006 and 2015 was averaged for each province
	Mean standard deviation of the daily average rainfall by month	Standard deviation of the average daily rainfall by month between 2006 and 2015 was averaged for each province

APPENDIX IV: Sub-Components LVI, Minimum and Maximum Values for Both Districts

MAJOR COMPONENTS	SUB-COMPONENTS	YILO (LVI)	AYENSUANO (LVI)	Minimum (Both districts)	Maximum (Both districts)
SOCIO-DEMOGRAPHIC PROFILE	Percentage of female-headed households	0.147	0.387	0.00	100.00
	Percentage of households where head of the household had not attended school	0.013	0.067	0.00	100.00
	Dependency level	0.946	0.822	0.00	20.00
	Percent of households with orphans	0.200	0.173	0.00	100.00
LIVELIHOOD STRATEGIES	Percentage of households with family members working outside the community	0.533	0.480	0.00	100.00
	Percentage of households solely dependent on agriculture as source of income	0.413	0.627	0.00	100.00
	Average number of households who have burden of loan	0.293	0.400	0.00	100.00
HEALTH	Percentage of households with family member suffering from chronic illness	0.107	0.187	0.00	100.00
	Average time to health facility(minutes)	0.296	0.353	5.00	170.00
	Per cent of households that do not have toilet facilities	0.267	0.307	0.00	100.00
	Average Malaria Exposure*Prevention Index (range:0–12)	0.167	0.163	0.00	12.00

Source: Field Survey, 2016.

SOCIAL NETWORK	Average Receive : Give ratio (range:0–15)	0.120	0.160	0.00	15.00
	Average Borrow : Lend Money ratio (range:0.5–2)	0.040	0.133	0.50	2.00
	Percentage of households that did not apply to their local government for assistance in the past 12 months	1.000	1.000	0.00	100.00
FOOD	Percentage of households who struggle to find food	0.000	0.067	0.00	100.00
	Percentage of households using only forest-based energy for cooking purposes	0.973	0.973	0.00	100.00
	Average Crop Diversity Index	0.012	0.014	0.00	100.00
	Percentage of households that do not save crops	0.000	0.013	0.00	100.00
	Percentage of households that do not save seeds	0.027	0.067	0.00	100.00
WATER	Percentage of households reported conflicts over water	0.320	0.240	0.00	100.00
	Percentage of households that utilize natural water source	1.000	0.973	0.00	100.00
	Percentage of households that do not have consistent water supply	0.893	0.573	0.00	100.00
	Average time to water source (minutes)	0.379	0.219	2.00	60.00
	Inverse of the average number of liters of water	0.003	0.004	0.00	1.00

	stored per household(range: 0–1)				
NATURAL DISASTERS AND CLIMATE VARIABILITY	Percentage of household that reported the occurrence of floods and droughts in the past 10 years	0.253	0.773	0.00	100.00
	Percentage of household members with an injury or death as a result of the most severe natural disaster in the past 10 years	0.000	0.067	0.00	100.00
	Percent of households that did not receive a warning about the pending natural disasters	0.947	0.813	0.00	100.00
	Mean standard deviation of the daily average maximum temperature by month	0.684	0.663	0.66	0.68
	Mean standard deviation of the daily average minimum temperature by month	0.312	0.345	0.31	0.34
	Mean standard deviation of the daily average rainfall by month	0.557	0.504	0.50	0.56

APPENDIX V: Statistical Tests

A. Contingency coefficient test for co-linearity between independent variables used for objective 2 (Pooled sample)

	AGE	GENDER	F.Labour	Farmsize	F.Exp.	Credit	F.Ext.	Temp.Per	H.Labour	Marital
AGE	1.000									
GENDER	0.023	1.000								
F.Labour	0.301	-0.253	1.000							
Farmsize	0.374	-0.008	0.267	1.000						
F.Exp.	0.693	0.039	0.290	0.468	1.000					
Credit	0.027	0.228	-0.109	0.049	0.095	1.000				
F.Ext.	-0.036	-0.288	0.144	-0.244	-0.214	-0.109	1.000			
Temp.Per	-0.042	0.125	-0.218	-0.025	0.050	0.122	-0.138	1.000		
H.Labour	0.061	0.076	-0.210	-0.105	0.048	0.058	-0.104	0.161	1.000	
Marital	-0.087	-0.436	0.346	0.161	0.033	-0.026	0.140	-0.171	-0.224	1.000

Source: Field Survey, 2016

B. Contingency coefficient test for co-linearity between independent variables used for objective 2 (Yilo Krobo Municipality)

	AGE	GENDER	F.Labour	Farmsize	F.Exp.	Credit	F.Ext.	Temp.Per	H.Labour	Marital
AGE	1.000									
GENDER	0.142	1.000								
F.Labour	0.367	-0.193	1.000							
Farmsize	0.528	-0.103	0.361	1.000						
F.Exp.	0.580	0.024	0.445	0.583	1.000					
Credit	-0.081	0.064	-0.157	0.109	-0.113	1.000				
F.Ext.	-0.133	-0.237	0.048	-0.207	-0.102	-0.108	1.000			
Temp.Per	-0.094	0.090	-0.182	0.064	-0.080	0.218	-0.109	1.000		
H.Labour	-0.025	0.146	0.020	0.124	0.110	0.129	-0.119	0.314	1.000	
Marital	0.058	-0.539	0.333	0.136	0.235	0.042	0.382	-0.200	0.014	1.000

C. Contingency coefficient test for co-linearity between independent variables used for objective 2 (Ayensuano district)

	AGE	GENDER	F.Labour	Farmsize	F.Exp.	Credit	F.Ext.	np.Percept	H.Labour	Marital
AGE	1.000									
GENDER	-0.089	1.000								
F.Labour	0.274	-0.252	1.000							
Farmsize	0.310	-0.091	0.355	1.000						
F.Exp.	0.785	-0.071	0.272	0.373	1.000					
Credit	0.063	0.273	-0.091	0.016	0.151	1.000				
F.Ext.	0.113	-0.068	0.012	-0.015	-0.004	-0.091	1.000			
np.Percept	-0.009	0.073	-0.221	-0.239	0.112	0.087	0.119	1.000		
H.Labour	0.072	-0.005	-0.305	-0.219	-0.030	0.037	0.109	0.110	1.000	
Marital	-0.194	-0.372	0.357	0.221	-0.077	-0.048	0.016	-0.124	-0.303	1.000

Source: Field Survey, 2016

D. Pearson's correlation table for objective 4

VARIABLES	AGE	GENDER	RAINFALL PERCEPTION	ACCESS TO CREDIT	FARMING EXPERIENCE	FARM SIZE
AGE	1.000					
GENDER	-0.005	1.000				
RAINFALL PERCEPTION	-0.001	0.115	1.000			
ACCESS TO CREDIT	-0.071	0.234	0.175	1.000		
FARMING EXPERIENCE	0.679	0.016	0.011	-0.055	1.000	
FARM SIZE	0.389	-0.079	-0.026	-0.061	0.450	1.000

Source: Field Survey, 2016

APPENDIX VI: Hausman Test for IIA

Choices	Chi-square	P-value
1	1.795	0.877
2	0.434	0.980
3	0.677	0.982

Chi-square>0, therefore IIA assumption is not violated.

Appendix VII: Turnitin Originality Report

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