UNIVERSITY FOR DEVELOPMENT STUDIES

EFFECTS OF CLIMATE CHANGE COPING AND ADAPTATION STRATEGIES ON FOOD SECURITY AMONG SMALLHOLDER MAIZE FARMERS IN THE TOLON DISTRICT AND SAVELUGU MUNICIPAL

AHMED ABDUL-RAHMAN

2018

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BY

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UDS/MIC/0033/12

A DISSERTATION SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL EXTENSION, RURAL DEVELOPMENT AND GENDER, FACULTY OF AGRIBUSINESS AND COMMUNICATION SCIENCE, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY IN INNOVATION COMMUNICATION

FEBRUARY, 2018

DECLARATION

Student

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Signature: …………………………… Date: …………….................

Name: **Ahmed Abdul-Rahman**

Supervisor

I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

Supervisor's Signature: …………………………..... Date: ………………………….

Name: **Dr. Francis K. Obeng**

ABSTRACT

The study assessed the effects of climate change coping and adaptation strategies on food security among smallholder farmers in the Northern Region of Ghana. Purposive and simple random sampling was used to select a total of 240 maize farmers from 8 randomly selected communities in Savelugu/Nanton municipal and Tolon district. The analytical methods used included descriptive analysis and the Kendall's coefficient of concordance. The results revealed that smallholder maize farmers were fully aware of the level of climate change in their various localities as this was seen in the mean of means value of 1.97, (approximately 2.0) with an SD = 0.76, which corresponds to the "Agree" response category on the likert scale. The results from the study also revealed among other that; farmers now practice mixed cropping, farmers now use fertilizers and pesticide, farmers now change their planting date, farmers resort to planting leguminous trees on farms, farmers have resorted to planting cash crops and also migrate to urban area in search of greener pastures. Also, some coping strategies that were adopted by smallholder farmers to respond to the effects of climate change are; reduction in the number of times they eat in a day, engagement in daily work for cash, engagement in micro-enterprise activities, reduction of household expenditure, sale of household assets, migrating to urban areas to seek for jobs and receiving remittances from family and friends to meet the household needs. The results further indicate that, generally respondents agree to some extent that climate change has had a negative effect on food security among smallholder maize farmers. The challenges farmers face in trying to cope and adapt to the effects of climate change are; lack of credit, inadequate subsidies, lack of support from government and the private sector among others. The research showed that the effects of climate change on food security is worsening with time, therefore it is recommended that Government, Non-Governmental Organisatios (N.G.O's) and all stakeholders in the agriculture sector should come out with pragmatic measures so as to mitigate the effects of climate change/variability on food security among the smallholder farmers.

ACKNOWLEDGMENTS

I would like to first and foremost express my greatest thanks to the Almighty Allah Who in the course this work granted me life and good health.

My sincere appreciation goes to my supervisor Dr. Francis Obeng for his constructive comments, guidance, encouragement and timeless dedication to my work. I really appreciate the opportunity you gave me to be successful in life.

I wish to thank Ahaji Nasam Shani for his support towards this research. I also wish to express my heartfelt gratitude to Mr. Kamal, Mr. Arror and all the lecturers in the department for their constructive comments and guidance toward this work

I will again like to thank Mr Sukarazu of Zion, the staff of MOFA, ACDEP, Savelugu/Nanton municipal and Tolon district for their support in obtaining secondary data for this work.

DEDICATION

I dedicate this piece of work to my loving mother Rakia Abdulai, my wife Mariam Sumani, my children Nusrat Nasara and Faaiz Kasuli, as well as all my relatives and friends.

TABLE OF CONTENTS

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATION

ACDEP	Association of Churches Development Projects
CEEPA	Centre for Environmental Economics and Policy forAfrica
FANTA	Food and Nutrition Technical Assistance Project
FAO	Food and Agricultural Organization
FASDEP	Food and Agricultural Sector Development Policy
FGDs	Focus Group Discussions
GDP	Gross Domestic Product
GES	Ghana Education Service
GoG	Government of Ghana
GSS	Ghana Statistical Service
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
ISD	Information Services Department
MEST	Ministry of Environment, Science and Technology
MoFA	Ministry of Food and Agriculture
NDMC	National Drought Mitigation Centre
NDPC	National Development Planning Commission
NGO	Non-Governmental Organization
PARED	Partners in Rural Empowerment and Development
SMEs	Small and Medium Enterprises

SPSS	Statistical Package for Social Sciences
SRID	Statistical Research and Information Department
SWC	Soil and Water Conservation
UDS	University for Development Studies
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
USAID	United States Agency for International Development.
VC	Value Chain
WG	Working Group
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Agriculture has been the main contributor to the Gross Domestic Products (GDP) of most countries in Sub-Saharan Africa (SSA). According to Moss etal (2010), majority of Africa's population is employed in the agricultural sector.In Ghana, the agricultural sector contributes significantly to the economy with estimates as high as 23.0 percent of GDP in 2012 and 22.0 in 2013. The estimates also showed an improvement in the growth of the agriculture sector, 5.2 percent in 2013, compared to 2.3 percent in 2012 (GSS, 2014). The agricultural sector is characterized by large numbers of smallholder farmers, most of whom produce under unfavorable climatic conditions, that is, low and eratic rainfall patterns, poor soils and limited labour availability. Scientific evidence gathered over the last couple of decades suggests that global climatic conditions are changing rapidly and this trend is likely to continue and even accelerate (IPCC 2007, Moss et al. 2010).

Evidence has also shown that, global climate change can be blamed largely on anthropogenic greenhouse gases (Morton et al, 2007). The unimpeded growth of greenhouse gas emissions continues to raise the earth's temperature. This has far-reaching consequences for agricultural production, thus posing additional challenges to meeting food security for the growing world population (Lobell et al., 2009).

In order to better prepare farmers for extreme weather events caused by climate change and to collaboratively learn about the evolution of weather patterns, efforts to focus on the smallholder farmers and their current activities, knowledge and perceptions are imminent (Di falco et al.2011, Jackson et al., 2007). The discussion on knowledge of potential adaptation strategies needs to be guided by empirical data on local and regional farmers' circumstances, and that of the potential agricultural systems used for food production. Currently, models used in these predictions are at a global scale and these need to be downscaled to accommodate realities at regional and local levels. The work of Thomton et al.(2009) in East Africa showed that there is a correlation between variability of crop yields and the ability of a smallholder to adapt to climate change hence the need to make these analyses at smallholder and local community levels. This study has taken the smallholder approach as an entry point in understanding the options available for farmers to cope and adapt to climate extremes.

Low crop yields being experienced on many smallholder farms in SSA can be attributed to poor agronomic practices, low utilization of improved gemplasm, limited use of soil fertility inputs, droughts, floods and land degradation (IPCC, 2007). Unlike large scale commercial farmers, smallholder farmers' capacity to cope with and adapt to climate change can be weakened by resource constraints leading to poor infrastructure at farm level, as well as their lack of advanced knowledge on crop management. However, the smallholder farmers are often endowed with indigenous knowledge and farming experience which may influence their choice of the adaptation strategies to climate change. Indigenous knowledge can be viewed as a base for developing innovative technologies and building improved knowledge systems (O'Farrella, 2009). Farmers have, in some instances, used methods that though not tested or documented, are suitable for managing the effects of unfavorable weather patterns. The climate change-related challenges that farmers face now and in future can be overcome through improved knowledge systems that encompass some aspects of indigenous knowledge. In mixed cropping systems, moderate yield losses can be offset by improved cultivars and agronomic practices while major losses may need crop type changes or opting for livestock production instead (Thomton et al., 2009).

As countries in SSA strive to achieve the United Nations' Millennium Development Goalsby 2015, including the reduction of extreme poverty and hunger (MDG1) and achieving environmental sustainability (MDG7), it is important to understand how climate change can derail the achievement of the MDGs, particularly in the developing countries (United Nations, 2013).

The climate of Ghana is tropical but temperatures vary with seasons and elevations. The climate is characterized by low and highly erratic or variable rainfall, limiting crop yield (Graef and Haigis, 2001). Moss et al., (2010) indicate that future climate projections in semi- arid tropics will become drier with increased temperatures and increased frequency of droughts.

The current climate situation in most part of the Northern Region already shows symptoms of climate change impact and effects, which can be best described as erratic, unreliable and insufficient rainfall with only one rainy season.

According to MoFA (2011), most part of the rainy season in the Northern Region is punctuated by mid-season droughts which affects crops yield resulting in poor harvests.

The economy of the region and the rest of Ghana is agriculture based, mostly depending on rain-fed agriculture and every economic activity revolves around a successful rainfall season.

Apart from rainfall, the capacity to adapt and cope with the negative impacts and effects of climate change due to low income, inadequate technologies, low resource-base, poor infrastructure and weak institutions are major issues among smallholder farmers.

The problem is further compounded by lack of coping and adaptive strategies, unclear policies, weak legislation and absence of service providers in the Northern Region.

This situation has already led many farmers into poverty and food insecurity and therefore many more smallholder farmers are likely to be vulnerable to the negative impacts and effects of climate change. The study thus sought to assess the effects of climate change coping and adaptation strategies on food security among smallholder maize farmers in the Northern Region.

Many believe that agriculture is the most susceptible sector to climate change. This is attributed tothe fact that,two most important elements of climate change (precipitation and temperature) which contribute significantly to climate change affect agriculture directly (Deschenes and Greenstone 2006). Climate change also indirectly affects agriculture by influencing emergence and distribution of crop pests andlivestock diseases, exacerbating the frequency and distribution of adverse weather conditions, reducing water supplies and irrigation; and enhancing severity of soil erosion (Watson et al. 1997; IPCC 2001).

A progressive change in the environmental conditions negatively affects the agricultural sector especially in the Northern parts of Ghana. According to the Ghana Environmental Protection Agency (EPA), the Sahara Desert advances southwards by an estimated 0.8 kilometers every year, with major consequences for the population (Dokurugu, 2010).

The rainy season now begins later in the year and the variability of the pattern of rainfall has been increasing steadily, with prolonged drought periods occurring even during the rainy season. This means that, farmers are expose to a higher risk of crop failure, a reduction in crop yields and the loss of livestock due to shortage of water without having any access to adequate insurance schemes (Dietz et al, 2004, Assan et al, 2009).

Moreover, higher concentrations in rainfall have increased the frequency and severity of floods in Northern Ghana over the last two decades. Between August and September 2007, and again in 2009, heavy rainfall led to major flooding, which killed at least 20 people, destroyed key infrastructure, livestock and crops and displaced an estimated 400,000 people (Armah et al, 2010).

1.2 Problem Statement

The agricultural sector is the backbone of Ghana's economy, and smallholder farmers constitute about 80 percent of the total agricultural producers in the country (MOFA, 2011).

Despite the important role the sector plays in the livelihood of the people and in the country's economic development, a lot of these smallholder farmers seem to be living below the poverty line (Bird and Shepherd, 2003). The Intergovernmental Panel for Climate Change (IPCC, 2007) states that, existing patterns of failure in achieving the MDGs correlates with areas where high climate vulnerabilities are expected (Yohe et al.,2007).

It has become critical to understand the effects of coping and adaptation strategies to climate change on food security of smallholder farmers. This is because the survival of the country depends on its agricultural sector. It has already been estimated that, high temperatures in Ghana will result in low yield of cereals such as maize and millets throughout the country especially in the North (Lobell et al., 2009).

In Ghana, dependence on rain-fed agriculture and erratic rainfall patterns have left the smallholder farmers and their households vulnerable to food insecurity. For decades, the farmers who contribute the most to food production in Ghana have run the risk of crop failure due to the effects and impact of climate change.Researchon climate change has been carried out in Ghana, much of which concentrates on the impacts and effects of climate change at the country or the global level. Little is done at the individual smallholder farmer level. The IPCC (2001) raises this concern and points to the fact that climate change research has largely focused on predicting impacts or effects on agriculture and other economic activities, with very little efforts being directed at examining the effects of climate change coping and adaptation strategies on food security among smallholder farmers.The need to assess the effects of climate change coping and adaptation strategies on food security among smallholder farmers stems from, the fact that the major source of livelihood of most smallholder farmers is agriculture. Hence, there is the need to examine the effects of climate change coping and adaptation strategies on food security among smallholder maize farmers. This will enhance the identification of problems regarding the effects of climate change and the development of better technologies to enable communities reduce vulnerabilities in order to mitigate the negative impacts and effects of climate change.

1.3 Research Questions

The main research question is: what are the effects of climate change coping and adaptation strategies on food security among smallholder maize farmers in Savelugu-Nanton Municipal and Tolon District?

1.3.1 Specific Research Questions

This main research question is further guided by the following specific questions:

1. What is the perceived level of climate change among smallholder maize farmers in the Tolon District and Savelugu Municipal?

2. What are the coping and adaptation strategies of climate change among smallholder maize farmersin the Tolon District and Savelugu Municipal?
3. What are the effects of the coping and adaptation strategies on food security among smallholder farmers?
4. What challenges do farmers face in coping and adapting to the effects of climate change?

1.4 Main Research Objectives

The main research objective of this study was to examine the effects of climate change coping and adaptation strategies on food security among smallholder maize farmers in the Savelugu-Nanton and Tolon District of the Northern Region.

1.4.1 Specific Objectives

The specific objectives of the study were as follows:

1. To determine the perceived level of climate change among smallholder maize farmers in the Northern Region.
2. To identify the coping and adaptation strategies of climate change among smallholder maize farmers in the Northern Region.
3. To determine the effects of the coping and adaptation strategies on food security among smallholder maize farmers.
4. To identify the challenges farmers face in coping and adapting to the effects of climate change.

1.5 Justification of the Study

Climate change has become a very keen area of interest globally where every continent and every nation is researching into trends and threats of climate change. Also, forecast on climate change have resulted in global projections that do not guarantee that the situations is getting better anytime soon but may get worsen if measures are not taken globally to stabilize or prevent it. Throughout the world, there is significant concern about the effects of climate change and climate variability on agricultural production (IPCC, 2007).

Agriculture is Ghana's most important economic sector employing more than half of the population on a formal and informal basis (56 percent) and accounting for almost half the Gross Domestic Products (GDP) and export earnings is 28.3 percent (MOFA, 2011). Ghana produces a variety of crops in various climatic zones which ranges from dry savanna to wet forest. These zones are vulnerable to climate change.

Smallholder farmers contribute about 80 percent of food production in Ghana. They are faced with challenges of high temperatures and erratic rainfall throughout the year. This affects their yields and for that matter income stability and food security.

Research shows that, there is a change in climate conditions every year for crops such as maize, millet, rice, groundnuts, guinea corn in semi-arid areas (Lobell et al., 2009), which the Northern Region is not an exception. This has negative implication on food production, food security and economic development in achieving the Millennium Development Goal (MDGs).

The majority of the farmers in Northern Ghana are smallholder farmers who depend on rain-fed agriculture. Most of these farmers reside in marginal agro-ecological areas where rainfall is low and unpredictable with lack of technology such as irrigation to curb these climatic effects. Some of these smallholder farmers are poor and many more are likely to be vulnerable to poverty and food insecurity due to the effects and impact of climate change.

Hence, efforts must be geared towards the local and institutional coping and adaptation strategies to climate change by looking at climate change and how it is linked to food insecurity among smallholder farmers in the Northern Region.

1.6 Significance of the Study

Examining the effects of climate change coping and adaptation strategies on food security among smallholder farmers in the study area will enlighten both smallholder farmers and policy makers to devise strategies that will enable them to cope and adapt to long term effects of climate change.

The study contributes to the research efforts on climate change through investigating the vulnerability of smallholder farmers in Northern Region in particular Ghana as a whole.

This also provides information on the effects of climate change on agricultural production and this will serve as indicator for policy makers to come out with appropriate local and institutional coping and adaptation strategies to climate change, so as to mitigate the effects and impact of climate change.

Also, understanding the challenges farmers face in coping and adapting to climate change can also provide insight into the formulation of policies to enhance the use of coping and adaptation measures among smallholder farmers and agriculture as a whole.

1.7 Limitation of the Study

The Savelugu municipal and the Tolon district are divided into 8 agricultural zones with serious extension services covering 22 communities. The study intended to cover two communities each from all the zones but due to financial and time constraints, the study was able to cover one community from each of the zones.

Also, the study relied on smallholder farmers' recall of climate and weather changes. This is a potential limitation in the study as it could be very difficult for most farmers to remember past events. To address this limitation the researcher probed more during the administration of the questionnaire so as to enable farmers to recall previous climate events.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

Climate change is now generally accepted to be a major global problem. With reference to smallholder farmers, questions that arise are; what do smallholder farmers understand about climate change, how will climate change affect their yield, livelihoods and how are they able to cope and adapt to the negative effects and impacts of climate change? To answer these questions this chapter reviews literature on the coping and adaptation strategies of climate change among smallholder farmers.

It begins by looking at global climate change in general and its impacts on the ecosystem and socio-economic system. Literature on climate change impacts on smallholder farmers in developing countries including Ghana is also reviewed. Lastly the chapter looks at vulnerability, how it is conceptualized in this study and how it is measured for smallholder farmers in Northern of Ghana.

2.2. Global climate change

Historically the earth's climate has always had cyclical trends and variations through the centuries, although with constant averages (IPCC 2001). Current climatic trends show a deviation from historic trends. The rate of change and the cause of change have been of concern to scientists all over the world. Temperature records collected for over a period of 100 years shows that, the Earth's surface temperature has risen by more than 0.7 degrees Celsius since the 1800s (IPCC 2007). Historical temperature data from Figure 1 shows deviation of global atmospheric temperature measures from the global average temperature, from 1850 to 2008 and the gradual increase in the temperature. The temperature anomaly refers to the difference from an average and this measure gives a more accurate picture of temperature change. The graph also shows that over the past three decades, the global air temperatures anomaly has since increased, thus showing a general warming of the atmosphere.

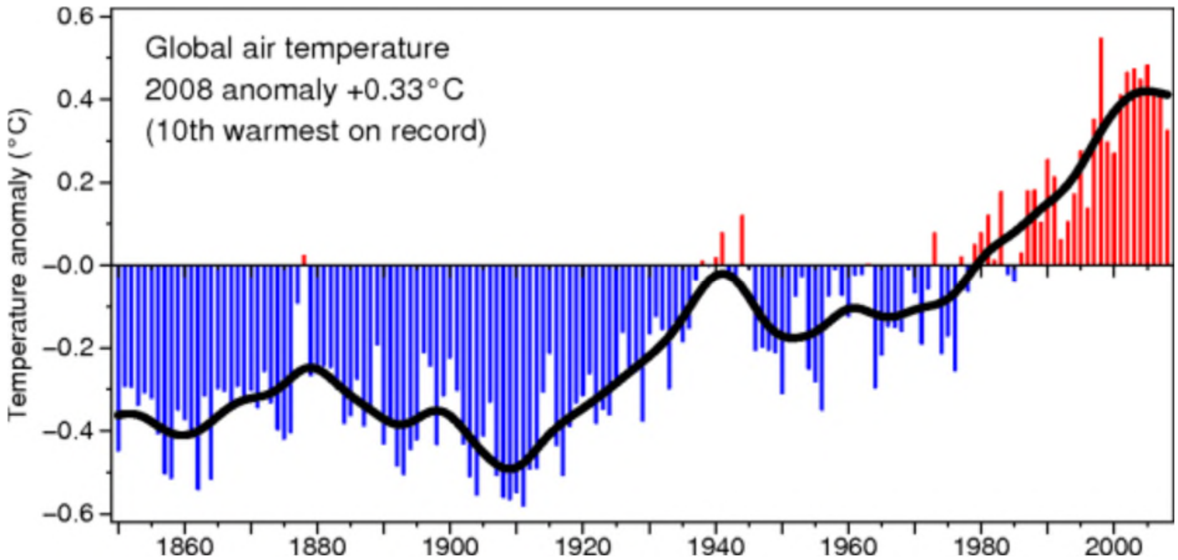

Figure 2.1: Deviation of global annual atmospheric temperature from the global average temperature.

Source: Brohan *et al*, 2006.

The warming of the atmosphere is also supported by the IPCC (2001a) reports that, globally, the 1990s were likely the warmest decades over the past millennium and the graph shows that the warming has gone beyond the 1990s to 2000s. Records from WMO (2004) report that; nine out of ten warmest years on record occurred between 1995 and 2004, with 1998, 2002, 2003 and 2004 being the warmest.

Accumulated evidence suggests that anthropogenic activities are to blame for the increasing concentrations of greenhouse gases (GHGs) in the earth's atmosphere and the consequent warming of the planet. The GHGs trap the heat in the atmosphere by preventing some of the radiation from escaping into space. While the greenhouse effect is important for life on earth, as they help trap some of the sun's radiation from reflecting back into space to keep the earth habitable for living creatures, the increasing quantities of greenhouse gases are now of concern because they cause increased global warming and dramatic climate change (IPCC, 2001).

The main greenhouse gas, carbon dioxide is emitted when fossil fuels, like coal and oil are burned. Since the industrial revolution in the 1800s, use of fossil fuels has increased at a rapid rate leading to increased emissions and buildup of GHGs in the atmosphere (IPCC 2007).

GHGs are also released when ecosystems are altered and vegetation is either burned or removed, the carbon stored in them is released into the atmosphere as carbon dioxide. The clearing of land through cutting down trees and woodland burning often leads to deforestation. Reasons for deforestation include urban growth, where land is cleared to build houses and factories; harvesting timber for fuel, construction and paper making; and agriculture activities. Agriculture involves land tilling which also often releases gases into the atmosphere. Moreover with the growing population more land is cleared for agriculture thus, there is expansion of cultivated land to meet the high food requirements. Currently up to a quarter of the carbon dioxide emissions can be attributed to land use activities (National Oceanic and Atmospheric Administration: NOAA, 2005).

Effects of global warming include the melting of the polar ice caps leading to a rise in sea levels and flooding in some regions especially areas near the coast. In regions where high temperatures have been the generally norm, like the semi-arid tropics, occurrence of droughts and dry spells will increase (Eriksen *et al*., 2008).

2.3 Observed and Projected Climate Change in Developing Countries

Many developing countries have already experienced weather events in terms of floods, droughts, heat waves, and tropical cyclones that are more frequent or intense than previous experiences (Dai et al., 2004; Trenberth et al., 2007), and the resulting impacts point to the consequences on the environment, production systems, and livelihoods from future climate variability and change. This section briefly reviews the observed and projected climate change that has been summarized by the IPCC and recent literature.

Expressed as a global average, surface temperatures have increased by about 0.74℃ over the past 100 years (Trenberth et al., 2007). However, the largest share of the increase (0.55℃) has occurred over the past 30 years. The largest temperature increases have occurred over land and in the arctic and subarctic regions. The observed temperature increases over the past 30 years in large parts of Africa, Asia, and Latin America are generally within the range of 0.5℃ to 1.0℃, although there are regions with larger observed changes (e.g., in southeastern Brazil and North Asia) (Magrin et al., 2007; Trenberth et al., 2007). Surface air temperatures over land have risen by about double the rate of temperatures over the ocean, which means that less warming has occurred in small island states (e.g., in the Pacific). Consistent with the warming, there has been an increase in the frequency of warm extremes (Trenberth et al., 2007).

Downward trends in precipitation have been observed in the tropics from 10°S to 30°N since the 1970s (Trenberth et al., 2007). It has become wetter in eastern parts of South America and northern and central Asia but drier in the Sahel, southern Africa, and parts of southern Asia. In accordance with this, more intense and longer droughts have been observed over wider areas since the 1970s, mostly in the dry tropics and subtropics (Dai et al., 2004). These droughts have often been linked with prolonged heat waves. There have been substantial increases in heavy precipitation events in many land regions, even in regions with no change or reductions in total rainfall (Grothmann et al., 2005), where droughts might be exacerbated if the reduced rainfall is increasingly falling in heavy precipitation events.

Globally, estimates of potential destructiveness of tropical cyclones show a significant upward trend since the mid-1970s (Emanuel 2005), with a trend toward longer lifetimes and greater storm intensity (Emanuel 2005). This is strongly correlated with the higher tropical sea surface temperatures. Even though these observations depend critically on data quality and the choice of start date (Chan 2006), the data available suggest that the potential destructiveness has not previously been as high as now (Trenberth et al., 2007). The largest increases in intense tropical cyclones have been observed in the North Pacific, Indian, and southwest Pacific Oceans (Trenberth et al., 2007).

Observations of changes in physical and biological systems across the globe are consistent with the observed changes in climate (Rosenzweig et al., 2007). Particularly large effects are related to enhanced glacial melt affecting river flows and to changes in phenology and productivity of biological systems as affected by temperature and rainfall changes. There are also emerging findings of climate effects on human systems, although these are often difficult to discern from other adaptation processes. In agricultural systems, both climate change and technological developments influence agricultural land use and management, but in many developing countries with traditional land management, the effects of climate change on agriculture might be more evident Van der Geest, et al (2004). The majority of the data and studies are from developed countries, in particular, in temperate climates.

There is thus a need to expand the observational series in developing countries and tropical and subtropical climates. Such studies might also increase the knowledge base on vulnerability and adaptive responses in subsistence agricultural systems and rural populations in developing countries.

Increasingly reliable regional climate projections are now available for many regions of the world, although the extent of available downscaled projections for many developing countries still lags behind those for the developed world (Christensen et al., 2007). The projections generally show greater warming over many land areas than global mean warming due to less water availability for evaporative cooling and a smaller thermal inertia compared to the oceans. The warming generally increases the spatial variability of precipitation with reduced rainfall in the subtropics and increases at higher latitudes and parts of the tropics. There is a tendency for increased precipitation in monsoonal circulations due to enhanced moisture convergence, despite a tendency for a weakening of the monsoonal flows. However, there are still many uncertainties in tropical climate responses (Christensen et al., 2007).

The warming in Africa is projected to be above the global annual mean warming throughout the continent and in all seasons (Boko et al., 2007). The dry subtropical regions will warm more than the moister tropics. The annual rainfall is projected to decrease in much of the Mediterranean Africa, Northern Sahara, and southern Africa. The mean annual rainfall in eastern Africa is likely to increase, whereas projections of changes in rainfall in the Sahel, the Guinean Coast, and the Southern Sahara remain uncertain (Christensen et al., 2007).

Warming is projected to be similar to global mean warming in Southeast Asia, stronger over South Asia and East Asia, and greatest in the continental interior of Asia (Cruz et al., 2007). Precipitation is projected to increase in Northern Asia, East Asia, South Asia, and most of Southeast Asia but to decrease in Central Asia (Christensen et al., 2007). These changes will be associated with an increase in frequency of intense precipitation events in South Asia and East Asia, partly associated with likely increase in tropical cyclone intensity in East Asia, Southeast Asia, and South Asia.

The annual mean warming in Latin America is projected to be similar to the global mean warming (Magrin et al., 2007). Annual precipitation is projected to decrease in most of Central America and in the southern Andes, although there might be large local and regional variations (Christensen et al., 2007). The changes in annual and seasonal rainfall over northern South America, including the Amazon forest, remain uncertain. However, climate change projections indicate increasing rainfall in Ecuador and northern Peru and decreasing rainfall in northern South America and southern northeast Brazil. The climate in large parts of the region is affected by the El Nin˜o Southern Oscillation (ENSO), so future changes in the magnitude and cycle of the ENSO will affect the climate of Latin America (Magrin et al., 2007).

2.4 Climate

According to Obeng (2005), climate can be viewed at either in a narrow sense or from a more rigorous perspective. It can be defined in a narrow sense as the average weather condition of a place over a period of time while from a more rigorous perspective climate can be defined as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. Climate plays a critical role in shaping the environment in which man lives and derives his livelihood and cannot therefore be ignored. IPCC (2001) also refers to climate as the average weather conditions of a place experienced over a long period of time, usually 30 years.

2.4.1 Climate change

The term climate change has several definitions. It is a significant change in the "average weather condition" experienced over an area" (IPCC, 2007). It is also defined as an "increase or decrease in the average precipitation caused by land use changes and the anthropogenic increase in the concentrations of greenhouse gases, particularly carbon dioxide (CO_2), in the earth's atmosphere" (IPCC,2005). It is referred to as "statistically significant variations in climate that persist for an extended period, typically decades or longer, which includes shifts in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global mean temperature"(IPCC, 2001). According to the United Nations Framework Convention on Climate Change (UNFCCC, 2007) climate change can be described as a change of climate which is attributed directly or indirectly to human activity that changes the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

2.4.2 Climate variability

Fussel and Klein (2006) refer to climate variability as the variations in the mean state and other statistics such as occurrence of extremes of the climate on all temporal and spatial scales beyond that of individual weather events. Obeng (2014) refers climate variability as the observed year-to-year differences in values of specific climate variables within an averaging period (30 years). Two major elements of climate, rainfall and temperature, whose variability affect the farmers directly were further looked at.

2.5 Rainfall variability

According to Van der Geest (2004) rainfall variability can be defined as a situation of insufficient rainfall or excess rainfall which can trigger food and livelihood stress when vulnerable people are affected. It is about the differences in rainfall from place to place (spatial variability), the differences in rainfall between years (inter-annual variability) and differences in rainfall distribution within the same year (intra-annual variability). For agricultural production the total amount of rainfall might not matter much as its distribution over the period of the rainfall (Obeng, 2014). This is supported by Van der Geest (2004) who also posited that average seasonal concentration of rainfall does not pose problems to farmers but rather distribution of rainfall which varies from year to year. According to Van Schaik & Reitsma (1992) unreliable rainfall poses production risks to farmers and other occupational groups and has the potential to trigger disaster. This situation makes farming in areas with high inter-annual variability a risky enterprise.

Hassan, Mendelsohn, and Benhin (2006) indicated that the mean annual rainfall varies across the seven ecological regions in Ghana , with wet evergreen forest recording the highest mean annual rainfall of above 2200 mm followed by rainforest (2200mm), deciduous forest (1500mm), transitional zone (1300mm), Guinea savannah (1100mm), Sudan savannah (1000mm) and coastal savannah (800mm).

Citing Blessing, Brett (2009) states that 75 to 250 million Africans are projected to be exposed to an increase of water stress due to changes in rainfall pattern, and the amount and availability of water stored in the soil which is a crucial input for crop growth, will be affected by changes in both the precipitation and seasonal annual evapo-transpiration.

This will lead to agricultural production and access to food in many African countries being severely compromised by climate variability. Again Brett (2009) in Blessing posits that the area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are projected to decrease in some countries up to 50% by 2020 especially from rain-fed agriculture.

According to studies conducted by some authors (Walker et al,2005; Gowing, 2003) crop production in many tropical semi-arid areas of Africa is adversely affected due to the erratic nature of rainfall even when the seasonal rainfall is considered adequate. Lazaro, Rodrigo, Gutiérrez, Domingo, and Puigdefábregas(2001) indicated that water is often the most limiting factor for biological activities and relatively small shortage in water input can have a strong effect on agricultural systems which may cause significant long-term changes in human livelihoods.

The adverse effect of climate change is alarming in developing countries, particularly sub-Saharan Africa due to declining precipitation levels, increasing temperatures, and low adaptive capacity Kandji, Verchot and Mackensen (2006). Obeng (2005) contends that over the years rainfall has stood out as a major element that has assisted to shape the life of man; especially farmers in developing countries in general and those in the sub-humid, arid and semi-arid regions in particular, who depend on it as their main source of precipitation for crops and livestock production. The distribution of rainfall has severe impact on the food security of the farmers and dictates what people's behaviour should be. Also Wang'ati (1996) cited in Obeng, (2005) argues that rainfall is the most variable and critical climatic parameter in the Sudano-Sahel region. Obeng (2005) and Dietz (2000) indicated that the total amount of rainfall an area records in any season might not matter so much as fluctuations in rainfall, from place to place, from year to year and within the season especially where agriculture is predominantly rainfed with very little or no irrigation .

Studies conducted in Ethiopia by Tesfaye (2003) revealed that rainfall is highly variable both in amount and distribution across regions and seasons. Higher rainfall variability results in higher meteorological drought risks and ultimately agricultural drought. Obeng (2005) citing Van Schaik (1992:22--23) identified three types of rainfall variability as follows: spatial variability, Inter-annual variability, and Intra-annual variability.

2.5.1 Spatial variability

This is the differences in rainfall from one place to another. There is the tendency for different places in the same town or area for instance, to experience different amounts of rainfall thus resulting in spatial variability. Spatial variability looks at the differences in rainfall received between places, either structurally or proximately when two nearby villages are separated by a mountain range one can expect structural differences in precipitation and thus high spatial variability. This variation has a positive side in terms of coping with food stress. If crops fail in one village due to drought, but neighboring villages harvest well, part of the food gap can be filled by inter-village transfer (Van der Geest, 2004). This makes it easier for affected households to purchase food at reduced prices.

2.5.2 Inter-annual variability

This is the annual deviation from a long-term average, or the differences in rainfall between years. The analysis of inter-annual variability is usually limited to a comparison of total annual amount of rainfall in different years, while the year to year variation in the rainfall distribution is neglected (Van Schaik and Reitsma 1992; cited in Van der Geest 2004).

2.5.3 Intra-annual variability

This is the distribution of rainfall within a year. In the semi-arid and sub-humid regions of Sub-Saharan West Africa, the rainfall pattern is unimodal i.e. rainfall is concentrated in one wet season in which the rainfed farming activities take place, leaving the dry season for other activities (Van der Geest 2004).

2.6 Drought

The concept of drought has different meaning across disciplines, regions and its impact can be felt differently by groups of people. Wilhite and Glantz (1996) revealed that, there were more than 150 published definitions of drought. Wilhite et al. (2000) described drought as a natural hazard that differs from other hazards because it has a slow onset, progresses over months or even years, and affects a large spatial region and causes little cultural damage. According to Hisdal and Tallaksen (2000) drought is an extreme rainfall deficit and the resulting periods of low flow of water, which can have severe effect on water managements in terms of river pollution, irrigation and drinking water supply.Van der Geest (2004) also refers to drought as a situation where crops do not get enough water to grow fully and produce acceptable yields. Wilhite and Glantz (1996) categorized drought into four basic types based on the approaches in measuring drought. The four categories are hydrological drought, meteorological drought, agricultural drought, and socioeconomic drought.

2.6.1 Meteorological drought

Wilhite and Glantz (1985) refer to meteorological drought as a temporary deficiency of rainfall which is significantly below the normal or expected in a year, season or month. Mortimore (1989:11) contends that the analysis of meteorological drought is relatively easy due to their definition in statistical terms. He further stated that meteorological drought in a certain area can, for instance is defined as a situation in which the rainfall is deficient by at least two times the standard deviation of the average. According to Olaleye (2010), cited in Nti, (2012) meteorological drought is a reduction in amount of rainfall compared with specified average condition over some specified period across regions resulting in deficiencies of precipitation. Meteorological drought can be referred to as the degree of dryness and the duration of the dry period. It is a reduction in rainfall supply compared with a specific average condition over a specified period of time (Obeng 2005; Dietz, 2004:51).

Meteorological drought is considered region-specific due to the variability across regions in the atmospheric conditions that result in deficiencies of precipitation (Olaleye, 2010; cited in Nti, 2012). Also Grundstein and Bentley (2001) refer to meteorological dry spell as a large decrease in precipitation for a prolonged period of time over a large region while a hydrologic drought is dry period of longer duration than a meteorological dry spell that can affect surface hydrologic processes such as stream flow.

2.6.2 Hydrological drought

The National Drought Mitigation Centre (NDMC, 1998; cited in Obeng, 2005) posits that hydrological drought is associated with the effects of periods of precipitation shortfalls on the surface or surface water supply.

2.6.3 Agricultural drought

Agricultural drought occurs when the amount of water in the soil no longer meets the needs of certain crops for acceptable yield (Backerberg and Viljoen, 2003). During agricultural drought crops do not get enough water to grow fully and produce acceptable yields (Wilhite and Glantz, 1985). Citing Kemp, Van der Geest, (2004) reveals that it is not the low average level of precipitation that makes an area drought-prone but rather the inter-annual variability of rainfall that causes dry years. The more the rainfall variability occurs, the higher the chance of receiving significantly below-average rainfall and thus the higher the risk of meteorological drought which may lead to agricultural drought (van der Geest, 2004).

In the view of Barrios, Quattara, and Strobl (2008) the declined in rainfall that occurred between 1960’s and 1990’s in much of sub- Saharan Africa was a major contributor to the reduced agricultural production rates and growth rates during that period. According to Lobell (2000) poor rainfall distribution within the growing season is often a cause for crop failure even for years with close to average rainfall, due to insufficient surface or groundwater to irrigate dry land crops even at critical periods of crop growth. Owusu, Walen, and Qiu (2008) reported that the rainfall pattern in Ghana, in recent times, have affected agriculture production with a resultant reduction in crop yield. Grundstein and Bentley (2001) defined agricultural dry spell as a short-term precipitation shortage or period of high evapotranspiration that could lead to soil moisture deficit. Adiku, Dayananda, Rose, and Dowuona (1997) indicated that agricultural dry spells have not received enough attention even though their effects could be as important as those caused by the longer dry spells.

2.6.4 Socioeconomic drought

This kind of drought associates the supply and demand of some economic good with elements of meteorological, hydrological and agricultural drought. The incidence of any of these drought forms can distort the equilibrium level of some economic goods and services by reducing supply leading to socioeconomic drought. This drought can be distinguished from the other droughts based on the time and space processes of supply and demand of economic goods and services (Obeng, 2005; Wilhite and Glantz, 1985). Again citing Dercon (2002), Obeng (2014) reported that rainfall shocks (droughts) are the primary reason why households fell into poverty in a study of six Ethiopian villages thus resulting in declined income growth by 20% relative to growth without the rainfall variability. Also, according to Mortimore (1989:11) an ecological drought occurs when the primary productivity of a natural or managed eco-system falls significantly due to reduced precipitation.

2.6.5 General impact of drought

The effects of drought vary from region to region in both economic and social terms and the need for water use differ across the regions (Wilhite 1996). Also Obeng (2005) stated that the atmospheric conditions that give rise to drought or deficiencies in precipitation vary from region to region. According to studies conducted by Marty (2006) and Judith (1993), regional climate change, in particular, reduced rainfall, had contributed to the conflict in Darfur. As a result of decades of drought, desertification and overpopulation the Baggara Arab nomads took their livestock in searched of water and pasture further South on land mainly occupied by farming communities. The impacts of drought cut across many sectors of the economy and therefore travel beyond a particular location experiencing physical drought. The impacts of drought can be felt economically, environmentally or socially in a society.

However, drought has both positive and negative impacts on people at a given period of time. According to Obeng (2005) "not all the impacts of drought are negative. For instance, a reduction in agricultural production as a result of drought leads to higher prices for agricultural produce outside the drought area as well as businesses providing water related services or alternatives to water-dependent services". The NDMC (1998) cited in Obeng, (2005) has outlined the impacts of drought as economic, environmental or social as indicated in the table 1 below.

Table 2.1: Impacts of drought

Economic Impacts
1.Loss from crop production
2.Loss from livestock production
4.Decline in food production
5.Disruption of water supply
6.Decreased land prices
7.Loss from fishery production
8.Cost of water transport

9.Increased cost to energy industry because of substituting expensive fuel for power
Environmental Impacts 1.Damage to animal species 2. Diseases and pests outbreak 3.Damage to plant species 4.Loss of biodiversity 5.Loss of wetlands 6. Wind and water erosion 7.Increased ground water depletion
Social Impacts 1.Food shortages 2.Loss of human lives 3.Increased disease caused by wildlife concentration 4. Loss of cultural sites 5. Population migration 6.Reduced quality of life, changes in lifestyle

Source: NDMC, 1998

2.7 Temperature variability

The Fourth Assessment Report of the IPCC (2007) revealed that most land areas will have warmer and fewer cold days and nights. Fancherean, Trzaska, Rouault, and Richard (2003) reported that the earth has over the years observed a significant increase in temperature but decreased precipitation. The temperature increase in Sub-Sahara African will reduce yields and quality of food-crops thereby worsening vulnerability in food supply (Henry and Clement, 2012). Darwin (2001) reported that global warming will shorten growing seasons in the Tropics and lengthen growing seasons at high latitudes leading to adverse effects on agriculture and food security by changing the spatial and temporal distribution of rainfall and the availability of water, land, capital, biodiversity and terrestrial resources. Also IPCC (2007) indicated that climate change impact will range from slightly negative to moderately positive leading to minimum reduction in world food production and significant reductions in agricultural productivity in developing countries.

2.8 Flood

Floodis defined by the EU Flood Directive as "a temporary covering by water of land not normally covered by water which may include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and may exclude flood from sewerage systems" (European Union, 2006,p33). According to Hirschboeck (1991) floods occur when drainage basins reach maximum capacity and are unable to absorb additional precipitation resulting from heavy rains, tropical cyclones and other climatic events.

Karley (2009) refers to flood as a situation which occurs when drainage basins reach maximum level and are unable to absorb additional precipitation resulting from certain situations such as heavy rainfall, human activities, and other events.

Tschakert (2009) reported that rainfall alone causes about 69% of floods as observed in 2007 in Ghana which led to the loss of several lives and properties, health risks, food shortages, and high prices of food stuffs in the entire country and was ranked as one of the three most devastating flood events in the world. According to National Disaster Management Organization (2010) floods in Ghana killed 20 people and rendered over 350,000 people homeless and destroyed several farm produce in 2005. Arthur and Irene (2011) also indicated that in 2007, floods following major rains in northern Ghana resulted in 61 deaths with 317,127 people displaced.

Again, Arthur and Irene (2011) pointed out that, about 25,112 people in the northern region were displaced in addition to farm land and livestock that were lost due to floods in 2010. It was estimated that the loss of cereals and food items amounted to 257,076 metric tons. The general effects of these recurrent floods have been food shortages, higher prices for agricultural commodities, and the destruction of natural resources in the country (Nti, 2014).

2.9 Conceptual Issues of Vulnerability, Adaptation, and Adaptive Capacity

Vulnerability and adaptive capacity have been discussed in the theoretical climate change adaptation literature as key concepts for understanding how developing countries cope with and adapt to climate change and variability (Adger 2006; Mimura et al., 2007; Schroter et al., 2005; Smit and Wandel 2006). Both terms are very useful for analyzing coupled human–environment interactions (Reenberg et al., 2009) and frameworks for vulnerability analysis have become a key component in sustainability science (Turner et al., 2003).

Vulnerability emerged as a concept in development debates in the 1990s (Bohle et al 1994; Chambers 1995; Watts and Bohle 1993) and was largely a term borrowed from life sciences. There have been quite many attempts to define vulnerability, and in relation to climate change, vulnerability has been defined as the susceptibility of exposure to harmful stresses and the ability to respond to these stresses (Adger 2006; Adger et al., 2007; Bohle et al 1994). It is important to recognize that vulnerability is highly contextual and must always be linked to specific hazards and the likely exposure to the impacts of these hazards (Brooks et al., 2005; Kelly and Adger 2000). Along this line, Luers (2005) suggested that vulnerability assessments should focus on the susceptibility of specific variables (such as food supply, income) that characterize the well-being of people to a specific damage (such as hunger and poverty). Adaptation is a broad term, and there have been many attempts to define the concept.

These are reviewed by Smit et al., (2002), and although the various definitions are rather similar, there are important nuances that might not answer completely the questions of, adapting to what?, who and what adapts?, and how does adaptation occur? (Smit et al., 2002). Identifying the precise driver of any given strategy is highly complex and it is therefore often difficult to establish the cause of an adaptive strategy or even determine whether it is adaptation or perhaps a cyclic activity occurring with longer time intervals. The IPCC Third Assessment Working Group II Report, based on Smit and Pilifosova (2003), presented a broad definition of adaptation to climate change as being adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts.

This definition is retained in the IPCC Fourth Assessment Report, where it is reiterated that adaptation comprises actions to reduce vulnerability or enhance resilience (Adger et al., 2007).

However, the complexity of understanding adaptation (especially what exactly triggers different adaptive measures) is still frequently discussed in the literature.

The linkages between vulnerability, adaptive capacity, and adaptation are often circular rather than linear in nature. The ability of people to control the variables that determine vulnerability might be translated into their capacity to adapt (Kelly and Adger 2000; Luers 2005; Smit and Wandel 2006). If people, for example, have a secure income and a diversified food supply, they are less likely to be poor and to experience hunger. This, in turn, will often enable them to respond to stresses by allocating resources differently or abandon/relocate farming areas—in other words, they have a better capacity to adapt to stress and the degree of vulnerability determines this capacity. It is thus prior damage that makes people vulnerable and hampers their capacity to adapt to potential future stress factors. However, adapting to stress might also in itself exacerbate vulnerability; if, for example, the needed adaptive actions to drought will lead to dependence of credit schemes to purchase drought-resistant crops and crop varieties, then a complete crop loss will not only cause hunger but also leave people with debts they are unable to repay. Therefore, the true vulnerability of people can only be assessed after adaptation has taken place (Adger and Kelly, 2000), and in some cases, it might be necessary to ''adapt to the adaptation,'' as some measures might solve one problem while creating another; credit schemes and new crops, for example, might have to be accompanied by ''weather insurance,'' as has been tried experimentally in some developing countries (Barnett et al., 2007).

In economic terms, adaptive capacity has been defined as ''a vector of resources and assets that represent the asset base from which adaptation action can be made'' (Vincent 2007), and it has also been described by the coping range of climate variability upon which communities or individuals are used to react.

When extreme events or more extreme variability go beyond the coping range, the adaptive capacity might be surpassed and the system threatened (Smit and Wandel 2006). At this point, the required adaptation is beyond the capacity of the people experiencing the threat and assistance is needed. A slightly different and more operational approach to the coping range concept suggests that adaptation of the system will occur only when thresholds of the coping range are exceeded, and the coping range thus signifies the resilience of a system (Yohe et al., 2002). In other words, coping is the short-term response to variability, whereas adaptation is the more fundamental change of the system to allow for a new coping range to be established. Thus, the coping range can been described as the ‘‘head room’’ or ‘‘room for maneuver’’ of the system (Thomas and Twyman 2005), and the whole point of successful adaptation in poor communities is to ensure that an adequate coping range is established after adaptive actions have taken place. This will eventually reduce the vulnerability of people, and in an ideal world, a ‘‘good circle’’ of reduced vulnerability (increased adaptive capacity) appropriate adaptation can be closed.

Following these lines of thinking, policies on adaptation to climate change must be very carefully devised as they find themselves in a complex reality of societies that are poor and vulnerable for a wide range of reasons. They must

be an integral part of a development policy process that ensures mainstreaming of climate adaptation in all relevant sectors of society while not forgetting the other multiple drivers (social, economic, and environmental problems). Concretely, the policies at the national level should be specific investments in physical and institutional assets that reduce climatic vulnerability and increase coping ranges without causing counterproductive effects. Examples of physical assets can be stronger infrastructure related to transport, energy, and water supply as well as new options for agricultural techniques, whereas institutional assets can be information systems, financial and risk-sharing systems, insurance, education, and warning systems that directly or indirectly address local, national, or regional vulnerability to climate change and variability.

It is also important to consider to what extent policies should be proactive (adapting in anticipation of a change) or reactive (adapting as a response to a change) or as suggested by several studies, they should be both (Smit and Others 2000; Smit and Skinner 2002). The choice among these must be dependent on the confidence in local climate predictions, as investments in adaptation to anticipated change might be wasted or even counterproductive if predictions turn out to be wrong. This is especially crucial in developing countries, where the capacity for investment and later remedial actions to correct mistakes is limited. On the other hand, it can also be risky to base long-term adaptation strategies on observed climatic trends, as is sometimes done in National Adaptation Programs of Action (NAPA)—for example, in Sahelian countries, where the decrease in average annual precipitation since the 1960s is expected to continue or at least remain low (Gouvernement du Burkina Faso 2007; Re´publique du Mali 2007) (see further discussions on NAPAs in the following section). This need for a better understanding of the actual and potential adaptation needs in developing countries has spurred an increasing interest in adaptation and development policy (Halsnæs et al., 2008; Michaelowa et al., 2007; O'Brien et al., 2008). Moreover, development of methodological frameworks for studying the links between vulnerability, poverty, and the complexity of adaptation to climate change, which is often not easily separated from adaptation to other factors that might stimulate change, has also attracted more interest (Tschakert 2009; Wheaton and Maciver 1999).

2.10 Climate Vulnerability and Adaptation in the Context of Current Development Policies

Climate variability is already creating serious impacts on major poverty alleviation goals in developing countries, and this means that the linkages between climate vulnerabilities and development policies are increasingly being
addressed in the literature as well as in international climate policy debates and in development assistance. A brief overview of these activities is given here.

Climate change mainstreaming issues related to vulnerability and adaptation were put on the agenda at the Conference of the Parties (COP) 7 in Marrakech, Morocco in 2001, where it was decided that special support should be given to a group of Least Developed Countries (LDCs) to the development of NAPAs (Burton and Lim 2005). COP 7 also further supported adaptation activities by a strong recognition of the special needs of developing countries (Adger et al., 2003). The NAPAs are part of the adaptation policy framework (APF) developed to aid national planning and comprises a five-step approach for studying vulnerability and for developing adaptation strategies (Adger et al., 2007; Burton and Lim 2005). Despite that NAPAs only provide limited small-scale first attempts to initiate full-scale planning of adaptation options in developing countries, they must be considered as important elements in the APF. The NAPAs are likely to contribute to the mainstreaming of climate adaptation in development policies and programs, and although this is important for adaptation purposes, increased focus on the Clean Development Mechanism (CDM) and mitigation might entail a risk of climate overshadowing other (and perhaps more important) poverty reduction and development needs (Michaelowa et al., 2007).

According to the United Nations Framework Convention on Climate Change, only 23 developing countries had submitted their NAPAs by November 2007 (http://unfccc.int/national_reports/napa/items/2719.php). Considering that the agreement was made in 2001, this appears to be relatively few and it is obvious from the list that many countries with immediate adaptation needs (e.g., small island states) and countries with a history of environmental challenges such as drought (e.g., Sahelian countries) have a high representation. However, 45 of the 50 LDCs are engaged in NAPA processes and more are likely to be ready in the near future (Downing 2007).

Climate change vulnerability and adaptation have in the COP 12 and COP 13 meetings in 2006 and 2007 been further emphasized. The COP decisions on climate vulnerability and adaptation have been supported by various donor mainstreaming efforts, including development of an Organization for Economic Cooperation Development– Development Assistant Committee (OECD-DAC) framework, the Danish Climate Action Programme, and the United States Agency for International Development (USAID) and UK Department for International Development (DfID) guidelines. These various donor efforts are summarized in the work of Gigli and Agrawala (2007).

The Danish Development Assistance (Danida) was one of the first international donor agencies to initiate the integration of climate change in its assistance (Danida 2005). Climate screening of Danida's development assistance is a key step in a process of identification and management of the risks of climate change for development cooperation and the identification and implementation of appropriate climate change adaptation and disaster-risk reduction measures. The approach adopted is to integrate risks of climate change and opportunities for adaptation into development programs rather than as stand-alone climate adaptation or mitigation projects. Thus, climate change screening includes assessment of the effects of climate change on achieving the outcomes of the development programs, identification of adaptation measures, and the development of a process action plan for further activities in relation to ''climate-proofing'' of development assistance.

The World Bank in its Investment Framework for Clean Energy and Development (World Bank 2006) similarly sees climate change as a serious threat to development goals. It is stated in the Executive Summary that ''failure to effectively address increasingly severe weather patterns and climate variability into development activities is a major threat to poverty alleviation. The economic impacts will be significant especially in developing countries, partial estimates of the economic impacts of a 2.5°C temperature increase (mid-range value associated with a doubling of the atmospheric concentration of CO2) without adequate adaptive efforts range from 0.5 to 2 percent of GDP with higher losses in most developing countries. Resources that are additional to Official Development Assistance (ODA) will need to be found by donors to compensate for the increased development costs, while developing country governments will need to re-assess policies and institutional structures to be proactive in reducing climate vulnerability.''

2.11 Regional Impacts and Adaptation

Developing countries will experience the effects of climate change differently, not only because of differences in the projected change of climate parameters but also because vulnerabilities and adaptive capacities vary greatly between nations and regions. This section will only provide a brief overview of the main regions with developing countries, as the IPCC Fourth Assessment WG II Report provides excellent discussions on this issue.

Sub-Saharan Africa is highly vulnerable to climate change and other stressors (Boko et al., 2007), and in an assessment of vulnerability to climate-related mortality, this region was represented with 33 of the 59 countries found to be highly or moderately–highly vulnerable (Brooks et al.,2005). Sub-Saharan countries also come out in the lowest quintile of a ranking on adaptive capacity of nations to climate change (Haddad 2005).

Generalizing the impacts of climate change in Africa is impossible, as regions will be affected differently and there is considerable uncertainty, particularly in West Africa. Water stress will be an even larger problem than currently in northern and southern Africa, and in the same regions, agricultural production (and thereby food security) is likely to be negatively affected (Boko et al., 2007). In general, climate problems, such as recurrent drought, exacerbate the many existing problems in the region (Kates 2000), and as mentioned earlier, it can often be very complex to identify climate as a direct driver of strategies. In southern Africa, Gregory et al., (2005) found climate to be among the most frequently cited drivers of food insecurity, whereas Mertz and others (2009) found that changes in agricultural strategies in a region in Senegal were not easily identified as adaptation to climate changeor variability but rather to economic and policy drivers.

It is also well established that people are generally resourceful in responding and adapting to climate variability and other external disturbances (Mortimore and Adams 2001; Thomas and Twyman 2005). IPCC provides a good overview of such adaptations already observed in Africa (Boko et al., 2007), although the relative weight of climate factors compared to other stressors is not always clear in the references cited. Future adaptation needs are likely to focus on enhancing the robustness of various sectors in Africa, not only to counter the impacts of climate change but also to improve the economic and social welfare and thereby improve the adaptive capacity of individuals and communities (Boko et al., 2007).

The developing countries of the Asia-Pacific region will also experience climate change very differently. Key future impacts were identified by the IPCC and included increased water stress in India, loss of mangroves and other coastal lands in Southeast Asia due to sea level rise, and disturbance of forests and agriculture due to the possibility of more intense El Nin˜o events (Cruz et al., 2007). Melting of glaciers in the Himalayas and resulting floods and water availability issues are also likely become important impacts. The small island states of the Pacific are even more vulnerable and impacts of possibly more intensive cyclones, sea level rise, drought, and coral reef degradation will be very important (Mimura et al., 2007). However, small island states did not come out as highly vulnerable in the national vulnerability assessment proposed by Brooks and others (2005) and nor did Bangladesh,which is usually considered very vulnerable to climate change. In both cases, it probably was caused by the focus on mortality in the assessment, which might not be specifically high in these countries, as they have already managed to significantly reduce such very negative outcomes of climate hazards (Brooks et al 2005).

The capacity for adaptation is generally higher in Asia- Pacific than in Africa, but the magnitude and consequences of adaptation needs might be larger. Potential flooding of the many highly populated river deltas will either be extremely costly to prevent or lead to mass movement of people to other areas (Cruz et al., 2007), and some Pacific islands might have to be abandoned altogether either because of flooding or loss of ecosystems needed for subsistence (Mimura et al., 2007; Rasmussen and others in press). Moreover, the predicted decline in agricultural production without adaptation in Asia will affect an even larger number of poor urban and rural populations than in Africa.

Many Latin American countries are now so-called emerging economies and even the poorest countries in the region are considerably less vulnerable to climate change than the poor countries of Africa and Asia. In the earliermentioned vulnerability assessment, only French Guyana and the Caribbean states (or territories) of Haiti, Guadeloupe, and Puerto Rico appeared among the 59 countries in the most or second most vulnerable categories (Brooks et al., 2005). Moreover, the uncertainty of future climate change in much of Latin America makes it difficult to predict impacts and adaptation needs with very high confidence (Magrin et al., 2007), although the likely intensification of extreme weather events will be very damaging, especially to the poorer countries of CentralAmerica and the Caribbean.

2.12 Climate change and agricultural sector in general

The IPCC (2001) predicted both negative and positive effects of climate change but stressed that the adverse effects would dominate with greater rates of climate change. Again in the words of Verner (2011) in Blessing et al. (2011) revealed that the negative impacts of climate change such as long term changes in average temperature and rainfall; changes in the intensity, timing, and geographic distribution of rainfall; an increase in the frequency of extreme events such as drought and flood; and sea level rise which will have adverse effects on agricultural productivity, biodiversity and ecosystem services are becoming increasingly evident in recent times, However Nelson et al. (2009) cited in Blessing et al. (2011) indicated that some crops in some regions of the world may experience gains, but generally it has been predicted that the overall impacts of climate change on agriculture will be negative, threatening global food security.

The IPCC (2001) reported that changes due to climate will severely affect agriculture production, especially in the developing world. The adverse impacts of climate change in Africa includes erratic rainfall, wide spread of crop pests and diseases, increase health risks, and changes in livelihood systems (Abaje, 2007).

IPCC (2007) reported that, too much precipitation can lead to disease infestation in crops, while too little can be detrimental to crop yield leading to decline in agricultural productivity. McCarthy, Canziani, Leary, Dokken, and White (2001) further indicated that the impact of climate change on agricultural productivity in developing nations is much severe as compared to other sectors of their economies and this is expected to be maintained or intensified. Additionally, Abaje andGiwa(2007) highlighted the droughts, floods, land degradation, low crop yield, depletion of household assets, increased rural-urban migration, increased biodiversity loss, depletion of wildlife and other natural resource base, change in vegetation types, increase in health risks, and changing livelihood systems as the most severe adverse impacts of climate variability.

FAO (2007) revealed that agricultural production and food security in Africa are expected to be placed under additional stress due to the changing climate. FAO (2004) in another studies reported that about 27% of the population of Africa and 16% of the population in West Africa are reported undernourished and hunger is directly linked to poverty. According to the World Bank (2010) the northern sector of Ghana is projected to be more vulnerable to climate change, especially flood and drought due to high temperature, high poverty level, low literacy rate, poor institutions and low rainfall as compared to the Southern sector.

According to Paul et al. (2008) cited in Ejembi (2012) the impacts of climate variability among Africa communities are highly differentiated based on land tenure, traditional beliefs, resource availability and gender. IPCC (2007) states that the current environmental variability and consequent climate change is predicted to cause increasing global temperatures, changing weather, rising sea levels and more frequent and intense extreme weather events. Africa is one of the most vulnerable continents to environment and climate variability change due to multiple stress and low adaptive capacity (IPCC WG II, 2007).

The IPCC (2012) states that parts of Africa may experience longer and more intense droughts, with other areas experiencing more erratic rainfall leading to environmental stressors that are beyond their previous understanding. The most vulnerable areas will be communities who depend on rain-fed agriculture and natural resource related activities. Climate change is expected to have serious environmental, economic, and social impacts on Ghana, particularly on rural farmers whose livelihoods depend largely on rainfall. The extent of these impacts depends largely on awareness and the level of adaptation in response to climate change and variability (Benedicta, Paul, and Manschadi 2010). The Ministry of Education Science and Technology (MEST, 2010) indicated that there has been rise in temperatures across the various ecological zones in Ghana whereas rainfalls patterns are becoming less predictable and recent increases in floods along the river banks also threaten settlements near the coastline Also, Kranjac-Berisavljevic' (1998) revealed that evapotranspiration in Northern region was 2,000mm with rainfall of about 1,000 - 1,300mm.

Parry, Rosenzweig, Iglesias, Fisher and Livermore (1999) contended that climate variability directly affects agricultural production, as agriculture is inherently sensitive to climate conditions and is one of the most vulnerable sectors to the risks and impacts of global change. Also Pearce et al. (1996) reported that Africa's agriculture has been negatively affected by climate change. Again, World Bank (2008) stated that climate change impacts have already felt by many people and ecosystems in many parts of the world and had the potential to cripple the drive for sustainable growth and development. Al-Hassan and Poulton (2009) revealed that climate change introduces several uncertainties over the livelihoods of farming communities that depend heavily on the elements of climate such as rainfall and temperature.

Climate change increases the heat stress on animals and crops, renders the land less suitable for agriculture and reduces the yield of agricultural production (Collier, Conway, and Venables, 2008). Citing Blessing et al. (2011), USDA (2007) indicated that crop yields are affected by many factors associated with climate change which includes: temperature, rainfall, extreme weather events, climate variability and even carbon dioxide concentration in the atmosphere which is predicted to cause global warming that will have a significant impact on crop production. Climate change poses a significant threat to Sub-Saharan Africa's (SSA) agriculture, especially in Ghana where agricultural production depends mainly on natural conditions thereby exposing the agricultural sector to the effects of present climate variability and the risks of future climate change. A study conducted by Deressa et al. (2008) revealed that agriculture in Africa is negatively affected by climate change and is therefore leading to adoption of certain adaptation technologies to cope with its harmful effects.

2.13 Climate change and agriculture in Ghana

Ministry of Environment, Science and Technology (2010) reported climate change as a threat to Ghana's development prospects, especially in deprived communities as the shocks will be experienced by people in varying degrees across different social groups, geographic locations and seasons of the year, with men, women and children all experiencing different levels of hardships and opportunities in the face of the changing climate. Again World Bank (2008) intimated that the growth and development in developing countries including Ghana is dependent on the agricultural sector and therefore climate variation influences agricultural development, which has impact on Ghana's development. According to Brown and Crawford (2008) the environmental changes emerging through the driver of climate change could inflict harsh environmental conditions upon smallholder farmers thus leading to unsustainable livelihood, particularly within agricultural sector. Boko et al. (2007) reported that the African continent is one of the most vulnerable to climate variability and climate change as a number of Africa countries are already encountering semi-arid conditions that are challenging to agriculture productivity. These developments make the smallholder farmers in Africa as a whole and Ghana in particular very vulnerable because of the almost complete dependence on rain-fed agriculture.

McCarthy et al. (2001) vulnerability is defined as "the degree, to which a system is susceptible to or unable to cope with adverse effects of climate change. Eriksen et al. (2008) reported that some of the factors that generate vulnerability to climate change are closely associated to poverty. This is evident among the poor who always suffer losses, harm from climatic extremes such as floods and droughts due to their less capacity to recover after such events because of lack of assets to engage in alternative economic activities.

Downing (2003) also indicated that it is the marginalized who suffer the impacts of changing environment conditions. Yaro (2010) indicated that the vulnerability of agriculture to climate change is largely due to its dependence on rain-fed agriculture, especially in the semi-arid north of Ghana. According to Armah et al (2010) cited in Alessandro, Pinto, Akiko, Jawoo, and Marian (2010) the changing climate is expected to exacerbate underlying problems that affect the agricultural sector in Ghana. The IPCC (2007) posits that Northern Ghana is considered part of the region most vulnerable to climate variability, as it is located in West Africa. The region is expected to experience changes in growing seasons and indices of drought, varied rainfall patterns, and rising temperatures, which will inflict harsh conditions on the livelihood options, especially among smallholder farmers.

Kranjac-Berisavljevic (2014) is of the view that even though Northern Ghana is vulnerable to the negative impacts of climate variation and at the same time has low adaptive capacity due to poverty the people are making efforts to adjust to the changes they experience. Ghana is vulnerable to climate change due to its location in the tropics. Because the Atlantic Ocean lies to its south the country is exposed to contracting oceanic influences and atmospheric changes leading to its exposure to extreme weather events (EPA, 2009).

According to IPCC (2007), the rural poor who are mostly smallholder farmers in developing countries, many of whom are food insecure, are likely to experience the most severe effects of climate change and are in greatest need of adaptation strategies and development assistance to cope with changing weather patterns.

Also, citing Parry, Rosenzweig, Iglesias, Fisher, and Livermore (1999), and Obeng (2014:111) reported that "climate variability directly affects agricultural production as agriculture is inherent sensitive to climate conditions and is one of the most vulnerable sectors to the risks and impacts of global climate change". Hence is often the poor, vulnerable, and marginalized within the developing countries that have the least capacity to adapt to the impacts of a changing climate given their limited resources. According to Van der Geest (2004) people living in politically marginalized areas with infertile soils and virtual absence of alternative income opportunities are collectively vulnerable because these characteristics of the local environment affect everybody.

Change in climate will have adverse effects on the soil. The soil structure will be affected by variation in temperature and rainfall, particularly during hotter and dryer season. There is an increased tendency for subsoil to become compact thus making it more difficult for aeration and roots to penetration. According to Brett (2009) there is likelihood of some of the soils becoming more compacted thus increasing the risk of run-off and floods which are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes. Cavero, Farre, Debaeke, and Faci (2000) indicated that inadequate soil moisture has significantly contributed to the huge food deficits currently experienced in sub-Saharan Africa (SSA), especially on maize production which has been reported to have relatively high water requirements and is very sensitive to water stress.

2.14 Climate change adaptation strategies

Alessandro et al. (2010) refer to climate change adaptation strategies as a set of actions, strategies, processes, and policies that respond to actual or expected climate changes so that the consequences for individuals, communities, and economy are minimized. Henry and Clement (2012) further revealed that adaptation measures always seek to reduce the risks and impacts of climate change, to moderate the negative effects, and to exploit beneficial opportunity. Hence, the devastating effects of climate change can be reduced if appropriate adaptation measures are employed.

Berkes and Jolly (2001) argued that, adaptive strategies are the strategies in which a region or a sector responds to changes in their livelihood through either autonomous or planned adaptation. However to Siri, Eriksen, Katrina, and Mick (2005) adaptation efforts are measures employed to reduce sensitivity by, for instance, diversifying of agriculture that are less climate sensitive, thus reducing the need for coping. Also Davies and Hossain (1993) indicated that adaptation concerns permanent changes in the mix of ways in which food is acquired, irrespective of the year in question.

Deressa et al.(2008) indicated that the common adaptation strategies to climate change in crop production in African countries are crop diversification, irrigation, changing planting dates, using draught tolerant varieties, using early maturing varieties, soil conservation and tree planting. According to Dazé (2007) the following are coping strategies used in response to climate change: mixed farming, drought tolerant crops or varieties, control of soil erosion, planting and conservation of trees, planting of early or late maturing varieties, chemical fertilizer usage, land use intensification, agricultural diversification, extension of farming into marginal lands, cropping in moist valley bottoms, integration of trees in crops and keeping of livestock. Paul et al. (2008) reported that early planting has been identified as a major adaptive strategy, but some farmers, particularly households headed by females, cannot meet this challenge due to other demands on their labour. Adaptation strategies can be likened to insurance strategies. According to Davies (1996) in Van der Geest (2004) insurance strategies are those activities undertaken to reduce the likelihood of failure of primary production or avoid future livelihood stress and food shortage.

2.15 Food insecurity

FAO (2010) states that there are more than 925 million people suffering from chronic food hunger globally. Sub-Saharan Africa (SSA) has a bigger share of those facing hunger, that is, from 168 million in 2000 to more than 239 million by 2010. According to FASDEP (2003), the Ministry of Food and Agriculture’s operational definition of food security is “good quality nutritious food, hygienically packaged, attractively presented, available in sufficient quantities all year round and located at the right place at affordable prices”.

The World Bank (1986) defined food security as the "access by all people at all times to enough food for an active and healthy life". Again (FANTA, 2003) defined food security as the availability of food in the world market place and on the food production systems of developing countries. However, FANTA (2003) argues that, global food availability does not ensure food security in any particular country because what is available in the world market may not necessarily be accessible by famine affected people in developing countries, as their economies in general cannot generate the foreign currency needed to purchase food from the world market.Ojo (1997) cited in Ijaiya, Abdul Raheem, and Abdulllah, (2007:170) refers to food security as a situation in which majority of the populace have access to domestically produced food at affordable prices at all times. According to FAO (1996) and World submit (1996) availability, accessibility, utilization, and food systems stability are the four main components of food security. Food system is considered vulnerable when one or more of these components is insecure due to poverty, unavailability of employment, lack of education, increase in food prices, climate and environment conditions and poor access to market. There are four main dimensions of food security as shown in Table 2.2.

Table 2.2: Dimensions of food security

Physical **Availability** of food	Food availability addresses the "supply side" of food security and is determined by the level of food production, stock levels and net trade.
Economic and physical **Access** to food	An adequate supply of food at the national or international level does not, in itself guarantee household level food security.
Food **Utilization**	Utilization is the way the body makes the most of various nutrients in the food. Sufficient energy and nutrient intake by individuals is the result of good care and feeding practices, food preparation, diversity of the diet and intra-household distribution of food. Combined with good biological utilization of food consumed, this determines the *nutritional status* of individuals.
Stability of the other three dimensions over time.	Even if your food intake is adequate today, you are still considered to be food insecure if you have inadequate access to food on a periodic basis, risking a deterioration of your nutritional status. Adverse weather conditions, political instability, or economic factors (unemployment, rising food prices) may have an impact on your food security status.

Source: Adapted from World Food Summit, 1996

2.15.1 Impact of climate change on food security

According to Blessing et al. (2011) climate change is a contributory factor to high food price crisis, and its impacts on agriculture in developing countries is expected to be severe due to disease and pests outbreak which may put agricultural production at risk of being lost through the impact of climate change.

Again (Nyanteng and Asuming-Brepong (2003) and Quaye (2008) revealed that food security is perceived to be affected by externalities in terms of deterioration of environmental, social and other factors such as climatic variation, outbreak of diseases and pests, poor farm-to market roads and increases in non-food prices that pose threat to increase the cost of food production and distribution. Again Quaye (2008) reported that low income developing countries are more likely to experience a significant increase in food insecurity and famine due to climate change, which may affect: the physical availability of food by shifts in temperature and rainfall.

People's access to food will be lowered through reduced incomes from coastal fishing as a result of rising sea levels or foreign exchange earnings by the destruction of export crops caused by the rising frequency and intensity of tropical cyclones. The subsistence farmers experience adverse impact in relation to the production of food and to access marketed food, which makes them the most vulnerable to the food security crisis (Maxwell, 1992). FAO (2008) indicated that food system performance depended more on climate now than it did 200 years earlier and the possible impacts of climate change on food security had tended to be in locations where rain-fed agriculture was still the primary source of food and income.

2.15.2 Impact of climate change on food availability

Boko *et al.* (2007) state that climate change is expected to have adverse impact on agricultural production and food security in sub-Saharan Africa where agriculture is a vital economic activity and the main source of food and income for livelihoods. Whereas countries in the temperate, high-, and mid-latitude regions are likely to enjoy increased crop production, those in tropical and subtropical regions are likely to suffer losses as a result of climate change in coming decades Devereux and Edwards (as in cited Ziervogel et al.,2006).

Hassan and Nhemachena (2008) indicated that climate change is expected to affect food and water resources that are critical for livelihoods in Africa where majority of the population especially the poor, rely on local supply systems that are sensitive to climate variation. The IPCC (2009) indicated that rising temperatures, drought, floods, desertification and weather extremes severely affect agriculture, especially in the developing world. Abaje (2007) outlined the following; frequent floods, droughts, wide spread of crop pests and diseases, increased rural urban migration, reduced natural resources, decline in soil fertility, increased health risks, changes in vegetation type and livelihood systems, as the most severe adverse impacts of climate change in Africa. IPCC (2007) indicated that excessive precipitation can lead to disease infestation in crops, while too little can be detrimental to crop yield leading to low crop yield. Also Tschakert (2009) pointed to the reduction in yield for crop and livestock during unfavorable climatic changes such as floods and droughts, especially the 2007 flood in Ghana which led to loss of several lives and properties, food shortages, and was ranked as one of the three most devastating flood events in the world by the Dartmouth Flood Observatory. Ford and Smit (2004) revealed that it is vital to understand the actual dynamics of climatic change effects at the lowest levels of the society, such as households, communities and districts to enhance the relevancy of the top-down policy approaches. Figure 2.2 below indicates how the variability of climate can lead to food insecurity in farm households.

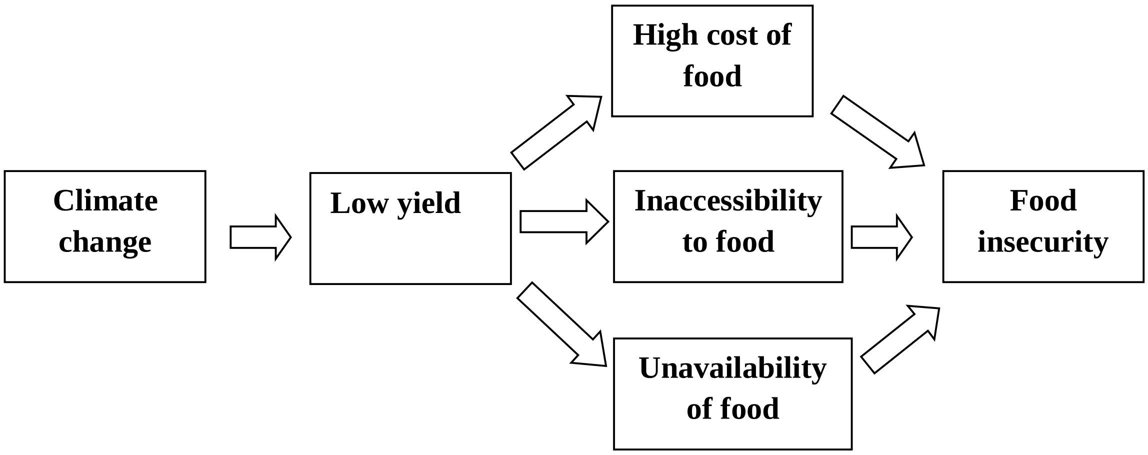

Figure: 2.2 Impact of climate change on food security

Source: Author's construct

2.15.3 Impact of climate change on food access

Ericksen et al. (2011) indicated that access to food is determined by physical and financial resources as well as social and political factors. Ringler, Zhu, Cai, Koo, and Wang (2010:P4) stated that, food access consists of affordability, allocation and preferences, because the physical availability of food is not sufficient for an individual to have access to food. They argued that food may be available in the market but some households may not be able to access it due to poverty, poor infrastructure, high prices, or the household may not prefer the type in the market. This is corroborated by Sen (1981) who indicated that famine can occur in spite of availability of food due to failure of entitlement by a group of people to food. Webb et al. (2006) also revealed that purchasing power which varies with market integration, price policies as well as temporal market condition is a key to food access. This is corroborated by IPCC (2001) in Ziervogel et al. (2006) that inefficient and ineffective transport systems retard the delivery of food and increase the price of food in several developing countries.

2.15.4 Impact of climate change on food utilization

The FAO (2010) refers food utilization as the individual or household ability to consume and benefit from food. Adequate food utilization is realized when "food is properly used, processed and storage techniques are employed, adequate knowledge of nutrition and child care techniques exists and is applied, and adequate health as well as sanitation services exist" (Ziervogel et al., 2006). Food utilization can be affected through loss ofnutrients during preparation or processing of food, cultural practices that may deny other people consumption of certain nutritious foods based on the values and, norms in certain families or communities and months of inadequate household food provision.

This can lead to reduction in both quality and quantity of meals resulting in malnutrition among children, and poor health issues among people at large. According to Negin, Reman, Karuti, and Fanzo (2009) food utilization is determined by food preparation, nutrition knowledge, access to clean drinking water, and women health care.

Citing IFAD (2007), Ijaiya et al. (2007:170) reveal that a household food security level would depend on how well this food was utilized. The utilization of food encompassed both preparation and storage. For instance, most rural households that produces their own food store food for at least a part of the lean season. In most case the storage facilities are exposed to some elements of climate especially rainfall and temperature resulting to substantial losses both in the quality and quantity of food. Also, women play a key role in proper utilization of food and a sudden illness of them due diseases and pests outbreak as a result of climate change can affect the food security of the population especially the smallholder farmers. Citing USAID (1992), Gina et al.(2006) revealed that adequate food utilization is realized when "food is properly used, proper food processing and storage techniques are employed, adequate knowledge of nutrition and child care techniques exists and is applied, and adequate health and sanitation services exist" Food utility involves how food is used.

2.16 Effects of climate variability on cereal crop production

Generally, climate regime is the most important climatic factor influencing crop production. This is because climate has the biggest effect in determining the crops that can be grown in different environments, the type of agricultural system to be practised in different parts of the world, the farming system, the sequence and timing of farming operations (Adejuwon, 2005; cited in Ayanlade and Orimoogunje, 2010 and Tunde et al., 2011).

In respect to the above, Tunde et al. (2011) and Fosu-Mensah (2012) have identified some important factors guiding rainfall in relation to crop production. According to them, the number of rainy days (the length of the rainy season), time of fall (onset) and total amount of fall, cessation and the type of soil are some of the important factors guiding rainfall in relation to crop production. Therefore, an interruption in the onset, length of the rainy season and cessation will affect soil moisture (soil moisture deficit and enhanced soil moisture), hence, crop development. According to Fosu-Mensah (2012), soil moisture deficit and also the timing of moisture deficits during growing seasons cause crop damage in stages of plant development. As such, water use for a given crop is a function of both the amount of water available to the crop and when that water is available relative to crop demand. On one hand, Rosenzweig et al. (2001) affirmed that enhanced soil moisture encourages the spread of nematodes and roundworms that inhabit water films or water-filled pore spaces in soils.

Moreover, increases in rainfall intensity in other regions could lead to higher rates of soil erosion, leaching of soil nutrients and agricultural pollutants, and runoff that carries soil and associated nutrients into surface water bodies leaving the soil impoverished to support plant growth (Kumar et al., 2004; cited in Gornall et al., 2010). If erosion and leaching of soil rates go unchecked, continued soil impoverishment would eventually force farmers to abandon their lands (Khan et al., 2009). From the foregoing, both direct and indirect effects of moisture stress make crops more vulnerable to damage by pests, especially in the early stages of their development. According to Cheke and Tratalos (2007 cited in Gornall et al., 2010), rainfall variability has the tendency to cause pest migration. A typical example is the migration pattern of locusts into Sub-Saharan Africa which Mowa and Lambi (2006) believe is influenced by variability in rainfall patterns. The migration of these locusts into Sub-Sahara Africa poses danger to food security and livelihoods in the region.

Historically, many of the largest declines in crop productivity have been attributed to sudden low precipitation events (Kumar et al., 2004 and Sivakumar et al., 2005 cited in Gornall et al., 2010). An open question is how susceptible food crop production might be to increased rainfall variability? Several studies have been carried out on specific crops in different parts of the world to reveal the situation on the ground. For example, according to Wheeler and Osbourne (2013), globally, between 1960 and 2009, rice yields declined significantly as a result of low rainfall. Consideration of the observed relationship between yield and climate suggests that the significant reduction in the variability of rainfall may have contributed to the reduction in rice yield. Similarly, recent analysis by Asha et al. (2012) in India also concluded that the yields of sorghum, maize, pigeon pea, groundnut, wheat and onion have decreased by up to 43.03, 14.09, 28.23, 34.09, 48.68 and 29.56 kilograms per hectare respectively. The decrease in the crops yield, according to sampled farmers is attributed to the reduction of rainfall.

Irrespective of the afore-stated studies, Cabas et al. (2010) are of the view that, with prolonged rainfall, some crops are likely to exhibit reduced yields while others will show improved yields. A case in point is a research carried out in Argentina which showed that during the last decades of the twentieth century, increases in the yield of summer crops were caused primarily by increases in precipitation (Magrin et al., 2005). In support of the above findings, Bradford et al. (2006) added that in wetter areas, warmer temperatures have less influence on water availability and can increase production by promoting longer growing seasons and faster photosynthetic rates. However, it is important to note that, minor changes in rainfall pattern during stages of crop production threaten crop productivity particularly if the rains fail to arrive during the crucial growing stage of the crops (Mowa and Lambi, 2006). Generally, at aggregated level as well as at the plot level, rainfall variability is a primary cause of inter annual yield variability (Thornton et al., 2014).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter provides a description of the study area, procedures that were followed during the selection of the study area, study population, sampling, questionnaire design and administration. The chapter ends by outlining how the data were collected and analyzed.

3.2.0 The Study Area

3.2.1 Location and Population

The Northern Region occupies an area of about 70,383 square kilometers and is the largest region in Ghana in terms of land area. It shares boundaries with the Upper East and the Upper West Regions to the north, the BrongAhafo and the Volta Regions to the south, and two neighbouring countries, the Republic of Togo to the east, and La Cote d'Ivoire to the west. The land is mostly low lying except in the north-eastern corner with the Gambaga scarp and along the western corridor. The region is drained by the Black and White Volta and their tributaries, Rivers Nasiaand Daka (GSS, 2012).

The current population of the Northern Region is estimated at 2,479,461 (GSS, 2012) and is varied in terms of ethnicity with Dagomba constituting the majority. The other ethinic groups include Gonja, Konkomba, Mamprusi, Akan and Hausa.The main religious groupings are Moslems, Christians and Traditionalists.Figure 3.1 is the map of the Northern Region indication the various districts.

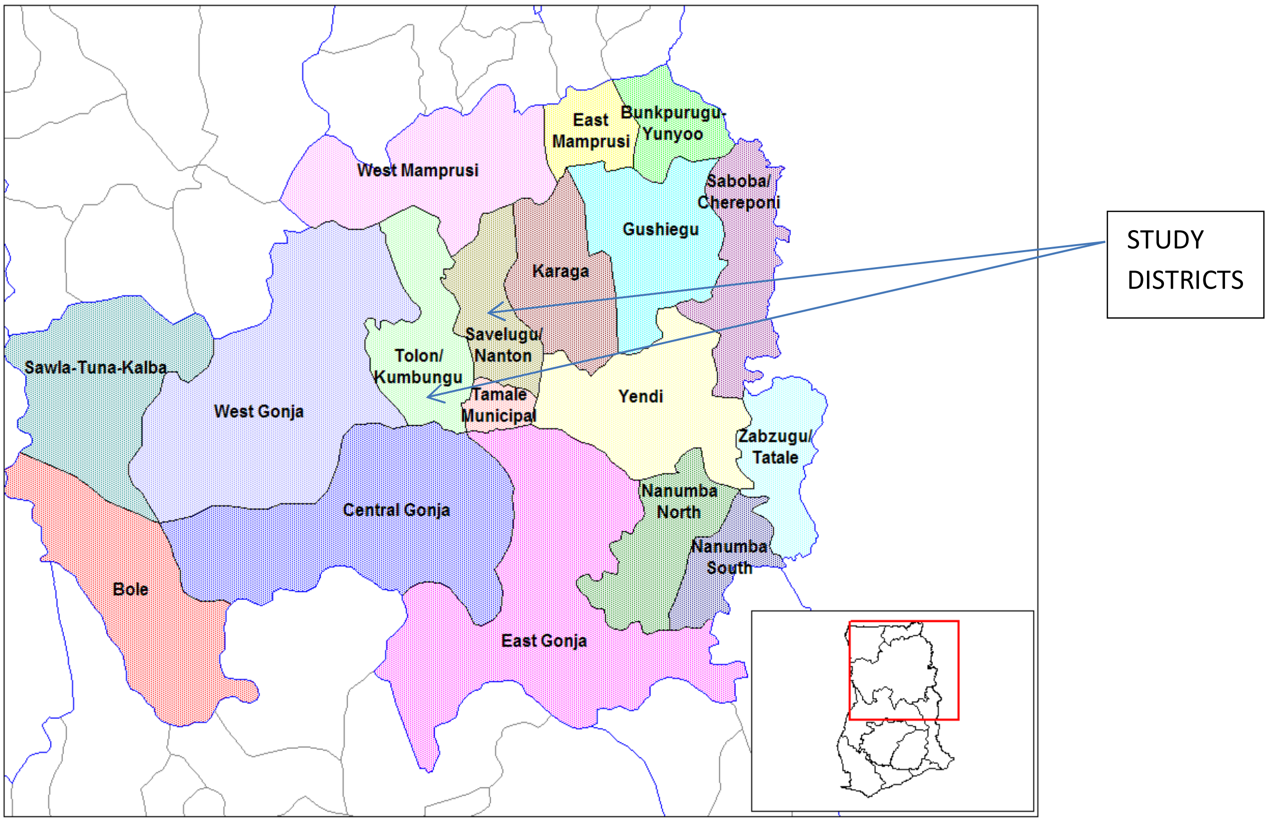

Fig. 3.1 Map of the Northern Region showing the study Districts

3.2.2 Climate and Vegetation

The climate of the region is relatively dry, with a single rainy season that begins in May and ends in October. The amount of rainfall recorded annually varies between 750 mm and 1050 mm. The dry season starts in November and ends in March/April with maximum temperatures occurring towards the end of the dry season (March-April) and minimum temperatures in December and January.

The harmattan winds, which occur during the months of December to early February, have considerable effect on the temperatures in the region, which may vary between 14°C at night and

40°C during the day. Humidity, however, which is very low, mitigates the effect of the daytime heat. The rather harsh climatic condition makes the cerebrospinal meningitis thrive, almost to endemic proportions, and adversely affects economic activity in the region.

The main vegetation is classified as vast areas of grassland, interspersed with the guinea savannah woodland, characterised by drought-resistant trees such as the acacia, baobab, shea, dawadawa, mango and neem (GSS, 2012).

3.2.3 Economic Characteristics

Agriculture is the main economic activities in the region. This accounts for the employment of 71.2 per cent of the economically active population, aged 15 years and older. Less than a tenth (7.0%) of the economically active people in the region are unemployed. The private informal sector absorbed 83.4 per cent of the economically active population. An additional 11.5 per cent are in the private formal sector leaving the public sector with only 4.3 per cent. majority, (40.5%) of the 251,221 the not economically active are homemakers and just under a quarter (24.4%) are students. those who are not working because of old age constitute14.8 per cent. a small proportion is not working because of disability (2.2%) or are pensioners who are on retirement (1.2%) while 16.9 percent are classified as others (GSS, 2012).

The main crops cultivated by households in the region are cereals (maize, millet, rice, and sorghum), legumes (soya bean, groundnut, cowpea, and pigeon pea), tubers (yam and cassava) and vegetables. Cash crops include cotton, tobacco, groundnut, cashew and soya bean. The main problems of crop production are unfavorable weather conditions (drought), erratic rainfall, perennial bushfires and declining soil fertility. Some of these problems are due to poor environmental management relating to inefficient farming practices and hunting for fuel wood and sheanuts (GSS, 2012).

3.3 Research Design

A research design is described as a plan, structure, and strategy for investigation so conceived as to obtain answers to research questions. It includes an outline of what the investigator will do from writing the hypotheses and their operational implications to the final analysis of data (Kerlinger, 1986) in (Kumar, 1996). According to Thyer (1993), traditional research design is described as a blueprint or detailed plan of how a research is to be completed- operationalizing variables so they can be measured, selecting a sample of interest to study, collecting data to be used as a basis for testing hypotheses, and analyzing the results. Bryman (2008) refers to research design as the framework for the collection and analysis of data. This study made use of the survey design.

According to Asante (2000) survey design is advantageous due to its flexibility and versatility, particularly in the early stage of an investigation. The survey design also requires minimal investment to develop and administer questionnaires, and is relatively easy for making generalizations. Twumasi (2001), posits that the questionnaire type used for personal interviews far out shadows the other instruments as the most powerful and useful tool of social scientific survey research. Babbie (1990) in Creswell (2008:12) states that survey design provides a quantitative or numeric description of trends, attitudes or opinions of a population by studying a sample of that population. Again Osuala (2005), says survey design is employed for studying various populations, both large and small, by selecting and studying samples chosen from the the population to ascertain the relationship between variables. The method is also agreed to be more realistic, as it investigates phenomenon in the natural setting. A survey design was thusdeemed necessary and useful in this study to determine the effects of climate change coping and adaptation strategies on food security among smallholder maize farmers.

3.4 Study Population

The study population was made up of all smallholder maize farmers in the selected districts, Tolon District and Savelugu/Nanton Municipal.

3.5 Sampling Techniques and Sampling Size

Purposive sampling technique was used to select two districts in the Northern Region since preliminary studies from the Association of Church Development Projects (ACDEP) food security intervention project in the Northern region reveals that, the majority of the smallholder maize farmers are found in these two districts (Armah, 2010).

Preston (2002), indicated that applying purposive sampling can yield insights and in-depth understanding rather than empirical generalizations. In this study, the researcher purposively selected the Tolon District and Savelugu Municipality of the Northern Region to constitute the sample districts based on the fact that majority of smallholder maize farmers under the ACDEP food security intervention programme were found in these two districts. The judgment of the researcher therefore, played an important role in this sampling technique.

Secondly, in the districts, eight (8) communities out of fifty-six (56) were randomly selected for the study using a simple random sampling technique. The population size of maize farmers in these 8 maize farming communities is about 856 farmers (Armah, 2010). Thirty (30) smallholder maize farmers were randomly selected from each community for the study. A total of two hundred and forty (240) farmers were therefore selected from the eight (8) communities for the research.

Eight (8) focus group discussion (FGD) were conducted with ten (10) smallholder maize farmers each. This was to enable the researcher acquire more insight on the effects of climate change on food security among smallholder maize farmers.

3.6 Methods of Data Collection

It is useful for the researcher to use more than one method in data collection. The methods were selected to complement each other and to allow for triangulation. Triangulation "reflects an attempt to secure an in-depth understanding of the phenomenon in question. It is a strategy that adds rigor, breadth, complexity, richness and depth to any inquiry" (Denzin and Lincoln, 2000). In the light of this, primary data were elicited by means of questionnaire, focus group discussions and interviews with other stakeholders in the farming communities.

The questionnaires for maize farmers for the objectives of the study was validated and pre-tested for consistency, clarity of questions in order to avoid duplications. Issues that came up during the pre-testing were used to refine the questionnaires. The use of the questionnaire and interviews as instruments for data collection in a survey is underscored by Dooley (2003) and Trochim (2006).

Apart from the primary data, the study also relied on secondary data obtained from Ghana Meteorological Service, Ghana Statistical Service, Ministry of Food and Agriculture and Association of Churches Development Projects (ACDEP).

Focus group discussions of maize farmers were employed in data collection. A "focus group discussion is a planned, facilitated discussion among a small group of stakeholders designed to obtain perceptions in a defined area of interest in a permissive, non-threatening environment" (Campbell, 2008). According to Millar and Apusigah (2004), a focus group discussion demands a focus on a subject area, interest groups, the use of the experiences and/or opinions of group members, and the generation of intense debates on the area of focus. A focus group typically consists of 6-10 people drawn from a population that the researcher is interested in.

To allow for perfect interaction, homogenous groups are recommended in focus group discussions. Open-ended questions and checklists are used to guide the discussions, taking notes and recordings of the session so that the information could be analyzed later (Campbell, 2008).

Ten (10) smallholder maize farmers within the selected communities were constituted separately to elicit in-depth information on the effects of climate change on their production levels as well as on food security. The FGDs were conducted using a checklist. Ideas, issues, interpretations and the content of the discussion were analyzed by looking at the trends and patterns within and among the various groups. Interviews were also conducted for key stakeholders in the farming communities who provided detailed information and opinion based on their knowledge of a particular issue.

3.7 Method of Data Analysis

Data was analysed with the aid of the Statistical Package for Social Science (SPSS) version 20.

Objective 1 sought to determine the perceived level of climate change among smallholder maize farmers in the Northern Region.

The likert-scale was used to rate the level of perception of climate change among smallholder maize farmers in the Tolon district and the Savelugu municipal. The likert scale is a research tool which is often used to measure respondents' opinions or perceptions by asking the extent to which they agree or disagree with a particular question or statement. The scale had the following response categories: Strongly Disagree = 5, Disagree =4, somewhat agree = 3, Agree = 2, Strongly Agree = 1. The mean score by the respondents indicated the overall level of agreement for each statement under consideration. The data were analysed using means, standard deviations and one-sample t-test. For instance, a mean score between 1.00 and 1.50 would indicate that the respondents strongly-disagreed on the variable under consideration and a mean score between 4.50 and 5.00 would indicate that the respondents strongly-agreed on the variable concerned.

Objective 2 sought to identify the climate change coping and adaptation strategies among smallholder maize farmers in the Tolon district and Savelugu municipal. Descriptive statistics; frequencies and percentages were employed in the analysis of this objective. The climate change coping and adaptation strategies were identified and ranked among the smallholder maize farmers in the Tolon district and the Savelugu municipal.

Objective 3 dealt with the determination of the effects of coping and adaptation strategies on food security among smallholder maize farmers in the Tolon district and Savelugu municipal. Here again, simple descriptive statistics, frequencies and percentages were employed in the analysis of this objective. The output was presented in the form of graphs, figures and tables.

Objective 4 sought to examine the challenges farmers face in coping and adapting to climate change. This objective was analysed by using the Kendall's coefficient of concordance. This is because the Kendall's coefficient of concordance (W) is a measure of agreement among several judges (n) assessing a given set of objects (p) (Legendre, 2005). The index makes it possible to find the sum of the ranks for each challenge being ranked. The Kendall's coefficient of concordance is given by the relation:

$$W = 12S\,[(m^2\,(n^3 - n)]^{-1}$$

Where, W = Kendall's concordance, S = sum of deviation, m = number of ranks, n = number of challenges.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and discussions of the study. It is divided into five sections in line with the study objectives as follows: section 1 deals with the demographic characteristics of the respondents; section 2 is concerned with the level of awareness of climate change among smallholder maize farmers ; section 3 presents the identification of climate change coping and adaptation strategies; section 4 seeks to determine the effects of climate change coping and adaptation strategies on food security among smallholder maize farmers; and section 5 presents the challenges farmers face in coping with and adapting to climate change.

4.2 Socio-Demographic Characteristics of Respondents

This section discusses the demographic characteristics of the respondents. It includes respondents' sex, age, marital status, educational qualification and household size.

4.2.1 Sex of respondents

The results of the survey show that male respondents constituted 80.8% and female respondents were also 19.2% of the sampled population as indicated in Table 4.1.

The unequal distribution of the sexes in the sample is because fewer females get into the cultivation of their own maize farm and agriculture production as a whole (GSS, 2012).. Females perform most of the farm activities in maize production although they are not direct owners of the farms due to the fact that male farmers have greater access to farm land and other production resources than the females.

Table 4.1: Sex of Respondents

Sex	Frequency	Percent
Male	194	80.8
Female	46	19.2
Total	240	100.0

Source: Field survey, September, 2015.

This finding agrees with Buyinza and Wambede (2006) who found out that male-headed households are relatively flexible in search of improved crop varieties and in a better position to pull their labor force in order to adapt improved crop varieties and crop diversification. The other possible reason for this is that much of the farming activities are done by male while female are more involved in the processing, this gives male smallholder maize farmers an edge in terms of farming experience and information on various adaptation strategies and what is needed to be done in response to the climatic instability.

Again, the findings agree with that of Deressa *et al.* (2008) who indicated that male-headed households are found to be more likely to adapt to climate change given that men do much of the agricultural work as compared to their females counterparts, and therefore are more likely to obtain information about new technologies, and to take greater risks than female-headed households.

4.2.2 Age Distribution of Respondents

Age is very important in determining the productivity of labour force. From Table 4.2, the modal age class is 36-45 representing 36.2% of the respondents, followed by 26-35 age group (33.3%), 46-55 (14.6%), and 15-25 (8.8). The age group above 55 years recorded the least percentage (7.1%). This shows that the number of farmers who engage in maize production decline progressively towards higher age. This finding suggests that, maize production is dominated by the farmers between the ages of 26 and 45. Together, the two age groups account for 69.5% of the respondents. Up to 55 years gives 84.1%. These age brackets normally constitute the economically active group. It is therefore not surprising that they constitute the majority of farmers engaged in maize production.

Table 4.2: Age distribution of Respondents

Age	Frequency	Percent
15-25	21	8.8
26-35	80	33.3
36-45	87	36.2
46-55	35	14.6
Above 55	17	7.1
Total	240	100.0

Source: Field survey, September, 2015.

The reason is that the youths are very energetic, ready to take risk, active and passionate as far as commercial maize production and adoption of new technologies are concerned. Significantly, the youth are the future farmers who are to carry on farming as a profession for sustainable food production in the nation.

In their view, Arokoyo and Auta (1992) suggested that it is only the youth which they described as energetic, creative, innovative, productive and committed workforce that can bring expected development in agriculture.

This finding is also in line with the findings of Dolisca et al. (2006) who found out that age is significantly and negatively related to farmers' decisions to adopt soil and water conservation and forestry management programmes respectively. This implies that as farmers get older, they are less inclined to adopt technologies when compared to the relatively young farmers. This is as a result of the strenuous nature of the activities involved in the implementation of technologies that enable farmers adapt to climate change/variability.

4.2.3 Marital Status of respondents

Table 4.3 shows the marital status composition of the respondents in the study area. Majority of the respondents (87.5%) were married while 9.2% were single, 2.5% divorced and 0.8% were widowed. Marriage is recognized by society as a union of man and woman and their families for the purpose of procreation, mutual support and companionship.

The fact that majority of the respondents are married is indicative of the likelihood that labour will be available for carrying out adaptation strategies that will enable the family to survive the effects of climate change on food security.

Table 4.3: Marital status of Respondents

Marital Status	Frequency	Percent
single	22	9.2
married	210	87.5
divorced	6	2.5
widowed	2	.8
Total	240	100.0

Source: Field survey, September, 2015.

4.2.4 Household Size of respondents

From the results in Table 4.4 below, 56.2% of the respondents had a fairly large family size of 7-14, followed by 24.6% with a family size above 14 and 19.2% had between 3-6 members. The large family size constitutes a ready source of family labour which most of the respondents rely upon in carrying out certain tasks in maize production and processing. Deressa *et al.* (2008), asserts that larger household or family size influences the adoption of climate change adaptation strategies positively and significantly in food production.

Table 4.4: Household size of Respondents

Household Size	Frequency	Percent
3-6	46	19.2
7-14	135	56.2
above 14	59	24.6
Total	240	100.0

Source: Field survey, September, 2015.

4.2.5 Level of Education

Education plays a significant role in the status and knowledge of an individual. From Table 4.5, 86.2% of the respondents, had no formal education, while the remaining 13.8% achieved formal education up to Senior High School (SHS). According to Deressa, Hassan, Alemu, Yesuf and Ringler (2008), Nkonya et. al. (1997) and Maddison (2006) the level of education of a farmers has a positive influence on the adoption of agricultural technologies and climate change adaptation decision. For instance, higher level of education is associated with greater access to information on climate change, improved technologies, and higher productivity of the farmers because education increases climate change awareness and the likelihood of soil conservation and changing planting dates as an adaptation method **.**The expectation is that the literacy level of the farmer significantly influences adoption decision on certain climate change adaptation strategies as reported by Maddison (2006) and Nti (2008).

Table 4.5: Level of education of Respondents

Level of education	Frequency	Percent
formal	33	13.8
no formal	207	86.2
Total	240	100.0

Source: Field survey, September, 2015.

4.2.6 Farm size of respondents

From the results in Table 4.6, 52.9% of the respondents had a fairly small farm size of 2-5 hectares, followed by 40.8% with a fairly large farm size between 6-10 hectares and 6.3% had less than 2 hectares. Since majority of the farmers have small farm size, it therefore suggest that very few lands would be allocated for adaptation strategies.

Table 4.6: Farm size of Respondents

Farm size	Frequency	Percent
less than 2	15	6.2
2-5	127	52.9
6-10	98	40.8
Total	240	100.0

Source: Field survey, September, 2015.

4.3 Level of awareness of climate change among smallholder maize farmers.

Respondents were asked to indicate their level of awareness of climate change in their area on a five point likert-scale. The results are presented in Table 4.7.

Table 4.7: Level of awareness of climate change among smallholder farmers

Statements	Mean	SD	t
Rainfall starts early and end late	**3.96**	**1.09**	**56.10*****
Rainfall starts late and ends early	**2.25**	**1.32**	**26.29*****
We experience long dry season during cropping season	**1.83**	**0.77**	**36.75*****
We now witness excessive rainfall	**3.4**	**1.17**	**45.17*****
We now witness high temperatures	**1.84**	**0.92**	**31.07*****
There is increased frequency of drought	**1.74**	**0.72**	**37.59*****
The rainfall amount is decreasing in the rainy season	**1.64**	**0.60**	**42.11*****
Seasonal flooding is now on the increase	**3.25**	**1.31**	**38.61*****
There is increase in pest and diseases on crops and animals	**1.59**	**0.89**	**27.72*****
Bush/wildfires is now on the increase	**1.50**	**0.68**	**34.04*****
We now witness reduction in crop yield	**1.28**	**0.47**	**41.61*****
Soil fertility is low	**1.35**	**0.58**	**36.01*****
Rainy season is becoming shorter	**1.60**	**0.55**	**44.85*****
Dry season is becoming longer	**1.50**	**0.52**	**45.03*****

Many of our rivers and streams are dried up	**1.92**	**0.68**	**43.57*****
Some of our wells and boreholes become dry during the season	**1.95**	**0.64**	**47.16*****
Hammatan is not as cold as it used to be in the past	**1.65**	**0.57**	**44.57*****
The heat period is longer than before	**1.63**	**0.54**	**46.43*****
It is more difficult now to predict when the rains will start	**1.29**	**0.51**	**39.43*****
Mean of Means	**1.97**	**0.76**	

Source: Field survey, 2015

Scale: 1 = Strongly Agree; 2 = Agree; 3 = Somewhat Agree; 4 = Disagree 5 = Strongly Disagree; SD= standard deviation; *df = 239* ***, ** and * represent significance at 1%, 5% and 10% respectively.

The results in Table 4.7 show that generally smallholder farmers are fully aware of the changing climate in their area. This is seen from the mean of means value of 1.97, (approximately 2.0) with an SD = 0.76, which corresponds to the "Agree" response category on the scale. This means that the respondents agree that they are aware of the change in climate in their various localities. The mean values range from 1.28 with SD = 0.47 (farmers now witness reduction in crop yield) to 3.96 with SD = 1.09 (rainfall starts early and ends late).This implies that the most pervasive indicator of the level of awareness of climate change among the smallholder farmers is the reduction in crop yield and the least indicator is that, the rainfall starts early and ends late. A mean value of 3.96 for rainfall starts early and ends late is approximately 4.00 and is equivalent to "Disagree" on the scale. Reduction in crop yield with a mean of 1.28, which is approximately 1.00 is equivalent to "strongly agree" on the scale.

The results further indicate that the following are indicative of the level of awareness of climate change among smallholder farmers: "soil fertility is low" (1.35, SD = 0.58), "dry season is becoming longer" (1.50; SD = 0.52), "rainy season is becoming shorter" (1.60, SD = 0.55), "increase in pest and diseases" (1.59, SD =0.89), "the heat period is longer than before" (1.63,SD =0.54), "we now witness high temperatures" (1.84, SD = 0.92), "increase frequency of drought" (1.74, SD = 0.72) and "rainfall amount decreasing in the rainy season" (1.64, SD = 0.60). The mean values for all these indicators correspond to the "Agree" response category on the scale. The respondents were not sure/neutral to the indicator that they witness excessive rainfall (3.4, SD = 1.17). This means that farmers were unable to use excessive rainfall to state their level of awareness of climate change. On the contrary, the remaining indicator recorded a mean value of approximately 4.00, meaning that they disagree with the statement that rainfall starts early and ends late.

All the perceptive statements were subjected to a one-sample t-test to determine if the responses vary from the mean score. All the statements had t-values thatwere statistically significant at 1% level. Hence all the responses to statements from the sample were representative of the population's perceptions regarding climate change situation in the area. The results of the t-test are also presented in Table 4.7.

Maddison (2006), found out that farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making and the overall increase in crop yield. This is in line with the findings that the most pervasive indicator of the level of awareness of climate change is reduction in crop yield

This study is also in line with Lobell et al,(2010) who found out that changes in the agriculturally-relevant variables of climate (example increasing temperatures and declining levels and distribution of rainfall) are likely to reduce the yield of maize, rice, wheat and other food crops in the semi-arid regions of the world.

4.4 Climate change adaptation strategies among smallholder farmers.

Table 4.8 presents the results of adaptation strategies adopted by respondents in response to the effects of climate change.

All the adaptation strategies statements were subjected to a one-sample t-test to determine if the responses vary from the mean score. All the statements had t-values that were statistically significant at 1% level. Hence all the responses to statements from the sample were representative of the population's adaptation strategies regarding climate change situation in the area. The results of the t-test are presented in Table 4.8.

The mean of means value of 2.65, (approximately 3.0) with SD = 0.99 as indicated in Table 4.8 above, corresponds to the "Somewhat Agree" response category on the scale. This means that smallholder farmers are of the view that to a certain extent they have adopted some adaptation strategies to help them deal with the effects of climate change.

The mean values range from 1.47, SD = 0.81 (farmers now use fertilizer and pesticides) to 4.18, SD = 0.89 (farmers resort to dry seasons gardening to supplement their main farming season).This implies that, the adaptation strategy employed by most smallholder farmers is "the use of fertilizer and pesticides" and the least adaptation strategy used by farmers is "farmers resort to dry season to supplement their main farming season". A mean value of 4.18 is approximately 4.00 and is equivalent to "Disagree" on the scale. They resort to the use of fertilizer and pesticides as the most adapted strategy is not out of place because the farmers have already agreed to the fact that climate change has led to increase in pest and disease infestation on crops and animals.

The results further indicate that the following adaptation strategies have been adopted by farmers in response to climate change/variability: planting crops late (1.97, SD = 0.84), use of fertilizer and pesticides (1.47; SD = 0.81), farmers change their planting date (2.01, SD = 0.91), smallholder farmers migrate to urban areas (2.02; SD = 0.86), practicing mixed cropping (1.54, SD = 0.76) and planting different crop varieties (1.71, SD = 0.54). The mean values for all these strategies correspond to the "Agree" response category on the scale. The respondents "Somewhat Agree" with the fact that they now farm along river banks (3.30, SD = 1.17), use of soil and water conservation practices (2.69, SD =1.31), household practice land rotation (3.30, SD = 1.30) and household resort to planting cash crops (3.17, SD = 1.33). This means that they resort to these strategies to a lesser extent. The remaining adaptation strategies recorded mean values of approximately 4.00. This implies that, they disagree with these adaptation strategies and therefore do not use them in response to climate change or variability.

IPCC (2007) asserts that adaptation measures help farmers guard against losses due to increasing temperatures and decreasing precipitation. The findings of this study are in line with those of Temesgen, Deressa, Rashid, Hassan, and Ringler (2008) who reported that farmers employed the following adaptation measures mixed cropping, tree planting, soil conservation, early and late planting, and use of irrigation in response to climate change.

Paul et al. (2008) reported that early planting has been identified as a major adaptive strategy, but some farmers, particularly households headed by females, cannot meet this strategy due to other demands on their labour.

Uddin, Bokelmann and Entsminger (2014) also identified crop diversification, crop rotation, cultivating short duration crops, use of drought tolerant varieties, engagement in non-farm activities and soil conservation practices as some of the strategies farmers in Bangladesh have adopted towards climate change.

Table 4.8: Adaptation strategies used by respondents in response to climate change

Strategy	Mean	SD	Mode	t
Smallholder farmers now plant different crops.	1.72	0.54	2	49.32***
Smallholder farmers implement soil conservation techniques.	2.69	1.31	4	31.78***
Farmers have now began to irrigate their farms more.	3.82	0.88	4	64.06***
Farmers now change their planting dates.	2.01	0.91	2	34.01***
Smallholder farmers now practice mixed cropping.	1.54	0.76	1	31.25***
Households have resorted to land rotation.	3.30	1.30	4	39.33***
Household have resorted to planting leguminous trees on farms.	2.56	1.16	2	34.25***
Smallholder farmers migrate to urban areas.	2.02	0.86	2	36.59***
Smallholder farmers now plant at river banks.	3.30	1.17	4	40.94***
Households now use fertilizers and pesticides.	1.47	0.81	1	28.22***
Household resort to planting cash crops.	3.17	1.33	2	36.86***
Households have resorted to dry season gardening to supplement the main season farming.	4.18	0.89	4	72.32***
Mean of Means	2.65	0.99	2.65	

Source: Field survey, 2015

Scale: 1 = Strongly Agree; 2 = Agree; 3 = Somewhat Agree; 4 = Disagree; 5 = Strongly Disagree; SD= standard deviation; *df = 239;* ***, ** and * represent significance at 1%, 5% and 10% respectively

4.5 Climate change coping strategies among smallholder farmers.

Table 4.9 presents the results of coping strategies adopted by respondents in response to the effects of climate change. The perceptive statements on coping strategies adopted by farmers were subjected to a one-sample t-test to determine if the responses vary from the mean score. All the statements had t-values thatwere statistically significant at 1% level. Hence all the responses to statements from the sample were representative of the population's perceptions regarding coping strategies adopted by respondents in the area. The results of the t-test are also presented in Table 4.9.

The mean of means value of 2.24, (approximately 2.0) with SD = 1.13 as indicated in Table 4.9, corresponds to the "Agree" response category on the scale. This means that smallholder farmers are of the views that, they have adopted some coping strategies to help them deal with the effects of climate change.

The mean values range from 1.74, SD = 0.76 (reduction in household expenditure on other household needs in order to purchase food) to 2.20, SD = 1.15 (smallholder farmers resort to the use of buffer stock for food).This implies that, the most used coping strategy by smallholder farmers is "reduction in household expenditure on other household needs in order to purchase food" and the least used coping strategy by farmers is "smallholder farmers resort to the use of buffer stock for food". A mean value of 2.50 for "smallholder farmers resort to the use of buffer stock for food" is approximately 3.00 and is equivalent to "somewhat agree" on the scale.

Reduction in household expenditure on other household needs in order to purchase food, as a coping strategy has a mean of approximately 2.00 and is equivalent to "agree" on the scale.

This research finding is in line with those of Arun (2006) and Richard (2009) who found out that the most important seasonal coping strategies include choice of cropping pattern to spread risks involving mixed cropping, off-farm income earnings, selling productive assets, constricting food- intake and migration.

Tony (2009) also asserts that the use of common property resources, changes in consumption pattern, share-rearing of livestock and mutual support networks are some of the coping strategies of climate change.

Table 4.9: coping strategies used by respondents in response to climate change

Strategy	Mean	SD	Mode	t
Smallholder farmers resort to sale of fuel wood.	2.18	1.04	2	32.43***
Smallholder farmers reduce the quantity of food eaten.	2.44	1.63	2	23.13***
Farmers reduce the number of times they eat in a day.	2.39	1.42	2	26.17***
Farmers now engage in daily work like construction for cash.	2.31	0.96	2	37.38***
Smallholder farmers engage in micro enterprise activities.	2.41	0.79	2	47.09***
Reduction in household expenditure on other household needs.	1.78	0.76	2	36.36***
Farmers resort to sale of household assets.	1.95	0.83	2	36.27***
Farmers now receiving remittances from family and friends to meet household needs.	2.33	1.69	2	21.44***
Smallholder farmers embark on urban migration to seek for job opportunity.	2.01	0.97	2	31.99***
Smallholder farmers now minimize the number of meals consumed per day.	2.09	0.97	2	33.32***
Farmers embark on seasonal migration to neighbouring community during peak season.	2.41	1.00	2	37.28***
Smallholder farmers now diversify their livelihood.	2.35	1.49	2	24.47***
Smallholder farmers resort to the use of buffer stock for food.	2.50	1.15	2	33.68***
Mean of Means	2.24	1.13	2	

Source: Field survey, 2015

Scale: 1 = Strongly Agree; 2 = Agree; 3 = Somewhat Agree; 4 = Disagree; 5 = Strongly Disagree; SD= standard deviation; *df = 239;* ***, ** and * represent significance at 1%, 5% and 10% respectively

4.6 Perceived effects of climate change on food security among smallholder maize farmers.

In this section, the study examined the effect of climate change on food security among smallholder farmers and the results are shown in Table 4.10.

Table 4.10 Effects of climate change on food security among smallholder farmers.

Indicators of food security in the last 12 months	Mean	SD	Mode	t
We always have enough to eat.	3.15	1.25	4	39.19***
We always eat the kinds of food we want.	3.38	1.09	4	47.81***
Sometimes we don't have enough food to eat.	2.16	1.17	2	28.74***
Household sometimes worried about my food running out in the last 12 months	1.86	0.71	2	40.43***
We were unable to eat the food we like in the last 12 months	2.46	1.08	2	35.27***
We have been missing a number of meals per day in the last 12	2.46	1.02	2	34.26***
My household couldn't afford to eat a balance (good quality) meal in the last 12 months	2.11	0.91	2	35.78***
My household relied on low cost food to feed children since there was no money to prepare quality food	2.12	1.54	2	21.21***
The children were not eating enough in the last 12 months.	2.72	1.20	2	35.02***
The household reduced the quantity of food serve because there was no money to buy food.	2.08	0.89	2	35.98***

The household reduced the number of times we ate in a day because there was no money to buy food.	**2.36**	**1.21**	**2**	**30.35*** **
In the last 12 months, household ate less than they should have eaten.	**2.51**	**1.31**	**2**	**29.79*** **
Household could not afford to eat some meals in the last 12 months	**3.44**	**1.33**	**4**	**40.12*** **
There were times that my household never had food to eat in the last 12 months.	**3.57**	**1.24**	**4**	**44.83*** **
Mean of Means	**2.71**	**1.26**	**2.75**	

Source: Field survey, 2015

Scale: 1 = Strongly Agree; 2 = Agree; 3 = Somewhat Agree; 4 = Disagree; 5 = Strongly Disagree; SD= standard deviation; *df = 239;* ***, ** and * represent significance at 1%, 5% and 10% respectively

Perceptive statements on the effects of climate change on farmers' household food security were subjected to a one-sample t-test to determine if the responses vary from the mean score. All the statements had t-values thatwere statistically significant at 1% level. Hence all the responses to statements from the sample were representative of the population's perceptions regarding effects of climate change on farmers' household food security. The results of the t-test are presented in table 4.10.

The results in Table 4.10 show that generally respondents agree to some extent that climate change has had an effect on food security of smallholder maize farmers in the study area. This is indicated by the mean of means value of 2.71 with a standard deviation of 1.26.

The 2.71 corresponds to the "somewhat Agree" category on the response scale. The two most important effects of climate variability on food security are "household sometimes worried about food running out" (1.84, SD = 0.71) and "household reduce the quantity of food served because there was no money to buy food" (2.08, SD = 0.89). Ten of the indicators of food security, have modal score of 2 each. These modal values are equivalent to the "Agree" response category on the scale. The respondents disagree with six of the indicators of climate variability effect on food security. The modal values of 4 correspond to the "Disagree" response category on the response scale. This implies that, smallholder farmers inability to accept the indicators that they always have enough food to eat, they always eat the kind of food they want and they often have enough food to eat shows that climate variability was having adverse effects on their food security.

These findings are consistent with the observations made by McConnell and Moran (2000) that the acquisition of food for marginal groups often entails a delicate balance of producing food for the household under stressed conditions while at the same time drawing on social and economic resources to access available food.

The findings of this research are also in line with that of Turner et al. (2006) which says that climate change and increasing population contributes to water scarcity and its availability for productive uses thereby making smallholder farmers vulnerable to food insecurity.

4.7 Challenges smallholder farmers face in coping with and adapting to climate change.

The fourth objective of this study was to identify the challenges facing smallholder maize farmers in coping with and adapting to climate change. This was achieved by seeking the views of smallholder maize farmers regarding the challenges they are facing in trying to cope with and adapt to climate change.

The Kendall's Coefficient of Concordance (W) was used to test for the agreement or association between sets of rankings provided by smallholder farmers. It measures the degree of agreement on a zero to one scale, the larger its value, the greater the agreement in the rankings. Among these challenges were lack of financial resources, inadequate subsidies, late supply of inputs, high cost of irrigation facilities, inadequate information or extension services and limited understanding of the nature or consequences of climate change. These rankings were used to obtain the W between the judges (farmers). The challenges were ranked on a scale of 1 to 12, with 1 being the most important challenge and 12 the least important. The order in which farmers ranked the challenges is shown in the Table 4.11.

Table 4.11: Identification of farmers' Challenges

CHALLENGE	STD. DEVIATION	MEAN RANK	RANK POSITION
Inadeq. Credit facilities	1.81	2.27	1st
High cost of inputs	2.51	4.52	2nd
Inadeq. support	3.08	5.04	3rd
Inadequate land	2.99	5.78	4th
Late supply of inputs	2.48	6.25	5th
Limited understanding.	3.21	6.31	6th
Poor infrastructure	2.78	6.44	7th
Inadequate extension	2.54	7.06	8th
Poor health status	3.91	7.58	9th
Dif. Innovation applicatn	2.77	7.70	10th
High cost of irrigation	4.07	8.60	11th
Belief system	2.29	10.44	12th

Sample size = 240, Kendall's W = 0.332, Chi-Square = 876.010, Df =11 and

Asymp. Sig. = 0.000

Sources: Field Survey

The results show that smallholder farmers are challenged in their quest to cope with and adapt to climate change. It was observed that inadequate credit facilities was the number one challenge to smallholder farmers in their bid to achieving higher crop yield as a result of coping and adapting to climate change. This came to light when it was realised that almost all the respondents contacted ranked it as the number one challenge confronting farmers in seeking to cope with or adapt to climate change in the study area. The estimated W was 0.332, chi-square statistics as 876.010 with 11 degree of freedom and asymptotic significance of 0.000. the chi-square critical obtained from the chi-square table was 19.7 at 5% level of significance. Thus, the estimated W of 0.332 indicates that, there is 33.2% agreement among the rankings of the challenges. The results show that smallholder maize farmers are challenged in their quest to achieve higher production yields as a result of climate change. It was observed that lack of credit remains a major challenge to smallholder farmers in their bid to achieve higher crop yield.

This finding agrees with IPCC (2007) cited in Mudombi (2011) that the most significant challenge that hinders smallholder farmers in coping with and adapting to climate variation is lack of financial support. Whether farmers' economic conditions are expressed in terms of economic assets, capital resources or financial means, they are clearly a determinant of adaptive capacity. The employment of adaptive strategies at the farm level through technological advancement and even local knowledge involves money. However, since poor communities are mostly financially incapacitated, they lack the empowerment to adapt, which keeps them in a more vulnerable situation (Mudombi, 2011).

The findings also agree with Ngigi (2009) who found out that it is extremely important that smallholder farmers are given the needed financial empowerment in order that they can cope with and adapt to climate variability.

In addition, Valdivia et al. (2003) recognised the importance of distance to markets, availability of extension advice (information), inadequate subsidies and tenure systems as some of the major challenges that determine farmers' ability to cope with and adapt to the changing climate. The findings are also in line with Bryman et al. (2013) who found out that in Kenya, access to irrigational facility is a major determining factor that influences farmers' strategy of changing crop types to cope with and adapt to the changing climate. This implies that, farmers would change the type of crops grown when the particular crop of interest requires irrigation. Beside irrigation are factors like having access to social safety nets (food emergency reliefs, food subsidies or other farm supports); access to extension services and availability of climate information.

The second limiting factor faced by smallholder farmers in coping and adapting to climate change is the high cost of inputs. Maize farmers cannot acquire inputs and equipment such as certied seeds, fertilizers, herbicides, tarpaulins and weighing scales due to high cost involved. This result in low yields, poor quality of grains and low prices of produce.

The subsidised fertilizer is not only expensive to the farmers but it is not readily available throughout the season because they are given on quota basis. According to the farmers the subsidised fertilizer is only available in thr rainy season. That means, maize farmers who have access to irrigation facilities and are willing to go into dry season farming would have to purchase the fertilizer at commercial price. This means that, they would run at loss.

This finding is suppoted by Emongor et al (2009) in which they found that at the producer level, rice production requires intensive use of farm inputs such as labour, fertiler and seeds which most farmers were not using optimally because of high costs involved.

These findings are again supported by Arror (2010) in his analysis of maize value chain in the northern Ghana which showed that, high cost of inputs is a limiting constraint faced by smallholder maize farmers in the supply chain for value addition. His study further revealed that maizw farmers cannot acquire inputs and equipment such as improved seeds and fertilizers due to high cost.

The third most limiting challenge hindering smallholder maize farmers coping and adaptation to climate change is lack of support. This means that farmers who receive support (either in kind or in cash) from public or private organisations are more likely to adopt climate change adaptation strategies than their counterparts who do not receive any support.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the findings of the study, conclusions, policy recommendations and suggestions for future research.

5.2 Summary

Climate change in Ghana has become a threat to the livelihood of smallholder farmers. The climate change impact in the Northern part of Ghana results in severe drought, severe floods, high temperatures, influx of pest and diseases which adversely affects human life and property. The smallholder maize farmer whose entire livelihood is dependent on natural resources has to face the effects of climate change. Therefore the coping and adaptation strategies of smallholder farmers in the agriculture sector are imperative to protect the livelihood of smallholder farmers in order to ensure their food security. It is in the light of this that, the study seeks to assess the effects of climate change coping and adaptation strategies on smallholder maize farmers in the Savelugu-Nanton municipal and the Tolon district. The study sought to determine the level of awareness of climate change among smallholder maize farmers, identify the coping and adaptation strategies among smallholder maize farmers, determine the effects of climate change among smallholder maize farmers and to examine the challenges smallholder maize farmers face in coping and adapting to the effects of climate change.

The study was conducted with 240 respondents selected by means of a simple random technique in the study areas. Data for the study were collected in eight (8) selected communities across the chosen district. The analysis involved both qualitative and quantitative approaches. Specifically, descriptive statistic (percentages), Kendall's coefficient of concordance and correlation methods were used. Also means and standard deviations were used to show respondents perceptions on climate change effects on food security among smallholder farmers.

With respect to respondents' socio-demographic characteristics, the study established that farmers who were within the age group of 36-45 years dominated with a percentage of (36.2%). Majority of the farmers between the age 36-45 years were people who were actively engaged in maize farming activities.

It was also found that 86.2% of the sampled respondents who engaged in the maize farming activities did not attained any level of education while 13.8% of the farmers were found to attain some level of education. The study also revealed that most of the men and women engaged in the farming are married with household size between 7-14 persons (56.2%).

With respect to objective 1 which sought to determine the level of awareness of climate change among smallholder maize farmers in the study area. This is seen from the mean of means value of 1.97, (approximately 2.0) with an SD = 0.76, which corresponds to the "Agree" response category on the scale. This means that the respondents agree that they are fully aware of the level of climate change among smallholder maize farmers in their various localities.

With regards to the coping and adaptation strategies pursued in response to climate change as captured in objective 2, the results from the study indicate that the following adaptation strategies have been adopted by farmers in response to climate change/variability; farmers now practice mixed cropping, farmers now use fertilizers and pesticide, farmers now change their planting date, farmers resort to planting leguminous trees on farms, farmers now resort to planting cash crops and farmers now migrate to urban area in search of greener pastures. The mean of means value for all these strategies is 2.65, (approximately 3.0) with SD = 0.99, which corresponds to the "Somewhat Agree" response category on the scale. This means that smallholder farmers are of the views that to a certain extent they have adopted some adaptation strategies to help them deal with the effects of climate change.

Also, some coping strategies were adopted by smallholder farmers to respond to the effects of climate change. These coping strategies are; reduction in the quantity of food eaten, reduction in the number of times they eat in a day, engage in daily work for cash, engage in micro-enterprise activities, reduction of household expenditure, resort to sale of household assets, embark on urban migration to seek for jobs and farmers now receiving remittances from family and friends to meet the household needs. All these coping strategies have mean of means value of 2.24, (approximately 2.0) with SD = 1.13, which corresponds to the "Agree" response category on the scale. This means that smallholder farmers are of the views that, they have adopted some coping strategies to help them deal with the effects of climate change.

With respect to objective 3, this sought to determine the effects of climate change on food security among smallholder farmers in the study area. The results indicate that,generally respondents agree to some extent that climate change has had an effect on food security in the study area among smallholder maize farmers. This is indicated by the mean of means value of 2.71 with a standard deviation of 1.26.

The 2.71 corresponds to the "somewhat Agree" category on the response scale. The two most important effects of climate variability on food security are "household sometimes worried about food running out" (1.84, SD = 0.71) and "household reduce the quantity of food serve because there was no money to buy food" (2.08, SD = 0.89).

Lastly, the smallholder maize farmers ranked the following as the top three challenges that they face in trying to cope and adapt to the effects of climate change. These are; lack of credit, inadequate subsidies and lack of support from government and the private sector. High cost of irrigation and belief systems were ranked as the least challenges (11th and 12th respectively) facing farmers in coping and adapting to the effects of climate change. The estimated W was 0.332, chi-square statistics as 876.010 with 11 degrees of freedom and asymptotic significance of 0.000. The chi-square critical obtained from the chi-square table was 19.7 at 5% level of significance. The asymptotic significance of 0.000 means that the null hypothesis should be rejected in favour of the alternate hypothesis. Thus the estimated W of 0.332 indicates that there is 33.2% agreement among the rankings of the challenges. The results showed that smallholder maize farmers are challenged in their quest to achieving higher production yields as a result of climate change.

5.3 Conclusions

In conclusion, respondents agreed that they were fully aware of the level of climate change among smallholder maize farmers in their various localities. As a result of the changing climate, smallholder farmers resort to some coping and adaptation strategies to mitigate the effects of the climate change/variability. Some of the adaptation strategies include, farmers now practice mixed cropping, farmers now use fertilizers and pesticide, farmers now change their planting date, farmers resort to planting leguminous trees on farms, farmers now resort to planting cash crops and farmers now migrate to urban area in search of greener pastures. Also some of the coping strategies include, reduction in the quantity of food eaten, reduction in the number of times they eat a day, engage in daily work for cash, engage in micro-enterprise activities, reduction of household expenditure, resort to sale household assets, embark on urban migration to seek for jobs and farmers now receiving remittances from family and friends to meet the household needs. It can also be concluded that generally respondents agree to some extent that climate change has had an effect on food security in the study area among smallholder maize farmers. The study again concluded that, inadequate credit facilities, inadequate subsidies and inadequate support from government and the private sector were the top three challenges that smallholder maize farmers face in their quest to achieving higher production yields as a result of climate change in the study area.

5.4 Policy Recommendations

From the findings of the study, the following policy recommendations were made;

I. N.G.O's and Government should step up provision of extension services through the Ministry of Food and Agriculture (MoFA) to enable farmers' to have more access to information about climate change coping and adaptation strategies.

II. Also, Government and other intervention organisations should set up community climate change information centres to provide farmers with climate change information as well as access to new climate change coping and adaptation technologies and their usage to enhance their adoption.

III. The research showed that the effects of climate change on food security is worsening with time, thus Government, N.G.O's and all stakeholders in the agriculture sector should come out with pragmatic measures so as to mitigate the effects of climate change/variability on food security among the smallholder farmers.

IV. Also, the Ministry of Food and Agriculture should set up an agricultural fund similar to the GETFUND to enhance access to credit so as to address the financial challenges of the smallholder maize farmers in the study area. This will help in minimising the bureaucracy the smallholder farmers have to go through in their quest to access credit in the various financial institutions.

5.5 Suggestions for Future Research

It is recommended that similar research is carried out for other commodity crops such as soy beans and rice in the study area. Future research should also be conducted to determine the factors that influence smallholder maize farmers' decision to adopt climate change coping and adaptation strategies in the study area.

REFERENCE

Abaje B., and Giwa P (2007) Urban Flooding and Environmental Safety: A Case Study of Kafanchan Town in Kaduna State. A Paper Presented at the Golden Jubilee (50th Anniversary) and 49th Annual Conferences of the Association of Nigeria Geographers (ANG) Scheduled for 15th-19th October, 2007 at the Department of Geography, University of Abuja, Gwagwalada- Abuja.

Abera, B. D. (2003) Factors Influencing the Adoption of Soil Conservation Practices in Northwestern Ethiopia. Discussion paper No.37, Vol.1.

Abraham B. Mekonne (2012). Analysis of Climate Variability and Its Economic Impact on Agricultural Crops (Thesis).

Abatey F. S. (2009). Climate Change Impacts on Livelihood, Vulnerability and Coping Mechanisms: A Case Study of West-Arsi Zone, Ethiopia (Thesis).

Adejuwon, J.O., 2005. Food crop production in Nigeria. I. Present effects of climate variability. Climate Research, 30(1), pp.53-60.

Adesina, A.A., and Zinnah, M. (1993) Technology Characteristics, Farmers' Perceptions and Adoption Decisions: A Tobit Model Application in Sierra Leone. Agricultural Economics 9: 297-311.

Adger, W.N., (1999).Social vulnerability to climate change and extremes in coastal Vietnam. World Development, 27(2), 249-269

Adger, W.N., Kelly P.M, Winkels A., Huy L. and Locke C., (2002): Migration, remittances, Livelihood trajectories and social resilience. *Ambio,*31, 358-366.

Adger, W. N. (2003). Social capital, collective action, and adaptation to climate change.

AIACC Working Paper No. 20 January 2006 Climate Variability and Change: Implications for Household Food Security Economic Geography, 79(4), pp.387-404.

Adiku, S.G.K., Dayananda, P.W.A., Rose, C.W., and Dowuona, G.N.N. (1997)An Analysis of the Within-Season Rainfall Characteristics and Simulation of the Daily Rainfall in Two Zones in Ghana. Agricultural and Forest Meteorology 86, 51-62.

Alemu, T. (1999) Land Tenure and Soil Conservation: Evidence from Ethiopia. Göteborg University, Sweden.

Al-Hassan, R. and Poulton, C. (2008) Agriculture and Social Protection in Ghana. Future Agricultures Working Paper No. 009.

Al-Hassan, R, and Diao, X. (2007) Regional Disparities in Ghana: Policy Options and Public Investment Implications. International Food Policy Research Institute, Sustainable Solutions for ending Hunger and Poverty. IFPRI Discussion paper, Washington D. C. USA.

Alessandro, D. Pinto, U. D., Akiko, H., Jawoo, K. and Marian, A. (2010) Climate Change Agriculture and Food Crop Production in Ghana. Ghana Strategy Support programme. International Food Policy Research Institute (IFPRI).

Anim, F. D. K. (1999) A Note on the Adoption of Soil Conservation Measures in the Northern Province of South Africa. Journal of Agricultural Economics 50, 336–45.

Anley, Y, Bogale, A and Haile-Gabriel, A, (2007) Adoption Decision and Use Intensity of Soil and Water Conservation Measures by Smallholder Subsistence Farmers in Dedo District, Western Ethiopia. Land Degradation and Development 18, 289–302.

Armah, F.A., Odoio, J.O., Yengoh, G.T., Obiri, S., Yawson, D.O., and Afrifa, E.K.A. (2010)

"Food Security and Climate Change in Drought-Sensitive Savanna Zones of Ghana. Mitigation and Adaptation Strategies for Global Change". 16(3), 291-306.

Arokoyo, I. and Auta, S.J. (1992). How to Reach and Work with Rural Youth. Proceedings of National Workshop on Extension Strategies on Reaching Rural Youth, National Agricultural Extension Research Liaison Services (NAERLS), Zaria, July 20-24.

or A.F,(2015). Value Chain approach to maize sector development by ACDEP/PAS in the Northern Region of Ghana. Mphil. Thesis,U.D.S.

ıur, J.L., and Irene, A.A., (2011) Movement Under Environmental Disaster: The Case of Flooding and Bush Fires for Selected Periods in Ghana. Journal of Disaster Research,

n K.C and Keshav L. M. (2006) Food Insecurity and Coping Strategies in Rural Areas of Nepal:A Case Study of Dailekh District in Mid-Western Development Region. Journal of International Development and Cooperation, Vol.12, No.2, 2006, pp. 25–45Vol.9 (4) 2014.

Asha, L. K. V., Gopinath, M. and Bhat, A. R. S. (2012). "Impact of climate change on rain- fed agriculture in India," International Journal of Environmental Science andDevelopment," Vol. 3 No. 4, pp.368-371.

Assan, K J; Caminade, C and Obeng, F. (2009) Environmental Variability and Vulnerability in Vulnerable Livelihoods: Minimising risks and optimizing Opportunities for Poverty Alleviation. Journal of International Development, 21: 403-418.

Awasina, R.A. (2015). Factors that influence smallholder farmers' decision to adopt climate change adaptation strategies in the East Mamprusi District of the Northern Region, Ghana. UnpublishedMphil. Thesis, U.D.S.

Ayanlade, T. A. and Orimoogunje, A. (2010). “Impacts of climate variability on tuber crops in Guinea Savanna part of Nigeria- A GIS approach,” Journal of Geography and Geology, Vol. 2 No. 1, pp. 27-35.

Ayuk, E.T. (1997) Adoption of Agroforestry Technology. The Central Plateaus of Burkina Faso. Agricultural Systems 54(2): 189-206.

Babbie, E. (2007) The Practice of Social Research (11th edition). Belmot, USA: Thomson Wadsworth Inc.

Backerberg, G.R., and Viljoen, M.F. (2003) Paper presented at a workshop of ICID Working Group on Irrigation under Drought and Water Scarcity, Tehran, I.R of Iran.

Balew, S., Agwata, J. and Anyango, S. (2014) Determinants of Adoption Choices of Climate Change Adaptation Strategies in Crop Production by Small Scale Farmers in Some Regions of Central Ethiopia. Journal of Natural Sciences Research, Vol.4, No.4. 78 – 93. www.iiste.org.

Barnett, T.P., Adam J.C. and Lettenmaier D.P., (2007): Potential impacts of warming climate on water availability in snow-dominated regions. *Nature*, 438, 303–309.

Barrios, S., Quattara, B. and Strobl, E.(2008) The Impact of Climate Change on Agricultural Production”: is It Different for Africa? Food Policy 33 (4): 287-298.

Bekele, W. and Drake, L.(2003) Soil and Water Conservation Decision Behaviour of Subsistence Farmers in Eastern Highlands of Ethiopia”: A Case Study of the Hundelafto Area. Ecological Economics 46: 437-451.

Benedicta, F., Paul, L., Vlek, A. and Manschadi, M. (2010) Farmers Perceptions and adaptation to Climate Change: A Case Study in Sekyedumase District in Ashanti region of Ghana. World Food System- A Contribution from Europe Tropentag, Zurich.

Benhin, J.K.A. (2006) Climate Change and South African Agriculture: Impacts and Adaptation Options. Centre for Environmental Economics and Policy for Africa (CEEPA) Discussion paper No. 21. CEEPA, University of Pretoria, South Africa.

Berkes, F. S. and Jolly, D. (2001) Adapting to Climate Change: Social-Ecological Resilience in a Canadian Western Arctic Community. Conservation Ecology, Vol.5 (2), p18.

Bilinsky P, and Swindale A (2007) Months of Adequate Household Food Provisioning for measurement of Household Food Access: Indicator Guide. Washington D.C.: Food and Nutrition Technical Assistance, Academy for Educational Development.

Blessing. K. F., Chukwudumebi L. E., Yusuf L. I. and Victoria C. A. (2011) Farmers' Perceptions of Climate Change and Adaptation Strategies in Northern Nigeria. African Technology Policy Studies Network, Research Paper No.15.

Boko, M., Njang. I., Nyong. A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, R., and Yanda, P..(2007) Africa. In Parry, M.L., Canziani, O.F., Palutikof. J.P., Vander Linden, P.J. and Hanson, C.E. (Eds) Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC. Cambridge University Press, Cambridge.

Brohan, P., Kennedy J.J., Harris I., Tett S.F.B., and Jones P.D., (2006): *Uncertainty estimates in regional and global observed temperature changes*: *a new dataset from 1850*. J. Geophysical Research **111**, D12106, doi:10.1029/2005JD006548

Brooks, N., Adger, W.N., Kelly, P.M., (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environmental Change 15, 151–163.

Brown, O. and Crawford, A. (2008) Assessing the Security Implication of Climate Changefor West Africa. IISD, Winnipeg, Manitoba.

Bryman, A. (2008) Social Research Methods. Third Edition, New York 'Oxford University Press Inc.

Burton, I., Huq, S., Lim, B., Pilifosova, O., Schipper, E.L., (2002): *From impact assessment to adaptation priorities: the shaping of adaptation policy*. Climate Policy 2:145–149.

Buyinza M. and Wambede, N.,(2008). Extension of agroforestry technology adoption: Mixed intercropping of crotalaria (*Crotaloria grahamiana*) and maize (*Zea mays L.*) in *Kabale* district, Uganda. *EnvironmentalResearch Journal*, 2 (3): 131-137.

Cabas, J., Weersink, A. and Olale, E. (2010). "Crop yield response to economic, site and climatic variables," Journal of Climate Change, Vol. 101 No. 3-4, pp. 599–616.

Cavero J., Farre I., Debaeke, P. and Faci J.M. (2000)Simulation of Maize Yield under Water Stress with the EPIC Phase and CROPWAT Models. Agronomy Journal 92, 679–690.

Campbell, R. (2008). *ACDI/VOCA:* United States Agency for Internationaln Development. Guide to focus group discussions micro REPORT #138.

Chan, N.W.,(2006): Drought trends in north western peninsular Malaysia: is less rain falling? *Wallaceana*, **4**, 8-9.

Cheke, R. A. and Tratalos, J. A. (2007). "Migration, patchiness, and population processes illustrated by two migrant pests", Bioscience, Vol.57 No.2, pp.145-154.

Christensen, J.H.,Hewitson B,Busuioc A.,Chen A., Gao X.,Held I., Jones R.,Koli R.K., Kwon W.T,Laprise R., Rueda V.M, Mearns L., Menéndez C.G., Räisänen L., Rinke L.Sarr A.and Whetton P, (2007): Regional climate projections. *Climate Change2007: The Physical Science Basis. Contribution of Working GroupI to the Fourth Assessment Report of the Intergovernmental Panelon Climate Change*.

Clay, D., Reardon, T and Kangasniemi, J. (1998) Sustainable Intensification in the High Land Tropics: Rwandan Farmers' Investments in Land Conservation and Soil Fertility. Economic Development and Cultural Change 46 (2), 351–78.

Collier, P., Conway., G. S. and Venables,. T. (2008) Climate Change and Africa. Oxford Review ofEconomic Policy, 24(2), 337.

Colman, D. and Young, T. (1989) Principles of Agricultural Economics: Markets and Prices in Less Developed Countries: Cambridge University Press.

Creswell, J.W. (2008) Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research" (3rd ed.). Upper Saddle River; NJ: Merrill.

Dai, A. and Trenberth K.E., (2004): Estimates of freshwater discharge from continents: Latitudinal and seasonal variations. *J.Hydrometeorol.*, **3**, 660–687.

Darwin, R. (2001) Climate Change and Food Security. Washington, DC. United States

Department of Agriculture.

Davies, S. and Hossain, N. (1993) Livelihood Adaptation, Public Action & Civil Society, Review of the Literature. IDS Working Paper No.57. Sussex Institute of Development Studies.

Dazé, A. (2007) Climate Change and Poverty in Ghana. CARE International, Accra, Ghana.

Denzin, N. K. and Lincoln Y.S.,(2000). Handbook of Qualitative Research: Thousand Oaks, CA, Sage.

Deressa, T., Hassan, R.M. and Ringler, C. (2010) Measuring Ethiopian Farmer's Vulnerability to Climate Change Across Regional States. International Food Policy Research Institute (IFPRI).

Deressa, T.; Hassan, R.M.; Alemu, T.; Yesuf, M. and Ringler, C. (2008) Analyzing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia. International Food Policy Research Institute (IFPRI) Discussion Paper No. 00798. Environment and Production Technology Division, IFPRI, Washington D.C.

Dercon, S, (2002)"Income Risk Coping Strategies and Safety Nets. The World Bank. Research Observer, 17(2): 141-166.

Deschenes, O. & Greenstone, M., 2006. The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather. *American Economic Review*, 97(1), 354-385

Dietz, Ton, Millar, D., Dittoh, S. Obeng. F. and Ofori-Sarpong, E. (2004) Climate and Livelihood Change in North East Ghana. In The Impact of Climate Change on Dry lands. With Focus on West Africa. A. J .Dietz, R.Ruben and A. Verhagen (Eds). Kluwer Academic Publishers. Dordrecht/ Boston/ London. Pp.149-172.

Dietz, A.J., Put. M and Subbiah, S. (2000) A Profile of Ranga Reddy and Mahabubnagar: A Drought Risk Assessment, Agricultural and Social Change, and the role of NGOs. In Government and NGO. In Government and NGO Interventions in Dryland Agriculture. A Study of Two Projects in Andhra Pradesh. M. Put and M. P. Van Dijk (Eds) Manohar Publishers, New Delhi.

Di Falco,S., Ringler, C., Kohlin,G., (2011). Impact of climate change and adaptation to climate change on food production in low income countries: household survey data evidence from the Nile basin of Ethiopia. IFPRI Discussion paper No. 828. International food policy research institute, Washington, DC.

Dinar, A., Hassan, R., Mendelsohn, R., and Benhin, J. (2008) Climate Change and Agriculture in Africa: Impact Assessment and Adaptation Strategies", Earth Scan, London.

Dokurugu T. O., (2010). Analysis of Value-Addition in a Soybeans Supply Chain in Northern Ghana*:* Mphil. Thesis, University of Ghana, Legon.

Dolisca, F., Carter, R.D. McDaniel, J.M., Shannon, D.A and Jolly, C.M. (2006) Factors Influencing Farmers' Participation in Forestry Management Programs: A Case Study from Haiti. Forest Ecology and Management 236, 324-31.

Downing, T.E. (2003) Linking Sustainable Livelihood and Global Climate Change in Vulnerable Food Systems. Vol. 133, pp.:363-378.

Drimie, S. and Gillespie, S. (2010) Adaptation to Climate Change in Southern Africa: Factoring in AIDS. Environmental Science and Policy13, 778-784.

Duffuor. K. (2011) The Budget Statement and Economic Policy of the Government of Ghana for the 2012 Financial year. 16-17.

Egeru. A. (2012) Role of indigenous Knowledge in Climate Change Adaptation: A Case Study of Teso Sub-Region, Eastern Uganda. Indian Journal of Traditional Knowledge, Vol.11 (2), 217-224.

Ejembi, E.P., and Alfa, G.B. (2012) Perceptions of Climate Change in Africa: Regional Agricultural Perspectives. Research on Humanities and Social Sciences.Vol.2,No.5.

EPA (2009) Ghana Climate Change Impacts, Vulnerability and Adaptation Assessment. Environmental Protection Agency (EPA), Accra.

Ericksen, P., Thornton, P., Notenbbaert, A., Cramer, L., Jones,P. and Herrero, M. (2011) Mapping Hotspots of Climate Change and Food Insecurity in the Global Tropics; CCAFS Report No.5; 1904-9005; CGIAR Research Programme on Climate Change, Agriculture and Food Security: Copenhagen, Demark. 1-29.

Ervin C.A., and Ervin, E.D. (1982) Factors affecting the use of soil conservation practices: Hypotheses, evidence, and policy implications. Land Economics.58 (3) 277pp

European Union (2006) Official Journal of the European Union. Common Position (EC) No.33

FASDEP (2003) Food and Agriculture Sector Development Project, Ministry of Food and Agriculture, Ghana, 2003 Technical Report.

Fancherean, N., Trzaska. M., Rouault, M. and Richard, Y. (2003) Rainfall Variability and Changes in Southern Africa during the 20th Century in the Global Warming Context. Natural Hazards (29) 139–154.

FANTA (2003) Food and Nutrition Technical Assistance Project (FANTA). Food Access Indicator Review. Washington D.C.:

Food and Agriculture Organisation (2010) Global Hunger Declining But Still Unacceptably High: International Hunger Targets Difficult to Reach. Economic and Social Development Department, Food and Agricultural Organization, Rome, September, 2010.

Food and Agriculture Organisation of the United Nations (2008) The State of Food and Agriculture in Asia and the Pacific. Asia Pacific Food Situation Update.FAO. September 2008.

Food and Agriculture Organisation (2007) Climate change and Food Security: a Framework for Action. Food and Agriculture Organisation (FAO) Interdepartmental Working Group on Climate Change. Rome.

Food and Agriculture Organisation (1996) Report of the World summit. Rome.

Fosu-Mensah, Y. B. (2012). “Modeling maize (Zea mays L.) productivity and impact of climate change on yield and nutrient utilization in sub-humid Ghana,” Ecology and Development Series, No. 87, pp, 12-129.

Ford, J.D. and Smith, B. (2004) A Framework for Assessing the Vulnerability of Communities in the Canadian Arctic to Risks Associated With Climate Change. Arctic, 57(4), 389-400

Fussel, H.M. and Klein R. J. T. (2006) Conceptual Frameworks of Adaptation to Climate Change and their Applicability to Human Health: PIK Report, No.91, Potsdam, Germany.

Gbetibouo, A. (2009) Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability" The Case of the Limpopo Basin, South Africa International Food Policy Research Institute (IFPRI).

Gina, Z. Anthony, N. Balgis, O. Cecilia, C.Sergio, C. and Tom, D. (2006) Climate Variability and Change: Implications for Household Food Security. AIACC Working Paper No. 20 January 2006. Online at **www.aiaccproject.org**.

Gornall, J., Betts, R., Burke, E., Clark, R., Camp, J., Willett, K. and Wiltshire, A. (2010). "Implications of climate change for agricultural productivity in the early twenty-first century," Philosophical Transaction of the Royal Society B, Vol. 365 No. 1554, pp. 2972- 2989.

GSS (2014). 2010 Ghana Population and Housing Census Report.Ghana Statistical Services

GSS (2011) Budget Statement, Ministry of Finance and Economic Planning, Accra, Ghana

GSS (2010). Population and Housing Census. Ghana Statistical Service (GSS). Accra, Ghana.

Glantz, M.H., Ed., (2001): *Once Burned, Twice Shy? Lessons Learned from the 1997–98 El Niño*, United Nations University, 294 pp.

Glantz, M.H., (1987). *Drought and hunger in Africa: denying famine a future*, Cambridge

University Press.

Gowing, J. (2003)Food Security for Sub-Saharan Africa: Does Water Scarcity Limit the Options? Land Use and Water Resources Research 3, 2. 1-2.7.

Graef F. and Haigis J., (2001): Spatial and temporal rainfall variability in the Sahel and its effects on farmers' management strategies. Journal of Arid Environments (2001) 48:221–231

Grothmann, T. and Patt A., (2005): Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Global Environ. Change.*,**15**, 199-213.

Grundstein, A.J. and, Bentley, M.L. (2001)A Growing-Season Hydro Climatology, Focusing on Soil Moisture Deficits, for the Ohio Valley Region. Journal of Hydrometeorology Vol. 2, (4), 345-355.

Halsnaes, T. Holt, K. Jylhä, B. Koffi, J. Palutikof, R. Schöll, T. Semmler and K. Woth,(2007): Future extreme events in European climate: an exploration of regional climate model projections. *Climatic Change,* 81(Suppl. 1), 71-95.

Hassan, R. and Nhemachena, C. (2008) Determinants of Africa Farmers' Strategies for Adapting to Climate Change. Multinomial Choice Analysis. African Journal of Agricultural and Resources Economics.

Henry. D., A. Clement. K.K. (2012) Estimating the Effect of Climatic Variables and Crop Area on Maize Yield in Ghana. Journal of Social and Development Sciences, Vol. 3 (9), 328-336. University of Cape Coast, Hirschboeck, K.K. (1991) Climate and Floods. InNational Water Summary 1988-1989 Hydrologic Events and Floods and Droughts: *U.S.* Geological Survey Water-Supply Paper 2375, 67-68.

Hisdal, H., and Tallaksen, L.M. (2000) Assessment of the Regional Impacts of Drought in Europe. Drought Event Definition. Technical Report No 6.

Ijaiya M. A, Abdul Raheem, A. and Abdullah I. B. (2007) Agricultural Credit Guarantee Scheme and Food Security in Nigeria: Journal of International Economic Review, Vol.2.(1-2). 167- 176.

IPCC (2012) Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge, UK: Cambridge University Press.

IPCC (2007) Summary for Policymakers. The physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the IPCC. Cambridge University Press, Cambridge, United Kingdom and New York, USA.

IPCC (2005) Report of the IPCC Expert Meeting on Emission Estimation of Aerosols Relevant to Climate Change, Geneva, Switzerland.

IPCC (2001) Climate Change Impacts, Adaptation, and Vulnerability. Cambridge University Press.

Isaac, A. (2014) Assessment of Capacity Building Initiatives Towards Enhancing Resilience to Climate Change in Ghana; the Role of University Education: Discussion Paper at International conference on Enhancing Resilience to Climate and Ecosystem Changes in Semi-Arid Africa (Uds-Tamale).

Jackson, R.B., Jobbágy E.G., Avissar R., Baidya R., Roy, D. Barrett,C.W. Cook, K.A. Farley, D.C. le Maitre, B.A. McCarl and B.C.Murray,(2007): Trading water for carbon with biological carbonsequestration. *Science*, 310, 1944-1947.

Judith, P. (1993) Climate of the Supercontinent Pangea. Chemical Geology. The University of Chicago Press.101 (2): 215-233.

Kandji, S.T. Verchot, L., and Mackensen, J. (2006) Climate Change and Variability in the Sahel Region: Impact and Adaptation Strategies in the Agricultural Sector. ICRAF-UNEP.

Kandlinkar, M. & Risbey, J. (2000) Agricultural Impacts of Climate Change": If Adaptation is the Answer, What is the Question? Climatic Change. Vol. 45, 529-539.

Karley, N.K. (2009) Flooding and Physical Planning in Urban Areas in West Africa: Situational Analysis of Accra, Ghana. Theoretical and Empirical Researchers in Urban Management vol.13 (4).

Kates RW., (2000) *Cautionary tales: adaptation and the global poor*. Climate Change 45(1):5–17.

Khan, S. A., Kumar, S., Hussain, M. Z. and Kalra, N. (2009). "Climate change, climate variability and Indian agriculture: Impacts vulnerability and adaptation strategies," in, Singh, S.N. (Ed.), Environmental Science and Engineering,

2009. Springer- Verlag Berlin Heidelberg, pp. 19-38.

Kibathi, M.W. (1994) Small Scale Farmers' Perception of and Response of Drought in Makuyu Division, Muranga district, Kenya. M.A thesis, Kenyatta University, Nairobi, Kenya.

Klein, R.J.T. (2002) Climate change, Adaptive Capacity and Sustainable Development. OECD Informal Expert Meeting on Development and Climate Change, Paris, France.

Kranjac-Berisavljevic, G. (2014) Studies of Resilience Efforts by Farmers in Northern Ghana: Indigenous Tillage Practices Used to Reduce the Effect of Rainfall and Temperature Variation. *Journal of Disaster Research, Vol.9, No.4.*

Kranjac-Berisavljevic, G. (1998) Recent Climatic Trends in Northern Interior Savannah Zone of Ghana. Implications for Agricultural Production. Journal of Disaster Research Vol.9, No.4 (2014).

Krejcie, V. Robert and Morgan, W. Daryle (1970). Determining Sample Size for Research Activities. Educational and Psychological Measurement. 30, 607-610.

Krishna, R., Tiwari, D., Awasthi, B. and Bishal, K. (2010) Local People's Perception on Climate, its Impact and Adaptation Practices in Himalaya to Terai Regions of Nepal.

Kumar, R. (1999) Research Methodology: A Step by Step Guide for Beginners. New Delhi India.

Kumar, K. R., Ashrit, R. G., Deshpande, N. R. and Hansen, J. W. (2004). "Climate impacts on Indian agriculture," International Journal of Climatology, Vol. 24 No. 11, pp. 1375–93.

Lapar, M.L.A., and Pandey, S. (1999) Adoption of Soil Conservation: the case of the Philippine uplands. Agricultural Economics 21: 241-256.

Lazaro, R.l., Rodrigo, F.S., Gutiérrez, L., Domingo, F., Puigdefábregas, J. (2001)Analysis of a 30-year Rainfall Record (1967-1997) in Semi-Arid SE Spainfor Implications on Vegetation. Journal of Arid Environments 48: 373-395.

Lobell, D.B, G. Mirin, A. Philips, T. Maxwell and D. Rotman (2009). Regional differences in the influence of irrigation on climate, J. Clim., 22(8), 2248-2255.

Lobell, D.B., Burke, M.B., Tebaldi, C.., Mastrandrea, M.D., Falcon, W.P., and Naylor, R.L. (2008) Prioritizing Climate Change Adaptation Needs for Food Security in 2030. Science 319 (5863): 507-10.

Lobell, C., (2000) Productive Water Points: Guidelines on Integrated Planning for Rural Water Supply. ITDG Publishing.

Mabe, F.N., Sarpong, D.B., Osei.Asare, Y. (2012) Adaptive Capacities of Farmers to Climate change AdaptationStrategies and their Effects on Rice Production in the Northern Region of Ghana. Journal of Disaster Research, Vol.9, No.4 (2014).

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

Magrin, G.O., Travasso M.I., and Rodríguez G.R., (2005): Changes in climate and crops production during the 20th century in Argentina. *Climatic Change*, 72, 229–249.

Marty, B. (2006) Water in the Early Earth. Reviews in Mineralogy and Geochemistry 62: 421

Maxwell, S., Frankenberger, T. (1992) Household Food Security Concepts, Indicators, and Measurements. New York, NY, USA: UNICEF.

McCarthy, J.J., Canziani. O.F., Leary, N.A., Dokken, D.J. and White, K.S. (2001) Climate Change: Impacts, Adaptation, and Vulnerability. Cambridge University Press. Cambridge.

Mertz, O., Mbow, C., Reenberg, A., and Diouf, A., (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental Management*, 43 (5): 804-16.

Mendelsohn, R., Dinar, A, Dalfelt, A (2000). Climate change impacts on African Agriculture.

Michaelowa and Tuan D.D., 2007: Synergy ofadaptation and mitigation strategies in the context of sustainable development: the case of Vietnam. *Clim. Policy*, **3**, S81-S96.

Miller D. and Apusigah A., (2004). Manual on Participatory Training Techniques Using Participatory Rural Appraisal Tools*:* A farmer project publication. Ministry of Food and Agriculture Project Office Tamale.

Ministry of Environment, Science and Technology [MEST] (2010) Ghana Goes for Green Growth; Discussion Document- Summary. MEST, Accra, 8-15.

Mitchell, T. and Jones, P. (2005) An Improved Method of Constructing a Database of Monthly Climate observations and Associated High-Resolution Grids. International Journal of Climatology. Vol. 25, 693-712.

MoFA. (2011). Food and Agriculture Sector Development Policy: Accra, Ghana.

Mortimore, M. (1989) Adapting to Drought: Farmers Famines and Desertification in West Africa. Cambridge University Press.

Morton, J.F., (2007). The impact of Climate change on smallholder and subsistence Agriculture, PNAS Vol. 104, No. 50, December 11.

Moss, B., D. Mckee, D. Atkinson, S.E. Collings, J.W. Eaton, A.B.Gill, I. Harvey, K. Hatton, T. Heyes and Wilson D., (2003): Howimportant is climate? Effects of warming, nutrient addition an fish on phytoplankton in shallow lake microcosms. *J. Appl. Ecol.*, 40, 782–792.

Mowa, E. L and Lambi, C. M. (2006). "Economic impact of climate change on agriculture in Cameron". Policy research paper No. 4364 World Bank, Washington, D.C. pp. 51-55.

National Disaster Management Organisation (2010). Flood Statistics for Buipe and Yapei in Ghana. NADMO Report for 2003-2010.

Nellemann, C., MacDevette, M., Manders, T., Eickhout, B., Prins, A., and Kaltenborn, B. (Eds.) (2009) The Environmental Food Crisis. The Environment' Role in Averting Future Food Crisis. A UNEP Rapid Response Assessment. Arendal, UNDP.

Nelson, G.C., Rosegrant, M.W., Koo, Robertson, R., Sulser, T., Zhu, T. and Ringler, C. (2009) Climate change Impact on Agriculture and cost of Adaptation. Washington D.C. International Food Policy Research Institute. Available at: www.ifpri.org/sites/default/files/publications/pr21.pdf. (Accessed 17 Aug 2011).

Negin, J., Reman R., Karuti, S. and Fanzo, J.C. (2009) Integrating a Broader Notion of Food Security and Gender Empowerment into the African Green Revolution. Food Security, No.1, 351-360pp.

Newmark, W.D., Leonard, N.L Sariko, H.I., and Gamassa, D.M. (1993) Conservation Attitudes of Local People Living Adjacent to Five Protected Areas in Tanzania. Biological Conservation vol.63 (2): 177-183pp.

Ngigi SN. (2009).Technical Evaluation and Development of Low-Head Drip Irrigation Systems in Kenya. Irrigation and Drainage, 57(2008): 450462.http://www.interscience.wiley.com

Nhemachena, C., and Hassan, R. (2007) Micro-level Analysis of Farmers' Adaptation to Climate Change in Southern Africa. IFPRI Discussion Paper No. 00714. International Food Policy Research Institute. Washington DC.

Njoku, J. E. (1991). Factors Influencing the Adaptation of Improved Oil Palm Production Technologies by Small Holders In Imo State Nigeria.

Njuki, J.M., Kihiyo, V.B.M., O'ktingati, A and Place, F. (2004) Male and Female Labour in an Agroforestry System in the Central Highlands of Kenya: Correcting the Misconception. International. Journal. Agriculture Resource Governance. Ecology 3 (1-2): 154-170pp.

Nkonya, E., Schroeder, T. and Norman, D. (1997). Factors Affecting Adoption of Improved

Maize Seed & Fertilizer in Northern Tanzania. Journal of Agricultural Economics 4: 1 12.

Ntege-Nanyeenya, Mugisa-M, Mwangi I, and Verkuul. (1997) An Assessment of Factors Affecting Adoption of Maize Production Technologies in Iganga District, Uganda. Addis Ababa, Ethiopia, NARO/CIMMYT.

NOAA, (2005): *Hazards/Climate Extremes*. National Climatic Data Center, U.S. Department of Commerce,http://www.ncdc.noaa.gov/oa/climate/research/2005/aug/hazards.html.Flooding.

Nti, F.K. (2008) Climate Change Vulnerability and Coping Mechanisms Among Farming Communities in Northern Ghana (a master thesis) Submitted to Kansas State University, Manhattan, Kansas state University, Manihattan, Kansas. Available at http://krex.k.state.edu/dspace/bitstream/handle/2097/15118/FrankNti2012rev.pdf[accessed January, 2014]

Nyong, A. (2005) Technologies for Adapting to Climate Change: Water Resources and Agriculture. UNFCCC Seminar on the Development and Transfer of Environmentally Sound Technologies for Adaptation to Climate Change, Tobago, Trinidad and Tobago.

Obeng, F.K. (2014) Impact of Climate Variability on Soil Moisture Availability in North Eastern Ghana: Implications for Agricultural Extension and Rural Development: International Journal of Agricultural Science, Vol. 4 (2) 109-118. International Academic Journals. Online www.inacj.com

Obeng F.K. (2005) Things are Hard for us but We see a Way Out of Them. Impact of Climate Variability on Geographical and occupational mobility and the effect of mobility on social Organisation in Farming Communities in North-Eastern Ghana. AMISDT. Published PHDThesis. University of Amsterdam.Pp.300.

O'Brien, K., Erikson, S., Schjolden, A., Nygaard, L., (2004). What's in a word? Conflicting interpretations of vulnerability in climate change research. CICERO Working Paper 2008:04, Oslo, Norway.

Osborne, T. M. and Wheeler, T. R. (2013). "Evidence for a climate signal in trends of global crop yield variability over the past 50 years," Environmental Research Letters, Vol.8 No.2,pp. 1-9.

Owusu, K., Walen, P. and Qiu, Y. (2008) Changing Rainfall In-puts in the Volta basin: Implications for Water Sharing in Ghana. *Geo Journal*, 71(4), 201-210.

Ozor, N., Madukwe, M.C., Enete, A.A., Amaechina, E.C., Onokala, P., Eboh, E.C. Ujah, O. and Garforth, C.J. (2010) Barriers to Climate Change Adaptation Among Farming Households of Southern Nigeria: Journal of Agricultural Extension Vol. 14 (1).

Parry, M., Rosenzweig, C., Iglesias, A., Fisher, G. and Livermore, M. (1999) Climate change and World Food Security. A New Assessment. Global Environmental Change 9:51-67.

Paul, M., Regis, C., Florence, M., Samuel, A. Freddy, B., Ricardo, M., and Ken, G. (2008). Farmers' perceptions lead to experimentation and learning. Agricultures Network. LEISA Magazine, vol.24 (4).

Pearce, D.W., Achanta, A.N., Cline, W.R., Fankhauser, S., Pachauri, R., Tol, R.S.J., and Vellinga, P. (1996) The social costs of Climate Change: Greenhouse Damage and Benefits of control. In Bruce, J., Lee, H., Haites, E. (Eds.).Economic and

Social Dimensions of Climate Change. Cambridge University Press, Cambridge, UK.

Pender, J., Sewanyana, S., Kato, E. and Nkonya, E. (2004) Linkages between poverty and land management in rural Uganda. Evidence from Uganda National Household Survey, 1999/00. EPTD Discussion Paper No. 122.

Pender, J. and Kerr, J. (1998) Determinants of farmers' Indigenous Soil and Water Conservation Investments in Semi-Arid India. Agricultural Economics19: 113-25.

Pindyck, R. S. and Rubinfeld, D. L. (1981) Econometric Models and Economic Forecasts. McGraw-Hill, London.

Powell, R.A., Single, H.M. and Lloyd, K.R. (1996) Focus Groups in Mental Health Research: Enhancing the Validity of User and Provider Questionnaires. International Journal of Social Psychology. Vol.42 (3).

Preston, M. (2002). Qualitative Research and Evaluation methods: Sage. International Educational and Professional Publishers thousand Oaks. London. New Delhi.

Quaye, W. (2008), Food Security Situation in Northern Ghana, Coping Strategies and Related Constraints. African Journal of Agricultural Research, Vol. 3 (5) 334-342, Academic Journals.

Quisumbing, A.L., Haddad and Peila, C. (2011) Gender and Poverty: New Evidence from 10 Developing Countries. FCND Discussion paper No. 9. International Food Policy Research Institute (IFPRI), Washington D.C.

Reenberg, A., and Diouf, A., (2009). Farmers' perceptions of climate change andagricultural adaptation strategies in rural Sahel. *Environmental Management*, 43 (5): 804-16.

Richard Longhurst (2009). Household FoodStrategies in Response to Seasonality and Famine. IDS Bulletin: Vol.17,No 3, pp 27–35, July 1986

Ringler, C., Zhu, T., Cai, X., Koo, J. and Wang, D. (2010) Climate Change Impacts on Food Security in Sub-Saharan Africa. Insights from Comprehensive Climate Change Scenarios. IFPRI Discussion Paper 01042.

Rogers, E. M., (2006) Diffusion of Innovations. The 5th edition. Free Press, New York

Rogers, E. M. (1983) Diffusion of Innovations. The Free Press, New York

Rosenzweig, C. and Tubiello F.N., (2007): Adaptation and mitigation strategies in agriculture: an analysis of potential synergies. *Mitigationand Adaptation Strategies for Global Change*, 12, 855-873.

Rosenzweig, C., Tubiello, F. N., Goldberg, R., Mills, E. and Bloomfield, J. (2001). "Increased crop damage in the United States from excess precipitation under climate change,"Global Environmental Change: Human Dimensions and Policy,Vol.12 No.3, pp. 197-202.

Schroteret al..(2005). Ecosystem service supply and vulnerability to global change in Europe.

Science, 310, 1333–1337.

Sen, A. (1981) Poverty and Famines: an Essay on Entitlement and Deprivation”. Oxford University Press, USA.

Siri, H., Eriksen, N., Katrina, B. and Mick, P.K. (2005) The Dynamics of Vulnerability; Locating Coping Strategies in Kenya and Tanzania. The Geographical Journal, Vol. 171, No. 4, December 2005, 23-32.

Sivakumar M. V. K., Das H. P. and Brunini, O. (2005). “Impacts of present and future climate variability and change on agriculture and forestry in the arid and semi-arid tropics”, Climate Change Vol.70, pp.31–72.

Smit, B. and Pilifosova, O. (2003) From Adaptation to Adaptive Capacity and Vulnerability Reduction. Imperial College Press. London.

Smit, B. and Skinner, M. (2002) Adaptation Options in Agriculture to Climate Change: a Typology. Mitigation and Adaptation Practices and Policies for Global Change 7 (1): 85 -114.

Smit, B., and Wandel, J., (2006): *Adaptation, adaptive capacity and vulnerability*. Global Environmental Change, 16:282-292.

Swinton, S. M. (2000). More Social Capital, Less Erosion: Evidence from Peruvian Altiplano. Selected Paper for the Annual Meeting of the American Agricultural Economics Association, Tampa, FL, July 30-Aug. 2, 2000.

Tesfaye, K. (2003) Field Comparison of Resource Utilization and Productivity of Three Grain Legumes under Water Stress. Ph.D. thesis in Agro meteorology, Department of Soil, Crop and Climate Sciences, University of the Free State, South Africa.

Temesgen T. Deressa, Rashid M, Hassan, and Claudia Ringler, (2008) 'Measuring Ethiopian Farmers' Vulnerability to Climate Change across Regional States", International Food Policy Research Institute (IFPRI), Environment and Production Technology Division Discussion Paper 00806.

Thomas, D.S.G. and Twyman C., 2005: Equity and justice in climate change adaptation amongst natural-resource-dependent societies. *Global Environ. Change,***15**, 115-124.

Thornton, P.K., Jones P.G., Owiyo T.M., Kruska R.L., Herero M., Kristjanson P., Notenbaert A., Bekele N. And Omolo A., with contributions from Orindi V., Otiende B., Ochieng A., Bhadwal S., Anantram K., Nair S., Kumar V. and Kulkar U.,(2006): *Mapping Climate Vulnerability and Poverty in Africa.* Report to the Department for International Development, ILRI, Nairobi, 200pp.

Thornton, P. K., Ericksen, P. J., Herrero, M. and Challinor, A. J. (2014). "Climate variability and vulnerability to climate change: A review", Global Change Biology, Vol.20 No.11, pp. 3313-3328.

Tizale, C.Y. (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.

Tony Beck (2009); Survival Strategies and Power amongst the Poorest in a West Bengal Village.Vol.20,no 2, pp 23–32.

Trenberth, K.E., and Shea D.J., 2007: Atlantic hurricanes and natural variability in 2005, *Geophys. Res. Lett.*, 33, L12704, doi:10.1029/ 2006GL026894

Troeh , F.R., Hobbs. J.A. and Donahue, R.L. (1980) Soil and Water Conservation for Productivity and Environmental Protection. Prentice Hall Inc., New Jersey.

Tschakert, P. (2009) Views from the Vulnerable: Understanding Climatic and other Stressors in the Sahel. Global Environment. Change. Vol. 17. 381–396.

Tsubo, M., Walker, S. and Ogindo, H.O. (2005). A Simulation Model of Cereal-legume Intercropping Systems for Semi-Arid Regions II. Model Applications. Field Crops Research 93, 23-33.

Tunde, A. M. (2011), "Perception of climate variability on agriculture and food security by men and women farmers," Ethiopian Journal of Environmental Studies and Management, Vol. 4 No. 2, pp. 19-32.

Turner M, (1999): Potential impactof climate change effects on preferences for tourism destinations:a psychological pilot study, *Clim. Res.*, **11**, 2477–2504.

Twumasi, P.A. (2001) Social Research in Rural Communities. (Second edition) Accra: Ghana University Press.

Uddin, M.N., Wolfgang Bokelmann, W. and Entsminger, J. S. (2014) Factors Affecting Farmers'

Adaptation Strategies to Environmental Degradation and Climate Change Effects: A Farm Level Study in Bangladesh. Climate 2014, 2, 223-241. www.mdpi.com/journal/climate, 09/08/2015.

United Nations Development Program (2013). Millennium Development Goals Report, New York, NY.

United Nations Framework Convention on Climate Change (UNFCCC), (2007). Climate Change:Impacts, Vulnerabilities and Adaptation in Developing Countries.

United States Agency for International Development. (1992). *Policy Determination 19: Definition of Food Security*. Washington, D.C.: United States Agency for International Development.

Valdivia, C. And Gilles J.L., (2003). Coping and adapting to climate variability in the Andes: strategies and local knowledge. Open Meeting of the Human Dimensions of Global Environmental Change Research Community. 16-18 October. Montréal, Canada

Van der Geest., K. (2004) We're Managing. Climate Change and Livelihood Vulnerability in Northwest Ghana. African Studies Centre. Leiden.

Van Schaik, A. and Henk, R. (1992) Agriculture in Dry-season Environments. Coping with Semi-Aridity. How the Rural Poor Survive in Dry-season Environments. Netherlands Geographical Studies 146, Amsterdam, 19-36.

Verner, D. (2011) Social Implications of climate change in Latin America and the Caribbean. Economic Premise Note 61. Washington, D.C.: The World Bank. Available at: http://siteresources.worldbank.org/INTPREMNET/Resources/ EP61.pdf.

Walker, P.A.,(2005). Political ecology: where is the ecology? Progress in Human Geography 29, 73–82.

Watson, R.T., Zinyowera M.C. and Moss R.H., Eds., (1997): *The RegionalImpacts of Climate Change: An Assessment of Vulnerability*.Cambridge University Press, Cambridge, 517 pp (17th August. 2011).

Webb, P., Coates, J., Frongillo, E.A., Rogers, B.L., Swindale, A. and Blinsky, P. (2006) Measuring Household Food Insecurity: Why It's so Important and Yet so Difficult to Do. Journal of Nutrition. (136) 1404-1408pp.

Wilhite, D.A. (1996) Reducing the Impacts of Drought: Progress towards risk management. In Ribot J.C,Magalhaes A.N. and Panagides S.S. (eds). Climate Change Variability, Climate Change and social Vulnerability in the Semi-Arid Tropics. Cambridge University Press, 1996. Great Britain.

Wilhite, D. A., and Glantz, M.H. (1985) Understanding the Drought Phenomenon. The Role ofDefinition. Water International. 10:111-120.

World Bank (2010) Economics of Adaptation to Climate Change: Ghana. The World Bank report.

World Bank (2009) Swimming against the tide: How Developing Countries are Coping with the Global crisis". Washington, DC.

World Bank (2008) Biodiversity, Climate Change and Adaptation. Nature-Based Solutions from the World Bank Portfolio. 1818 H Street NW Washington DC, USA. 102p. World Bank Discussion paper no. 15. Washington: The World Bank.

World Bank (2008). The Growth Report: Strategies for Sustained Growth and Inclusive Development. Washington, DC.

World Bank (1986) Poverty and Hunger: Issues and Options for Food Security in Developing Countries". Washington, DC, USA: World Bank.

World Food Submit (1996) Food Security Information for Action Practical Guides.

Yaro, J. A. (2010). The Social Dimensions of Adaptation to Climate Change in Ghana. The World Bank Discussion paper no.15. Washington: The World Bank.

Yaro, J. A. and Hesselberg, J. (2010). The Contours of Poverty in Northern Ghana: Policy Implications for Combating Food Insecurity. Research Review of theInstitute of AfricanStudiesno. 26 (1).

Yeraswork, A. (2000) Twenty Years to Nowhere: Property Rights, Land Management, and Conservation in Ethiopia: The Red Sea Press, Inc., Lawrenceville, NJ.

Yin, R.K. (1993) Case study Research: Design and methods. Beverly Hills; Sage Publications.

Yohe, G., Strzepek, K., Pau, T., Yohe, C., (2003). Assessing Vulnerability in the context of changing socioeconomic conditions: a study of Egypt. In: Smith, J.B., Klein, R.J.T., Huq, S. (Eds.), Climate Change, Adaptive Capacity and Development. Imperial College Press, London.

Ziervogel G., Nyong, A., Osman, B., Conde, C., Cortes, S. and Dowing, T. (2006) Climate Variability and Change: Implications for Household Food Security. Assessments of Impacts and Adaptations to Climate Change (AIACC) Working Paper No. 20, January 2006. The AIACC Project Office, International START Secretariat, Washington DC, USA.

APPENDIX 1

QUESTIONNAIRE FOR FARMERS

EFFECTS OF CLIMATE CHANGE COPING AND ADAPTATION STRATEGIES ON FOOD SECURITY AMONG SMALLHOLDER MAIZE FARMERS IN THE TOLON DISTRICT AND SAVELUGU/NANTON MUNICIPAL.

All questions are related to the above subject and I will be grateful if you can give me some of your time. The survey is meant for academic purpose. I assure you that everything you say will be kept confidential.

Thank You.

A. SOCIO-DEMOGRAPHIC DATA OF RESPONDENTS (SMALLHODER FARMER).

District…………………………………………………………………………………

Name of farmer…………………………………………………………………………

Name of community/Village……………………………………………………………

Group Name……………………………………………………………………………

Age…………………………………………………………………………………...

Phone Number if any……………………………………………………………………

1.01 SEX

1= male

2= female

1.02 MARITAL STATUS

1= single

2= married

3= divorced

4= widowed

1.03 RELIGION

1= Islamic

2= Christianity

3= traditional

1.04 EDUCATIONAL STATUS

1= formal education

2= no formal education

1.05 HOUSEHOLD SIZE

1= 3-7

2= 7-14

3= Above 14

1.06 FARM SIZE

1= 2-5 hectares

2= 5-10 hectares

B.DETERMINATION OF THE LEVEL OF AWARENESS OF CLIMATE CHANGE AMONG SMALLHOLDER MAIZE FARMERS IN THE NORTHERN REGION.

For each of the statement below, please indicate the extent of your agreement or disagreement of your awareness of climate change by selecting the appropriate box.

The response scale is as follows:

1= Strongly Agree, 2= Agree, 3= somewhat agree, 4= Disagree, 5= Strongly Disagree.

Table: 1

B	STATEMENTS	SCALE				
		1	2	3	4	5
2.01	Rainfall starts early and end late					
2.02	Rainfall starts late and ends early					
2.03	Long dry season during cropping season					
2.04	Excessive rainfall					
2.05	Excessive temperatures					
2.06	Increased frequency of drought					
2.07	The rainfall amount is decreasing in the rainy season					
2.08	Seasonal flooding is now on the increase					
2.09	Increased in pest and diseases on crops and animals					
2.10	Increased cropping diversity					
2.11						
2.12						

SECTION C: IDENTIFICATION OF THE CLIMATE CHANGE COPING AND ADAPTATION STRATEGIES AMONG SMALLHOLDER MAIZE FARMERS IN THE TOLON AND SAVELUGU MUNICIPAL.

For each of the statement below, please indicate the extent of your agreement or disagreement by selecting the appropriate box.

The response scale is as follows:

1= Strongly Agree, 2= Agree, 3= somewhat agree, 4= Disagree, 5= Strongly Disagree.

Table: 2

C	STATEMENTS	SCALE				
		1	2	3	4	5
3.01	Smallholder farmers now plant different varieties					
3.02	Smallholder farmers implement soil conservation technique.					
3.03	Smallholder farmers now begins to irrigate their farms more					
3.04	Farmers now change their planting dates					
3.05	Smallholder farmers now practices mixed cropping					
3.06	Farmers resort to sale of wood					
3.07	Farmers reduce the amount of food eaten					
3.08	Smallholder farmers migrate to urban areas					
3.09	Smallholder farmers now farm along river banks					
3.10	Farmers now engaged in daily work cash like construction.					
3.11	Smallholder farmers engage in micro-enterprise					

	activities					
3.12	Farmers resort to sale of household assets					

SECTION D: DETERMINATION OF THE PERCEIVED EFFECTS OF COPING AND ADAPTATION STRATEGIES ON FOOD SECURITY AMONG SMALLHOLDER MAIZE FARMERS IN THE TOLON AND SAVELUGU MUNICIPAL.

For each of the statement below, please indicate the extent of your agreement or disagreement by selecting the appropriate box. Does each of the following have an influence on your ability to cope and adapt to climate change?

The response scale is as follows:

1= Strongly Agree, 2= Agree, 3= somewhat agree, 4= Disagree, 5= Strongly Disagree.

Table: 3

Indicators of food security in the last 12 months				
We always have enough to eat.				
We always eat the kinds of food we want.				
Sometimes we don’t have enough food to eat.				
We often don’t have enough food to eat.				
I am sometimes worried about my food running out in the last 12 months				
We were unable to eat the food we like in the last 12 months				

We have been missing a number of meals per day in the last 12				
My household couldn't afford to eat a balance (good quality) meal in the last 12 months				
My household relied on low cost food to feed children since there was no money to prepare quality food				
The children were not eating enough in the last 12 months.				
The household reduced the quantity of food serve because there was no money to buy food.				
The household reduced the number of times we ate in a day because there was no money to buy food.				
In the last 12 months, household ate less than they should have eaten.				
I was hungry but didn't eat because i could not afford to eat in the last 12 months				
Some members of the household slept without eating any food in the last 12 months				
There were times that my household never had food to eat in the last 12 months.				

SECTION E: TO EXAMINE THE CHALLENGES FARMERS FACE IN COPING AND ADAPTING TO CLIMATE CHANGE.

Please rank the challenges faced by smallholder maize farmers as a result of coping and adapting to climate change in the table below in order of importance, with one (1) being the most pressing and twelve (12) being the least.

Table: 4

Challenges (E)	**Ranks**
Lack of financial resources	
Poor rural infrastructure	
Inadequate extension contact	
High cost of irrigation facilities	
Limited understanding on the nature and consequences of climate change	
Poor health status among farm families	
Inadequate subsidies	
Late supply of inputs	
Inadequate land or system of land ownership	
Lack of support from government and private sector.	
Religious or belief systems smallholder families	
Difficult application of technology or innovation	

Thank you.

APPENDIX II

QUESTIONNAIRE FOR FARMERS (FOCUS GROUP DISCUSSION)

EFFECTS OF CLIMATE CHANGE COPING AND ADAPTATION STRATEGIES ON FOOD SECURITY AMONG SMALLHOLDER MAIZE FARMERS IN THE TOLON DISTRICT AND SAVELUGU MUNICIPAL.

All questions are related to the above subject and I will be grateful if you can give me some of your time. The survey is meant for academic purpose. I assure you that everything you say will be kept confidential.

Thank You.

Socio-Demographic Data of Respondents (Focus Group).

District…………………………………………………………………………………

Name of community/Village…………………………………………………………

Group Name……………………………………………………………………………

Determination of the Level of Awareness of Climate Change among Smallholder Maize Farmers in the Northern Region.

1. How has the rainfall pattern change over the last twelve (12) months?

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

…………………………………………………………………………………

2. In the last 12 months, how often did you experience drought during the raining season?

………………………………………………………………………………………………………

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3. Have you experience an increase in pests and diseases on crops and animals over the last 12 months. Explain?

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4. In the last 12 months were you compelled to diversify your cropping as a result of the changing climate or variability? Explain?

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Identification of the Climate Change Coping and Adaptation Strategies among Smallholder Maize Farmers in the Tolon and Savelugu Municipal.

5. How do farmers in the district adapt to climate variability extremes in recent times?

Please explain.

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6. What adaptation strategies do farmers in the district practice to mitigate the effects of the changing climate or variability?

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7. How do farmers in the district cope to climate variability extremes in recent times?

Please explain.

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8. What coping strategies do farmers in the district practice to mitigate the effects of the changing climate or variability?

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Perceived Effects of Coping And Adaptation Strategies on Food Security among Smallholder Maize Farmers in the Tolon and Savelugu Municipal.

9. Do people in the district in recent years have to worry about food insecurity due to climate variability extremes? Please explain.

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10. Do some of the people in the district have to reduce the number of meals per day in the in recent years due to climate variability extremes? Please explain

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11. In the last 12 months, did the household reduce the quantity of food serve because there was no money to buy food? Please explain.

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12. Were you able to eat the food you like in the last 12 month? Please explain

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13. How often were members of your household slept without eating any food in the last 12 months? Please explain

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Challenges Farmers Face in Coping and Adapting to Climate Change.

14. What are the main challenges farmers face in coping and adapting to climate change/variability?

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15. What in your view can be done to improve upon smallholder coping and adaptation strategies on climate change/ variability?

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16. How does your farmer group help one another to solve these challenges?

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17. What is the main source of credit facilities for farmers?
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18. How do farmers get information in relation to early warnings on climate variability?...

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19. Is there any comments/suggestions in relation to climate change/variability?

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THANK YOU FOR YOUR TIME