UNIVERSITY OF CAPE COAST

RICE FARMERS' PERCEPTION OF CLIMATE CHANGE AND ADAPTATION STRATEGIES IN THE KETU NORTH DISTRICT, VOLTA REGION OF GHANA

JACOB BINDA KOLLEH

2015

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BY

JACOB BINDA KOLLEH

Thesis submitted to the Department of Agricultural Economics and Extension, School of Agriculture, College of Agriculture and Natural Sciences (CANS), University of Cape Coast in partial fulfillment of the requirements for award of Master of Philosophy Degree in Agricultural Economics.

AUGUST 2015

DECLARATION

Candidate's Declaration

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: Jacob Binda Kolleh

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Signature:... Date:..................................

Principal Supervisor's Name: Dr. Henry De-Graft Acquah

Signature:... Date:..................................

Co-Supervisor's Name: Mr. Samuel Akuamoah-Boateng

ABSTRACT

This study assessed rice farmers' perception of climate change and adaptation strategies towards tackling the challenges climate change poses to the rice farmers in Ketu North District, Volta Region of Ghana. The multistage sampling technique was used to obtain a sample size of 340 rice farmers from six (6) farming sections and a structured questionnaire was used to elicit data from the respondents. The data collected from the rice farmers were analyzed using descriptive statistics and binary logistic regression analysis. The results of the study showed that majority of the rice farmers' perceived decreasing precipitation and increasing temperature. Farmers' level of adaptation was found to be relatively high with majority of the farmers using irrigation, changing crops, changing planting dates and planting short season varieties as the major adaptation measures to decreasing precipitation and increasing temperature. The binary logistic regression analysis found household size, education level, farming experience and financial support as significant predictors of the probability to adaptation to decreasing precipitation and increasing temperature respectively. Findings of the study also indicate that the major barriers to climate change adaptation by rice farmers in the district are lack of information about climate change, lack of knowledge about adaptation, lack of credits, no access to irrigation water and poor soil fertility. The study concludes that rice farmers in the district perceived changes in climate and employ adaptation strategies. And socio economic characteristics are important in determining farmers' adaptation to climate change.

ACKNOWLEDGEMENTS

It is my wish to thank my supervisors; Dr. Henry de-Graft Acquah and Mr. Samuel Akuamoah-Boateng for their guidance and efforts in the successful completion of this work. It is important for me to thank Dr. Festus Annor-Frempong, Head of Department of Agricultural Economics and Extension of the University of Cape Coast, Mr. Selorm Akaba and other lecturers of the Department for their suggestions and contributions.

I wish to express my gratitude to the Excellence in Higher Education for Liberian Development (EHELD) for their support towards my education. Many thanks to the Staffs and Faculty members at the College of Agriculture and Sustainable Development (CASD), Cuttington University for their moral support.

I would also like to thank Prof. James S. Guseh for his effort towards my education; it is through his aid I reached this far of my career. Thanks to the Kokulo's family, the Harris's and the Kolleh's family for their guardians. I would also like to acknowledge my siblings: Daniel P. Kolleh, Gormah Kolleh, Alex Kolleh and Deddeh Kolleh.

My acknowledgement will not be complete without mentioning the research assistants who helped with the collection of data; and also the farmers who were interviewed for this study. All members of my family, friends and well-wishers, thank you for your support, prayers and encouragement.

DEDICATION

To my beloved parents: Yassah Kolleh and Joseph F. Kolleh

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LIST OF ACRONYMS

AEA	Agricultural Extension Agent
APF	African Partnership Forum
CAE	Changes are Expensive
CFC_S	Chlorofluorocarbons
CH_4	Methane
CO_2	Carbon dioxide
CRI	Crops Research Institute
EPA	Environmental Protection Agency
FAO	Food and Agricultural Organization
GCM	General Circulation Models
GDP	Gross Domestic Product
GHGs	Greenhouse gases
GNA	Ghana News Agency
GPRS	Ghana Poverty Reduction Strategy
GPRS	Growth and Poverty Reduction Strategy
GSS	Ghana Statistical Service
HFCs	Hydrofluorocarbons
IAI	Insufficient Access to Inputs

IPPC	Intergovernmental Panel on Climate Change
IPR	Insecure Property Rights
ISSER	Institute of Statistical, Social and Economic Research
KNDA	Ketu North District Assembly
LC	Lack of credit
LICC	Lack of Information about Climate Change
LKAO	Lack of knowledge about adaptation options
METASIP	Medium Term Agriculture Sector Investment Plan
MiDA	Millennium Development Authority
MOFA	Ministry of Food and Agriculture
N_2O	Nitrogen oxide
NAIW	No access to irrigation water
NASA	National Aeronautics and Space Administration
NBA	No Barriers to Adaptation
NDPC	National Development Planning Commission
NRC	National Research Council
O_3	Ozone
OB/F	Other Barriers (Flooding)
PC	Productivity Commission

PFCs	Perfluorocarbons
PSF	Poor Soil Fertility
SARI	Savannah Agricultural Research Institute
SL	Shortage of land
SPSS	Statistical Package for Social Research
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development

CHAPTER ONE

INTRODUCTION

Background to the Study

The agriculture sector is the backbone of the economies of most of the developing world, employing about 60 percent of the workforce and contributing an average of 30 percent of Gross Domestic Product (GDP) in Sub-Saharan Africa (World Bank, 2011). Climate change is a serious problem worldwide as it affects agriculture. This challenge is composed of the likely impacts on ecosystem services, agricultural production, and livelihoods. Generally, losses in the agriculture sector due to climate change has economy wide consequences, like loss in gross domestic output, a decline in the income/consumption of the most vulnerable population; hence, a general deterioration in households' welfare Food and Agricultural Organization [FAO], (2007).

Climate change and weather patterns changes are already being experienced as it is evident in severe impacts on food production, food security and natural resources all over the globe. Without the appropriate responses, climate change is likely to constrain economic development and poverty reduction efforts and exacerbate already pressing difficulties especially in countries whose economies are rooted in climate sensitive sectors such as agriculture. For instance, Taderera (2010) reported that South African awareness of climate change was literally interpreted as “changing weather” and this may influence the extent of adaptation. Adaptation is widely recognized as a vital component of any policy response to climate change.

Perceptions are influenced not only by actual conditions and changes, but are also influenced by other factors. A study by Gbetibouo (2009) found that having fertile soil and access to water for irrigation decrease the likelihood that farmers will perceive climate change; however, education, experience, access to extension services increase the likelihood that farmers perceived climate change. According to Dai, Aiguo, Kevin, Trenberth, and Taotao (2004), & Trenberth *et al.,* (2007), 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 and the resulting impacts point to the consequences on the environment, production system and livelihoods from future climate variability and change, hence to minimize the impacts of climate change requires a knowledge of the perception and adaptation of climate change strategies to deal with the phenomenon.

Adaptation to the adverse consequences of climate change could be viewed from two distinct perspectives; the awareness of the risks of climate change and the capacity to adapt to climate change and how adaptation can be carefully planned and implemented to avoid the possibility of mal-adaptation (FAO, 2007). In effect, adaptation is a way of reducing vulnerability, increasing resilience, moderating the risk of climate impacts on lives and livelihoods and taking advantage of opportunities posed by actual or expected climate change (Taderera, 2010).

Adaptation in agriculture occurs at two main scales: household-level (micro) and national level (macro). Micro-level analysis of adaptation in agriculture focuses on tactical decisions that farmers make in response to seasonal variations in climatic, economic and other factors. These micro-level tactical decisions of households in agriculture include using different adaptation options (Temesgen, Rockstrom, Savenije, Hoogmoed, & Alemu, 2008). On the other hand, national level or macro-level analysis is concerned with agricultural production at the national and regional scales and its relationships with domestic and international policy (Bradshaw, Dolan, & Smith, 2004; & Nhemachena, & Hassan, 2007).

Climate change is likely to pose a serious threat on environment, agricultural production and food security of most developing countries including Ghana. In particular, rural farmers, whose livelihoods depend on the use of natural resources, are likely to bear the brunt of adverse consequences Taderera (2010). This is largely because most developing countries experience high incidence poverty and as a result are incapable to adapt to climate change. However, the extent of impact of climate change on agriculture can be ameliorated by the perception and level of adaption of farmers (Taderera, 2010).

Ghana, like many other African countries, faces enormous social, economic and environmental challenges that are likely to be exacerbated by the impacts of climate change. At both the individual and the national levels, climate change is serious concern because of the nation's overdependence on climate-sensitive sectors, such as hydro-power generation, agriculture, fisheries and wildlife resources.

Projections indicate that temperature will continue to rise and the survival of coastal communities will be threatened by rising sea level. Reduction in rainfall is already impacting on rain-fed agriculture and hydro-power generation, causing significant decreases in industrial production. The rural poor are forced to adopt non-sustainable measures such as migration, farming and building in flood plains. These in turn increase their vulnerability and make the fight against poverty increasingly difficult. Presently, some of the challenges facing Ghana are the inadequate climate science professionals and institutional capacities to contribute effectively to Ghana's ability to adapt to the climate change phenomenon, Asiedu, Owusu, & Yankson (2011).

Rice is very sensitive to climatic, environmental and soil conditions Abdulai & Huffman (2000). Changes in these climatic factors are expected to affect rice yield adversely. Rice is the second most important cereal after maize in Ghana and is fast becoming a cash crop for many farmers (Millennium Development Authority [MiDA], 2010; Osei-Asare, 2010). Hence, the need to meet the demand for local rice has become a major concern with the current increase in rice consumption in the country. Though there has been an increase in the production of local rice, this has not met domestic demand (Ministry of Food and Agriculture [MoFA], 2009). The importations of rice continue to increases considerably year after year. The local rice has contributed much to Ghana’s capability in achieving food security even though most urban dwellers consume imported rice.

For the past three decades, rice production in Ghana has increased but this has not correlated with rice yields. Since the yields have declined by close to 12 percent from 2.72 metric tonnes per hectare in 2008 to 2.40 metric tonnes per hectare in 2009 (ISSER, 2010).

Statement of the Problem

Ghana's economy can be best described as agrarian, with the agricultural sector contributing 21.3 percent of GDP and employing 55 percent of the work force, as mainly smallholder farmers (Ghana Statistical Service [GSS], 2013). Although this high percentage of the national workforce is engaged in farming, they do not produce sufficient food to feed the ever increasing populace. This is because agriculture is predominantly rain fed, and exposes agricultural production to the effects of present climate variability and the risks of future climate change.

Agriculture is affected by climate change, especially by decreasing precipitation and increasing temperature and these reduce agricultural production. Rice farmers in the Ketu North District are not immured against the effects of climate change. Since most of the population of the district derive their livelihood from agricultural activities, hence changes in the climate is of great concern to their agricultural production activities in the district.

The production of rice accounts for 15 percent of agricultural output and 45 percent of the total land area used in cereal grain production in Ghana (Stanturf *et al.,* 2011). In the production of rice, farmers mostly make use of irrigation, rain-fed lowland and rain-fed upland systems and so years of extensive drought, has decreased the production of rice in the country. With expected rise in temperature and decline in rainfall in the years 2020, 2050 and 2080 it is believed that rice production in these years will steeply decline.

Although the issue of climate change and agriculture is not a recent development, there has been little or no efforts aimed at scientifically documenting the existing climate change situation among rice farmers in the Ketu North District in the Volta Region of Ghana, with regards to the various indigenous innovative technologies and adaptation measures to combat the negative effects of climate change.

Despite the importance of perceptions and adaptation strategies to climate change, very few studies have examined farmers' perceptions and adaptation strategies to climate change and its effects on other crops grown in the district. Virtually, no study has been conducted in the study area to investigate the effect of climate change on rice production and adaptation strategies by farmers to deal with the problem.

General objective

The general objective of the study is to analyse rice farmers' perception of climate change and adaptation strategies in the Ketu North District in the Volta Region of Ghana.

Specific objectives

The study specifically sought to:

1. Analyse rice farmers' perception of precipitation and temperature patterns in the study area.
2. Assess rice farmers' choice of adaptation measures in response to climate change.

3. Ascertain the determinants of rice farmers' adaptation strategies to change in precipitation and temperature.
4. Examine barriers to rice farmers' adaptation measures in response to climate change.

Research Questions

Based on the problem and specific objectives stated, the following research questions were formulated to guide the study.

1. How do rice farmers' perceive changes in precipitation and temperature pattern?
2. What are the choices of adaptation measures to climate change impacts?
3. What are the determinants of rice farmers' adaptation strategies to changes in precipitation and temperature?
4. What are the barriers to rice farmers' adaptation measures in response to climate change?

Significance of the Study

In order to enhance policy towards tackling the challenges climate change poses to farmers, it is important to have knowledge of farmers' perception on climate change, their choice of adaptation methods and the barriers affecting adaptation to climate change. Adaptation to climate change has the potential to substantially reduce many of the adverse impacts of climate change, reduce vulnerabilities and promotes sustainable development through enhancing the welfare of the poorest members of society (Acquah, 2011). Farmers in the Volta Region are no exception as they also experience the challenges of climate change. Therefore there is a need for farmers to adapt to climate change in order to improve their agricultural production.

This work will provide vital information on strategies farmers in the Ketu North District are using to adapt their rice farming to climate change in order to reduce losses, to improve their livelihood resources obtained from agricultural production activities. Again, due to the complex interactions between climatic, environmental, economic, political, institutional, social and technological processes, the findings of this study will be relevant to the farmers, the researchers, policy makers, the government and international organizations for information and policy formulation.

Delimitation of the Study

The study assessed rice farmers' perceptions of climate change and adaptation strategies in the Ketu North District of the Volta Region of Ghana. The study covered six (6) out of eleven (11) farming communities in the district that are growing rice at the Weta irrigation scheme.

Limitations of the Study

The inability of the student researcher to interact with the respondents directly to have first hand information served as a limitation to data collection. Therefore the student researcher employs the services of graduate students who understand the local dialect to conduct the data collection. As a foreigner, the student researcher relied heavily on the assistance of these graduate research assistants in addition to critical field observations during the data collection.

Most of the farmers are not educated and they do not keep adequate records of the challenges climate poses, so much of the study relied on farmers' ability to recall climate change situation in the area. In addition, most of the farmers do not keep records of their rice farming activities and it was difficult getting actual and accurate data; the study therefore relied heavily on the ability of the respondents to recall their farming activities.

Organisation of the Study

The study is structured into five major chapters. Chapter One consists of introduction to the study which include; background of the study, statement of the problem, general objective, specific objectives, significance of the study, delimitations and limitations of the study. Chapter Two review of related and empirical literature that supports the study and the conceptual framework. Chapter Three consists of the methodology of the study and the design used in the study. Chapter Four presents and discusses the results of the Study. Chapter Five presents the summary, conclusion and recommendation for policy implication as well as suggestions for further studies.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This chapter presents review of relevant literature on the major issues of climate change in the study area.

Concept of Climate Change

Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i.e., more or fewer extreme weather events). Climate change is known to be caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. However certain human activities have also been identified as significant causes of recent climate change, often referred to as "global warming" (National Research Council, 2010).

Scientists actively work to understand past and future climate by using observations and theoretical models. A climate record extending deep into the Earth's crust has been assembled, and continues to be built up, based on geological evidence from borehole temperature profiles, cores removed from deep accumulations of ice, floral and faunal records, glacial and periglacial processes, stable-isotope and other analyses of sediment layers, and records of past sea levels. More recent data are provided by the instrumental record. General circulation models, based on the physical sciences, are often used in theoretical approaches to match past climate data, make future projections, and link causes and effects of climate change.

United Nations Framework Convention on Climate Change (UNFCCC, 1992) defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes. Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer) (IPCC, 2007a). Alternatively, climate change may be due to natural internal processes or external forces, or due to persistent anthropogenic changes in the composition of the atmosphere or in land use.

According to De Chavez and Tauli-Corpus (2008), global warming is the average increase of the earth's surface temperature and oceans as compared to previous centuries. This is a result of the continuous trapping of heat within the earth's atmosphere due to increased quantity of greenhouse gases. Global warming is one of the key aspects of climate change, and it can lead to the rise in sea levels, warm oceans and melt the glaciers thereby threatening agricultural productivity and human settlements. Other impacts may include; changes in rainfall patterns and increase in soil erosion, storms, floods and drought. The ultimate result at the end would be a deepening food crisis, as well as worsening weather, energy crisis and general environmental breakdown throughout the world.

Causes of Climate Change

Factors that can shape climate are called climate forcings or "forcing mechanisms." According to NASA, (2011) these include processes such as variations in solar radiation, variations in the Earth's orbit, variations in the albedo or reflectivity of the continents and oceans, mountain-building and continental drift and changes in greenhouse gas concentrations. Additionally, the NASA report notes that there are a variety of climate change feedbacks that can either amplify or diminish the initial forcing. However, it suggests that some parts of the climate system, such as the oceans and ice caps, respond more slowly in reaction to climate forcings, while others respond more quickly. Forcing mechanisms can be either "internal" or "external". Internal forcing mechanisms are natural processes within the climate system itself (for example, the thermohaline circulation). External forcing mechanisms can be either natural (e.g., changes in solar output) or anthropogenic (for example, increased emissions of greenhouse gases).

Whether the initial forcing mechanism is internal or external, the response of the climate system might be fast (for example, a sudden cooling due to airborne volcanic ash reflecting sunlight), slow (for example, thermal expansion of warming ocean water), or a combination (for example, sudden loss of albedo in the arctic ocean as sea ice melts, followed by more gradual thermal expansion of the water). Therefore, the climate system can respond abruptly, but the full response to forcing mechanisms might not be fully developed for centuries or even longer.

According to the summary of the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (IPCC, 2007b), human actions are very likely the cause of global warming; meaning a 90 percent or greater probability is attributable to human action. A comprehensive assessment by the IPCC of the scientific evidence suggests that human activities are contributing to climate change, and that there has been a discernible human influence on global climate. Climate change caused by human activities, most importantly the burning of fossil fuels (coal, oil, and natural gas) and deforestation, are superimposed on, and to some extent masked by natural climate fluctuations.

Climate change and global warming are caused by the buildup of greenhouse gases (GHGs) such as carbon dioxide, nitrous oxide, chlorofluorocarbons (CFC_S) and methane, in the atmosphere as a result of human activities among them, the burning of fossil fuels, bush burning, use of machines that produce smoke when cooking. Various activities carried out by human beings have varying contributions to the changes in the climate systems. The burning of coal, oil, and natural gas, as well as deforestation and various agricultural and industrial practices, are altering the composition of the atmosphere and contributing to climate change. These human activities have led to increased atmospheric concentrations of a number of greenhouse gases.

According to De Chavez and Tauli-Corpus (2008) GHGs are chemical compounds such as water vapour, carbon dioxide, methane, and nitrous oxide found in the atmosphere. These are gases that are able to absorb and radiate heat. Many greenhouse gases occur as such as water vapour, carbon dioxide (CO_2), methane (CH_4), Ozone (O_3) and nitrous oxide occur naturally.

However, other such as the hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) result exclusively from human industrial processes. All of these gases are responsible for greenhouse effect, but water vapour and CO_2 contribute 90 percent of this effect. In their direct contribution of these greenhouse gases, CO_2 contributes 55 percent, methane 15 percent, CFCs 7 percent, CFC (11 and 12) 17 percent, and N2O 6 percent.

Natural changes in climate result from interactions such as those between the atmosphere and ocean, referred to as internal factors, and from external causes. However, variations in the sun's energy output which would externally vary the amount of solar radiation received by the earth's surface and in the amount of material injected into the upper atmosphere by explosive volcanic eruptions.

Impact of Climate Change in Africa

According to African Partnership Forum [APF], (2007), Sub-Sahara Africa is among the most vulnerable regions to climate change impacts, because the majority of the sub-Sahara African population lives in abject poverty, and are heavily dependent on rainfed agriculture for their economic and livelihood sustenance. Therefore, variations in rainfall patterns and temperature adversely impact their economic and social survival. The main long-term key impacts include significant changes in rainfall patterns and temperature which affect agriculture, which invariables lead to there is a projected significant reduction in food security; worsening water security; decreasing fishing resources in large lakes due to rising temperature; increasing vector-borne diseases; rising sea level affecting low-lying coastal areas with large populations; and rising water stress (APF, 2007).

Trends in Climate Change in Africa

The historical climate record for Africa shows warming temperature of approximately 0.7°C over most of the continent during the twentieth century; a decrease in rainfall over large portions of the Sahel (the semi-arid region south of the Sahara); and an increase in rainfall in east and central Africa. Over the twenty first century, this warming trend, and changes in precipitation patterns are expected to continue and be accompanied by a rise in sea level and an increased frequency of droughts and floods (Intergovernmental Panel for Climate Change [IPPC], 2001). The report shows an increase in temperature in all the regions of sub-Sahara Africa. The same source predicts an increase in precipitation of 2 percent in West Africa and 7 percent in East Africa, but a decrease of 4 percent in southern Africa.

However, other sources have predicted a general decrease in precipitation and water availability. For example, Shiklomanov (1997) shows that between 1970 and 1995, Africa has experienced a 2.8 times decrease in water availability, and that the average discharge of West African rivers has dropped by 40-60 percent since 1970. Under SRES scenarios, Arnell (2004) projects that by the year 2025 about 370 million African people will experience increases in water stress, while about 100 million people are likely to experience a decrease in water stress by the year 2055, as a result of a likely increase in precipitation. In the Nile region, most scenarios of water availability estimate a decrease in river flow up to more than 75 percent by the year 2100, with implications for agriculture and conflict (Nyong, 2005).

Severe droughts have been recorded for southern Africa. Over parts of southern Zimbabwe and south-eastern Botswana, rainfall amounts were as low as 10 percent of the average value during the rainy season of 1991/92. Droughts in southern Africa are mainly due to the result of the El Niño/Southern Oscillation (ENSO) phenomenon, the periodic warming of the tropical Pacific Ocean and related shifts in the atmospheric circulation which brings climatic disruption to many low latitude areas (Glantz, 1992). There is a historic link between the occurrence of ENSO events and droughts in southern Africa. The ENSO event of the early 1990s was unusual in that it continued for longer than usual. The drought conditions in southern Africa only eased slightly during the 1992/93 season, although by 1993/94 higher rainfall levels were experienced in the region (Hulme, 1994).

Key Climate Change Impacts in Africa

The most vulnerable areas or sectors to climate change in Africa are water resources, agriculture, health, ecosystems and biodiversity, forestry and coastal zones. In general, climate change presents a substantial challenge to regional agricultural development. From food security and nutrition to sustainable management of natural resources, climate change is a significant threat to the welfare of millions of the continents rural poor. If adequate measures are not taken to adapt to the adverse consequences of climate change in sub-Sahara Africa, the region will remain vulnerable to the widespread effects of climate change (Food and Agricultural Organization [FAO], 2009). The same source predicts a loss of 2-7 percent of GDP by 2100 in parts of sub-Sahara Africa; 2-4 percent and 0.4-1.3 percent in West and central Africa, and northern and southern Africa respectively (FAO, 2009). Arid and semi-arid land could expand in coverage by 60-80M ha. Fisheries will be particularly affected due to changes in sea temperatures that could decrease trends in productivity by 50-60 percent and that productivity in Africa will be further undermined by a reduction in fertile agricultural land available and an expansion in the coverage of low potential land (FAO, 2009).

Studies have shown that while agriculture is a primary climate change impact sector, other sectors in the economy are also impacted because of the induced effect from the agriculture sector. For example, Juana, Mangadi, and Strzepek (2012) show that 20 percent reduction in water availability in South Africa due to climate change will lead to a 12 percent decline in agricultural output. Because of the backward and forward linkages between agriculture and the other sectors of the economy, this 12 percent decline in agricultural output will lead to about 8 percent decline in gross sectoral output. Also, the showed that a 10 percent loss in agricultural output in Botswana due to drought will lead to about 8 percent decline in total sectoral output.

Studies also show that the impact of climate change or climate variability is not evenly spread among the different socio-economic household groups. For example, Juana, Mangadi and Strzepek (2012), show that poor households in South Africa are the most vulnerable population group to climate change. Similar results are also recorded in Juana, Makepe, & Mangadi (2012). These studies show that the impact of climate change leads to general deterioration in households' welfare, but that poor or rural households who depend primarily on agriculture for their economic or livelihood sustenance are the most vulnerable population group.

The increase in temperature, especially in the summer months will lead to increased human death (Conway, 2008). Diseases carried by insects and other vectors are especially susceptible to the effects of climate change. For example, the geographical distribution and the rates of development of mosquitoes are highly influenced by temperature, rainfall and humidity. Increased temperatures and more prolonged rainy seasons may extend the transmission period of the disease. In general, an extension of the range of malaria carrying mosquitoes and malaria into higher elevations, particularly above 1000m is expected. Dengue, another mosquito borne disease is also likely to increase (Conway, 2008). In addition to the above impacts, climate change can have significant negative impacts on the natural environment including the loss of biodiversity and changes in ecosystem services and functions (Mwingira *et al.,* 2011).

According to IPPC (2007a), any increase in global average temperature above the range of 1.5- 2.5°C is likely to result in significant alterations in the structure, function and geographical ranges of ecosystems, which negatively influences species distribution and survival. Several species around Africa are now affected by the combined impacts of climate factors and their interactions with other anthropogenic stressors such as encroachment, land fragmentation and destruction of natural habitats. Together, climatic and non-climatic stressors may have considerable impacts on the ecosystems functions and on ecosystem services (Lovejoy, 2005). Other impacts include destruction of infrastructure like dams, roads, bridges, water and electricity distribution networks and coastal ecosystems.

Farmers Perception and Adaptation to Climate Change in Africa

Farmers are vulnerable to shocks (unexpected events such as flooding), seasonal variation, particularly timing and amount of rainfall, and long-term trends (for example, increased mean temperature). Coping strategies commonly in place to reduce vulnerability to seasonal variation include planting mixtures of crops and cultivars adapted to different moisture conditions (reducing the risk of complete crop failure), using landraces resistant to climate stresses and mulching or water conservation. Multi-year droughts, however, will overpower these short-term coping strategies and may cause long-term impacts if capital assets are lost and no effective local or national support system is in place (Challinor, Wheeler, Garforth, Craufurd, & Kassam, 2007). An alternative to rainfed agriculture for some farmers may be small-scale irrigation; this requires suitable land, access to water, and ideally, capital to invest in a pump. In the northern savanna zones, dry season vegetable crops are grown in floodplain fields that often are hand watered. Many irrigation options require infrastructure or cooperation among groups and are thus beyond the resources of a single farmer.

Given the uncertainty of climate change projections for precipitation, the prudent adaptation strategy is one of “no regrets.” Reducing vulnerability to current climate stress may increase adaptive capacity and increase resilience to future climate change. Many options are available for adapting agriculture to climate variability and change. Some farmers may opt to leave agriculture by diversifying entirely into non-farm activity or migrate to urban areas. With increasing populations, this option may be unavailable, forcing some households to remain in agriculture (Challinor *et al.,* 2007). Diversification of livelihoods in the coastal region will be a necessity for fishing households. A promising industry is the emerging tourism sector on the coast and eco-tourism near attractions such as national parks. Investment in infrastructure would provide employment in short-term construction jobs as well as in the long-term. Infrastructure (especially restaurants, lodging, developed recreational activities) would also enable local communities to capture more benefits from tourism.

Farmers who depend on annual rains have already demonstrated considerable ability to adapt to uncertain climate at least within the range of historic variation. Their ability to adapt to future variation climates will depend in part on a supportive institutional and macroeconomic environment. Ghana is fortunate among West African nations in that it is politically stable, yet its governance structures are weak and its public sector underperforms, especially in the northern savanna zones (Challinor *et al.,* 2007). Clarification of land tenure, tree tenure, and carbon rights is necessary for smallholders to access capital and make long-term investments in conservation practices, agroforestry, and improved crop varieties and inputs. Access to knowledge and assistance from extension workers is needed for farmers to modify their cropping systems. Community-based approaches to identifying climate change adaptation strategies as well as strategies for enhancing food security have been implemented in the northern regions and appear to hold promise.

Focusing food security investments entirely on commercialization, mechanization, and large-scale agriculture will result in adverse social impacts unless the needs of small farmers are simultaneously addressed. A multiscaled approach to agricultural development appropriate to the local socio-cultural context should be considered. Farming for profit will require concentrating agriculture on fewer larger farms to take advantage of economies of scale, mechanization efficiencies, and market access. Such commercialization or rationalization of agriculture may be desirable from a national development perspective. However, given the traditional land tenure system and the insecurity of many smallholders, development of large-scale farms by overseas investors may displace many smallholders. Moreover, the food insecurity of local populations could be worsened in bad crop years if they are priced out of the market for food. Given the likelihood that oil, fuel, and petroleum-based agricultural chemicals will increase in price in the future and most smallholders cannot afford such inputs without subsidies, questions of economic viability also arise. Commercialization and large-scale agriculture also pose uncertainties with or without climate change interactions with regard to environmental effects and long-term sustainability.

A study by de Wit (2006), investigated the ability of farmers to detect and adapt to climate change. The study collected data from Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa and Zambia on the natural trends in temperature and precipitation, perceived barriers to adaptation, and socio-economic factors influencing adaptation in each country. A significant number of farmers across the 10 countries indicated that average temperatures had increased while precipitation had decreased. A significant minority reported that they had experienced a change in the timing of the rains. Adaptation strategies across these countries varied from planting varieties of the same crop, changing the planting dates, increased use of irrigation, to water and soil conservation techniques. However, in some of the countries farmers indicated that they had made no adjustments to their agricultural practices. What the farmers considered as barriers to adaptation also differed among the countries. These barriers included lack of credit, lack of access to water and appropriate seed as well as lack of information about the weather or long-term climate change.

Maddison (2006), reports that perceptions about climate change showed that a significant number of farmers believe that temperature has already increased and that precipitation has declined. Farmers with the greatest farming experience were more likely to notice changes in climatic conditions which according to the study are consistent with farmers engaging in Bayesian-updating of their prior beliefs. The study also reported that farmers' experiences, access to free extension services and markets are important determinants of adaptation.

Gbetibouo (2009), argues that farmers with access to extension services in South Africa are likely to perceive changes in the climate because extension services provide information about climate and weather. Consequently, awareness and perceptions of changes in climatic conditions shape action or inaction on the problem of climate change.

Nyanga, Johnson, Aune, and Kahinda (2011), interviewed 469 farmers from 12 districts in Zambia to elicit information on their perceptions of climate change impacts in the country. Most farmers reported that they had perceived increase in the duration of the cold season, no change in the duration of the hot season and a reduction in the rainy season's duration. Also, farmers perceived an increase in the frequency of droughts and floods. The study revealed that crop diversification, conservation agriculture and gardening were the common adaptation measures used by arable farmers, while increasing livestock diversity and seeking support from veterinary officers are the measures taken by pastoral farmers.

Mandleni and Anim (2011), used information collected from 500 livestock farmers who participated in extension training courses in the Eastern Cape of South Africa. The information included farmers' perceptions about climate change in the province and the adaptation measures they considered appropriate. The analytical results show that about 86 percent of the farmers were aware of increase in temperature, and that weather conditions in the province was dominated by drought. About 83 percent of the respondents reported that harsh weather conditions led to the reduction in cattle numbers.

Gandure, Walker, and Botha (2012), investigated farmers perception and adaptation to climate change impacts in a South African rural community. The discussion centered on how they perceived climate change variables, how they have adapted to changes in the perceived climatic conditions, and the factors inhibiting adaptations to climate change in the study area. The results showed that most farmers had perceived increase in temperature, and that summer temperatures were warmer, while winter temperatures were colder. Warmer temperatures were associated with high evaporation and increased crop water requirements. Furthermore, the farmers also reported that there has been a perceived decrease in rainfall or precipitation. They particularly noticed delayed rainfall and early cessation. They reported that weeds, insects and worms have the strongest influence on their livelihoods. Generally, education and awareness about climate change impacts and therefore coping capacities were found to be very low among most farmers partly due to weak institutional coordination and support. The analysis of livelihood risks, which was done through scoring and ranking of responses, showed that the impact of weeds, insects and worms posed the highest risk to farmers in Gladstone. Poor security is the second most important factor followed by poor access to markets. Rainfall variability ranked fourth, while old age, poor health and extreme temperatures ranked fifth, sixth and seventh respectively. The barriers to adaptations to climate change included lack of access to early warning information and unreliability of seasonal forecast. Farmers also reported that lack of access to adequate cropland was a barrier to adapting to climate change.

Yesuf, Di Falco, Deressa, Ringler, and Kohlin (2008), analysed the impact of climate change and adaptation on food production in Ethiopia. They used two separate models to examine the factors influencing farmers' decision to adapt and to perceived climate change impacts. The results of the study revealed that changing crop variety, soil and water conservation, water harvesting, planting of trees and changing planting and harvesting dates were the choices of adaptation measures adopted by the farmers. Among these methods of adaptation, planting trees was the measure adopted by most farmers. However, about 42 percent of the farmers did not use any adaptation method for climate change impacts. The study also showed that household wealth represented by farm and non-farm income and livestock ownership, increased the likelihood of climate change awareness and adaptation.

Empirical Studies on Farmers' Perceptions and Adaptations to Climate Change in West Africa

Acquah (2011), assessed farmers' perceptions and adaptation to climate change as well as the socioeconomic determinants of willingness to pay for climate mitigation policies in Ghana. Through the using of descriptive statistics and the logit model the study results indicated that 60 percent reported that there had been a noticeable increase in temperature and 49 percent reported a decrease in rainfall. The farmers' level of adaptation was found to be relatively high with majority of the farmers' stating that planting different varieties of crops, changing planting dates, and soil and water conservation were the main adaptation measures taken to cope with climate change. The farmers reported that insufficient access to inputs, lack of knowledge about other adaptation options and no access to water were the main climate change adaptation constraints. Other barriers included lack of credit and lack of information about climate change, high cost of adaptation and insecure property rights. Furthermore, the study revealed high level of willingness to pay for mitigation policies among the farmers. Years of farming experience, ownership of farm land, farm size and other income are significant predictors of the probability to pay for climate change mitigation policy.

Acquah and Onumah (2011), analyzed information collected from 185 farmers from Western Region of Ghana about their perceptions on, and adaptations to climate change in the region. While the majority of the farmers interviewed perceived increase in temperature and decreased precipitation as the climate change variables experienced in that region, only 18 percent of the respondents did not perceive any changes in the two climatic variables. While about 60 percent of the respondents reported the use of one or more adaptation methods, 40 percent did not adopt any adaptation measures.

The main adaptation measures adopted by farmers include changing planting dates, using different crop varieties, planting tree crops, practising irrigation, soil conservation and water harvesting. The farmers identified lack of information on climate change impacts and adaptation options, lack of access to credit, access to water, high cost of adaptation, insecure property rights and lack of access to sufficient farm inputs as the main barriers to the adoption of any adaptation measure. The probit analysis indicated that the significant determinants of adaptation to climate change are age, gender, years of education, years of farming experience, own farm land and other income generating activities.

In Osun State, Nigeria, Sofoluwe, Tijani, and Baruwa (2011), surveyed 100 farmers to gather information on their perceptions about changes in temperature and precipitation. The study used the multinomial logit model to analyze the factors that determine farmers' adoption of various climate change adaptation measures. The results showed that more than 75 percent of the respondents were aware of increase in temperature and decreasing precipitation in the region.

The farmers reported that late planting, irrigation, soil conservation, planting different crop varieties are the common adaptation strategies used, and that lack of information on climate change impacts and access to credit, labour shortages, shortage of land and poor potential for irrigation are the barriers to adapting to the perceived changes in climatic conditions. The regression results showed that livestock ownership, access to loans, off farm income generation, gender and household size were the significant determinants of adapting to climate change impacts.

In south western Nigeria, Apata, Samuel, and Adeola (2009), analysed arable food crop farmers' perceptions about climate change and adaptation strategies. The study administered structured questionnaire and held focus group discussions. From the 350 valid respondents they employed the binomial logit analysis to explore the characteristics that best explained variation in the measures of attitudes of the poor perception and adaptations to climate change, and factors that influence such decisions. The focus group discussions revealed that farmers had experienced a change in climatic conditions. About 89 percent indicated that there has been a significant increase in temperature, 72 percent perceived higher evapo-transpiration rates, 70 percent experienced the spread of agricultural pests and weeds on crop land, 68 percent indicated that there has been violent rain and hailstorms, and 65 percent experienced delayed rainfall and early cessation. As a result of low rainfall and increased temperature, farmers seem to be abandoning mono-cropping for mixed cropping and mixed crop-livestock systems. Farming experience and access to education were found to promote adaptation. This implies that educating farmers to improve their awareness of potential benefits of adaptation is an important policy measure.

Akponikpè, Johnson, and Agbossou (2010), conducted a survey of 234 farmers in 78 villages in Benin, Burkina Faso, Ghana, Niger and Togo. Result from the study revealed that most of the respondents reported that there has been a decrease in rainfall and a significant increase in temperature over the years. The pattern of rainfall had changed, with delayed rains and early cessation; and that there had been an increase in the number of hot days. However, there were variations in these reports according to differences in agro-climatic zones. The farmers reported that they had adopted water and soil conservation strategies to deal with the prolonged lack of rain. Most farmers also delay planting to adapt to the delayed rains.

Mertz, Mbow, Reenburg, and Diouf (2009), analysed farmers' perceptions of climate change and adaptations in the savanna zone of Senegal. The results of the study showed that farmers in this zone are aware of climate variability, and identified intensive wind and occassional excess rainfall as the most destructive climatic factors. They therefore attributed poor livestock health and reduced crop yield to these adverse climatic factors. However, the farmers also attributed crop failures and other perceived climate impacts to the political problems in the country.

Nzeadibe, Egbule, Chukwuone, and Agu (2011), used descriptive statistics to analyse farmers' perception of climate change governance in the Niger Delta as well as to examine the factors that limit adaptations to climate. The respondents believed that the involvement of the state through legislature is very important in aiding climate change adaptation. The study showed that majority of farmers in the study area were not aware of climate change consequences and the effectiveness of policies and programmes by government regarding climate change. Furthermore, the main factors that prevented farmers from adapting to climate change impacts were found to include: information asymmetry, irregularities of extension services, poor government attention to climate problems, inability to access available information and improved crop varieties/seeds, ineffectiveness of indigenous methods, no subsidies on planting materials, limited knowledge on adaptation measures, low institutional capacity, and absence of government policy on climate change.

Trends in climate change in Ghana

Ghana is located in West Africa on the guinea coast and has a tropical climate. Agriculture constitutes the mainstay of Ghana's economy, accounting for 21.3 percent of GDP and employing 55 percent of the economically active population (GSS, 2013). Agriculture is predominantly rain fed, which exposes it to the effects of climate variability and the risks of future climate change. The rainforest zone may experience an increase rain fall but this may have implications for erosion and floods coupled with drifting of climate induced migrants from the north to this zone in search of better livelihoods and serving as source of farm labour for an increased encroachment into forest reserves for extensification of cocoa, palm and other crops'. This certainly will aggravate deforestation rates.

A projected sea level rise of 1mm by 2100 could see the loss of over 1000km² of land due to flooding and shoreline recession will impact availability of arable land and have consequences for livelihoods; of 132,000 people particularly on the east coast of Ghana. Damage to the coastal zone in the form of flooding, land loss, and forced migration is projected to be $4.8 million per annum by the 2020s, rising to $5.7 million per annum by the 2030s (Organisation for Economic Cooperation and Development [OECD], (2011). Water availability both on-surface and ground recharge will be affected constraining efforts to provide clean water for drinking and irrigation.

The impacts are observable and place stress on the country's vulnerable sectors: agriculture, coastal zones/marine ecosystems, water resources, and energy production. Increased climate variability reflected in changing climate regimes on agriculture is evident (World Bank, 2011).

Although Ghana has experienced extreme flood events in 1969, 1972/73, 1991 and 1995, latest (IPCC), model predictions for Africa, drawing upon empirical downscaling of general circulation models (GCM) simulations by Hewitson and, Crane (Christensen et al., 2007), suggest strong drying over the centre of the Sahel but wetter trends along the coast, especially the gulf of guinea. In fact, extremely wet seasons, high intensity of rainfall events, and associated flooding in West Africa are expected to increase by 20 percent over the next decades (UNDP, 2010) and National Development Planning Commission [NDPC], 2010). The 2007 floods will go down in the history of Ghana as one of the worst flooding events in the country. In all 330,000 people were affected, 56 killed and 6,000 farms destroyed (United Nations, 2007).

More so, evidence of scenarios developed for climate change impact assessment in Ghana shows trends towards rising temperatures and declining rainfall for all ecological zones (Environmental Protection Agency [EPA], 2000; Minia, 2004). In recent times the country has experienced increases in minimum and maximum temperatures. Analysis of the mean rate of annual change in both minimum and maximum temperatures in the Wenchi and Afram plains districts between 1960 and 2004 show an increase of 0.03^0c (UNDP & NDPC, 2010).

The effect of rainfall variability on Ghana's agricultural GDP and overall GDP is expected to be devastating. Toward 2050, annual real GDP is projected to be 1.9 to 7.2 percent lower than in a dynamic baseline scenario without anthropogenic climate change (World Bank, 2010a). Climate change modeling projects losses in agriculture could be as much as $122 million per annum, while losses in transport and hydro- power could be up to $630 million and $70 million, respectively. Total economy wide impacts are estimated to range from $158-$765 million per annum (Ghana country study, 2010).

Agriculture, a major driver of poverty reduction, almost exclusively dominates the livelihoods of rural households, who cultivate on average 1-2 ha plots of land, and produce 80 percent of the country's agricultural output (MOFA, 2008). Based on a 20-year baseline climate observation, it is forecasted that crops -maize and other cereal crop yields will reduce by 7 percent by 2050 (United States Agency for International Development [USAID], 2011). These are staple food crops that are the primary farming and economic produce of Ghana and especially cultivated in the north of Ghana. Even more so agro biodiversity is expected to be severely impacted. Agro biodiversity is a component of biodiversity and its loss as a result refers to the reduction of the components of biodiversity in and around agricultural land or farms, including absence of previously existing crops or crop varieties, and the reduction in crop yield. However, the persistent bush fire and over-exploitation of the rich and extensive savanna vegetation found in northern Ghana is quickly eroding biodiversity. In Ghana's northern savanna zones, "widely open cultivated savanna" (<6 trees/ha) did not exist, but by 2000, 33.6 percent of the savanna ecosystem fell into this category with a 5.9 percent increase projected by 2050 (USAID, 2011). This has diminished the resilience to hunger since communities have reduced access to agro biodiversity products as “food of sustenance” especially in lean seasons when intense labour is even required for planting. Real household consumption is expected to decline (World Bank, 2010).

Rainfall trends in Ghana

Annual rainfall in Ghana is highly variable on inter-annual and inter-decadal timescales and long-term trends are difficult to identify. Rainfall over Ghana was particularly high in the 1960s, and decreased to particularly low levels in the late 1970s and early 1980s, producing an overall decreasing trend in the period 1960 to 2006, with an average precipitation of 2.3 mm per month (2.4 percent) per decade (UNDP & NDPC, 2010). Projections for precipitation indicate a cyclical pattern over the period 2010-2050 for all regions, with high rainfall levels followed by a drought every decade or so (UNDP, 2000; World Bank, 2010b).

Temperature Trends in Ghana

According to (UNDP and NDPC, 2010), temperature data since 1960 indicates that mean annual temperature has increased by 1.0˚c, at an average rate of 0.21˚c per decade. The rate of increase has been higher in the Northern Region of the country than in the South. Daily temperature data indicate that the frequency of 'hot' days has increased extensively in all seasons except for December, January, and February, and the frequency of 'hot nights' has increased considerably in all seasons (UNDP & NDPC, 2010).

The mean annual temperature is projected to increase by 1.0 to 3.0°c by the 2060s, and 1.5 to 5.2°c by the 2090s (UNDP, 2000; World Bank, 2010b). The projected rate of warming is most rapid in the northern inland regions of Ghana. When considering the Ghana dry climate scenario, temperatures in the three regions of the north are projected to increase by 2.1-2.4°c, in the western, western-central, and Volta regions by 1.7-2.0°c, and in the Brong Ahafo region by 1.3-1.6°c. UNDP and NDPC, (2010) further indicated that most projections show substantial increases in the frequency of days and nights that are considered ‘hot’ in current climate, but the range of projections between different models is large.

Impact of Climate Change on Agriculture in Ghana

According to the IPCC (2007a), global climate (air temperature) rose by 0.6˚C in the twentieth century and is expected to keep rising, having factored in all uncertainties and expectations at this rate. This has meant that there has been a discernible change in atmospheric conditions necessary for the growth and cultivation of many very useful crops that lack a sound resistance to heat and drought.

Change in climate will also have an effect on the soil. Soil structure is affected by variation is temperature and rainfall, particularly during hotter and dryer season; there is an increased tendency for subsoil to become strong making it more difficult for roots to penetrate. Some soils are likely to form impenetrable caps, increasing the risk of run-off and subsequent pollution events and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes (Brett, 2009).

Farmers' Perception of Climate Change

Climate is one of the key factors that influences agricultural production and has enormous impacts on food production in most Sub Saharan African countries. Changes in climate are expected to adversely affect agriculture, food security, water resources and biodiversity as a whole. According to Acquah & Onumah (2011), rural farmers, whose livelihoods depend on the use of natural resources, are likely to bear the brunt of adverse consequences;

and their perception of climate change is crucial in reducing their vulnerability and increasing resilience to the negative impacts of climate change.

In a study to analyse farmers' perception and adaptation strategies to climate change in India, Dhaka, Chayal and Poonia (2010), found that significant number of farmers believe that temperatures have already increased and the precipitation has declined along with late onset and early withdrawal of monsoon with long dry spells.

Climate Change Adaptation

Adaptation to climate change is generally defined as the process of adjusting or intervening in natural or human systems intending to respond to actual or anticipated climate change or its effects (IPCC, 2001). It is the process of improving society's ability to cope with climate change and its effects across time scales, from short term. It is a mechanism that helps in managing the losses or exploiting beneficial opportunities presented by climate change. Adaptive capacity is defined as the ability of a system to adjust to climate change and its effects, to moderate potential damages and to take advantage of opportunities (IPCC, 2001).

Adaptation in agriculture is identified as one of the policy options to reduce the negative impact of climate change on agricultural productions (Kurukulasuriya & Mendelson, 2006). Adaptation in agriculture occurs at two main scales: household-level (micro) and national level (macro). Micro-level analysis of adaptation in agriculture focuses on tactical decisions that farmers make in response to seasonal variations in climatic, economic and other factors. These micro-level tactical decisions of households in agriculture include using different adaptation options. The most common micro-level adaptation options in crop agriculture include crop diversification, using irrigation, mixed crop-livestock farming systems, using different and new crop varieties that are better suited to drier conditions, changing planting and harvesting dates, and mixing less productive, drought-resistant varieties and high-yield water sensitive crops (Temesegen *et al*., 2008). On the other hand, national level or macro-level analysis is concerned with agricultural production at the national and regional scales and its relationships with domestic and international policy (Bradshaw *et al*., 2004 & Nhemachena & Hassan 2007). For example, crop adaptation measures can be supply-side measures (such as providing more water), demand side measures (such as reuse of water) and combinations of both. While some measures may be taken at the individual or farm level, others require collective action (e.g. rain water harvesting), or investments at the agency or government level (e.g. building dams, releasing new cultivars that are more water efficient) (Jawahar & Msangi, 2006).

Defining successful Adaptation to Climate Change

Defining success simply in terms of the effectiveness of meeting objectives, however, is not sufficient for two reasons. First, whilst an action may be successful in terms of one stated objective, it may impose externalities at other spatial and temporal scales. What appears successful in the short term turns out to be less successful in the longer term. Second, whilst an action may be effective for the adapting agent, it may produce negative externalities and spatial spillovers, potentially increasing impacts on others or reducing their capacity to adapt. Much coastal planning for increased erosion rates, for example, involves engineering decisions that potentially impact neighbouring coastal areas through physical processes of energy dissipation and sediment transport (Pethick & Crooks, 2000).

The definition of success clearly, therefore, depends on both the spatial and the temporal scale, and should not simply be assessed in terms of the stated objectives of individual adaptors. The issues of governance and the wider effectiveness of adaptation are also critical, and can be assessed through reference to equity, legitimacy and the economic efficiency of adaptation. Adaptation to climate change, therefore, can be evaluated through generic principles of policy appraisal seeking to promote equitable, effective, efficient and legitimate action harmonious with wider sustainability (Fankhauser, Smith, & Tol, 1999; de Loe, Kreutzwiser, & Moraru, 2001; Burton, Huq, Lim, Pilifosova, & Schipper, 2002). In the following sections, we address first the issue of effectiveness and efficiency, before examining the equity and legitimacy of adaptation actions.

It is, however, important to note that these criteria of efficiency, effectiveness, equity and legitimacy are contested and context specific, and are based on competing values (Adger, Brown, Fairbrass, Jordan, Paavola, Rosendo, & Seyfang, 2003). The relative importance attached to each criterion will vary between countries, between sectors within countries, and over time as attitudes and expectations change. Most importantly, the relative weight placed on these values varies between actors engaged in adaptation processes, depending on their world view and perceived limits to responsibility (Haddad, 2005). Arguably, conflicts over the allocation of resources, for adaptation and other purposes, reflect different perceptions of progress as a central dilemma of development (Low & Gleeson, 1998). Private-sector decisions are often assumed to focus on economic efficiency, particularly when the outcomes of the decisions are judged by share performance in capital markets. Nonetheless, the distributional effects and the legitimacy of the decision are also important.

Effectiveness in Adaptation to Climate Change

Effectiveness relates to the capacity of an adaptation action to achieve its expressed objectives. Effectiveness can either be gauged through reducing impacts and exposure to them or in terms of reducing risk and avoiding danger and promoting security (Jones, 2001). Effectiveness depends on the sequence and interaction of adaptations over time. The impacts of interventions in public health to reduce the risks from extreme temperatures or epidemics, for example, can be estimated through standard techniques such as estimating the avoided impact of disease burden, and dose–response estimates of projected cases associated with particular risks (McMichael *et al.,* 2004). Yet the complex causal chain of behavioural feedbacks makes any such estimation of the effectiveness of public health interventions and the effectiveness of individual actions problematic (McMichael & Githeko, 2001; Kahn, 2003).

There are a number of issues surrounding measurement of the effectiveness of adaptation. First, there may be uncertainty over how a particular adaptation option will work even under defined conditions. The effectiveness of physical flood defences in reducing inundation is relatively well-known, for example, whilst the effectiveness of 'softer' engineering approaches such as creation of coastal wetlands, river channel restoration or managing farmland to reduce flood runoff may be equally effective. Yet this effectiveness is rather more difficult to predict or evaluate.

Second, the effectiveness of an adaptation option introduced by an organisation may be reliant on actions taken by others. Demand reduction as an adaptation option in the water supply industry, for example, relies on individual consumers to reduce their consumption of water; the effectiveness of flood warning schemes depends on whether and how floodplain occupants respond to warnings. The individual uptake of adaptation options is highly uncertain, but there is considerable empirical evidence (often from hazard research: Wilbanks and Kates, 1999) that there are many constraints on individual adaptation.

Third, the effectiveness of an adaptation action may depend on the future unknown state of the world. The effectiveness of a measure to reduce sensitivity to a physical hazard will depend on future climate. For example, the degree to which a new reservoir provides future security of water supply will depend on the extent of climate change, and the standard of service provided by a flood protection embankment will depend on the future flood regime.

Declining incomes, for example, may reduce the effectiveness of measures which rely on individuals taking adaptation actions themselves, and changes in attitudes towards regulation may influence the effectiveness of adaptation measures based on rules and regulations. Some adaptation measures are inherently more robust and less sensitive to changing conditions than others. For example, the future technical effectiveness of flood protection embankment depends on the future relationship between flood frequency and flood magnitude (in other words, its design standard may be significantly reduced in the future). In contrast, the effectiveness of a flood warning scheme would be unaffected by future changes in climate (as long as the climate change did not change the physical nature of the hazard).

Fourth, whilst an adaptation measure may be effective at reducing the impacts of climate change or increasing opportunities in one location or time period, it may increase pressures "downstream", or lessen the abilities of others to adapt to climate change. A flood embankment, for example, often simply increases flood hazard downstream.

Potentially, any adaptation action can create unintended impacts on other natural and social systems. Measures to reduce exposure and sensitivity to a climate hazard have the greatest potential to impact on other elements of the physical and ecological environment. Measures to increase resilience are less likely to have an environmental impact, although clearly they can if they focus solely on achieving short-term objectives without taking into account wider sustainability considerations.

In practice, there may be considerable uncertainty over the impact of an adaptation action. In some cases the impact may be clear and immediate, and past experience may be a very useful guide. The adverse effects of traditional 'concrete' engineering approaches to flood management, for example, are well known, but the adverse and beneficial effects of soft engineering approaches (such as river channel restoration) are very uncertain. Significantly, however, the assessment of the effectiveness of an adaptation action may be dependent on the spatial and temporal scales over which the change is viewed. Longer time scales may reveal greater change as the natural and social systems adjust to altered circumstances; larger spatial scales may reveal "downstream" impacts of an action.

Efficiency in Adaptation to Climate Change

According to Ingham and Ulph (2003), adapting to climate change entails costs, but should also yield significant benefits. At the scale of the individual organisation the costs will be those of implementation, including transaction costs and the costs of inaccurate prediction, and the benefits, those of reduced impacts or enhanced opportunities. There is, however, at any scale of analysis far more to economically efficient adaptation than a simple comparison of quantified costs and benefits.

Any assessment of the economic efficiency of adaptation actions requires consideration of, first, the distribution of the costs and benefits of the actions, second, of the costs and benefits of changes in those goods that cannot be expressed in market values, and, third, the timing on adaptation actions. The distributional issue in adaptation has itself two specific dimensions: the balance between private and public costs and benefits of adaptation actions, and the regulatory system that determines the 'publicness' of benefits. Some elements of adaptation to climate change response are, in effect, public goods. These include conservation of nationally or internationally important habitats, conservation of common cultural heritage and the conservation of resources for future use. Other types of adaptation effectively involve private goods. If private firms in the water industry invest in knowledge of climate change risks, the costs and the benefits of this response are largely private.

Climate change planning by governments at present tends to concentrate on providing public goods such as scenario information, risk assessments in the public domain and public awareness campaigns (Callaway, 2004). But the public and private elements of responding to climate change are not fixed: they are shaped by institutional and regulatory features in each sector of the economy. Further, they can change from public to private and back again over time (Bakker, 2003). The second issue in assessing efficiency of adaptation relates to decisions concerning non market benefits. Any assessment of the efficiency of an adaptation that incorporates only goods with market proxies (such as property, human health, or economic production) risks seriously underestimating both costs and benefits. Government-led adaptation to climate change often stresses public good elements of the problem such as ecological and aesthetic impacts and non-traded ecosystem goods and services as much as private market impacts (Fankhauser *et al.,* 1999; Azar, 1998; Azar and Schneider, 2003). Environmental economics research demonstrates, however, that estimates of stated or revealed preferences for non marketed goods are based on reference points of priced marketed goods which themselves are non-sustainable and distorted (Common and Perrings, 1992; Arrow, Dasgupta, & Maler, 2003). In other words, the prices of traded goods which form the basis of valuation of costs and benefits of non-traded goods are the prices which have led to non-sustainable exploitation of resources in the first place. The assessment of the underlying social costs and benefits of adaptation, and their distribution, is therefore problematic.

The timing of the adaptation action in relation to the climate change impact will also affect the perceived economic efficiency of an adaptation action. For organisations or individuals, where planning horizons are short (less than one year), capital turnover rates are high and systems can readily adjust, adaptation to short term climate variability is all that is required to create an economically efficient response to climate change. A farmer deciding on which crops to plant next year needs to know the likelihood of drought next year rather than the likelihood of drought in 50 years time: long-term events are not relevant. On the other hand, where planning horizons are long, capital turnover rates are low and systems cannot quickly adjust, longer-term climate changes have to be factored in order to avoid costly planning errors. For example, a farmer considering investing in expensive irrigation works with a long life will need to take longer-term climate change into account to ensure that the investment generates net benefits.

Characterising adaptation to Climate Change

Given the inevitability of changes to the global climate, adaptation actions are needed to ensure that societies are resilient to harmful impacts, and take advantage of any new opportunities. While the term adaptation is in wide circulation, there is no single definition that is applied universally. The broad description given by the Intergovernmental Panel on Climate Change is a useful starting point, defining adaptation as ‘adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities’ (IPCC, 2001).

At its simplest, adaptation within social systems relates to the processes people use to reduce the adverse effects of climate on their livelihood and well-being, and take advantage of new opportunities provided by their changing environment (TERI, 2007). Adaptation can be categorised more specifically into various types and forms: in terms of timing it can be ‘anticipatory’ or ‘reactive’, and on the level of preparation and outside intervention, it can be either ‘planned’ or ‘autonomous’ (Tol, Klein, Richard., Nicholls, & Robert, 2009). Adaptation within natural and ecological systems is reactive, while adaptation at the individual and societal levels can be both anticipatory and reactive in light of observed and expected climate.

In practice, adaptation actions tend to constitute 'on-going processes, reflecting many factors or stresses, rather than discrete measures to address climate change specifically' (IPCC, 2007a). It is important to note that adaptation actions, though prompted indirectly by climatic events, will often occur as a result of a whole host of non-climatic shocks and stresses, such as conflict over scarce resources or rising prices of food and water.

Determinants of adoption choices of Climate Change Adaptation Strategies

Factors that affect the decision of farm households to use/choose among crop adaptation strategies can include access to information, households financial capacity, lobar, education, age, marital status, gender, farm (plot) characteristics, and access to extension and credit, and input and output markets (Temesegen, Rockstrom, Savenije, Hoogmoed, & Alemu, 2008 & Di Falco, Veronesi, & Yesuf, 2011). Availability of better climate and agricultural information helps farmers make informed and comparative decisions among alternative crop management practices and this allows them to choose a better strategy that makes them cope well with changes in climatic conditions (Nhemachena & Hassan, 2007). Lack of information (about seasonal and long-term climate changes and agricultural production) can constraint farmers from adopting different climate change adaptation strategies thereby increasing high downside risks arising from failures associated with non-uptake of new technologies and adaptation measures.

Farmers who lack capital and other resources will fail to cover costs necessary to take up adaptation measures and thus may not make beneficial use of the information they might have. The availability and quality of labour can affect the involvement of households in other income (money) generating activities. Farm households with more available and quality labour can have higher probability to get involved in other income generating activities (Kandlinkar & Risbey, 2000). Shortage of labour is also deemed as an important input constraint. Households with more labor are believed to be better able to take adaptation measures in response to changes in climatic conditions compared to those with limited labor. In this sense, family size is one important variable that can determine the availability of labour (Temesegen *et al.,* 2008). On the other hand, education is an important source of information for farm-level management activities. Similarly, age can also affect the quality of labour as it is connected with experience. Elder household heads are expected to have more experience in farm practices and management (Nhemachena & Hassan, 2007; Temesegen *et al*., 2008 & Di Falco *et al*., 2011). Limited market access also can negatively affect the potential for farm-level adaptation. Farmers with access to both input and output markets are likely to have more chances to use adaptation measures. Input markets allow farmers to acquire the necessary inputs required to take adaptation measures. Such inputs include different seed varieties, fertilizers, and irrigation technologies. On the other hand, access to output markets provide farmers with positive incentives to produce cash crops that can help improve their resource base and hence their ability to respond to changes in climatic conditions (Mano *et al*., 2003; Nhemachena & Hassan, 2007).

In Ethiopia, Deressa, Hassan, Ringler, Alemu, and Yesuf (2008), analysed the determinants of farmers' choice of adaptation methods in the Nile Basin. Using cross-sectional data from a survey of farmers to illicit information on adaptation methods. The study found that the adaptation methods currently in place in the study area are: changing planting dates, using different crop varieties, planting tree crops, irrigation, soil conservation and not adapting. The farmers reported that the use of different crop varieties was the most common adaptation method, while irrigation was the least common. They also reported that the reasons for not adapting are lack of information on climate change impacts and adaptation technologies, lack of financial resources, labour constraints and land shortages. The level of education, age, sex and household size of farmers were found to be significant determinants of adaptation to climate change in the study area. Also farmers in different agroecological settings employ different adaptation methods.

Fosu-Mensah, Vlek, and Manscheadi (2010), conducted a survey of 180 farmers in Sekyedumase District in the Ashanti Region of Ghana to investigate how farmers perceive long-term changes in temperature, rainfall and vegetation cover over the past twenty years. The survey also posed questions about adaptations and barriers to adaptations. The explanatory variables included household's characteristics. Main adaptation strategies reported by farmers are crop diversification and changing planting dates. Land tenure, soil fertility levels, access to extension services, access to credit and the community in which the farmers lived were found to be the significant determinants of their choice of adaptation measures farmers took.

Barriers to Climate Change Adaptation

Productivity Commission (2011), defines a barrier as something that could reduce the willingness or capacity of individuals, business or other organizations to adapt to the impacts of climate change. This means that the existence of barriers is likely to make farmers in particular and communities in general not to effectively adapt to climate change impacts.

A study by Jones (2010), identified three broad categories of barriers to adaptation. Ecological and physical limits which comprise the natural limitations to adaptation, associated largely with the natural environment, ranging from ecosystem thresholds to geographical and geological limitations. Human and informational resource-based limits relating to knowledge, technological and economical restrictions. These include the various spatial and temporal uncertainties associated with forecast modeling, and low levels of awareness and information amongst policy makers on the impacts of climate change as well as a lack of financial resources and assistance to facilitate adaptation interventions. Social barriers are made up of various processes relating to cognitive and normative restrictions that prevent individuals or groups from seeking the most appropriate forms of adaptation.

Farmers' ability to cope or adapt to climate change has been challenged by numerous barriers. These include, but not limited to: i) Institutional factors: the institutional factors that influence adoption of new technologies are access to information via extension services (climate information and production technologies) and access to credit Maddison, (2006), Kurukulasuriya & Mendelson, (2006); Deressa, Hassan, Ringler, Alemu, & Yesuf, (2008); Nhemachena & Hassan, (2008); Sofoluwe, Tijani, & Baruwa,

(2011) Acquah-de Graft & Onumah, (2011). The majority of farmers in sub-Sahara Africa found extension education to be an important factor that motivates increased intensity of the use of specific soil and water conservation practices (Gbetibuou, 2007; Mandleni & Anim, 2011; Deressa, & Hassan, 2009; Apata, Samuel, & Adeola, 2009). Farmers expressed the view that among many of the sources of information, agricultural extension is the most important for analyzing the adoption decisions of adaptive measures. Accordingly, it is hypothesized that farmers who have significant extension contacts have better chances of being aware of changing climatic conditions as well as adaptation measures in response to the changes in these conditions (Deressa et al., 2009; Gbetibuou, 2009). ii) Access to credit is another important factor affecting adoption of agricultural technologies.

Access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to adopt (Nhemachena & Hassan, 2008; ACCCA, 2010; Acquah & Onumah, 2011). Hence, access to credit is hypothesized to be a positive and significant factor affecting climate change adaptation measures. iii) Other barriers to climate change adaptation technologies include; high cost of adaptation measures, insecure property rights (Mandleni & Anim, 2011; De Wit, 2006; Mengistu, 2011; Nyanga et al., 2006), and land disputes and land fragmentation due to population growth in parts of Africa where land is inherited (De Wit, 2006; Deressa et al., 2009).

Onyeneke and Madukwe (2010), found that there are five major constraints to adaptation in the southeast rainforest zone of Nigeria. According to the authors, these are lack of information on appropriate adaptation option confirmed by 50 percent of the farmers, lack of finance cited by 35 percent of the farmers, shortage of labour reported by 15 percent of the farmers, shortage of land confirmed by 5 percent of the farmers, and poor access to market agreed by 5 percent of the farmers.

Nhemachena and Hassan (2007), examined farmers' adaptation strategies in South Africa, Zambia and Zimbabwe. The study describes farmers' perceptions about long-term changes in temperature and precipitation, as well as various farm-level adaptation measures adopted, and barriers to adaptation. The results indicated that using different crop varieties, crop diversification, changing planting dates, switching from farm to non-farm activities, increased use of irrigation, and increased water and soil conservation techniques were the different adaptation measures employed by farmers in these countries. The study also reported that most farmers perceived long-term increase in temperature and that the region was getting drier, with changes in the timing of rains and frequency of droughts. The farmers reported that lack of credit facilities and information on adaptation options and insufficient inputs are the main barriers to adopting any climate change adaptation options. The results of the multivariate discrete choice analysis show that gender, years of farming experience, access to extension services, access to credit facilities and markets are the significant determinants of adaptations to climate change in the region.

Conceptual Framework

Growth in rice production is as a result of many factors such as soil fertility, climate, prevailing management practices among others. Climatic factors such as temperature and precipitation influence crop production and their negative effects (such as increasing temperature or decreasing precipitation or drought etc.) may lead to decline in yield which prompts farmers to employ adaptation strategies in order to increase rice yield. However, in the adaptation process, the farmers need to identify or overcome barriers to adaptation.

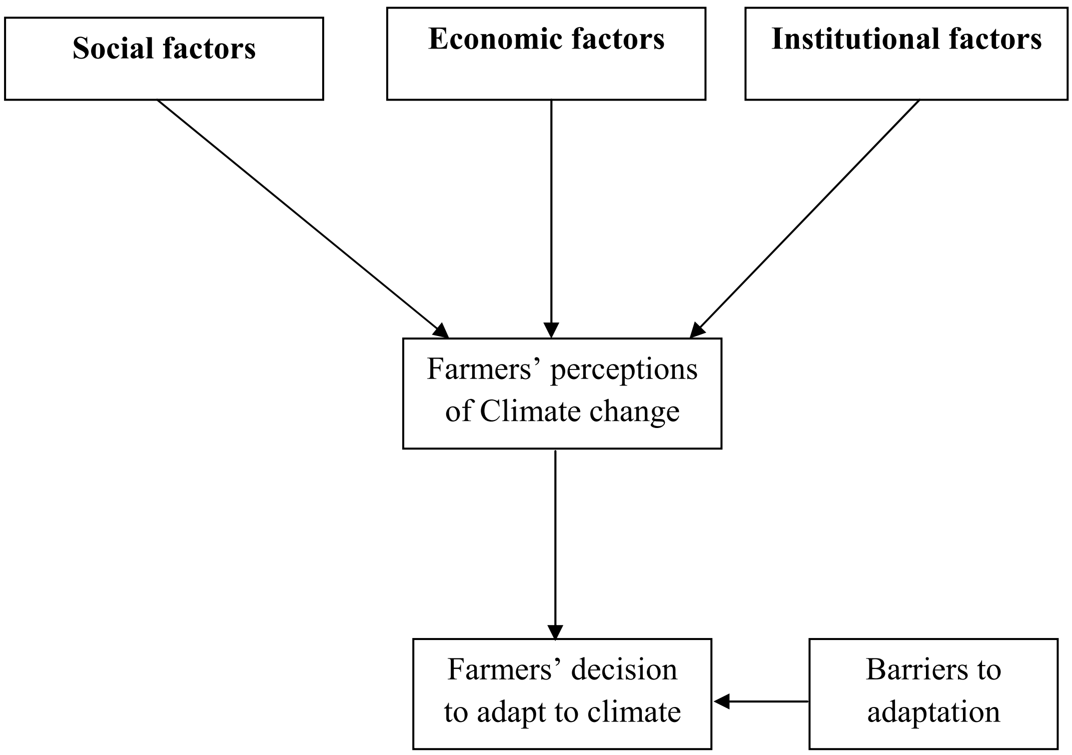

Figure 1: Conceptual Framework on Rice Farmers' Perception of Climate Change and Adaptation Strategies.

Source: Author's construct (2014)

CHAPTER THREE

METHODOLOGY

General Overview

This chapter presents the methodology of the study. It gives account of climate change situation in the study area and discusses the research design, the population and sampling procedures, data collection and data analysis.

Study Area

Ketu North District is one of the 25 districts in the Volta Region of Ghana. It is located between latitudes 6^o 03' N and 6^o 20' N and longitudes 0^o 49'E and 1^o 05'E. It shares boundaries with the Akatsi North District to the North and the Republic of Togo to the East. To the South, it is bounded by Ketu South district and Keta Municipality and to the west it is bounded by the Akatsi South District. The district capital (Dzodze) is about 80km from Ho the Regional capital of Volta Region. The district has a surface area of about 754 square kilometers. Figure 2 shows the district within the national context and its administrative divisions respectively.

Climate

The District experiences the dry Equatorial type of climate. The average monthly temperatures vary between 24℃ and 30℃, which are generally high for plant growth throughout the year. The mean annual rainfall for the District is around 800 mm. The rainfall is of double maximum type occurring from April to July and September to October. The dry season, which is mainly dominated by the dry harmattan winds, extends from December to February in the district. Generally rainfall in the District is considered low and erratic particularly during the minor season.

Vegetation

The original vegetation of the District is Savannah woodland made up of short grassland with small clumps of bush and trees as well as Mangrove forests in the marshlands are found in the District. However, the extensive farming activities in the district have, over the years, reduced the natural vegetation. In the course of these are cultivated holdings of cassava, maize, coconut, oil palm, and velvet tamarind, the occasional baobab and fan palm. The decimation of the vegetation by population pressure may have adversely affected rainfall in the district.

Implications for Development in the District

The physical characteristics of the Ketu North District contain a basket of potentials that can be tapped for the socio-economic development of the area. In terms of relief and drainage, the vast expanse of flat land is a potential for large scale mechanized farming. Road construction and other activities are also relatively less costly.

The water resources in the district could also be harnessed for irrigation purposes, especially for rice cultivation and dry season gardening aside its current use for the supply of potable water for some communities in the district. The high intensity of the sun in the area provides abundant solar energy, which is already being used by farmers for preservation and storage purposes.

The district's population derives a lot of benefits from the savanna woodlands, including housing and energy. However, these often lead to overexploitation of the vegetation, which consequently results in environmental degradation. The soils, vegetation and climate of the district constitute suitable ecological conditions for both arable farming and livestock rearing. However, the excessive rainfall experienced sometimes causes flooding, rendering feeder roads unmotorable.

Geology and Soil

The area of the district is emphasized by 3 main geological formations. Viz the Dahomenyan formation to the North made up of soils such as Tropical Grey and Black Earths, the Regosolic Groundwater Laterites, the Recent Deposits of the littoral consisting of the Tertiary formation comprising Savannah Ochrosols for its soil type. These soil types are suitable for the cultivation of different types of crops.

Relief and Drainage

In terms of relief, Ketu North District is relatively low lying with altitudes around 66 metres. The plain nature of the terrain makes movement within the district easy. The Drainage of the district is towards the South and is dominated by several seasonal streams that flow in wide valleys between Ohawu and Ehie to end in the swamplands of Afife. The major rivers include Kplikpa and Tsiyi. There are about 6 large fresh water reservoirs (dams) - Ohawu, Kporkuve, Dzodze, Tadzewu, Dekpor-Adzotsi and Lave as well as a few small community dugouts in the district.

Population Characteristics Size and Growth Rates

The population of the Ketu North District has its own unique features. It has always experienced growth in numbers over the years and has a large youthful population which is male dominant. The population of the district is not evenly distributed, and the number of persons per square kilometer is also on the increase.

The population size, growth rate, structure and distribution of the Ketu North District have been estimated from various census figures of the Ketu District which has now been split into the Ketu South and Ketu North Districts. Based on estimates from the 2010 population census, the Ketu North District has a population of 99,913. The population of the District has always been experiencing growth over the years. From 1970 to 1984, the District experienced a population growth rate of 1.9 percent. This growth rate remained unchanged for the1984 – 2000 censal year.

Sex Structure

According to the 2010 population census, the district has a relatively large Female population compared to that of Male. This structure is not different from that of the Volta Region where the district is located. In terms of age structure, the district has a large youthful population. The two cohorts that contain most of the people are the 0-14 group and 15 – 64 groups.

Another significant feature of the district population is its large labour force. The cohort that falls within the active labour force constitutes 52.5 percent of the district population. This is a bit lower than the national active labour force of 55.2 percent and higher than that of the regional figure of percent. This large active labour force could be positioned to harness and maximize the vast agricultural potentials of the district.

Population Density

The population density of the district has never been stable nor has it experienced any decline over time. The increase in population over time is reflected in the high population densities recorded for the period 1970, 1984 and 2000 (See Table 7) The number of persons per square kilometer (density) as at each of the population censuses has increased from 60.2 persons in 1970 to 81.6 persons in 1984 and to 110.4 persons in the 2000. The increasing density in time shows the increasing pressure of the district's population on the land and its resources. This may be an indication of growing pressure on the district's fragile environment which may gradually result in environmental degradation.

Rural/Urban Split

The population of the District is basically rural. About 70.7 percent of the people reside in the rural areas. The remaining 29.3 percent of the people can be found in the only two main towns of the District, Dzodze and Penyi. Apart from these two towns, the other settlements have their population figures below 5000 as at 2000 (GSS, 2000).

Major Households Characteristics

For people in the District, especially in the major towns of the District, the rapid population growth has become a great source of worry. This is because population growth far exceeds the rate of increase in the provision of shelter. Opening up of the District in recent years is making the problem of meeting quality-housing requirements more acute in the District. It should be noted however that the housing problem in the District is not of quantity but of quality.

Household income

As an agro based District, Chunk of the household's income is derived from agriculture 58 percent, basically crop farming and livestock rearing. 17.0 percent of the household's derive their income from trading activities, while others derive it from other economic activities such as tailoring, sign writing, handicraft and services. Remittances accounted for 2.0 percent of the household's income.

Agriculture

Agriculture is the mainstay of the Ketu North District economy. It employs about 70 percent of the economically active labour force. Nearly every household in the District is engaged in farming or agricultural related activity. There are over 27,781 (13,752 males, 14,029 females) members of household who are into Agriculture. Farming in the District is largely carried out on small-scale basis. The average acreage cultivated ranges between 1-2 acres for the major staples like maize, cassava, rice, cowpea and sweet potato, whilst the area under vegetable production is considerably smaller. Most farming households keep small ruminants like goats and sheep. Despite its importance in the District economy, much of the agricultural potentials in the District remain unutilized. The District's irrigation potential remains fully untapped. Apart from the dam at Weta, the numerous dams and dugouts in the District are not being used efficiently.

The Crop Sub-Sector

The crop sub-sector accounts for about 60 percent of agricultural activities in the District. The crops in the sub-sector can be categorized as arable crops, plantation crops and vegetables. The soils in the area favour the production of a variety of crops. Currently, crops grown in commercial quantities in the District include maize, cassava, sweet potato, cowpea and rice. Continuous cropping is generally practiced in the district. Few farmers engaged in crop rotation to improve on the soils and break diseases and pests cycle. 86.2 percent of the total population in the agricultural sector practice mixed cropping while 13.8 percent practice mono-cropping. The soil quality which is loamy and rich in nutrients is able to support the production of varieties of crops at the same time.

Rainfed Rice

Rice has gradually become a major staple. Rice is cultivated under rain-fed conditions through-out the district. Most of the low-lying valleys from Klenormadi, Tsiyinu, Vume, Agbledomi to Agorve are used for rice cultivation. The estimated area under rain-fed conditions is over 1,200 ha. Yield figures (3.5-4.0 tons/ha) from these fields are slightly lower than the irrigated ones. Two streams, Kpli and Tsiyi pass through the valleys mentioned. This creates the opportunity for the development of these valleys into irrigated fields.

Irrigation Farming

Irrigated Rice production in the District, which is solely the Afife Irrigation project, is under the management of Ghana Irrigation Development

Authority and the developed area under production is 880 ha out of the total land size of 950 ha. The farmers have formed themselves into a very strong Co-operative Society for input credit acquisition for production as well as inventory credit mobilization system for loan repayment. There are a total of 1,024 farmers on the project with an estimated yield of 4.5-5.0 tons/ha.

Agro-Processing

Some efforts have over the years been made in the District to add value to the agricultural produce through processing. Agro-processing is currently on a small scale. The only few crops that are processed to add value include Cassava, Pepper, Maize, Cowpea, Palm nut, Groundnuts etc. There are uncompleted gari producing facilities in Ehi and Tornu. Should they be completed they will serve as sources of employment for a lot of youth with the district producing cassava in the excess of over 120,000 tons.

Agricultural Land Acquisition

Land in the District is vested in individual families. For agricultural purposes, the land can easily be accessed by both natives and non-natives, and this is a great potential for agricultural development. In line with the customs and traditions of the area, non-natives in need of land for agricultural activities are required to approach the appropriate landlords for negotiation. Farm lands are either acquired by outright purchase, lease or on share cropping basis. For outright purchase, farmers buy the land and make the necessary documents of ownership on the land. Lease term differs from area to area. Land is leased on terms or on a fixed amount of years after which agreement is renewed. In some areas, share cropping is practiced (Abusa) where farm produce is shared into 3 equal parts. The farmer takes 2/3 while the landlord takes 1/3.

Environmental Situation

The need to expand economic activities and to produce more food, fibres and other raw materials to feed, clothe, house and improve the living conditions of the rapidly expanding population of most agro-ecological area/zones has commonly led to the mismanagement of natural resources and to the degradation of the physical and biological environments, such that the long term, sustained yield use of renewable natural resources will be impossible. The physical environment of the District exhibits Savannah woodland made up of short grassland with small clumps of bush and trees as well as Mangrove forests in the marshlands.

Access to Extension Services

The essence of extension services is to upgrade the knowledge of farmers in improved techniques and modern methods of agriculture with a view to improving upon incomes and output. Extension services have not been within easy reach of the prospective farmer. According to the District Directorate of Agriculture, the District is zoned into 18 agricultural operational areas. For an efficient extension service delivery, one operational area needs to be manned by One (1) Agricultural Extension Agent (AEA).

There are currently 8 Agric Extension Agents (AEA) in the District expected to man the 18 operational areas. If the entire District should be covered, then one operational area would be just too big for one AEA to cover. It is no wonder therefore that majority of the farmers do not have access to the services.

Farmer- Extension ratio is too high (3,500:1) in those areas that have access to their services. These are in areas where the AEAs are resident. In these cases, they attend to other farmers outside their operational areas based on demand through phone calls as well as home visits. The use of mass media, e.g Radio Stations (Denyigba Radio FM-104.7) should be supported to benefit a large number of farmers who do not have access to AEAs and extension services directly. More of the agents must be employed or those available should adequately be resourced. This will help disseminate appropriate technology to farmers and help them produce efficiently. Their yields will be increased and value will be added through grading and storage.

KETU NORTH TH DISTRICT MAP

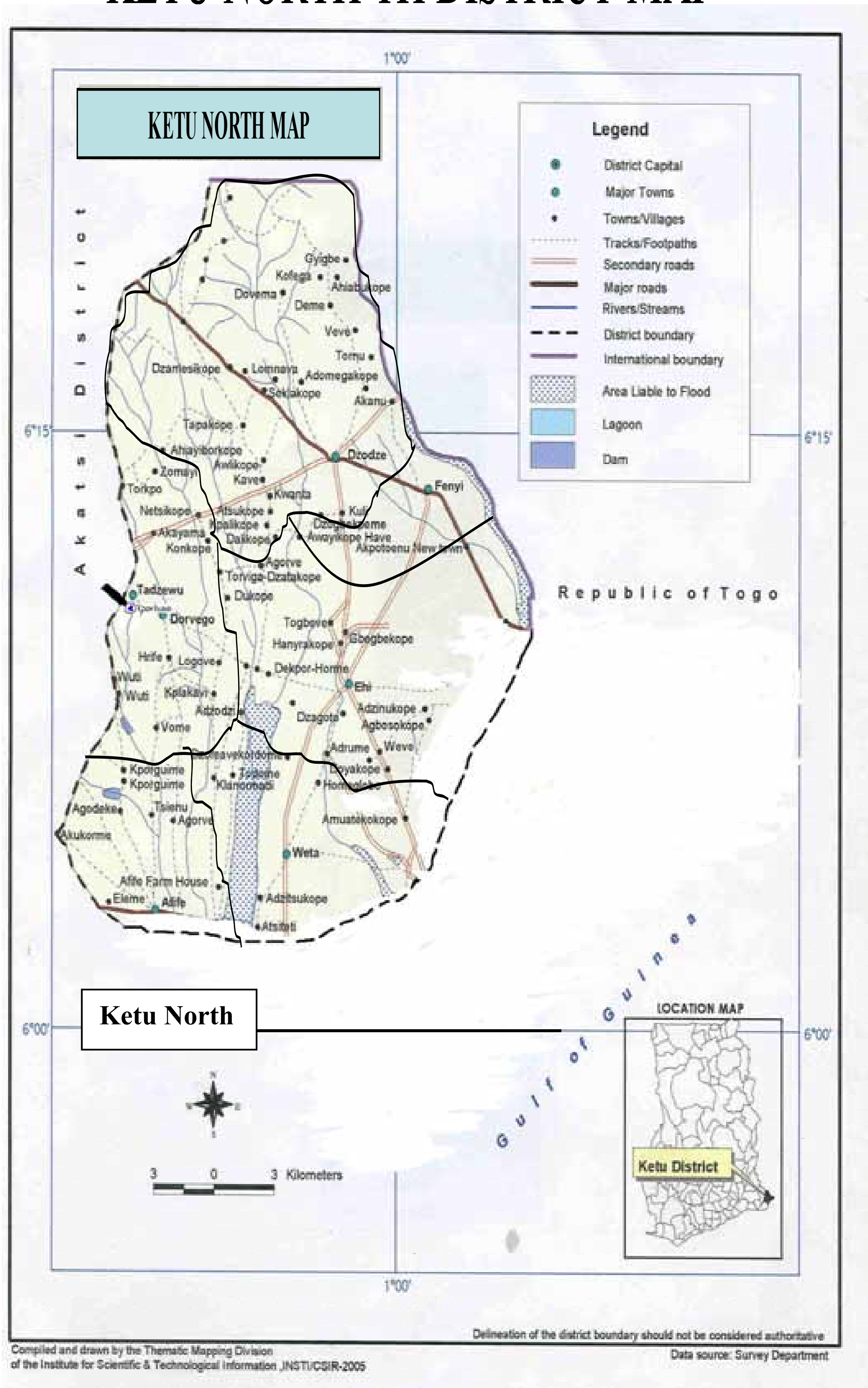

Figure 2: Ketu North District, Volta Region of Ghana

Research Design

The study used cross-sectional survey design to assess rice farmers' perception of climate change and adaptation strategies in the study area. It is one of the most common and well-known study designs. In this type of research study, either the entire population or subset thereof is selected, or from these individuals, data are collected to help answer research questions of interest. It is called cross-sectional because the information about the phenomenon that is gathered represents what is going on at only one point in time Olsen, & St. George, (2004).

Cross-sectional survey design is the appropriate design for the study because data was collected to make inferences about the population of interest at one point in time. In this case, the population of interest includes rice farmers' in the Ketu North District in the Volta Region of Ghana. Furthermore, cross-sectional survey design can be conducted using any mode of data collection.

The Study Population

The target population for the study includes all rice farmers farming at the Weta irrigation scheme within the Ketu North District of the Volta Region of Ghana. The estimated population of rice farmers within the Ketu North District is one thousand and twenty four (1024), KNDA (2009).

Sample and Sampling Procedure

A multistage sampling technique was used to select the respondents from the study. The sampling technique was chosen because it allows larger clusters to be subdivided into smaller, more target groupings for the purposes of surveying (Agresti & Finley, 2008).

At the first stage, a simple random sampling technique was used to select six (6) of the eleven (11) rice farming sections farming at the Weta rice irrigation scheme in the district. At the second stage, a list of registered farmers was obtained from the District Agricultural Assembly. Based on the population of these six (6) farming sections, a random sampling technique was used to randomly select three hundred and forty (340) rice farmers using the sample size table constructed by Krejcie & Morgan (1970). This was done based on time and resources available. Table 1 provides the summary of farmers selected from the Weta irrigation scheme, Ketu North District, Volta Region of Ghana.

Table 1: Sample size used for the Study

Rice farming section	Total number of rice farmers	Selected sample size
Section 2	74	47
Section 3	94	59
Section 5	107	67
Section 6	82	51
Section 7	95	59
Section 9	91	57
Total	**543**	**340**

Source: Field survey data, 2014

Instruments

The primary data was collected through the use of self-administered questionnaires and interview schedule. The questionnaire and interview schedule were specifically designed to measure variables of the study. The variables were broadly categorized into socio-demographic characteristics, production activities, climate change information, adaptation measures in response to climate change and barriers to adaptation measures. Primary data was collected using open and close ended interview schedules.

The questionnaire for the farmers was grouped into 38 items with five sections, A-E. Section A was made up of 12 items that extracted information on the socio-demographic characteristics of sampled population. Section B was on the production activities, Section C on climate change information, section D was on adaptation measures in response to climate change and finally section E, which was on barriers to adaptation measures.

Pre-testing

The research instruments for the primary data collection were pre-tested in South Tongu District in August, 2014. The purpose of the pre-test was to identify errors associated with the instrument and omit double barrelled questions and ambiguous statements. Furthermore, pre-testing was conducted to detect issues that were not anticipated and to assess 1) Clarity of questions regarding rice farming, 2) whether the questions are understandable and 3) whether the order and wording of the questions elicited the desired responses for each question. The total number of questionnaires administered was 15. Based on the responses provided, modifications were made in the research instruments before administration.

Data Collection

Two (2) research assistants were selected from the district with permission from the District Agricultural Assembly who understand the local dialect and are familiar with the study area. These research assistants were trained on how to administer the instrument. It involves the meaning and interpretation of the items on the interview schedule to the respondents. It took about four (4) weeks for the administration and collection of the instrument. Interviews were conducted in the local dialect (Ewe) and transcribe into English. Monitoring of the process of administration was also undertaken. Data was collected in December, 2014.

Data Analysis

The study utilizes descriptive statistics and logistic regression analysis. Descriptive statistics such as frequencies, mean, standard deviation and percentages were used to present rice farmers' perception on climate change, rice farmers' decision to adapt to climate change and the barriers to adaptation. Logistic regression analysis was employed to analyze the determinants of rice farmers' adaptation to decreasing precipitation and increasing temperature.

Frequencies and percentages were used to describe farmers socio-demographic characteristics depicted in objective one (1). Objective two (2) is to identify farmers' choice of adaptation measures in response to climate, thus frequencies and percentages were used to identify their choice of adaptation measures. For objective three (3), Binary Logistic regression analysis was used to investigate the determinants of farmers' adaptation to decreasing precipitation and increasing temperature. Objective four (4) was to identify barriers to farmers' adaptation measures in response to climate change. Descriptive statistics was used to illustrate the barriers affecting farmers.

Statistical Package for Social Sciences (SPSS version 21.0) and STATA version 13.0 software were used for all the analysis.

Model for the Study

In this study, binary logistic regression model is employed. Though the logit and probit can be applied, this study adopt the logit. Logistic regression, or logit regression, is a type of probabilistic statistical classification model. Bishop (2006), also noted that it is used to predict a binary response from a binary predictor, used for predicting the outcome of a categorical dependent variable (i.e., a class label) based on one or more predictor variables (features). That is, it is used in estimating the parameters of a qualitative response model. The probabilities describing the possible outcomes of a single trial are modeled, as a function of the explanatory (predictor) variables, using a logistic function. "Logistic regression" is used to refer specifically to the problem in which the dependent variable is binary that is, the number of available categories is two while problems with more than two categories are referred to as multinomial logistic regression or, if the multiple categories are ordered, as ordered logistic regression.

Logistic regression measures the relationship between a categorical dependent variable and one or more independent variables, which are usually (but not necessarily) continuous, by using probability scores as the predicted values of the dependent variable as such it treats the same set of problems as does probit regression using similar techniques.

The dependent variable in this case is the adaptation to decreasing precipitation and increasing temperature. The dependent variable can take the value 1 with the probability of success and 0 with the probability of failure. As mentioned previously, the independent or predicator variables in logistic regression can take any form. Thus, logistic regression makes no assumption about the distribution of the independent variables. They do not have to be normally distributed, linearly related or of equal variance with each group.

Regression Model Specification

$$z_i = In\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_i x_i + u \qquad \text{Eqn (1)}$$

Where:

Where p = the probability function which is the rice farmers yes/no response to adaptation to decreasing precipitation and increasing temperature. x_i are the factors related to the respondents. They include the socio-economic characteristics of the rice farmers. For this study, the precise equation is given as;

$$ADP = \beta_0 + \beta_i x_i + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + u \qquad \text{Eqn (2)}$$

Where ADP = adaptation to decreasing precipitation which is 1 if rice farmers adapt to decreasing precipitation and 0 otherwise.

x_1 = Sex

x_2 = Age

x_3 = Household size

x_4 = Education level

x_5 = Farming experience

x_6 = Farm size

x_7 = Financial support

u = the disturbance term

$$AIT = \beta_0 + \beta_i x_i + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + u \qquad \text{Eqn (3)}$$

Where AIT = adaptation to increasing temperature which is 1 if rice farmers adapt to increasing temperature and 0 otherwise.

x_1 = Sex

x_2 = Age

x_3 = Household size

x_4 = Education level

x_5 = Farming experience

x_6 = Farm size

x_7 = Financial support

u = the disturbance term

Description of the selected variables of the study

Sex: sex is a dummy variable coded 1 for male and 0 for female. Male in this study is expected to have positive correlation to adaptation to decreasing precipitation and increasing temperature. This is because cultural experience in terms of various management practices, and the ability to carry out labour-intensive agricultural innovations, might be challenges faced by female farmers. Moreover, female-headed households might be slow to respond to changing climate conditions through the adaptation of diversification strategies due to the challenge posed by customary household duties (example: childcare) and the fact that they are by nature less physically able to perform labour-intensive agricultural work. In addition, a variety of constraints play a role in the decisions made by farmers in this regard, including constraints with respect to available production technologies, bioghysical or geophysical constraints, labour and input market constraints, financial and credit constraints, social norms, inter-temporal tade-offs, policy constraints and constraints in terms of knowledge and skills (Teweldemedhin & Van Schalkwyk, 2010).

Furthermore, female-headed households are less likely to adapt to climate change compared to their male counterparts. A study by Tenge *et al.* (2004) found that female headship negatively influenced adoption of technologies because female heads have less access to land, and other resources due to traditional social barriers. Earlier gender studies (IFPRI, 2001; Meinzen-Dick et al., 2010) also highlighted unequal distribution of assets between men and women in rural households, which favour or constrain their adaptive capacities. On the contrary, Nhemachena and Hassan (2008) found that female headed households were more likely to take up climate change adaptation methods in the Nile basin of Ethiopia. This seems to suggest that the influence of sex on adaptation varies among cultures and social structures.

Age of the rice farmers: Hofferth (2003), in his study, argues that the higher the age of the household head, the more stable the economy of the farm household, because order people have also relatively richer experiences of the social and physical environments as well as greater experience of farming activities. Moreover, older household heads are expected to take adaptation strategies than younger heads. The age of the rice farmers was measured in years.

Household size: is one of the factors expected to have influence on adaptation to decreasing precipitation and increasing temperature. The majority of the farm households in the study area are small-scale rice farmers. Because land and finance to purchase agricultural inputs are very limited, increasing family size tends to exert more pressure on consumption than the labour it contributes to production. Thus a positive correlation between household size and adaptation to decreasing precipitation and increasing temperature is expected. Households with more labor are believed to be better able to take adaptation measures in response to changes in climatic conditions compared to those with limited labor (Temesegen *et al.,* 2008). Family size is one important variable that can determine the availability of labour. Furthermore, farm households with more available and quality labor can have higher probability to get involved in other income generating activities (Kandlinkar & Risbey, 2000).

Educational level: Education is an additional factor which is thought to influence the farmer's adaptation. Educational attainment by the household head could lead to awareness of the possible advantages of modernizing agriculture by means of technological inputs; enable them to read instructions on fertilizer parks and diversification of household incomes which in turn would enhance their adaptation to increasing temperature and decreasing precipitation. This is expected because such households are assumed to have better food management techniques that will improve their livelihoods. On the other hand, education is an important source of information for farm-level management activities as reported by (Temesegen *et al.,* 2008).

Farm size: Farm size is a continuous variable. This study expected farm size to affect adaptation to increasing temperature and decreasing precipitation positively. According to Najafi (2003), food production can be increased extensively through expansion of areas under cultivation. Therefore, under subsistence agriculture, farm size is expected to play a significant role in influencing rice farmers' adaptation increasing temperature and decreasing precipitation.

A study by Advancing Capacity to Support Climate Change, (ACCCA, 2010), reported that large farm size positively influenced adoption of soil and water conservation, tree planting and use of improved varieties. Daressa *et al.* (2009) also reported that land size represents wealth, an argument also emphasised by Knowler & Bradshaw (2007) & Bashaasha *et al.* (2010).

Farming experience: farming experience is expected to positively influence rice farmers' adaptation to decreasing precipitation and increasing temperature. Farming experience increases the farmers' likelihood of adapting climate change strategies. This is due to the fact that the knowledge of the recommendations and application of these strategies is gained over time, with practice. In addition, farmers with more years of farming experience are more likely to notice changes in climatic conditions, due to their prior experiences. This finding is consistent with Nhemachena & Hassan (2007); Temesegen *et al*., (2008) and Di Falco, Veronesi, & Yesuf, (2011). They suggested that elder household heads are expected to have more experience in farm practices and management.

Financial support: Financial services are recognized as playing multiple roles in development so that improved access can have a far greater and more ample impact on poor households. Access to credit, which also represents the ability to purchase inputs, is expected to positively influence the decision to adopt a climate change. Access to credit increases financial resources of farmers, reduces cash constraints and allows farmers to purchase inputs (Benhin, 2006; Daressa *et al.,* 2009; Gbetibouo, 2009).

In addition to the virtuous production and investment cycle, financial services can smooth consumption and improve farmer warefare. Furthermore, rice farmers with access to both input and output markets are likely to have more chances to use adaptation measures. Input markets allow farmers to acquire the necessary inputs required to take adaptation measures. Such inputs include different seed varieties, fertilizers, and irrigation technologies. On the other hand, access to output markets provide farmers with positive incentives to produce cash crops that can help improve their resource base and hence their ability to respond to changes in climatic conditions (Mano *et al*., 2003; Nhemachena & Hassan, 2007). Access to financial services are expected to be have positive relationship with their adaptation since it improves their farming activities. A dummy variable was therefore used whereby rice farmer who had access to any form of financial services took a value of one (1) and households who did not have access to financial service took a value of zero.

Definition of the selected Variables of the Study

The study seeks to analyse rice farmers' perception of climate change and adaptation strategies in the Ketu North District of the Volta Region of Ghana. The variables of the study are presented in Table 2. The study looked at two separate dependent variables. These dependent variables were adaptation to decreasing precipitation and increasing temperature.

Table 2: Definition of the selected Variables of the Study

Variables	Definitions
Dependent variable	
Decreasing precipitation (dummy: 1,0)	Whether respondents adapt to decreasing precipitation: 1 for yes, 0 for no.
Increasing temperature (dummy: 1: 0)	Whether respondents adapt to increasing temperature: 1 for yes, 0 for no.
Independent Variables	
Sex (dummy:1,0)	Sex of respondents: 1 for male, 0 for female
Age	Age of respondents in years
Household size	Total number of persons in household
Education Level	Years of schooling of the respondents
Farming experience	Number of years respondent has been growing rice
Farm size	Area of land cultivated in acre
Financial support (dummy: 1,0)	Access to financial supports: 1 for yes, 0 for no for the use of adaptation strategies

Source: Field survey data, 2014

CHAPTER FOUR

RESULTS AND DISCUSSION

General Overview

This chapter presents results and discussions of the study. Essentially the chapter presents the results of the study in relation to the specific objectives. These specific objectives are: Rice farmers' perception of precipitation and temperature patterns, rice farmers' choice of adaptation measures in response to climate change, the determinants of farmers' adaptation to change in temperature and rainfall and barriers to farmers' adaptation measures in response to climate change.

Socio-economic characteristics of the Respondents

This section of the report presents information on the socio-economic characteristics of the respondents with respect to sex, age, marital status, household size, educational level, farming experience, farm size, financial support, access to extension services, monthly incomes, fertilizers used and cost of fertilizers.

Age distribution of the respondents

Table 3 presents the age distribution of the respondents. The study revealed that younger people are involved in the rice enterprise than the aged in the study area. The result implies that the older the rice farmer, the more experienced he/she is in farming and the more exposure he/she has had to past and present climatic conditions over longer periods of time. Furthermore, mature rice farmers are better able to access the characteristics of modern technology than younger rice farmers, who might be more concerned about profit than the long-term sustainability of their operations. As shown in Table 3 below, ages of the farmers ranged from 20 to 80 years. The mean age of all the respondents is 47 years with a standard deviation of 10.22 and modal age of 50 years.

Table 3: Frequency Distribution of Age of Respondents

Age of respondents	Frequency	Percent
20-29	12	3.5
30-39	61	17.9
40-49	121	35.6
50-59	92	27.0
60-69	49	14.4
70-79	4	1.2
80-89	1	0.3
Total	**340**	**100**

Mean = 47.3 SD = 10.22 Youngest = 20 Oldest = 80
Source: Field survey data, 2014

Cross-tabulation between marital status and Sex of the rice farmers

The marital status and sex of the respondents were investigated and presented in Table 4. The number of male respondents who were married was more than that of the females (92.2 percent and 87.3 percent respectively).

Table 4: Cross tabulation between marital status and Sex of the rice farmers

Marital status	Sex				Total	
	Male		Female			
	Frequency	Percent	Frequency	Percent	N	Percent
Single	9	4.4	4	3.0	13	3.8
Married	190	92.2	117	87.3	307	90.3
Divorced	3	1.5	2	1.5	5	1.5
Widowed	4	1.9	11	8.2	15	4.4
Total	**206**	**100**	**134**	**100**	**340**	**100**

Source: Field survey data, 2014

It could be attributed to the fact that because some males marry more than one wife, they could only become widowed if and only if all the wives are dead. Thus the probability of men becoming widowed is less than that of the women. Also, it is tangible to adopt the reason given by Ducan and Brants (2004), who found similar result in the region that this could be related to differences in remarriage patterns between widowed men and widowed women. Also, traditionally, most of the household heads in the study area should always be a male or the husband rather than the female or the wife unless the man is debilitated due to accident or illness.

Summing up both male and female respondents, the majority of the respondents (about 89.4 percent) are married. The high rate of marriage among the farmers can be attributed to the complementary roles that gender issues play in agricultural production. For instance, the male roles are synonymous with land preparation and other production activities, while females are normally involved in farm maintenance, harvesting and marketing.

Household Composition in the Study Area

The size and composition of the households are important aspects that impact on household welfare. Table 5 shows information collected in the study area on household composition. The 340 respondents interviewed had a total household membership of 2,186. The mean household size is about 6, a little bit higher than the size of the country's average of 4.4 as reported by Ghana Statistical Service (GSS, 2010). The household size range from a minimum of one (1) to a maximum of twenty five (25) with a standard deviation of three (3). Majority (91.2) of the rice farmers had household size of 10 and below. It also means that there is a high number of people for the labour force.

Table 5: Frequency Distribution of Household size of the Respondents

Household size	Frequency	Percent
1-5	156	45.9
6-10	154	45.3
11-15	25	7.4
Above 16	5	1.4
Total	**340**	**100**

Mean = 6.4 SD = 3.21 Min = 1 Max = 25
Source: Field survey data, 2014

Educational Levels of the Respondents

Education is extremely important in that it facilitates individuals to make informed decisions that impact their health and well being. Education also provides people with the knowledge and skills that can lead to a better quality of life. Literacy is widely acknowledge as benefiting both the individual and society and, in particular among women, is associated with a number of positive outcomes, including intergenerational health and nutrition benefits Ghana Statistical Service (GSS), Noguchi Memorial Institute for Medical Research (NMIMR), & ORC Macro (2004). Table 6 presents the distribution of male and female rice farmers according to their educational background characteristics.

Table 6: Frequency Distribution of Educational status of Rice Farmers

	Male		Female		N	Total
Education levels	F	%	F	%	F	%
No formal edu.	50	24.3	35	26.1	85	25.0
Primary school	49	23.8	57	42.5	106	31.2
Middle School/JSS	78	37.9	41	30.6	119	35.0
O'level/SSS	25	12.1	1	0.7	26	7.6
Tertiary level	4	1.9	0	0.0	4	1.2
Total	**206**	**100**	**134**	**100**	**340**	**100**

Source: Field survey data, 2014

Majority (89.7 percent) of the rice farmers in Table 6 had some formal levels of education, whilst 11.3 percent did not have any form of formal education. With respect to formal education, majority (61.2 percent) of the male respondents acquired formal education; whilst 38.8 percent of the female respondents also had some levels of formal education. Table 6 revealed that men have more formal education than women in the study area. This finding is supported by (GSS *et al*., 2004) that females continue to lag behind males in education. Conforming to the outcomes of GSS 2000, the study underlined the relatively high literacy rates of men and women in the study area. Also Duncan and Brants (2004), reported that education levels of male respondents were higher than those of the female respondents in the Region.

In Ghana, it is generally believed that education standard up to JSS or Middle School level is enough to make one literate (GSS, 2004). The impact of the level of education on agriculture stems from the fact that farmers who are literate, generally tend to adapt innovations quickly which increase total factor productivity of rice and for the matter, agricultural development in general (Adesina & Djato, 1996).

Rice production Experience of the Respondents

Farming experience plays extremely important role in decision making of what to produce, when to produce, how to produce and how much to produce to satisfy the demands of the prevailing markets. The rice farming experience of the respondents is shown in Table 7. Out of the 340 respondents interviewed, 35.9 percent of them had been producing rice between ten to eighteen years and 33.5 percent had farming experience between twenty to twenty eight years.

Table 7: Frequency Distribution of Farming experience of the Respondents

Years of farming	Frequency	Percent
Less than 9	31	9.1
10-19	122	35.9
20-29	114	33.5
30-39	57	16.8
Above 40	16	4.7
Total	**340**	**100**

Mean = 20.46 SD = 9.41 Mode = 20 Min. = 1 Max. = 45
Source: Field survey data, 2014

The farmers had rice farming experience ranging from 1 to 45 years with a mean experience of 20 years and a mode of 20. Majority (69.4 percent) of the farmers had farming experience less than 28 years. The average years of farming experience revealed that virtually all farmers have wealth of experience in rice production. These results confirm Gbetibouo (2009) that experienced farmers have diverse skills in farming techniques and management, and are able to spread risk when faced with climate variability. Highly experienced farmers tend to have more knowledge of changes in climatic conditions and the relevant response measures to be applied.

Farm sizes of the Respondents

The farm sizes of the rice farmers under cultivation are small with an average of 2.2 acres. Finding indicates that 44.1 percent of the rice farmers interviewed had farm size of two (2) acres. This is followed by farm size of one (1) acre with 22.6 percent Table 8. This result clearly reveals that the farm sizes under cultivation are small; with a minimum farm size in acre of 1 and maximum of 5 acres.

Table 8: Frequency Distribution of Farm sizes of Respondents (n = 340)

Farm size in acre	Frequency	Percent
1.0	77	22.6
1.4	1	0.3
1.5	10	2.9
2.0	150	44.1
2.5	6	1.8
3.0	48	14.6
3.5	2	0.6
4.0	34	10.0
5.0	12	3.5
Total	**340**	**100**

Mean = 2.22 SD = 1.03 Min. = 1.0 acre Max. 5.0 acres
Source: Field survey data, 2014

This finding is consistent with Aryeety & Nyanteng (as cited by Owusu, 2011) that food crop producers are predominantly small scale in terms of the area cultivated. The small land areas under cultivation may be attributed to the land tenure system pertaining in the production areas.

Financial resources available for Rice Production

Finance plays a very important role in rice farming since it determines farmers' ability to secure farm inputs for the establishment and maintenance of farms. Access to credit for productive purpose can effectively reduce the vulnerability and improve their household welfare. This therefore necessitates investigating access to finance and financial credits. From the findings of the study, money lenders form a major source of financial capital for establishing rice farms in the study area.

It is shown in Table 9 that credit sources used by the respondents to finance their farming activities are mainly from external sources. Out of the 340 respondents interviewed, majority (77.3 percent) rely mainly on taking loans from money lenders for their farming purposes. Observations from the study revealed that only few rice farmers 15.2 percent rely on their own savings for production. The most worrying revelation from Table 9 is the funding from the banks (less than 5 percent) to the rice farmers. Duncan and Brants (2004) revealed similar results in the region where they reported that only 4 percent of their respondents access credits from formal institutions such as banks and financial NGOs.

Table 9: Source of Finance for Rice Production (n = 340)

Source of finance	Frequency	Percent
Money lenders	263	77.3
Own savings	52	15.2
Friends and Relatives	19	5.59
Farmers' Organization	4	1.18
From Banks	2	0.58
Total	**340**	**100**

Source: Field survey data, 2014

Farmers access to Extension Services

The results of the analysis in Table 10 showed that majority (69.7 percent) of the respondents had access to extension services; 30.3 percent of the rice farmers did not have access to extension services shown in Table 10.

Table 10: Farmers access to Extension Services (n = 340)

Access to extension services	Frequency	Percent
Yes	237	69.7
No	103	30.3
Total	**340**	**100**

Source: Field survey data, 2014

The main source of technical knowledge for the rice farmers is the District Agricultural Extension within the District Assembly. Finding of the study is consistent with Gbetibouo (2009), who argued that farmers with access to extension services are likely to perceive changes in the climate because extension services provide information about climate and weather. Consequently, awareness and perceptions of changes in climatic conditions shape action or inaction on the problem of climate change. Furthermore, access to extension services increases the likelihood of perceiving changes in climate, as well as the likelihood of adapting to such changes through the creation of opportunities for the farmer to adapt suitable strategies that better suit the changed climatic conditions. This suggests that extension services assist farmers to take climate changes and weather patterns into consideration, through advice on how to deal with climatic variability and change.

Monthly incomes of the Respondents

Income is an important factor in household economies and therefore also in food security, since it allows greater access to food. The average income derived from rice production by the farmers in the Ketu North District in the Volta Region of Ghana is 433 Ghana Cedis, with 24.1 percent earning between 400-499 Ghana Cedis, 18.8 percent earning between 300-399 Ghana

Cedis, 16.8 percent earning between 200-299, 15.9 percent earning between Ghana Cedis 500-599, 11.1 percent earning between 600-699 Ghana Cedis, 7.6 percent earning above 700 Ghana Cedis and 5.6 percent earning between 100-199 Ghana Cedis respectively (Table 11).

Table 11: Frequency Distribution of Monthly income of Respondents

Income (Ghana Cedis)	Frequency	Percent
100-199	19	5.6
200-299	57	16.8
300-399	64	18.8
400-499	82	24.1
500-599	54	15.9
600-699	38	11.1
Above 700	26	7.6
Total	**340**	**100**

Mean = 432.8 SD = 164.62
Source: Field survey data, 2014

Types of Fertilizers and Number of Times applied by the Farmers

When the rice farmers were asked about types of fertilizers applied for first application in Table 12, 75.5 percent applied NPK, 21.8 percent applied NPK and Urea, 1.2 percent applied ammonia, 0.9 percent applied urea and 0.6 percent applied NPK and Ammonia. For second stage of fertilizer application, 41.9 percent applied NPK and Urea, 28.9 percent applied Urea, 20.6 percent applied NPK, 5.6 percent applied Ammonia, and 2.9 percent applied NPK and Ammonia. For third stage of fertilizes application, most of the rice farmers 29.8 percent applied Ammonia, 28.9 percent of the respondents applied NPK and Urea, 25.9 percent applied Urea, 10.4 percent applied NKP and only 2.4

percent applied ammonia and urea. For the fourth stage of fertilizers application, majority of the farmers 50.7 percent of the respondents applied Ammonia, 19 percent applied NPK and Urea, 14.9 percent applied Urea, 10.4 percent applied NPK, 3.2 percent of the respondents applied Ammonia and Urea, 1.8 percent of the population applied NPK and Ammonia (Table 12).

Table 12: Types of Fertilizers and Number of Times applied by the Farmers

	Number of fertilizers application			
Types of fertilizer	First fertilizer application (Freq=339)	Second fertilizer application (Freq=339)	Third fertilizer application (Freq=336)	Fourth fertilizer application (Freq=221)
NPK	75.5	20.6	10.4	10.4
Ammonia	1.2	5.6	29.8	50.7
Urea	0.9	28.9	25.9	14.9
NPK + Ammonia	0.6	2.9	2.7	1.8
NPK +Urea	21.8	41.9	28.9	19.0
Ammonia + Urea	0	0	2.4	3.2
Total	**100**	**100**	**100**	**100**

Source: Field survey data, 2014

Cost of Fertilizers and Stage of Application

When the rice farmers were asked about their total cost of fertilizers applied on their farm in Table 13, majority (63.2 percent) of the respondents spent between 100-299 Ghana Cedis for their first stage of fertilizers application, followed by 15 percent of the respondents who spent between 300-399 Ghana Cedis, 7.9 percent of the respondents spent above 400 Ghana

Cedis and 5.9 percent of the respondents spent between 1-99 Ghana Cedis on their first stage of fertilizers application on their farm land.

For the second stage of fertilizers application, majority of the respondents (69.2) percent spent between 100-299 Ghana cedis, 14.7 percent spent between 1-99 Ghana cedis, 9.7 percent spent between 300-399 Ghana cedis, 3.5 percent spent between 400-499 Ghana cedis and 2.9 percent spent above 500 Ghana cedis for stage two of fertilizers application on their farm land.

Majority (86 percent) of the respondents spent between 1-299 Ghana Cedis for their third stage of fertilizers application, 9.2 percent spent between 300-399 Ghana cedis, 2.9 percent spent between 400-499, Ghana cedis and 1.8 percent spent above 500 Ghana cedis on fertilizers for third stage of application farm land.

Of the respondents interviewed for their fourth stage of fertilizers applications, majority (50 percent) spent between 100-199 Ghana cedis, 19.9 percent spent between 200-299 Ghana cedis, 18 percent spent between 1-99 Ghana cedis, 9.5 percent spent between 300-399 Ghana cedis, 1.8 percent spent between 400-499 Ghana cedis and 0.5 percent spent above 500 Ghana Cedis for their fourth stage of fertilizers application on their farm land (Table 13). Results shows that farmers tend to spend more on fertilizers for the beginning (first stage) of their rice cultivation than the subsequent stages of fertilizers application.

Table 13: Cost of Fertilizers and Stage of Application

Cost (GH)	First stage of application (Freq=339)	Second stage of application (Freq=339)	Third stage of application (Freq=336)	Fourth stage of app. (Freq=221)
1-99	5.9	14.7	17.3	18.0
100-199	31.9	40.4	45.8	50.0
200-299	31.3	28.6	22.9	19.9
300-399	15.0	9.7	9.2	9.5
400-499	7.9	3.5	2.9	1.8
Above 500	7.9	2.9	1.8	0.5
Total	**100**	**100**	**100**	**100**

Source: Field data, 2014

Rice farmers' Perception of Changes in Precipitation and Temperature pattern

Rice farmers' Perception of Climate Change

In an effort to examine whether the farmers' perceived changes in climate, the farmers were asked questions relating to their perception of temperature and rainfall pattern. Results revealed that 84.4 percent of the rice farmers perceived climate change as a severe trend: however, 15.6 percent did not perceived changes.

Findings of this study is consistent with Sofoluwe, Tijani, and Baruwa (2011), who surveyed 100 farmers to gather information on their perceptions about changes in temperature and precipitation in Osun State, Nigeria. Their results showed that more than 75 percent of the respondents were aware of increase in temperature and decrease in precipitation in the region.

Similarly Maddison (2006), also reports that perceptions about climate change showed in a study that a significant number of farmers believe that temperature has already increased and that precipitation has declined for eleven African countries.

Rice farmers' Perception of Changes in Precipitation

With respect to changes in precipitation in Figure 3, the study revealed 3.2 percent perceived an increase in rainfall; 54.1 percent perceived a decrease in rainfall; 15.3 percent of the farmers did not see any change in rainfall pattern and 27.4 percent perceived an irregular rainfall pattern.

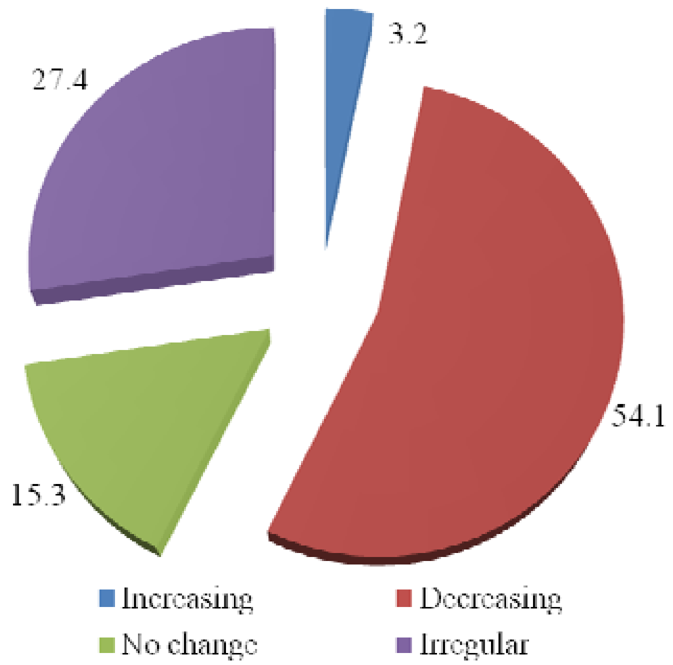

Figure 3: Rice Farmers' Perception of changes in Precipitation (%) in the Ketu North District, Volta Region of Ghana

Source: Field survey data, 2014

Rice farmer's Perception of Changes in Temperature

According to the same study in Figure 4, majority of the rice farmers 59.7 percent of the farmer's perceived increasing temperature, and 3.5 percent of the rice farmer's perceived decreasing temperature, 16.5 percent of the farmers perceived no change in temperature, whilst 20.3 percent of the farmers perceived irregular pattern of temperature.

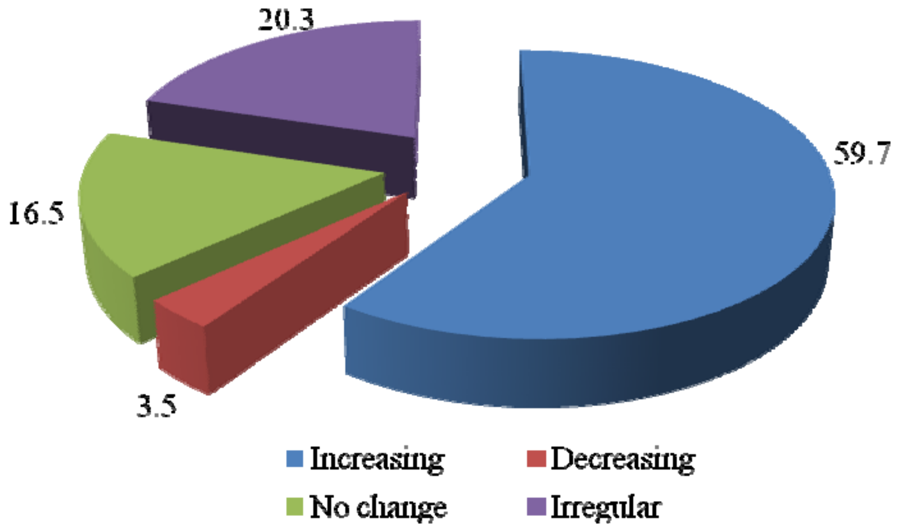

Figure 4: Rice farmers' Perception of changes in Temperature (%) in the Ketu North District, Volta Region of Ghana

Source: Field survey data, 2014

These findings of the study are consistent with Acquah and Onumah (2011), who assessed farmers' perception and adaptation to climate change in the Western part of Ghana, found that majority of the farmers' perceived increase in temperature and decrease in rainfall pattern.

In a study to analyse farmers' perception and adaptation strategies to climate change in India, Dhaka, Chayal and Poonia (2010), also found that significant numbers of farmers believed temperatures have already increased and the precipitation has declined along with late onset and early withdrawal of monsoon with long dry spells.

Rice farmers' choice of adaptation measures in response to changes in precipitation and temperature

Rice farmers' were asked if they employ some adaptation measures due to decreasing precipitation and increasing temperaturein Table 14. Majority of rice farmers 99.7 percent who perceived decreasing precipitation adapted irrigation, 85 percent of the rice farmers adapted change in crops cultivation measures, 77.9 percent adapted changing planting dates as their main adaptation measures and 12.1 percent adapted planting short season variety as the adaptation strategies to decreasing precipitation.

Similarly, majority 82.9 percent of the rice farmers who perceived increasing temperature, adapted irrigation and change in crops cultivation, 60 percent adapted changing planting dates and 11 percent adapted planting short season variety.

Table 14: Rice farmers' choice of adaptation measures in response to changes in precipitation and temperature (percent)

Adaptation strategies	Decreasing Precipitation (%)	Increasing Temperature (%)
Changing planting dates	77.9	60.0
Crop diversification	2.1	1.4
Reduce farm size	1.0	0.4
Change in crops	85.0	82.9
Find off farm jobs	1.0	3.2
Plant short season variety	12.1	11.0
No adaptation	0.3	2.5
Irrigation	99.7	82.9

Source: Field survey data, 2014 (Multiple responses)

Findings of this study is consistent with Deressa, Hassan, Ringler, Alemu, and Yesuf (2008). These researchers analysed the determinants of farmers' choice of adaptation methods in the Nile Basin, Ethiopia. Using cross-sectional data from a survey of farmers to obtain information on adaptation methods. Their study found that the adaptation methods currently in place in the study area were: changing planting dates, using different crop varieties, planting tree crops, irrigation, soil conservation. Farmers' use of different crop varieties was the most common adaptation method, while irrigation was the least common.

Also, Fosu-Mensah, Vlek and Manscheadi (2010), investigated how farmers perceive long-term changes in temperature, rainfall and vegetation cover over the past twenty years. The main adaptation strategies reported by the farmers were crop diversification and changing planting dates.

Determinants of Rice farmers' Adaptation to decreasing Precipitation and increasing Temperature

Logistic regression of the Adaptation to decreasing Precipitation

The Maximum Likelihood Estimation (MLE) technique was used to estimate the logit models. From the results, the Wald chi square value of 65.16 with 7 degrees of freedom and a p-value of 0.000 less than 0.05 shows that the model provides a good fit to the data. Besides, the Hosmer–Lemeshow model fitness test shows that we cannot reject our model which also means our model fits reasonably well. The link test also reveals no problems with the specification of our model with p-value greater than 0.05.

In the table below, it should be emphasized that a negative sign of a parameter indicates that high values of the variables tend to decrease the probability; while a positive sign implies that high values of the variables will increase the probability of the adaptation to decreasing precipitation.

The results show the estimated coefficients of the variables for whether respondents adapt to decreasing precipitation or not. Five independent variables were found to be significant. These variables are therefore interpreted and explained as indicated in Table 15.

Table 15: Logistic regression of the Adaptation to decreasing Precipitation

Dependent variable: Decreasing precipitation		
Independent variables	Coefficient	Marginal effects
Sex	0.479	0.036
	(1.08)	
Age	0.023	0.001
	(0.82)	
Household size	0.218	0.016
	(2.44)*	
Education level	0.867	0.065
	(3.84)**	
Farming experience	0.071	0.005
	(2.13)*	
Farm size	-0.963	-0.072
	(4.87)**	
Financial support	2.036	0.153
	(4.56)**	
Constants	-3.640	
	(2.24)*	
N	340	
P-value of link test (_hat sq.)	0.140	
Wald chi2(7)(P-value)	65.16(0.000)	
P-value of Hosmer-Lemeshaw test for goodness of-fit	0.286	

t statistics in parenthesis
*P<0.05; ** p<0.01
Source: Survey field data, 2014

An increase in the household size of respondents by one person increases the probability of the respondents adapting to decreasing precipitation by 1.6 percent at 5 percent significant level holding other variables constant. This finding is consistent with Kandlinkar and Risbey (2000). Shortage of labor is also deemed as an important input constraint. Households with more labor are believed to be better able to take adaptation measures in response to changes in climatic conditions compared to those with limited labor. In this sense, family size is one important variable that can determine the availability of labour Temesegen, Rockstrom, Savenije, Hoogmoed, & Alemu (2008).

With respect to educational level of respondents, an additional year of education increases the probability of the respondents' adaptation to decreasing precipitation by 6.5 percent at 1 percent significant level holding other variables constant. The study is consistent with Temesegen *et al.,* (2008). Education is an important source of information for farm level management activities. Rice farmers with more formal education are believed to be better able to take adaptation measures in response to climate change compared to those rice farmers without adequate education.

An experienced rice farmers have an increased likelihood of adapting to decreasing precipitation. As the level of experience increases by 0.5 percent, the level of adaptation to decreasing precipitation increases by 5 percent significant level. The estimated coefficient being positive implies that farming experience has a strong influence on farmers' level of adaptation to decreasing precipitation. This finding is consistent with Nhemachena & Hassan (2007); Temesegen *et al*., (2008) and Di Falco, Veronesi, & Yesuf, (2011). They suggested that elder household heads are expected to have more experience in farm practices and management.

An additional acre of farm land of respondents reduces the probability of the respondents adapting to decreasing precipitation by 7.2 percent at 1 percent significant level. That is, farmers with smaller farm sizes are likely to adapt to decreasing precipitation compared to those farmers with larger farm sizes. Independent variables that have demonstrated negative relationship to adaptation such as farm size could be attributed to the fact that adaptation is plot-specific as documented by Deressa, & Hassan (2009). In other words, it is not the size of the farm, but the specific characteristics of the farm that dictate the need for a specific adaptation method to climate change. In addition, factors identified as affecting the perception of an adaptation to climate change in the study areas are directly related to the development of institutions and infrastructure.

Receiving financial support increases the probability of respondents adapting to decreasing precipitation by 15.3 percent at 1 percent significant level as compared to respondents who do not receive any financial support. This result indicates that farmers who have financial assets use more fertilizer and labour and are more likely to consciously adapt to climate change. Such inputs include different seed varieties, fertilizers, and irrigation technologies. This finding is consistent with Kandlinkar and Risbey (2000). They suggested that farmers that lack capital and other resources will fail to cover costs necessary to take up adaptation measures and thus may not make beneficial use of the information they might have (Table 15).

These result of the constant means that without any of the independent variables taken into consideration, farmers' adaptation to decreasing precipitation reduces.

Logistic regression of the Adaptation to increasing Temperature

The results below in Table 16 below shows the Wald chi square value of 98.31 with 7 degrees of freedom and a p-value of 0.000 less than 0.05. The Hosmer–Lemeshow model fitness test shows that we cannot reject our model which also means our model fits reasonably well. The link test also reveals no problems with the specification of our model with p-value greater than 0.05.

The results in Table 16 show the estimated coefficients of the variables for whether respondents adapt to increasing temperature or not. Five explanatory variables were found to be significant. These variables are therefore interpreted and explained as indicated in Table 16.

Table 16: Logistic regression of the Adaptation to increasing Temperature

Dependent variable: Increasing temperature		
Independent variables	Coefficient	Marginal effects
Sex	0.450	0.047
	(1.21)	
Age	-0.003	-0.000
	(0.15)	
Household size	0.144	0.015
	(2.18)*	
Education level	0.466	0.049
	(2.57)*	
Farming experience	0.094	0.009
	(3.40)**	
Farm size	-0.809	-0.085
	(4.69)**	
Financial support	1.896	0.199
	(4.81)**	
Constants	-2.267	
	(1.70)	
N	340	
P-value of link test (_hat sq.)	0.700	
Wald chi2(7)(P-value)	98.31(0.000)	
P-value of Hosmer-Lemeshaw test for goodness of-fit	0.190	

t statistics in parenthesis
*P<0.05; ** p<0.01
Source: Survry field data, 2014

The findings in Table 16 revealed that an increase in the household size of respondents by one person increases the probability of the respondents adapting to increasing temperature by 1.5 percent at 5 percent significant level holding other variables constant. This finding is consistent with Kandlinkar and Risbey (2000); and Temesegen *et al.,* (2008). They explained that households with more labor are believed to be better able to take adaptation measures in response to changes in climatic conditions compared to those with limited labor. In this sense, family size is one important variable that can determine the availability of labour.

With regards to education level of respondents, an additional year of education increases the probability of the respondents' adaptation to increasing temperature by 4.9 percent at 5 percent significant level holding other variables constant. This finding is consistent with Temesegen *et al.,* (2008). Education is an important source of information for farm level management activities. Farmers with more formal education are believed to be better able to take adaptation measures in response to climate change compared to those without adequate education.

An additional year of farming of respondents increases the probability of the respondents adapting to increasing temperature by 0.9 percent at 1 percent significant level holding other variables constant. This finding is consistent with Nhemachena and Hassan (2007); Temesegen *et al*., (2008) and Di Falco *et al*., (2011). They recommended that elder household heads are expected to have more experience in farm practices and management.

An additional acre of farm land of respondents reduces the probability of the respondents adapting to increasing temperature by 8.5 percent at 1 percent significant level. That is, farmers with smaller farm sizes are likely to adapt to decreasing precipitation compared to those farmers with larger farm sizes. The study is consistent with Deressa *et al.,* (2009). Independent variables that have demonstrated negative relationship to adaptation such as farm size could be attributed to the fact that adaptation is plot-specific. In other words it is not the size of the farm, but the specific characteristics of the farm that dictate the need for a specific adaptation method to climate change. In addition, factors identified as affecting the perception of an adaptation to climate change in the study areas are directly related to the development of institutions and infrastructure.

Access to financial support increases the probability of respondents adapting to increasing temperature by 19.9 percent at 1 percent significant level as compared respondents who do not receive any financial support. Finding indicates that farmers who have financial assets to use more fertilizer and labour are more likely to consciously adapt to climate change. Alternatively, farmers with financial support acquire necessary inputs required to adapt to climate change and enhance their production. Such inputs include different seed varieties, fertilizers, and irrigation technologies. Finding of this study is consistent with Kandlinkar and Risbey (2000). They suggested that farmers that lack capital and other resources will fail to cover costs necessary to take up adaptation measures and thus may not make beneficial use of the information they might have.

Barriers to Adaptation Strategies

The study also investigated barriers preventing farmers from adapting to climate change in Figure 5. The results of the study indicates lack of information about climate change, lack of knowledge about adaptation options, lack of access to credit, no access to irrigation water, expensive changes, poor soil fertility, insufficient access to inputs, and insecure property rights are the major barriers inhibiting farmers' ability to adapt to climate change impacts.

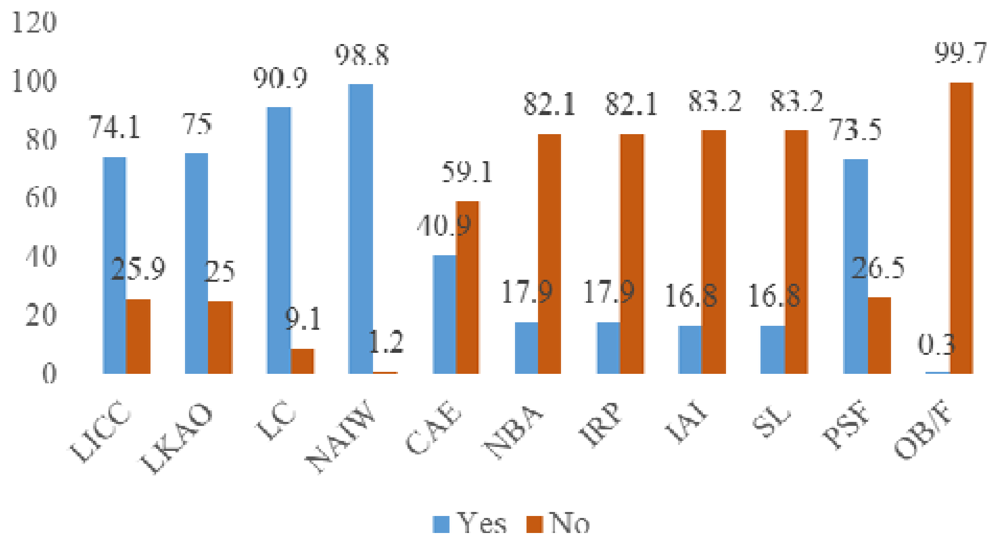

Figure 5: Barriers to Adaptation Measures in the Ketu North District, Volta Region of Ghana

Source: Field survey data, 2014

Result shows majority (90.9) percent of the farmers identified lack of access to credit as the main barrier to effective adaptation to climate change while 9.1 percent did not think so. Finding indicates 74.1 percent identified lack of information regarding adaptation measures while 25.9 percent think otherwise. Majority of the rice farmers (75) percent identified lack of knowledge about adaptation options whilst 25 percent did not think so, 73.5 percent identify poor soil fertility while 26.5 percent did not. Findings also indicate 17.9 percent identified insecure property rights while 82.1 percent think otherwise. 40.9 percent of the farmers' think that changes are expensive, while 59.1 percent did not think so. Finding revealed that 36.8 percent identified insufficient access to inputs while 63.2 percent did not. Result shows that 3.2 percent did not identify any barriers to adaptation whilst 96.8 percent think otherwise. Finding shows that 16.8 percent of the respondents identified shortage of land as their main barriers, while 83.2 percent did not think so. Finding also shows that 0.3 percent identified flooding as others barrier to their rice production while 99.7 percent did not think so.

Findings indicate lack of information about climate change, lack of knowledge about adaptation options, lack of credit, no access to irrigation water and poor soil fertility are the major barriers rice farmers' face in adapting to climate change (Figure 5).

These findings of the study are also consistent with Acquah and Onumah (2011) who identified lack of information on climate change impacts and adaptation options, lack of knowledge about adaptation measures, lack of access to credit and no access to water as some of the barriers inhibiting the ability of the farmers in Western part of Ghana as the main constraints to adapt to climate change impacts. Also Nhemachena and Hassan (2007), investigated barriers to adaptation, their study indicated that farmers reported that lack of credit facilities and information on adaptation options and insufficient inputs are the main barriers to adopting any climate change adaptation options.

Summary of Results

Results from the socio economic characteristics of the rice farmers' interviewed, revealed that farmers were characterized by active labour force, small farm size, high farming experience, large household size, and some level of formal education. Findings also indicate that majority 84.4 percent of the rice farmers interviewed perceived changes in climate specifically decreasing precipitation and increasing temperature. Based on the findings, the rice farmers' adapted some level of adaptation measures to improve their production. The logistic regression analysis finds household size, educational level, farming experience and financial support as significant predictors to adapt to changes in precipitation and temperature patterns. Most farmers adapted to the changes in climate and face one or more barriers in adapting to climate change.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

General Overview

This chapter summarises the study, draws conclusions and presents recommendations for policy. It also presents suggested areas for further studies.

Summary

Climate change and weather patterns have being experienced as negative impacts on food production, food security and natural resources all over the globe. Farmers' adaption to climate change is crucial to combating food insecurity and related problems. This study sought to empirically understand Rice farmers' perception of climate change and adaptation strategies in the Ketu North District in the Volta Region of Ghana.

Specifically, the study sought to achieve the following objectives:

1. Analyse farmers' perception of precipitation and temperature patterns in the study area.
2. Identify farmers' choice of adaptation measures in response to climate change;
3. Investigate the determinants of farmers' adaptation to change in precipitation and temperature;

4. Identify barriers to farmers' adaptation measures in response to climate change;

The summary of the major findings are presented with respect to the objectives of the study; which were as follows:

1. **Rice farmers' Perception of changes in Precipitation and Temperature Patterns**

Rice farmers in the study area were aware of climate change situation on their production, with majority 84.4 percent perceived changes in climate as a severe trend whilst 15.6 percent did not perceived any changes. With respect to precipitation, the study revealed that majority 54.1 percent of the rice farmers perceived a decrease in precipitation; 3.2 percent perceived an increase in precipitation; 27.4 percent of the rice farmers perceived an irregular precipitation and 15.3 percent of the farmers did not see any change in precipitation. Similarly, majority 59.7 percent of the rice farmer's perceived increases in temperature, 3.5 percent of the rice farmer's perceived decrease in temperature, 20.3 percent of the farmers perceived irregular pattern in temperature and 16.5 percent of the farmers perceived no change in temperature.

2. **Rice farmers' Choice of Adaptation measures in response to Climate Change**

Rice farmers' in the study area employ some adaptation methods due to decreasing precipitation and increasing temperature. These adaptation measures includes: Irrigation, change in crops, changing planting dates and plant short season variety were identified as the major adaptation strategies used to overcome decreasing precipitation and increasing temperature respectively.

3. **Determinants of rice farmers' Adaptation to decreasing Precipitation and increasing Temperature**

   Empirical results from the logistic regression analysis reveals household size, educational level, farming experience and financial supports positively influence rice farmers adaptation to decreasing precipitation while farm size negatively influence adaptation to decreasing precipitation. With respect to increasing temperature, household size, education level, farming experience and financial support positively influence the probability of adaptation to increasing temperature whilst farm size has negatively influence the probability of adaptation to increasing temperature.

4. **Barriers to rice farmers' adaptations measures**

   The rice farmers were faced with barriers to their adaptation to climate change. These barriers include: lack of information about climate change, lack of knowledge about adaptation options, lack of credit, no access to irrigation water and poor soil fertility are the major barriers rice farmers' face in adapting to climate change.

Conclusions

From the findings of the study, the following conclusions are drawn:

1. Majority of the rice farmers perceived decrease in precipitation and increasing temperature.
2. Rice farmers' used variety of measures to adapt to decreasing precipitation and increasing temperature. These measures include:

irrigation, change in crops, changing planting dates and plant short season variety as the major adaptation measures to climate change impacts.

3. Findings from the logistic regression analysis indicate household size, education level, farming experience, and financial support are significant predictors of the probability to adaptation to decreasing precipitation and increasing temperature respectively.
4. Lack of information about climate change, lack of knowledge on adaptation, lack of credits and poor soil fertility were identified as the major barriers to adaptation.

Recommendations

Based on the findings of study, the following recommendations are made.

1. Ghana Meteorological Agency should provide information on climate related issues through the District Directorate of Agriculture to enhance adequate information on climate change.
2. The Ministry of Food and Agriculture (MoFA) should educate farmers on specific adaptation options to enable them adapt to climate change situation in the district.
3. MoFA should provide education to rice farmers in the study area since it improves adaptation to climate change.
4. Banks and Microfinance institutions should provide financial support to rice farmers since it improves adaptation to climate change.

Suggestions for Further Research

The following suggestions are made for further research.

1. Further studies should analyze farmers' perception of climate change and adaptation strategies of other staples crops grown in the district.
2. Further studies should analyse the effect of climatic factors on crop production in the district.

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APPENDICES

APPENDIX A: STRUCTURED UESTIONNAIRES

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

COLLEGE OF AGRICULTURE AND NATURAL SCIENCES

SCHOOL OF AGRICULTURE

UNIVERSITY OF CAPE COAST

CAPE COAST, GHANA

Introduction

This interview schedule is administered as part of a study to gather data on the research topic “rice farmers’ perception of climate change and adaptation strategies in the Ketu North district of Ghana”. The research is purely academic and information given will be treated confidentially.

Thank you.

Date of interview: Day:________ Month:___________ Year:____________

SECTION A: SOCIO ECOMOMIC CHARACTERISTICS OF RESPONDENTS

1. Location of respondent ____
2. Sex (a) Male [ ] (b) [ ]
3. Age of farmer at last birthday: ______________________ years.
4. Marital status of farmers: (a) single [ ] (b) Married [ ] (c) Divorced [ ] (d) Widowed [ ] (e) Co-habiting/consensual relationship
5. Are you the head of the household? (a) Yes [ ] (b) No [ ]
6. Household size (#) _______________________________

7. Educational level of respondents (a) No formal education [ ] (b) Primary school [ ] (c) Middle school leaver/Junior high school [ ] (d) O'level/senior high school [ ] (e) Tertiary level [ ]
8. How many years have you been growing rice?______________ years.
9. What is your monthly income? ________________________________
10. Do you have other income generating source? (a) Yes [ ] (b) [ ]
11. Indicate the main sources of household income:

    (a) ________________________ (c) _____________________________

    (b) ________________________ (d) ____________________________
12. What is/are your main purpose(s) of growing rice? ________________

SECTION B: PRODUCTION ACTIVITIES

13. What is the size of your rice farm in acres? _______________________
14. Do you cultivate rice both in the major and minor seasons? (a) Yes [ ] (b) No [ ] if No why? ____
15. What changes in rice yields do you perceive? (a) Increase [ ] (b) Decrease [ ] (c) No change [ ]
16. What do you think is contributing to this change? _________________
17. Do you have access to credits? (a) Yes [ ] (b) No [ ]
18. Do you irrigate your farm? (a) Yes [ ] (b) No [ ], if no why? ____
19. Do you have access to extension services? (a) Yes [ ] (b) No [ ]

    If yes, how many times_______________________________________
20. Do you get financial support from any quarters for rice production? (a) Yes [ ] (b) No [ ] if yes from where?____________________________
21. Do you use fertilizer on your farm? (a) Yes [ ] (b) No [ ]

22. Please indicate in the table the amount of fertilizer applied on your rice farm during last season____ times.

Application	Type(s) of fertilizer applied	When/Stage of fertilizers applied	Amount of fertilizers applied per acre in kilo grams	Method of fertilizers application	What did you use to apply the fertilizers	Total cost of fertilizer
1^{st}						
2^{nd}						
3^{rd}						
4^{rd}						

23. Do you apply manure on your rice farm? (a) Yes [ ] (b) No [ ]
24. Source of manure: (a) Own farm [ ] (b) Farmers in the same community [ ] (c) Farmers in another community [ ]

    (c) others (specify) ____

SECTION C: CLIMATE CHANGE INFORMATION

25. Do you perceive changes in climate? (a) yes [ ] (b) No [ ]
26. If yes, in question 26, is climate change a serious condition? (a) yes [ ] (b) No [ ]
27. What are your perceptions of the changes in temperature and precipitation?

27_ a. Perceptions of changes in temperature; select one of the following:

1. Increase in temperature [ ]
2. Decrease in temperature [ ]
3. No change in temperature [ ]
4. Irregular temperature pattern [ ]

27_b. Perception of changes in rainfall; select one of the following:

1. Increase in rainfall/precipitation [ ]
2. Decrease in rainfall/ precipitation [ ]
3. Irregular rainfall pattern [ ]
4. No change in rainfall pattern [ ]

SECTION D: ADAPTATION MEASURES(S) IN RESPONSE TO CLIMATE CHANGE

28. Do you adapt to climate change? (a) Yes [ ] (b) No [ ]

29. Do you adapt to decreasing precipitation? (a) Yes [ ] (b) No [ ]

30. If yes, what major adaptation strategy do you usually use?

    1. Changing planting dates (a) Yes [ ] (b) No [ ]
    2. Crop diversification (a) Yes [ ] (b) No [ ]
    3. Reduce farm size (a) Yes [ ] (b) No [ ]
    4. Change in crops (a) Yes [ ] (b) No [ ]
    5. Find off farm jobs (a) Yes [ ] (b) No [ ]
    6. Plant short season variety (a) Yes [ ] (b) No [ ]
    7. No adaptation (a) Yes [ ] (b) No [ ]
    8. Others (specify)______________________________________

31. Why do you prefer your choice of adaptation strategy in question 33 to other strategies?

   1. It improves the land (make land fertile, add nutrients) [ ]
   2. It prevents erosion [ ]
   3. It is more economical [ ]
   4. It reduces the direct impact of climate change (drought, flood etc) [ ]
   5. Others (specify) ____

32. Do you adapt to increasing temperature? (a) Yes [ ] (b) No [ ]

33. If yes, what major adaptation strategy do you usually use?

   1. Changing planting dates (a) Yes [ ] (b) No [ ]
   2. Crop diversification (a) Yes [ ] (b) No [ ]
   3. Reduce farm size (a) Yes [ ] (b) No [ ]
   4. Change in crops (a) Yes [ ] (b) No [ ]
   5. Find off farm jobs (a) Yes [ ] (b) No [ ]
   6. Plant short season variety (a) Yes [ ] (b) No [ ]
   7. No adaptation (a) Yes [ ] (b) No [ ]
   8. Others (specify) ____

34. Why do you prefer your choice of adaptation strategy in question 36 to other strategies?

   1. It improves the land (make land fertile, add nutrients) [ ]
   2. It prevents erosion [ ]
   3. It is more economical [ ]
   4. It reduces the direct impact of climate change (drought, flood etc) [ ]

5. It is environmentally friendly [ ]

6. Others (specify) ____

SECTION E: BARRIERS TO ADAPTATION MEASURES

35. Do the following under listed factors constrain you from using adaptation strategies?

1. Lack of information about climate change

   (a) Yes [ ] (b) No [ ]

2. Lack of knowledge about adaptation options (a) Yes [ ] (b) No [ ]

3. Lack of credit (a) Yes [ ] (b) No [ ]

4. No access to irrigation water (a) Yes [ ] (b) No [ ]

5. Changes are expensive (a) Yes [ ] (b) No [ ]

6. No barriers to adaptation (a) Yes [ ] (b) No [ ]

7. Insecure property rights (a) Yes [ ] (b) No [ ]

8. Insufficient access to inputs (a) Yes [ ] (b) No [ ]

9. Shortage of land (a) Yes [ ] (b) No [ ]

10. Poor soil fertility (a) Yes [ ] (b) No [ ]

11. Others barriers(specify)________________________________