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EFFECTS OF CLIMATE VARIABILITY ADAPTATION STRATEGIES ON MAIZE PRODUCTION IN THE MION DISTRICT OF THE NORTHERN REGION OF GHANA

ABUBAKARI ABU-NASHIRU

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BY

ABUBAKARI ABU-NASHIRU

(UDS/MIC/0057/15)

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

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DECLARATION

I, Abubakari Abu-Nashiru, hereby declare that this thesis does not incorporate, without acknowledgement, any material previously submitted for a degree or diploma in any University; and that to the best of my knowledge and belief, does not contain any material previously published or written by another person, except where due reference has been made in the text.

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SUPERVISOR

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

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Name: **DR. ELIASU MUMUNI**

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ABSTRACT

Climate variability is posing a serious challenge to crop production in Ghana through erratic rainfall patterns, increase in temperature and decreasing crop yields which can cause food insecurity and hunger, not only in Ghana but across SSA. Maize is one of the major staple crops and consumed by almost all ethnic groups in Ghana. Recent reports partly attribute low maize yields to climate variability. Based on this unfavourable experience, maize farmers have been introduced to a number of adaptation strategies or mechanisms to increase their resilience in the sector. The study analyzed the effects of climate variability adaptation strategies employed in maize production in Mion District of the Northern Region of Ghana. The study used descriptive statistics to determine the adaptation strategies employed by maize farmers in the district. A simple random sampling technique was used to select 140 household respondents for questionnaire administration. The data from questionnaire were inputted into SPSS and analysed using descriptive statistics such as frequencies, percentages and means. The study applied Ordered Logistics Regression (OLM) model to determine the factors effecting the choice of climate adaptation strategies. The data from interviews and FGDs were analysed based on theories and relationships. The findings revealed that the smallholder farmers in the district widely practice changing planting dates, improved maize varieties, inorganic fertilizer, making ridges and diversify into nonfarm activities as adaptation strategies. The OLM analyses revealed that the factors explaining farmers' choice of climate variability adaptation strategies include age, gender, income level, level of education of household head, membership of FBO and household size of farmers. Challenges to the strategies include inadequate access to credit, inadequate extension officers/services, high input prices, pest and diseases and inadequate information on climate characteristics. The study recommends that policies focus on adaptive capacity of maize farmers through input subsidy, access to credit, sensitization on climate change as well as provision of irrigation facility in farming communities.

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DEDICATION

I dedicate this piece of work to the Almighty Allah for His strength and guidance; to the great Bakere family for their great support, and to all my able brothers and sisters who supported me both morally and financially for making this study a successful one.

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LIST OF ACRONYMS

AATF – Africa Agricultural Technology Foundation

ADP – Area Development Programme

ADRA – Adventist Development and Relief Agency

ADVANCE – Agricultural Development and Value Chain Enhancement

AEAs – Agricultural Extension Agents

AGRA – Alliance for Green Revolution in Africa

ATTP – Agricultural Technology Transfer Project

CLIP – Community Life Improvement Programme

EPA – Environmental Protection Agency

FAO – Food and Agriculture Organization

FBOs – Farmer-Based Organizations

FGDs – Focused Group Discussion

GDP – Gross Domestic Product

GHG – Greenhouse Gases

GSS – Ghana Statistical Service

IITA – International Institute for Tropical Agriculture

IMWIC – International Maize and Wheat Improvement Centre

IPA – Innovation for Poverty Action

IPCC – Intergovernmental Panel on Climate Change

MOFA – Ministry of Food and Agriculture

MNL – Multinomial Logistic Regression

NARS – National Agricultural Research Systems

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NGOs – Non-Governmental Organization

OLM – Ordered Logit Model

OECD – Organization for Economic Co-operation and Development

PHC – Population and Housing Census

SARI – Savanna Agricultural Research Institute

SPRING – Strengthening Partnership, Results, and Innovations in Nutrition Globally

SPSS – Statistical Package for Social Scientists

UNEP – United Nations Environmental Protection

USAID – United States Agency for International Development

WAAPP – West Africa Agricultural Productivity Programme

WEMA – Water Efficient Maize for Africa

WIAD – Women in Agricultural Development

YIIFSWA – Yam Improvement Income for Food Security in West Africa

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CHAPTER ONE

1.0 Introduction

1.1 Background

Climate change is a global phenomenon that is widely recognized for its threat to the development of agricultural productivity (MacCarthy *et al*., 2014). Several reports of the Intergovernmental Panel on Climate Change (IPCC) have attributed this change to the increased atmospheric carbon dioxide (CO_2) and other greenhouse gases (GHG) (IPCC, 2007; IPCC, 2014). The IPCC further predicts that it is most likely, greater than 90 percent probability, that changes cannot be attributed to natural causes alone. The panel has since, provided strong evidence of accelerated global warming as a result of these gases (IPCC, 2007).

Whereas climate change can simply be defined as any change in climate over time, whether due to natural variability or human activity, climate variability is variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (Burroughs, 2007). Climate variability is therefore used to denote the statistical deviations of individual weather events over a given period of time (e.g. a month, season or year) from the long-term statistics relating to the corresponding calendar period (Selvaraju *et al*, 2006).

According to the third report of the IPCC, the world's average temperature has increased over the 20th century by about 0.6°C and is expected to increase by 1.4°C to 5.8°C by 2100, depending largely on the scale of fossil-fuel burning (Acharya, 2011). The panel has shown substantial evidence indicating that most of the warming observed over the last 50 years is attributed to the activities of human beings (Acharya, 2011). Most affected among the many

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sectors is the agricultural sector which derives directly its inputs from the elements of the weather. The 4th Assessment Report of the IPCC states that climate change will have adverse impact not only on agriculture, but on people's health, safety and livelihoods, with the poorest people in the poorest countries expected to suffer first and foremost. The report also predicted climate change will be accompanied with challenges to future poverty reduction and reverse many of the important socioeconomic gains made by developing countries (Lee *et al*., 2012).

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1.1.2 Climate Change and Agriculture

In Asia, agriculture is an important part of the economy in most countries such as china and Japan though some of these countries depend less on the sector in terms of its contribution to GDP (Lee *et al*., 2012) due to their economic enhancement in technology and industry. For instance, according to the FAOSTAT, the share of agricultural output in GDP fell from 35% to 19% in East Asia from 1970 to 1991 (Lee *et al*., 2012). Climate change in this region poses a threat in the form of extremely heavy rainfall pattern which adversely affects the agricultural activities of farmers located in mountainous areas. Adaptation measures and policy interventions have been put in place to mitigate some of these adverse impacts of the climate variability and change. It has however been established that the impact of the change in climate in Asia tends to benefit rice production among others, as most countries in this region have the ideal climate condition such as availability of water, high average temperature, suitable soil type to support its production (Lee *et al*., 2012).

Similarly, climate change impact on the agricultural sector of countries in Europe and America (north and south) regions is as alarming as any other region, however, in a different way (Wrefold *et al*., 2010). In the light of this, the Organization of Economic Co-operation and Development (OECD), which has been working on climate change economics and policies since

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the late 1980s, has been assisting especially its member countries to identify and implement policies that are least-cost to reduce Greenhouse Gas (GHG) emissions in order to limit climate variability and change, as well as integrate adaptation in all relevant sectors and policy areas (OECD, 2013).

Serious attention should be paid to the vulnerability of African countries to the impact of climate change on agriculture as well as related sectors that are sensitive to climatic events. Agricultural activities in Africa are mainly controlled by rainfall amounts and distribution (Ngaira, 2007). According to Dinesh *et al*. (2015), without adaptation measures, African crop production could have been greatly reduced by the climate change, due mainly to increase in regional temperatures. Maize and beans are two main staple crops cultivated across Africa, which shows significant levels of decline relative to the period between 1970-2000 (Dinesh *et al*., 2015).

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Agriculture is the main livelihood activity of the majority of the population living in Sub-Saharan Africa. It is characterized by its rain-fed nature and as well susceptible to drought. The key challenge on further increase in agricultural production is the scarcity of water for farming activities. Based on this, national planners are strongly attracted to irrigation as a means of supporting future food strategies. About 85% of Sub-Saharan Africa's poor live in the rural areas and depend largely on agriculture for their livelihoods (Dinesh *et al*., 2015), yet agriculture in the region remains largely subsistence, production has not kept pace with population growth and food self-sufficiency is on serious decline. In this region, not only does agricultural productivity is affected directly by erratic rainfall pattern and persistent high temperature, the adverse impact is also accompanied by the outbreak of pest and diseases, which affects the growth and yield of these food crops (Dinesh *et al*., 2015), since countries in this region are situated in the tropics.

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Expectations are that, with climate change, (a) the prevalence of crop pests will increase; (b) the occurrence of major pest outbreak will be on the rise; and (c) the risk of pesticide residue will also increase (Dinesh *et al*., 2015).

In Ghana, agriculture accounts for approximately 22.7% of the country's GDP and employing over 50% of its work force (GSS, 2010). Agriculture as a livelihood activity plays a vital role in employment generation, poverty reduction, food security and enhancing the standard of living by increasing income levels of the rural population. The World Bank (2010) reports that an increase in GDP derived from agricultural was averaged 2.9 times more effective in increasing the incomes of the poorest in developing countries than from other sectors. However, climate variability and change has been the major challenge to the development of the sector. Agriculture is inherently sensitive to climate conditions and is one of the most vulnerable sectors to the risks and impact of global climate change (Parry *et al*., 1999). Rainfall has seen a decline all over Ghana since the 1970s and has only begun to increase slightly since 2006 (Owusu and Waylen, 2012; Lacombe *et al*., 2012).

The impact of climate change and variability is due mainly to the high dependence on weather for agricultural production (Foster *et al*., 2007, Moriondo *et al*., 2011). Majority of farmers in Ghana still depend on rainfall for their crop production. Moreover, the method of farming is mainly traditional; thus, the use of hand-hoe and cutlass is still common (Fosu-Mensah *et al*., 2012). Northern Ghana accounts for over 40% of agricultural land in Ghana and is considered to be the food-basket of the country (Anslem el al., 2016). The main livelihood activity of the rural people in Northern Ghana is crop farming, which shows a high level of sensitivity to the variability of the climatic system (Mu and McCarl, 2011). This describes the extent of vulnerability of crop farming to the adverse effects of the variability of climate (FAO, 2009).

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Based on this, farmers in this area have been modifying their farming practices to better adapt to the current climate variability and change (FAO, 2009).

1.1.3 Maize Production and Issues of Climate Variability

In the agricultural sector, maize is one of the staple crops that is cultivated and consumed in virtually all regions in Ghana (Barimah *et al*., 2014) and accounts for more than 50 percent of the country's total cereal production (IFPRI, 2014). Maize is produced on nearly 100 million hectares in developing countries (FAO, 2010). Since the farming system is rain-fed, farmers await the coming of rains before the season's planting. Maize cropping is highly dependent on sustained rainfall, especially during its critical development stages (Celia *et al*., 2009). One could therefore correlate good seasonal precipitation to a good maize production. In the same light, climatic irregularities could affect local maize farmers.

In Ghana, for the past five years, maize yields have been projected to be dwindling. In 2010, 954,000 hectares was covered with maize production, with a production volume of 1,870,000 tons (MOFA, 2013) and decreased in 2014 with a volume of 1,762,000 (FactFish, 2014). Although increasing temperatures and irregular rainfall pose as main causes (Amikuzuno and Donkoh, 2012), other factors may also be contributing to the decreasing yields.

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Maize accounts for 62% of total grain production and is consumed throughout the country. The demand for maize is very high which makes its production very profitable. The rising population, urbanization, and growing poultry and fish sectors in Ghana have contributed to increased demand for maize (Ragasa *et al*., 2014). For instance, it serves as feed for poultry and also as raw material for the brewing industry, for making malt drinks (GAIN, 2011; Barimah *et al*., 2014).

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Despite the high demand, maize production is dominated by rural smallholder farmers in Northern Ghana (MiDA, 2010; Barimah *et al*., 2014) and it is usually planted either as a mono-crop or together with other crops, such as yam and cassava (Morris *et al*., 1999; Barimah *et al*., 2014). The level of production in the sector is mainly dependent on rainfall amount and spatial distribution (MOFA, 2013). The use of irrigation facilities for maize cultivation in Ghana is not widespread (MEST, 2010). The dependence on rainfall makes the maize production highly vulnerable to climate variability and change (Dazé, 2007; Barimah *et al*., 2014). As a result, various adaptation strategies, as reported in many studies, have been adopted by Ghanaian farmers to maintain maize yield amidst the climatic challenges (MOFA, 2013; Raymond *et al*., 2014; Barimah *et al*., 2014).

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Boon and Ahenkan (2011) indicated that, farmers in SefwiWiawso district in the Western Region plant maize varieties that have shorter gestation periods and has the ability to tolerate drought. These varieties include Aburohemaa, Abontem and Enii-pii. These varieties thrive well in the current conditions. Farmers within the transition zone were also reported to be practicing similar adaptation measure (Fosu-Mensah, 2012).

Some of the maize varieties that were introduced to farmers to increase productivity include but not limited to the following; Obatanpa, Mamaba, Abontem, Aburohemaa, Golden Jubilee etc (Kpotor, 2012). The Obatanpa maize variety is a widely known and used variety in Ghana (Kpotor, 2012), however, due to the variability in the weather and climatic systems new varieties are currently being introduced to replace the existing ones (MoFA, 2013). In April 2015, the Savanna Agricultural Research Institute (SARI) in collaboration with other crop research institutes introduced new hybrid maize varieties for use by farmers. These introduced varieties (yellow and white variety) namely Kunjor-Wari, Zaayura, Warikamana, Kpari-faako and Aburosika are said to be drought tolerant, and are aimed at increasing productivity, ensuring food security and enhancing the incomes of all stakeholders including farmers in the maize value chain (SARI, 2015).

Drought in Northern Ghana is gradually becoming a common phenomenon which has the potential of causing food security threat in Ghana (Amikuzuno and Donkoh, 2012). Raymond *et al*. (2014) showed in their research conducted simultaneously in Bawku and Yendi districts, that farmers reduced the production of maize due to persistent drought; until the introduction of a drought resistant maize variety as an adaptation strategy intervention.

Moreover, as part of the adaptation strategies and as reported by many writers, farmers tend to adjust seasonal planting dates in order to fit the rainy season. This mechanism helps especially maize farming to correspond with the erratic nature of the recent rains (Barimah, 2014). Adjei-Nsia and Kermah (2012) observed this in their study among the farmers in the Wenchi area, and Ejura as well by Fosu-Mensah (2012).

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Some of the rural farmers, in order to stay in business or sometimes for reasons of sustenance, tend to switch to the cultivation of other crops that can withstand the changing trend of recent rainfall pattern (Boon and Ahenkan, 2011; Adjei-Nsiah and Kermah, 2012). Millet and sorghum are normally the perfect substitute for maize in the Northern savannah zone of Ghana. Other farmers resort to the cultivation of cash crops such as cashew, mangoes etc. (Barimah, 2014)

Low soil fertility as a result of continuous production on the same piece of land, or leaching of essential soil nutrients through excessive flooding has also been a major challenging factor facing maize farmers in Northern Ghana (Anslem *et al*., 2016); and this relationship between

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flooding/leaching and low soil fertility is the direct effects of climate variability and change experienced in Ghana and Africa at large.

Morton (2007) reports that in most cases the significant negative impacts of climate change hit hard on the smallholder farming households in developing countries. According to (GSS, 2010), smallholder farming households dominate in the agriculture sector in the Ghanaian economy with about 90 percent being resource poor. They mainly depend on family labour and also operate under rain-fed conditions (Chamberlin, 2008). This has contributed to the inability of Ghanaian farmers to increase maize production to feed its people leading to average shortfalls of 12% in domestic supply (MiDA, 2010).

Vulnerability to climate change in Ghana is spatially and socially differentiated. Each ecological zone has unique physical and socio-economic characteristics that define their sensitivity and resilience to climate change impacts. Climate change seems to have a relationship with poverty levels with the exception of the coastal savannah in Ghana whose economy is highly urbanized. This correlation is the result of high dependence of a majority of the people on natural resource-based activities (Ezekial, 2015). In the Northern region, nearly all the rural farmers, predominantly smallholders are usually engaged in the cultivation of staple crops including yam, maize, cassava, cowpea and groundnut. They also engage in the rearing of small ruminants such as sheep and goats (MOFA, 2013). The adverse effects of climate change and variability on crop growing and animal rearing cannot therefore be overstated.

In July 2014, the government of Ghana launched a National Climate Change Policy (NCCP), which was born out the Medium-Term Agriculture Sector Investment Plan (METASIP 2011 – 2015) of Ghana which seeks to essentially ensure a coherent and pragmatic approach in dealing with the impact of climate change on the socio-economic development agenda of the economy.

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The agricultural sector is one the five prioritized areas of the policy. It is aimed at finding measures to reduce the adverse impact climate variability and change as a result of its continuous adverse impact on people's source of livelihood and survival (Ezekiel, 2015).

1.2 Problem Statement

According to Obayelu *et al*. (2014), the idea of adaptation is to maintain long-term resilience, to create the conditions in which society can manage ecosystem and their livelihood activities in a way that they are able to absorb the impacts from climate variability and change, such that any residual impacts beyond their coping capacity remains within (socially defined) acceptable limits of risks. Common adaptation strategies in agriculture include the use of new crop varieties - varieties that are more suited to drier conditions, irrigation, crop diversification, mixed crop livestock farming systems, change of planting dates, diversification from farm to non-farm activities, increased use of soil and water conservation techniques, changed use of capital and labour, and trees planted for shade (Bradshaw *et al*., 2004; Kurukulasuriya and Mendelsohn, 2006; Maddison, 2006; Nhemachena and Hassan, 2007; Obayelu *et al*., 2014). Some of these strategies practiced in maize farming are intended to reduce the adverse effects of climate variability and at the same time increase yield (Ahmed, 2016).

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Maize is one of the staple food crops that is cultivated (mainly in Northern Ghana) and consumed nationwide, but its production is challenged by effects of climate variability and change not only in Ghana but globally (Raymond *et al*., 2014). The dwindling production of maize in the country could be a potential threat to food security (Raymond *et al*., 2014). With the ever-increasing population and high demand, maize production is supposed to increase at a much higher rate to be able to feed the growing rural and urban populations (Cairns *et al*., 2013). As a result of climate variability being the bane of crop production in general, farmers naturally would

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adopt various adaptation strategies in especially maize production in order to either maintain or increase resilience amidst the climatic challenges (MOFA, 2013; Raymond *et al*., 2014; Barimah *et al*., 2014).

Could it be that maize farmers are not appropriately or adequately adopting the adaptation strategies? Or is it the climate variability and change factors that are too much for maize farmers to bear? Raymond *et al*. (2014) identified some climate variability factors(such as food deficits, poor land and water management due to lack of environmental consciousness) that have the potential for climatic stress on food security in two districts (Bawku and Yendi) as well as the coping strategies of the communities. The study however concluded by attributing the climatic stresses to lack of environmental consciousness which results in poor land and water management. On a broader scale, Cairns *et al*. (2013) also investigated the adaptation strategies in maize production focusing mainly on the drought resistant crop varieties, thus germplasm improvement. It was discovered in the study that despite the global steady increase in maize production, South Saharan Africa records the lowest maize yield since the early 1990s (Ray *et al*., 2012; Cairns *et al*., 2013).

Despite the fact that considerable research has done on the adaptation strategies on crop production in Ghana, only a handful is focused on adaptation strategies on maize production in specific locations in Ghana (Bawakyillenuo *et al*., 2014); some of which include but not limited to the works of Boon and Ahenkan (2011), Fosu-Mensah (2012), Adjei Nsia and Kermah (2012), Kpotor (2012) and Gutu (2014). These researches have investigated various adaptation strategies in some communities in the transitional and guinea savannah zones of Ghana. Others have investigated the factors that affect the choice of adaptation strategies (Obayelu *et al*., 2014; Gutu, 2014; Shongwe and Masuku, 2014). It is however worth noting that no studies have been done to

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specifically investigate the adaptation strategies on maize production in major maize producing communities in the Northern region.

Mion District has most of its farmer population mainly engaged in maize farming. The 2012 Population and Housing Census (PHC) indicated that 23,543 (78%) of the 29,997 crop farmers cultivated maize in the district (GSS, 2014). Other major food crops cultivated includes, but not limited to, yam, cassava, groundnut, beans, rice and soya beans. Maize happens to be the number one food crop that provides 50% of the basic calories. It also serves as a check against food insecurity and economic improvement in the district.

However, vast majority of maize is produced by these smallholder farmers under rain-fed conditions. This probably has been the cause of overall maize production being relatively unstable in terms of farm size harvested as well as volume harvested per hectare. The purpose of this study is to examine the effects of climate variability adaptation strategies on maize production in Mion district in the Northern savannah zone of Ghana

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1.3 RESEARCH QUESTIONS

1.3.1 Main Research Question

What are the effects of climate variability adaptation strategies on maize production in the Mion district?

1.3.2 Specific Research Questions

2. What are the climate variability adaptation strategies practiced in maize production?
3. What factors influence the choice of climate variability adaptation strategies for maize production?

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4. How do these climate variability adaptation strategies contribute to livelihood improvement of maize farmers?
5. What challenges do farmers encounter in adapting to climate variability strategies?

1.4 Research Objectives

1.4.1 Main Research Objectives

To examine climate variability adaptation strategies and its effects on maize production in Mion district

1.4.2 Specific Research Objectives

1. To examine the climate variability adaptation strategies practiced by maize farmers
2. To determine the factors that influence the choice of adaptation strategies
3. To examine how climate variability adaptation strategies contribute to the improvement of maize farms and other livelihood activities
4. To investigate the challenges maize farmers encounter in adapting climate variability strategies

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1.5 Justification for the study

This study has the potential of helping to increase the adaptive capacities and yields of maize farmers. It will also aid local farmers to appreciate the idea that challenges of climate variability and adaptation strategies that are developed as a result, differ spatially.

It is imperative to have adequate location-specific knowledge about the choice and practice of adaptation strategies of communities. These strategies are influenced and interlinked with geographical, social, economic, and political factors.

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Furthermore, the study will serve as a useful reference material to future researchers who would want to focus their research into similar areas, since it will serve as an important document that will guide prospective researchers in their quest to researching into areas related to climate variability impact and adaptation.

Even though research on adaptation to climate variability seems to be on the increase, there is still the need to conduct further research to enable the sharing of different adaptive strategies adopted by farmers at different places. This analysis will go a long way to influence policy makers to enable them document effective adaptive strategies that will help to reduce the negative effect of climate variability on rural farming communities, especially those with similar environmental characteristics.

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1.6 Organization of the Study

The study is presented in five chapters. Chapter one introduced the research topic, research questions and objectives, as well as the justification of the study. Extensive review of the existing body of knowledge on climate variability and climate change, indigenous and introduced adaptation strategies used by maize farmers for coping with climate variability; theory of adaptation and associated concepts, a review of the methods of analysis employed by the study among others are presented in Chapter two.

Chapter three focused on the methodology of the study. It discussed the conceptual basis to the empirical models employed by the study which is followed by a description of the conceptual framework that is required to achieve each of the outlined objectives of the study. The chapter also described the method and sources of data employed by the study. The results and discussions of the study were presented in Chapter four, with Chapter five containing the summary, conclusions and policy recommendations emanating from the study.

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CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of various literatures relevant to the study. This includes definitions of the main terms and concepts, climate change and variability, adaptation strategies employed by smallholder farming households to mitigate climate change, adaptation strategy initiatives implemented in Ghana and how it has impacted on farming systems and livelihood, various challenges to adaptation strategies as well as a review of the methods of analysis employed in the study.

2.2 Definition of Terms and Concepts

This section defines key concepts such as climate change, climate variability, and adaptation strategies practiced by farmers in the literature.

2.3 Climate Change

Climate has generally been defined as the mean weather conditions which are found in a place over a long period of time, usually 30 years (IPCC, 2007). Several institutions at separate times have reported incidence of climate change and have defined it in different ways, some of which include but not limited to the following. According to the IPCC, climate change is the alteration in either the average state of the climate or in its variability, which occurs for a number of years usually decades or more (IPCC, 2001). Food and Agricultural Organization, (FAO, 2006) also came out with its definition of climate change as "any change in climate over time regardless of the cause of the change". According to ISDR/UNEP (2009), climate change may surface from natural events (internal processes or external forces) or through the activities of humans which changes the composition of the atmosphere or land use. The UNEP looked at the definition from

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both the natural and the anthropogenic perspectives where the latter can actually be a contributor to the changes in climate.

2.4 Climate Variability

Climate variability can be understood as seasonal variability that is experienced year-by-year, unlike the weather which changes day-by-day (Dince, 2011). In some literature, there is no clear-cut difference in the definition of climate variability and climate change. According to the third assessment report of the IPCC (2001), climate variability refers to "deviations in the average state, occurrence of extremes, and standard deviations of the climate on all temporal and spatial scales beyond that of individual weather events". Climate variability may result through natural internal processes which is either within the climate system (internal variability), or deviations in natural or artificial external forces (external variability) (IPCC, 2001).

In the case of Africa and for that matter Ghana, climate variability is what is typically observed and experienced in terms of irregular pattern of rainfall, less predictive seasonal transitions and many others.

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2.5 Climate Change and Agriculture Production

Agricultural production serves and continuous to serve as a source of food for every human being on earth. It is important for food security in two ways as follows; it produces the food people consume serves as the major source of livelihood for 36% of the world's total labour force (FAO, 2007). According to FAO (2007), the heavily populated continents such as Asia and the Pacific, a share of their population that ranges from 40% to 50%, and in sub-Saharan Africa, two-thirds of the working population still earn their living from agriculture (ILO, 2007; FAO, 2008). Agricultural production has become industrialized and reliant on technology and this has

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gone a long way to advance productivity, but problems associated with the climate systems are making it more challenging to reach maximum efficiency in productivity.

Economists have spent almost half a decade quantifying the impacts of climate variability and change on agriculture (Seo and Mendelsohn, 2008). FAO (2008) has it that, if agricultural production in the low-income developing countries of Asia and Africa is negatively affected by climate variability and change, the livelihoods of large numbers of the rural poor will be in danger and their susceptibility to food insecurity will intensify. In the meantime, it is indicated that, climate variability is most pronounced in the arid to semi-arid lands that encompass about two-thirds of the African mainland (Mariara, 2008).

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In Ghana, according to some literature, the agricultural sector consists of approximately 30% of the country's GDP and employs approximately 50% of the entire population (Kolavalli *et al.*, 2012; De Pinto *et al.*, 2012). The agricultural sector is believed to have the potential to develop at rates as high as 6% (Breisinger, 2008; De Pinto *et al.*, 2012), but climate variability and change could potentially challenge such progress in the long run. The agricultural sector is particularly exposed to this ongoing phenomenon – climate change. Some literature has it that, Ghana is already experiencing an increase in mean annual temperature of 1°C per decade since 1960. In the same vein, monthly rainfall reduced by about 2.4% per decade during the same period, although in the 1960s, the rainfall over Ghana was particularly high (GoG, 2011; De Pinto *et al.*, 2012).

2.5.1 Climate Change and Food Security

FAO (2008) has it that, at the global level, food system performance today rely more on climatic systems than it did some generations ago. The possible impacts of climate change on food

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security have tended to be observed with most concern in areas where rain-fed agriculture is still the main source of food and income. Food security is the outcome of food system processes all along the food chain. Food system comprises the activities related to production, processing, distribution, preparation and consumption of food (GECAFS Online, 2008; FAO, 2008), whereas the food chain is linear, containing a sequence of activities that need to transpire for people to obtain food (FAO, 2008). A household's food system comprises all the food chains it participates in to meet its consumption requirements and dietary preferences. However, the climate is particularly an important driver of food system performance at the farm end of the food chain, affecting the quantities and types of food produced and the suitability of production-related income. Extreme weather events can damage the transport and distribution infrastructure and affect other non-agricultural parts of the food system negatively (FAO, 2008).

FAO (1996a) indicates that, food security exists when all people at all times and at all levels have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. FAO (2008) reports again that, there are four dimensions of food security which includes: food availability, food accessibility, food utilization and food systems stability and that, climate variability and change will affect all these dimensions; as temperature and rainfall vary, agriculture-based livelihood systems that are already susceptible to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock. The implication is that, people who are already susceptible and food insecure are likely to be seriously affected.

Nelson and Agbey (2005) reported that, over 60% of the Ghanaian population are found in the rural areas and are directly dependent on locally grown crops of food that are harvested from the

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immediate environment for consumption and for the urban populace. The country's agricultural output contributes over 20% to GDP. Major food crops grown in the country include maize, yam, cassava, cowpea, millet, cocoyam and plantain. However, production of these crops is based heavily on climate, and is therefore influenced by weather patterns. It has been observed that during a period of lesser rainfalls (drought), crop production and livestock herd declined quite significantly. It is also indicated by Nelson and Agbey (2005) that, in the 1980's particularly in 1983, the severe drought and bush fires encountered nation-wide affected food security in the country leading to famine in some parts of Ghana. This shows the level of vulnerability of Ghana's agriculture to prevailing climatic condition and the consequences that a variation in climate would cause to food security if no proper mechanisms are taken.

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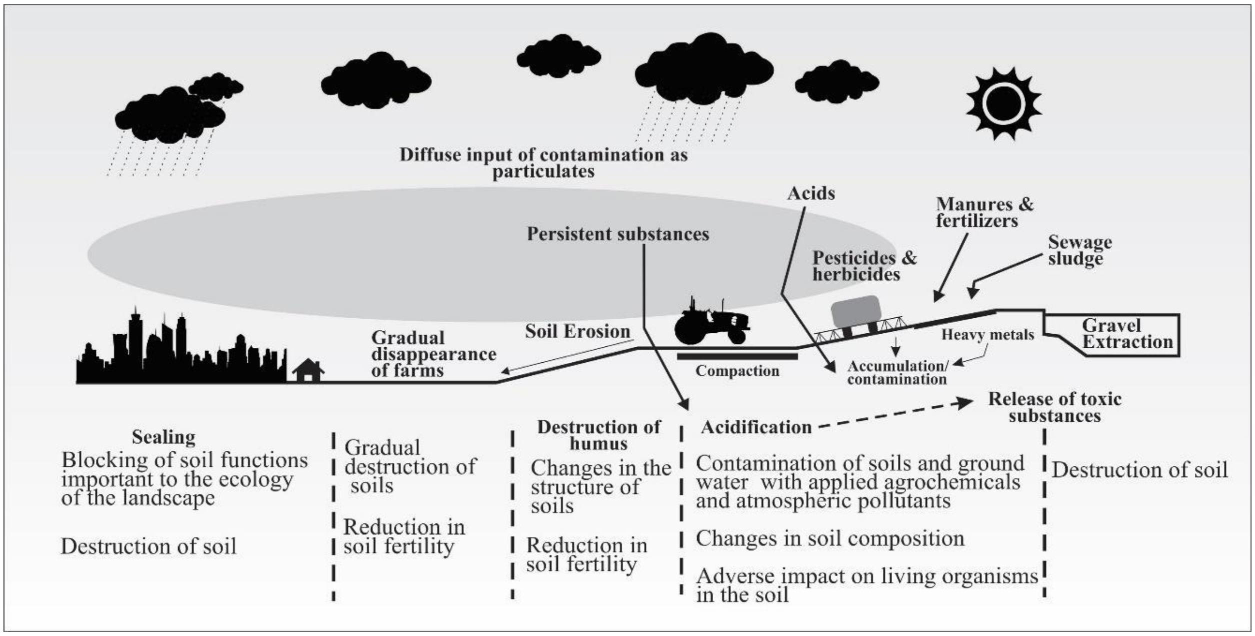
2.5.2 Causes of Climate Change

According to Yamin and Depledge (2009), the climate itself is subject to natural variability, and is also influenced by both natural and anthropogenic factors. The most important challenge is to be able to establish how the scale of these compares with the natural variations of the climate. Natural factors that affect global climate systems include variation in the sun's output of energy, ocean currents and volcanic eruptions. There is a wide variety of ways in which human activities can influence the climate through the release of chlorofluorocarbon (CFC) into the atmosphere. These activities include stratospheric ozone depletion (Ozone-hole), greenhouse gas (GHG) emission, dusts and aerosols and other very small airborne particles from fossil and biomass burning (Yamin and Depledge, 2009). When CFCs come into contact with the sun's ultraviolet rays in the ozone layer, they begin to break down into component atoms, which include chlorine. These disassociated chlorine atoms can then critically destroy ozone before they diffuse down into the lower atmosphere (Datto and Schiff, 1978; Garfield, 1988). Figure 2.1 presents the pictorial view of the causes of climate change and variability.

Figure 2.1: Contribution of Human activities to Climate Change



Adapted from Jones 2002; Ecological Institute, SERI, 2010 and Owusu, 2015

According to the United Nations Conference on Environment and Development (UNCED) (United Nations, 1992), the felling of trees is the desiccation of previously moist forest soil, that is, the soil is exposed to the sun, gets baked, and the lack of canopy leaves nothing to prevent the moisture from quickly evaporating into the atmosphere (Selby, 2010). The United Nations (1992) research indicates that the most topical survey on deforestation and greenhouse gas emissions, reports that deforestation may be responsible for as much as 10% of current greenhouse gas emissions. In most sub-humid and semi-arid areas, much of the grazing land is burnt annually during the dry season to remove the old and coarse vegetation and encourage the growth of young and more nutritious grasses (FAO, 2001). Burning causes the loss of soil

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organic matter and thus impairs the sustainability of agricultural production. Moreover, the soil is exposed to the erosive forces of the wind during the dry season and of the rain at the end of the dry season. In the drier areas, destruction of trees and other vegetation is an important part of land degradation, commonly referred to as desertification (FAO, 2001).

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Land degradation is induced by human activities which makes it an anthropogenic cause of climate change. It results from the direct and indirect activities of human beings. The causes of land degradation have therefore been grouped under the indirect and direct categories (FAO, 2001). The direct causes of land degradation are mainly; deforestation, overgrazing and over-cutting of trees, shifting cultivation, agricultural mismanagement of soil and water resources such as non-adoption of soil and water conservation practices, improper crop rotation, use of marginal land, insufficient and or excessive use of fertilizers. The indirect causes of land degradation are mainly; population increase, land shortage, short-term or insecure land tenure, poverty and economic pressure (FAO, 2001).

2.5.3 Consequences of Climate Change and Variability

Kankam-Yeboah *et al*. (2011) established that Ghana is experiencing climate change and variability already and has caused previous permanent rivers to dry up during the dry season, thus harmattan. More intensive rainfall events for instance are the rainfall and flood events that occurred on 23rd April 2008, 24th June 2009 and 3rd June 2015 in some parts of Accra that wrecked property and life (Etwire *et al.*, 2013). Evidence of the impacts of climate variability in Ghana includes the recurrent drought events that result in low levels of water in the Akosombo dam (example, the drought that resulted in hydroelectric power rationing in 2006, 2012, and still persisting).

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According to FAO (2011), the adverse effects of climate variability and change and its vulnerability has been found to differ between genders. It affects food insecure people in different ways depending on socio-demographic factors such as age, health, and education. According to Dunlap & McCright (2010) females compared to their male counterparts are more able to express understanding to climate change and variability notwithstanding that males underrate their knowledge on climate.

Lambrou & Piana (2006) found that women are mostly susceptible to climatic stresses than men, because men usually use sophisticated means of farming such as irrigation schemes and mechanization. Women are mostly involved in less labour-intensive and subsistence agriculture.

According to the World Bank (2010), gender inequality exacerbates vulnerability to climate change and women are often the victims of gender based inequality in rights, household responsibilities, resources and voice. According to ISDR/UNEP (2009), women are frequently more defenseless than their male counterparts in post-disaster situations. This is due to their care-giving roles which exacerbates during and after a disaster. It is also argued by Dunlap & McCright (2010) that females' access to resources for recovery is mostly limited.

According to Etwire (2013), women especially those in the Brong-Ahafo Region of Ghana are often challenged in terms of access and control of economic resources such as land thereby making them more vulnerable to climatic stresses. Lambrou & Nelson (2010) have it that, the gender of an individual influences his/her preferences with regard to longer term coping strategies. For example, while males tend to be more interested in migrating to other places in search for greener pastures, especially, in the Brong-Ahafo Region of Ghana, females tend to prefer local wage labour as a coping strategy for climate change and variability.

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2.6 Climate Change and World Agriculture

2.6.1 Evidence of Climate Change and Variability in Ghana

Ghana is a tropical country and among countries particularly vulnerable to climate change and variability (Etwire, 2013). About 35% of the total landmass of Ghana is estimated to be desert and the desertification is currently estimated to be proceeding at a rate of 20,000 hectares yearly (EPA, 2009).

World Bank (2010) conducted an analysis on the rainfall pattern in Ghana within and between years and reported that annual rainfall in Ghana is highly variable. The analysis showed based on historical data that rainfall was mostly high in the 1960s, but significantly reduced in the latter part of the 1970s and early 1980. A trend analysis showed a decreasing trend between 1960 and 2006 with an average decrease of 2.3 millimeters per annum.

According to Kankam-Yeboah *et al.* (2011), the climate in Ghana has changed significantly with a 1ºC increase in temperature over 30-year period based on historical data. In the Northern Region of Ghana, for example, high temperature was previously recorded in March (peak of the dry season) but recently it is being recorded in January (Kankam-Yeboah *et al.*, 2011). It is now not easy to predict the onset of the rainy season. In the past, the rainy season began in April and ended in late September or early October (Kankam-Yeboah *et al.*, 2011). However, in recent times, the rainy season starts in June or July with heavy rainfall in September or October (Kankam-Yeboah *et al.*, 2011).

It is highly anticipated that climate change will have significant impacts on climate change and variability on Ghana. There is high expectation that temperatures and rainfall will fluctuate, and the trend in temperature over the period 2010-2050 indicates warming in all regions in the country. The three Northern regions in the country Northern, Upper East and Upper West are

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projected to experience the highest increases in temperature. Under one of the climate scenarios (Ghana Dry) for example, temperatures in the three Northern regions are projected to rise by 2.1-2.4ºC by 2050. Comparatively, the projected rise in the Volta, Western, Central, Ashanti and Eastern Regions is 1.7 – 2.0ºC, and that elsewhere in the Northern region will be 1.3-1.6ºC (World Bank, 2010).

2.6.2 Climate Related Initiatives Implemented in Ghana

Several initiatives have been implemented on climate change and variability in Ghana. Table 2.1 summarizes some climate related initiatives implemented together with the beneficiaries and implementation organizations and the duration of the projects (Van Tilburg *et al.*, 2011; Etwire *et. al*. 2013).

The Netherland Climate Assistance Program started in 2003, and was intended to support farmers to adapt to climate change. The main focus of this program was to assess the linkages between poverty and climate change and the consequences of climate change on the livelihood systems of poor communities.

One of the major studies on climate change and variability adaptation in Ghana is the economics of adaptation by Van *et al*. (2011). The study focused on filling the gap in knowledge by analyzing the predicted impacts and estimating the costs of adaptation.

Community based rural development projects are an example of the many developmental projects focusing on rural development and income generation with the objectives of enhancing adaptation to climate change and variability. The natural resources and environmental governance program seek to address governance issues concerning natural resources and the environment. Both Government and Non-Governmental Organization (NGOs) implemented

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these initiatives with donor support (Van *et al.* 2011). Table 2. presents a survey of the many climate-related strategies that have been done using data from Ghana.

2.7 Theory of adaptation

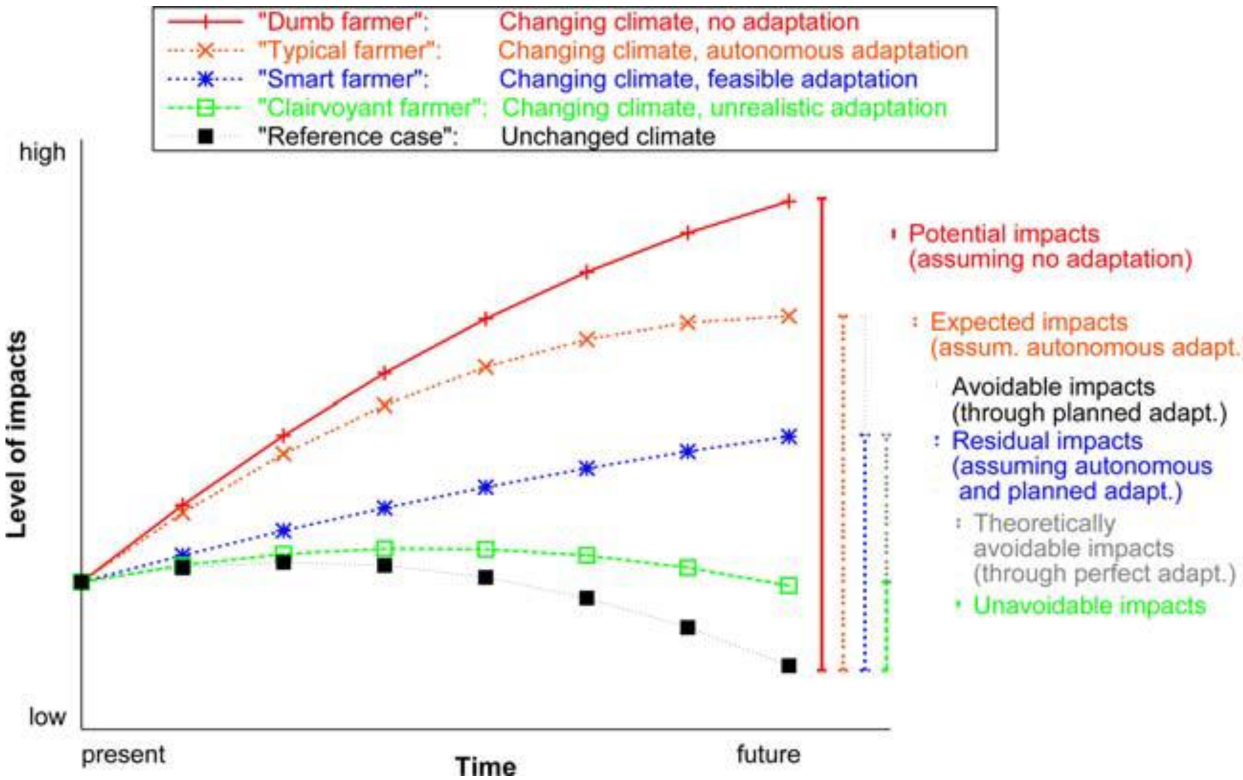

Fig. 2.2 Different concepts of climate impacts and adaptation (adapted from Fussel and Klein 2006)

The Action theory of adaptation to climate change is based on the theory modified by Fussel and Klein (2006). In this theory, ideally adaptation to climate change is understood as a strategy for preventing all adverse impacts of present and future climate change. Such a goal implicitly assumes a world that is perfectly adapted to current climate conditions, that has perfect knowledge of future climate change, and that has abundant resources for adaptation. Clearly these assumptions are clearly unattainable; in particular, in the context of developing countries such as Ghana that already suffer from substantial climate-sensitive risks.

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The objective of real-world adaptation is at the same time more and less ambitious than the 'ideal' objective suggested above. It is more ambitious because most actions to adapt to climate change would also reduce the risks associated with current climate variability and possibly support other societal objectives. It is less ambitious because adaptation in general cannot completely prevent adverse impacts of climate change, thus despite adaptation to climate change there will still be residual impacts of climate change.

Figure 2.2 illustrates these ideas by defining various terms related to climate impacts and adaptation. The diagram indicates hypothetical trajectories for the level of climate-related impacts on a system because of both natural variability and anthropogenic climate change. The lowest trajectory denotes the (unrealistic) reference case of an undisturbed climate. Impacts are, nevertheless, changing with time, for instance because of economic growth, technological development, and demographic changes. The other trajectories depict the impacts associated with a changing climate for four different assumptions regarding adaptation. They include (in descending order of impacts) the 'dumb farmer', who does not react at all to changing climate conditions; the 'typical farmer', who adjusts his practice in reaction to persistent climate changes only; the 'smart farmer', who uses available information on expected climate conditions to adjust proactively; and the 'clairvoyant farmer', who has perfect foresight of future climate conditions and faces no restrictions in implementing adaptation measures. Of course, in this case, the metaphorical names used to characterize the effects of different assumptions on adaptive behaviour can be applied to any affected agent. They are applied here because of their frequent use in the pertinent literature (Rothman and Robinson 1997; Schneider 1997; Fussel, 2007). The vertical bars on the right of Figure 2.2 illustrates different interpretations of the term (climate) impacts: potential impacts show the level of impacts assuming there is no adaptation; expected

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impacts assume only autonomous adaptation; residual impacts assume autonomous adaptation and feasible planned adaptation; and unavoidable impacts refer to the level of climate impacts assuming perfect adaptation.

At this point it is worth noting climate change has some impacts that cannot be avoided even with perfect adaptation. Fussel and Klein (2006) also projected some requirements for effective planned adaptation strategies. The benefits of planned adaptation thus correspond to the difference between expected and residual impacts rather than between potential and unavoidable impacts. It was based on the assumption that a climate-related problem either exists in the present times or will certainly exist in the future. Based on this a list of prerequisites was explained showing how each of them can be potentially addressed to a larger extent by the effects of climate change, vulnerability and adaptation strategies:

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Table 2.1: List of Prerequisites and Explanations on Adaptation Strategies

Prerequisites	**Explanations**
Awareness of the problem	Assessing and communicating vulnerability to climate change
Availability of effective adaptation measures	Triggering research that may lead to the development of new adaptation options
Information about these measures	Identifying and assessing effective adaptation measures
Availability of resources for implementing these measures	Evaluating co-benefits of adaptation (thus increasing perceived benefits); identifying ways for the most efficient use of resources, e.g. by mainstreaming adaptation in existing activity (thus reducing costs); and motivating the provision of additional resources, either domestically or internationally
Cultural acceptability of these measures	Educating people about risks and response options to increase the acceptability of unfamiliar measures
Incentives for implementing these measures	Identifying obstacles for implementation of effective measures and suggesting options to overcome them

Source: Fussel, 2007

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2.8 Conceptual Framework

The conceptual framework focuses on drawing linkages and explaining how various climate variability adaptation strategies affect smallholder maize farming households and the entire world population. Adaptation strategies are practiced as a result of direct and indirect effects of the unstable climate system that impacts on the smallholder maize farming households. This implies that the idea and the practices of adaptation strategies may arise as a result of the different ways farmers perceive and experience these variabilities and change in various communities in Mion district.

According to Schipper (2007), the idea of adaptation to climate variability and change rose as a result of the lack of progress, effectiveness or failure of the world policy to ensure reduction of the Greenhouse Gas emissions that contribute to the change in world climate. Based on this, adaptation here is geared towards responding directly to the impact of climate variability and change due to increased concentration of Greenhouse Gas in both proactive and reactive ways rather than trying to prevent it (usually referred to as mitigation).

Vulnerability to the impact of climate change is defined as the function of exposure, sensitivity and adaptive capacity of most farming households in sub-Saharan Africa (Taylor, 2015). This was defined by the IPCC (2007) and has been employed in many studies to measure the vulnerability indices of smallholder households across the sub region. Adaptation is dependent on the nature of vulnerability that is experienced by a given community. A successful adaptation strategy or plan requires that adequate knowledge be gathered or acquired on the underlying causes of the vulnerability (Schipper, 2007).

Adaptation to climate variability and change are not without challenges. It is confronted with numerous challenges which include but not limited to lack of access to meteorological

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information, lack of access to credit, poor extension service, lack of education on climate change, lack of a ready market for produce and lack of climate change adaptation policy as discovered by some studies (FAO-ADAPT, 2011; Taylor,2015; Daniel, 2015). These challenges are location specific. Thus, it varies spatially from one geographic or climatic zone to another. When the smallholder farming households are able to overcome the constraints, and adopt the strategies it will result in an increase in their production, and reduce their vulnerability level to the barest minimum or may not be vulnerable at all.

Below is a conceptual framework for the impact of adaptation strategies in maize production on the livelihood of farmers. It is modified from the conceptual framework of Selvaraju *et al.*, (2006) on improving livelihood security and sustainable livelihoods through adaptation to climate change in drought-prone areas of Bangladesh.

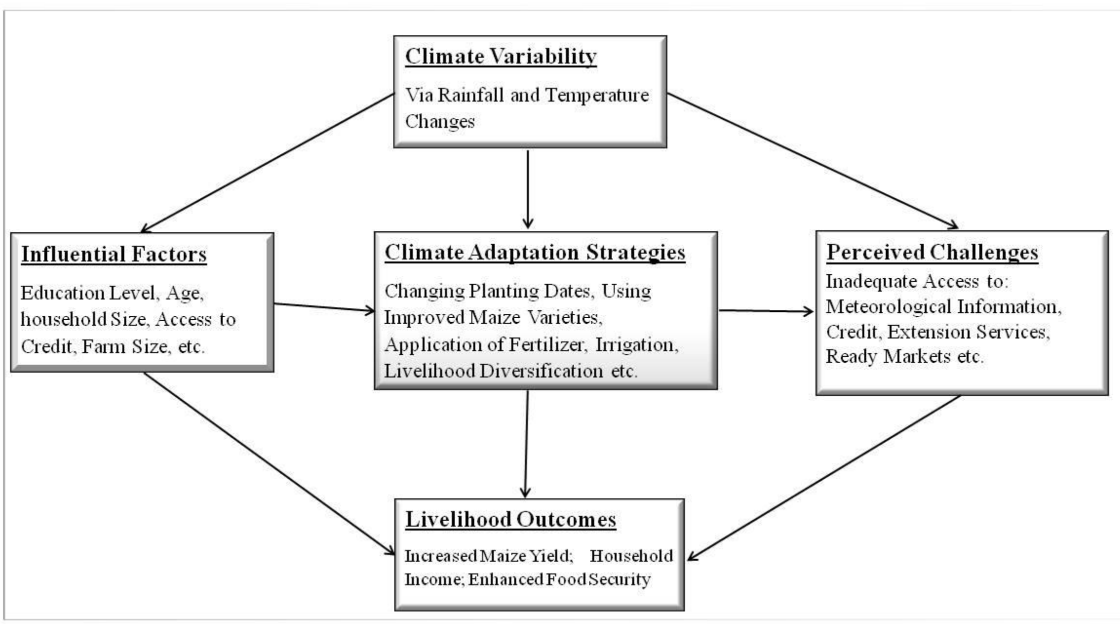

Figure 2.3 Conceptual Framework

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Figure 2.3 shows the conceptual framework of the study. The entry point of the framework is climate variability. Climate variability at the local/community level is a real phenomenon that has direct impact on agriculture. This climatic alteration is highly emanated from agricultural activities. According to wreford *et al*. (2010), agriculture is essentially a man-made adjunct to natural ecosystem and is mainly dependent on weather and climate. At the same time, it is a significant source of anthropogenic greenhouse gases (GHG), which are coming under increasing scrutiny by governments around the world. The framework also shows how climate variability can adversely affect livelihood outcomes of smallholder farmers and global food security (IPCC, 2007). Also highlighted are the uncertainties in relation to impact categories in terms of unequal global coverage of existing information.

Based on this, climate adaptation strategies are developed by farmers in order to maintain or increase resilience in their livelihood outcomes in terms of crop yields, annual income and enhanced food security. It is important to note that adaptation measures in the agricultural sector are highly significant for poverty reduction and sustainable management of natural resources (Wreford, 2010; Tao and Zhang, 2010). Some of the measures are clearly stated in the framework model above. There are three roles for public policy intervention to promote adaptation in the agricultural sector: reducing the vulnerability of those least able to adapt, provision of information to stimulate widespread of adoption of adaptation techniques and opportunities, and an enhanced role for provision of public goods associated with agriculture.

It can also be shown in the framework that, farmers' decision on their choice adaptation measures are not born out of a vacuum, some influential factors affect their choices and practices. The main influential factors are the demographic characteristics of farmers which include variables such as age, education level, income, access to credit, farm size of farmers etc.

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According to Shongwe *et al*. (2014), adaptation to climate change requires that households first appreciate that climate has changed, identify useful adaptation options and choose among a wide range of adaptation strategies. This therefore, makes households within the same geographical location to use different adaptation strategies in response to climate change and variability. Socioeconomic factors that usually influence households' choice when adapting to climate variability are in two ways, while some hinders, others promote adoption of adaptation strategies.

Obviously, climate change adaptation by smallholder farmers (including maize farmers) are faced with challenges that inhibit effective adoption and practices by farmers. There have been issues of inadequate supply of access of certain vital requirements that can help reduce farmers' vulnerability as well as increase their resilience. At different levels and locations, there are perceived challenges relating to the inadequate access to meteorological information, inadequate access to credit, extension, as well as ready market for farm produce

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2.8.1 Types of Adaptation Strategies in Maize Farming

The changes in the amount and distribution of rainfall largely determine the high/low yield of maize production by the resource-poor farmers (MoFA, 2013). Market forces and input prices rarely determine the yield fluctuations of maize farmers who use the traditional production methods. Their yields are approximately on average 1.5 metric tons per hector. However, yields as high as 5.0-5.5 metric tons per hectare have been realized by some farmers using improved seeds, fertilizer, mechanization and irrigation in years with favourable rainfall (Klutse *et al*., 2013). Cairns *et al*. (2013) suggest that in order to increase maize production and maize yield across the sub-Saharan Africa region, there is the urgent need to direct the focus of research strategies that solely prioritizes on climate change resilient germplasm development to offset the predicted yield declines.

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Klutse *et al* (2013) listed in their study a number of adaptation strategies adopted by maize farmers in a selected ecological zone in Ghana, which include the use of improved seeds, fertilizer application, mechanization and irrigation. The study showed that, farmers in Ejura-Sekyedumase district of the Ashanti Region, aimed at increasing maize yield in metric tons per hector based on these adaptation strategies. The study observed maize production to be the dominant agricultural activities in the area and concluded that the erraticism of maize production systems to climate variability in Ghana depends on its time of occurrence relative to the growth stage of the crop.

In a study conducted by Tao and Zhang (2010) entitled, *adaptation of maize production to climate change in north China Plain*, tried to quantify and measure the relative contribution of the various adaptation strategies. The studies discovered that, for these farming communities, early planting or late planting was considered the most effective adaptation option among others to reduce yield loss from climate change averagely close to 6.0%. One of their findings suggested that the relative contribution of adaptation option can be quite different spatially and geographically, depending on the weather and climatic conditions. Another suggestion was that adequate adaptation options should be region and variety specific in order to maintain accurate record of farming communities' adaptation strategies.

According to Amikuzuno and Asafu-Adjaye (2015), at an international conference on climate change and national development held in the University of Ghana's centre for African wetlands, Legon, their research findings revealed the negative impacts of climate change on smallholder farmer's net revenue, per capita income and poverty rates without adaptation and with adaptation for mid-century. However, adaptation (irrigation) results shows that farms will have an increase in net revenue gains by as much as 10% to 17%, per capita income rise between 1% and 7%

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within upland farms but shows a decrease between 2% and 9% for lowland farms. Accordingly, poverty rates are shown to decline from 16% to 8% in the Lawra district across all farms household.

2.8.2 Challenges to Climate Change Adaptation Strategies

Numerous writers have investigated into what actually are contributing factors of the constraints to the adaptation strategies of climate variability and change. These authors have given different explanations with regards to the challenges to climate change adaptation strategies. For the sake of clarity in the use of terminologies, challenges here are defined as factors, conditions or obstacles that lessens the effectiveness of climate change adaptation strategies (Moser and Ekstrom, 2010; Huang *et al*., 2011). There is a difference between challenges and limits as some authors have tried to differentiate between the two. In the fourth assessment report of the IPCC, limits were defined as conditions or factors that render adaptation strategies ineffective as a response to climate change. Adaptation strategies and the challenges associated with each have been identified by several authors as shown in table 2.2. This is a modification from Antwi-Agyei *et al*. (2013) and Taylor (2015).

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Table 2.2 Challenges to Climate Change and Variability Strategies

Adaptation Strategies	Literature	Challenges
Planting trees, planting improved varieties of crops, diversification of livelihood activities, changing the timing of planting.	(Bryan *et al.* 2009); Huang *et al*.(2011); (Maldonado, Shearer, Bronen, Peterson, & Lazrus, 2014); (Gero, Kuruppu, & Mukheibir, 2012); (Antwi-Agyei, Fraser, Dougill, Stringer, & Simelton, 2012);	Financial
Planting early maturing varieties, using irrigation, development of early warning systems	(Jones & Boyd, 2011);(Miller *et al.* 2010); (Measham *et al.* 2011); (Adger *et al.* 2009)	Lack information on climate change characteristics
Temporary migration, changing the timing of planting.	(Adger, Huq, Brown, Conway, & Hulme, 2003), (Jones & Boyd, 2011)	Social-cultural
Planting of improved varieties of crops, Development of early warning systems, using irrigation systems.	(Jantarasami, Lawler, & Thomas, 2010); (Biesbroek *et al.*, 2010),(Bierbaum *et al.*, 2013); (Eriksen, 2009); Measham *et al.*, (2011); (Ford *et al*., 2011)	Institutional and political
Planting drought-tolerant crops, diversification of livelihoods and crops diversification.	This is related mostly to lack of resources to mitigate the adverse impacts of climate change and variability	Lack of infrastructural development including ready markets.
Developing drought-tolerant variety of crops	Most studies relate technological constraints to development of early warning systems (Boyd *et al.* 2013) as well as technical expertise in climate research see (Washington *et al.* 2006)	Technological/Institutional

Source: Modified from Antwi-Agyei *et al*. (2013) and Taylor (2015)

2.8.2.1 Financial challenges

Some studies have indicated that financial constraint is one of the key challenges to the climate change adaptation by smallholder farming households in Sub-Saharan Africa (Peterson *et al.*, 2013; Antwi-Agyei *et al.*, 2012; Bryan *et al.*, 2009). The Un-habitat (2010) also agreed to this assertion in which it is reported that budget deficit has a direct positive relationship (effect) on climate and variability in many economies in the Sub-Saharan Africa.

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Bryan *et al.* (2009) suggested that financial constraint which is as a result of the lack of credit facility, or sometimes the unsustainable credit is one of the noticeable challenges to appropriate climate adaptation strategies by smallholder farming households. In addition to this, Peterson *et al.* (2013) also found that each adaptation strategy requires some direct or indirect cost. For instance, the use of improved varieties of crops such as improved maize is well noted as one of the common adaptation strategies for smallholder farming households in especially the Northern Region of Ghana.

Some studies have also suggested that core value systems, beliefs, cultural practices, and the perception of group of people greatly affect their attitudes and behaviours toward climate change and adaptation strategies (Jones & Boyd, 2011; Smith *et al*., 2011; Adger *et al*., 2012).

Adger *et al.* (2013) noted culture as one of the principal factors influencing the decision to adopt a particular innovation or technology. At the time it helps in identifying risks involved in adoption, and the implementation of appropriate climate change adaptation strategies. Adger *et al.* (2013) again reported that people who live in the same locality with dissimilar cultural backgrounds are most likely to respond differently to risks such as the negative impacts of climate change and variability. Both Moser and Ekstrom (2010) and Adger *et al.* (2013) reached similar conclusions in their separate studies and concluded that people's response to risk might be greatly influenced by their pre-existing belief systems, values, and norms.

2.8.2.2 Lack of Information on Climate Change Characteristics

According to the IPCC (2007), smallholder farming households who are the majority in the agricultural sector in Sub-Saharan Africa depend largely on weather and climatic patterns for all their activities. However, only few climate projections are available for farmers to benefit from due to lack of appropriate climate data. This assertion was also supported by Adger *et al.* (2009)

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which revealed that information and awareness on climate change characteristics could seriously serve as a challenge to the successful implementation of adaptation strategy.

According Ziervogel *et al*. (2010), data on climate change features are periodic so even when it is forecasted it may not be beneficial in the long-term planning of agricultural activities. In addition to what Ziervogel *et al* (2010) asserted, Patt & Gwata (2002) also added that usefulness of periodic projections on climate is most likely to be limited by issues related credibility, measurement, intellectual capacity, legality as well as procedural and institutional.

Antwi-Agyei *et al*. (2013) also argued out that lack of adequate state of the art equipment at the meteorological agencies across the regions of Sub-Saharan Africa inhibits the well-timed prediction and forecast of the rainfall and temperature pattern. This makes it extremely difficult for smallholder farming households to make cognizant decisions on their activities which are climate dependent. This challenge makes the smallholder farming households in most villages in Ghana to resort to the use of local agro-ecological knowledge. They also forecast the weather based on their past farm experiences, which fails most often (Antwi-Agyei *et al.*, 2013).

2.8.2.3 Institutional Challenge

Agrawal & Perrin (2009) reported in a study that institutions play a significant role in a society. It helps the local communities to withstand the adverse impacts of climate variability and change. It also provides the mechanisms that help to shape the social and individual interactions within the society.

According to Biesbroek *et al*. (2013), institutions that are established by the Government play a key role in assisting the elimination of inhibitors to the adoption of climate change strategy. They also concluded that the climate change adaptation policies in many Sub-Saharan Africa countries tend to be made by few people in authority rather than the smallholder households who are

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affected. In most cases, these policies are compelled by the central government that has often been constrained to adaptive strategies at the regional and local levels in the agricultural sector.

According to Antwi-Agyei *et al.* (2013), in many farming communities in Sub-Saharan Africa, the supposed duties of the extension officers are to link between the research institutions and farming households. This facilitates the smooth flow of scientific method from the researchers to the farming households and the problems from the households to the researchers for the required solutions. However, in most countries the extension officers, farmer ratio is very large. This makes it extremely hard for the officers to respond to the needs of all farming households.

There has been the assertion that the lack of climate change adaptation information, including weak institutional capacity combined with the intra-annual rainfall fluctuations and rise in mean temperatures will render many households in Sub-Saharan Africa countries more food insecure.

Antwi-Agyei *et al.* (2013) suggested that institutional constraint in one way or the other has some relationship with political constraint in terms of climate change and variability. This was also supported by Ford *et al.* (2011) who reported that the lack of political will at the local levels is a major barrier to climate adaptation.

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2.8.2.4 Technological Challenge

According to Kithiia (2011), technology is considered as one of the principal hindrances to climate change adaptation. This assertion was also supported by Smit & Skinner (2002) who argued that improvement in technology, example, the development of improved crop varieties, early warning systems as well as establishing irrigation techniques are very crucial to climate change adaptation. Due to that, these four factors are considered as the four main pillars of agricultural adaptation.

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Farming households can only use the adaptation strategies and options that have been already developed (Kolikow *et al.*, 2012) and which can be applied in their dwelling places. According to Frich *et al.* (2002), it is necessary to highlight the fact that the choice of technology for climate change adaptation is also made within appropriate socio-economic, legal and institutional structure. However, countries in Africa tend to lack these structures.

According to the Africa climate report commissioned by the UK Government, low technical know-how in climate modeling is one of the key challenges to climate change research in Africa (Washington *et al.*, 2006). Enete & Amusa (2010) also reported that the technological constraint has been a major challenge in Africa. This is due to the fact that governments in Africa do not budget for agriculture and climate change research.

2.8.2.5 Lack of Infrastructure Development

It has been reported that lack of ready market for produce by smallholder farming households is one of the major barrier to the successful implementation and adaptation of climate change strategies such as planting of crop that can withstand drought or crop diversification.

According to Antwi-Agyei *et al*. (2013), the lack of market for farm produce is interconnected with the lack of appropriate storage facilities in most Sub-Saharan African countries. This assertion was supported by Vermeulen *et al.* (2012) who posited that the lack of storage facilities weakens the trading power of the smallholder farming households compared with other agents within the agricultural marketing value chain. This normally happens during price negotiating on farm produce. This is because most of smallholder farming households cannot store their produce and therefore accept whatever price the other agents offer them for the fear that their produce will spoil.

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In situations where farming households do not receive of good prices for their produce, it will be difficult for them to fulfill their credit obligations. This will have adverse effect on their ability to contract future credits to adopt a climate change strategy. It is believed that the lack of access to ready market has a link with the poor physical infrastructure development such as road networks in majority farming communities across Africa.

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2.9 Factors Influencing the Choice of Adaptation Strategies

Adaptation to climate change has been, and will continue to be the suggestive measure to combating the adverse effects and consequential impacts of climate variability and change. According to Gutu (2014), factors affecting the choice of various adaptation strategies are area specific, and thus different strategies are noted in different farming communities based on different influential factors.

Several previous studies have identified various factors affecting the choice of adaptation strategies in many farming communities across the sub-Saharan Africa which include but not limited to sex of the household head, age of the household, education level of the household, household size, farm size, input prices etc. (Gutu, 2014; Obayalu *et al*., 2014; Shongwe and Masuku, 2014; Phiri, 2010)

A study conducted in Chikhwawa district, south Malawi, indicated that farming households resorted to irrigation farming, income-generating activities, crop diversification and shifting planting dates as adaptation strategies in the study area, and that flood, droughts, gender and education are important factors on influencing household choice of adaptation strategies (Phiri'2010). Similar studies took place in Ekiti state, Nigeria, where emphasis was made on the criticality of studying the choice of farmers' adaptation strategies as I helps in ensuring food and poverty alleviation not only in Nigeria but the entire Africa (Obayelu *et al*., 2014).

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A development programme organized in Mpolonjeni area, Swaziland, indicated that the continuous decline in agricultural production due to climate variability change has prompted households to respond by developing various adaptation strategies. The programme which aimed at exploring these strategies and its accompanied influential factors indicated that drought tolerant varieties, switching crops, irrigation, crop rotation, mulching, minimum tillage, early planting, late planting and intercropping were significantly influenced by age of household head, occupation of household head, being a member of a social group, land category, access to credit, access to extension services and training, high incidences of crop pest and disease, high input prices, high food prices, perceptions of households towards climate change. The study however discovered that sex and education level of household heads impact little on the choice of adaptation strategies. So, the recommendation was that farmers be well educated beyond their perception since perception significantly influences all adaptation strategies. This was to ensure they choose effective adaptation strategies (Shongwe and Masuku, 2014).

In summary, Factors that influence the choice of climate variability adaptation strategies are varied in nature. Whereas some factors such as education level, income status, access to credit facilities could be found to have positive relationship with the likelihood of choice of climate related adaptation strategies, other factors such as household size, farm size, perception of climate variability and many others may negatively affect farmers' decision to adopt some adaptation strategies.

2.10 Climate Variability and Yields of Major Staple Food Crops in Northern Ghana

The level and distribution of rainfall variability is the most important determinant of crop yields in smallholder, resource-poor farming systems in arid and semi-arid areas, where farmers often lack adequate yield improving inputs or technology

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In their study, Amiluzuno and Donkoh (2012) examined the relationship between climate variability and yields of major staple food crops in Northern Ghana. Having shown empirical evidence of the inter-dependence of climate variability and agriculture, and with the help of appropriate models in analysis, the study indicated that there is a strong relationship between seasonal, total rainfall and crop yield in Northern Ghana. Temperature variability in this area was however found to be stable and has minimal effects on crop yield. Poor and excessive precipitation has reduced (by 30%) global food crop production. This has led to an increment in food insecure households from 160 million in 1996 to over a 200 million in the 2000s (Parry, 2007). According to the World Bank (2008), climate variability and change has been knowledgeable in Ghana with three major physical impacts detected, namely changes in rainfall and temperature as well as rise in sea level.

Lobell *et al.* (2011) indicated that under optimum rain-fed management, maize-growing regions in Africa could be hit by yield losses to about 65% at 10C increase in temperature. Under drought conditions, nearly 100% of these regions would experience substantial yield losses. Owusu *et al*. (2008) report that there has been a fluctuation in the rainfall pattern in Ghana towards a longer dry season and short dry spell. High temperatures particularly in Northern Ghana have resulted in low yield of maize due to the reduction in growing period and increase in evapotranspiration rate (Dazé, 2007).

2.11 Adaptation Strategies and Livelihood Improvements of Farmers

Across the tropics, it is common to observe the numerous risks faced by farmers in agricultural production due to climate variability. This situation is expected to make their livelihood even more unstable. The livelihood insecurity is clearly manifested as farmers are frequently exposed

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to dangers such as pest and disease outbreaks, droughts, floods as well as other extreme weather events, which significantly result in income and crop loses and ultimately worsens food insecurity (Harvey *et al*., 2014). The subsequent paragraphs will review how the livelihoods of farmers are improved as a result of the strategies employed in response to the adverse impacts of the climate variability and change.

Drought tolerance has been recognized as one of the most important targets for crop improvement programs in the entire Africa (UNEP, 2015). Moreover, biotechnology is considered a powerful tool to achieve significant drought tolerance by the United Nation's Food and Agriculture Organization. In 2008, Monsanto announced a public–private partnership called Water Efficient Maize for Africa (WEMA) to develop drought–tolerant maize varieties for Africa. WEMA aims to develop drought-tolerant African maize varieties using conventional breeding, marker-assisted breeding and biotechnology (UNEP, 2015). The goal is to eventually offer the drought-tolerance trait to small farmers in sub-Saharan Africa, royalty-free, so they are able to achieve harvests that are more reliable. During moderate drought, the new varieties are expected to increase yields by 24–35 %. The partnership brought together Bill & Melinda Gates Foundation, Howard G. Buffet Foundation, Monsanto, African Agricultural Technology Foundation (AATF), the International Maize and Wheat Improvement Center (IMWIC) and National Agricultural Research Systems (NARS) of eastern and southern Africa.

The Bill and Melinda Gates Foundation and the Howard G. Buffett Foundation contributed $47 million to fund the first five years of the project. AATF provided technology stewardship and project management expertise. IMWIC provided expertise in conventional breeding and testing for drought tolerance while Monsanto will provide proprietary germplasm, advanced breeding tools and expertise. More importantly, the national agricultural research systems, farmers'

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groups, and seed companies participating in the project contributed their expertise in field testing, seed multiplication, and distribution. Furthermore, the project involved local institutions, both public and private, and in the process expand their capacity and experience in crop breeding, biotechnology, and bio–safety (UNEP, 2015).

The varieties developed through the project were distributed to African seed companies through AATF without royalty and made available to smallholder farmers. Moreover, promising new traits and varieties, which were mostly still in development, emerged from traditional breeding techniques that harnessed existing varieties well suited the local environment as well as from more advanced bio-technology techniques such as marker assisted selection and genetic modification (UNEP, 2015).

Some of the benefits accrued from the project included the following: enhanced human capital through training and capacity building for natural resource management, introduction of women's gardens and changing building practices to conserve wood; improved natural capital owing to improved land management and rehabilitation of degraded land; financial capital was improved through access to local and national markets, greater access through revolving credit funds and production of marketable sheep; social capital benefits include the formation of community development committees and enhanced living conditions of women through participation in community gardens and other activities (UNEP, 2015).

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CHAPTER THREE

METHODOLOGY

3.1 Study Area and Population

Mion District is located in the eastern corridor of the Northern Region of Ghana between Latitude 9^o– 35" North and 00^o – 30" West and 00^0 – 15" East. The district shares boundaries with the Tamale Metropolis, Savelugu Municipal and Nanton District to the west, Yendi Municipal to the east, Nanumba North and East Gonja districts to the south and Gushegu and Karaga districts to the north. The district covers a surface area of 2,714.1 sq. km and has a population density of 30.1 persons per square kilometre (GSS, 2014).

According to the 2010 Population and Housing Census (PHC), Mion district has a population of 81,812 of which 7,278 (8.9%) lives in urban localities while the rest (91.1%) lives in rural localities (GSS, 2014). Agriculture is the main occupational activity of households in the district. The PHC shows that 8,143 households are engaged in agriculture, of which majority of them (93.1%) are found within the rural settings (GSS, 2014). The commonly practiced agricultural activities are crop farming and livestock rearing. While majority of them are into crop farming (95.2%) the rest are into tree planting and livestock rearing (GSS, 2014).

The high proportion of agricultural households in rural areas is mainly due to the fact that agriculture is essentially a rural activity (GSS, 2012). The 2010 PHC presented the farming systems in Mion district in the table below.

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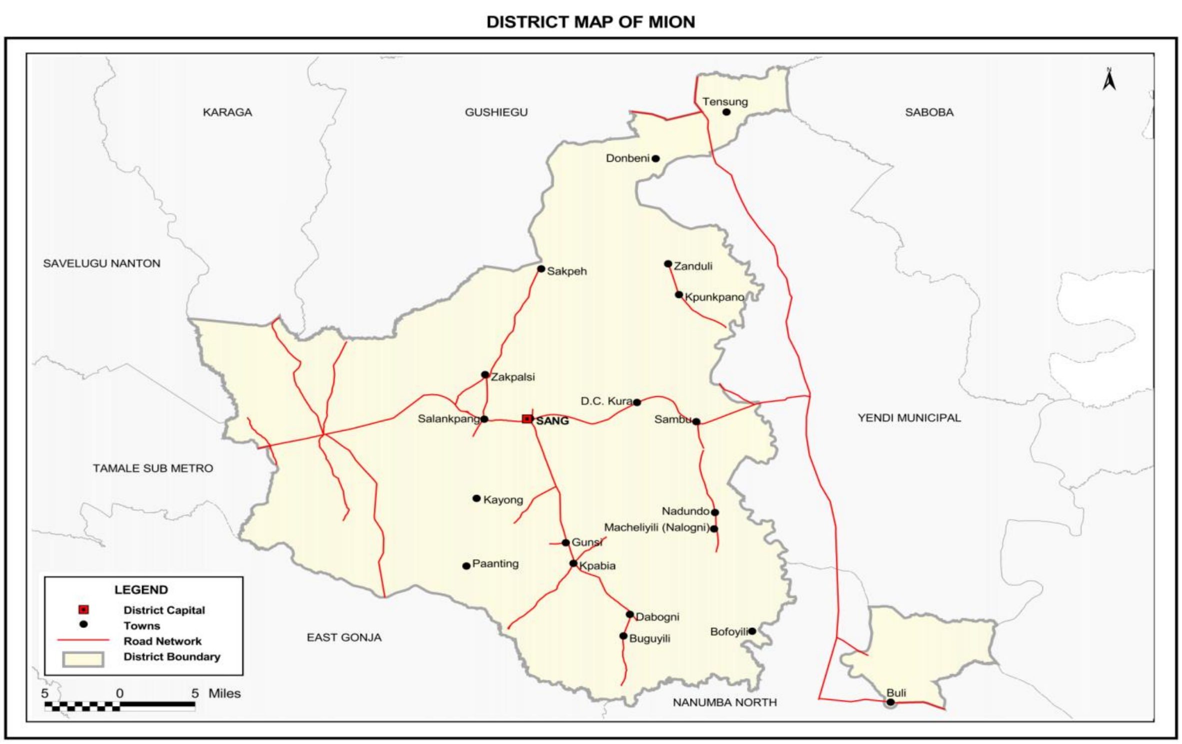
Table 3.1: Distribution of Households by Agricultural Activities

Households by agricultural activities	Total		Urban		Rural	
	Number	Percent	Number	Percent	Number	Percent
Total Households	8,842	100.0	669	100.0	8,173	100.0
Households engaged in Agriculture	8,143	92.1	564	84.3	7,579	92.7
Crop Farming	8,040	98.7	541	95.9	7,499	98.9
Tree Planting	21	0.3	1	0.2	20	0.3
Livestock Rearing	4,465	54.8	268	47.5	4,197	55.4
Fish Farming	2	0.0	0	0.0	2	0.0

Source: Ghana Statistical Service, 2010 Population and Housing Census

Figure 3.1: District Map of Mion District



Source: Ghana Statistical Service, PHC (2014)

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3.2 NGOs in Mion District

The agriculture department of the Mion district has been collaborating with some NGOs to promote agricultural technology transfer dissemination. Some of the NGOs include the following; West Africa Agricultural Productivity Programme (WAAPP), Yam Improvement Income for Food Security in West Africa. YIIFSWA, Strengthening Partnership, Results, and Innovations in Nutrition Globally (SPRING)/USAID, Innovation for Poverty Action (IPA), Adventist Development and Relief Agency (ADRA) Ghana, Ghana Agricultural Development and Value Chain Enhancement (ADVANCE)/USAID, Alliance for Green Revolution in Africa (AGRA), International Institute for Tropical Agriculture (IITA) –Nigeria, the Regional Advisory Information and Network Systems (RAINS), Ghana Agricultural Technology Transfer Project (ATTP) – feed the future, Community Life Improvement Programme (CLIP) (Source: Mion District Agricultural Department).

Table 3.2: NGOs and What They Do in the Mion District

Non-governmental Organization (NGO)	What They Do	In the District
The Ghana Agricultural Development and Value Chain Enhancement (ADVANCE)	The project supports the scaling up of agricultural investments to improve the competitiveness of the maize, rice, and soybean value chains in Ghana. The project adopts a facilitative value chain approach, where smallholder farmers are linked to markets, finance, inputs, equipment, and information through larger commercial farmers and traders who have the capacity and incentive to invest in smallholder production. These linkages build the capacity of	They engage - Nuclear farmers in proper record keeping. - Proper agronomic practices in maize cultivation. - Good agronomic practices – 800cm by 400cm planting techniques - Fertilizer application

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	smallholder farmers to increase the efficiency of their farm businesses with improved production and post-harvest handling practices.	- Post-harvest management -
Yam improvement for Income and Food Security in West Africa. (YIIFSWA)	It is a five-year program funded by the Bill & Melinda Gates Foundation. The program seeks to multiply the production of yam in the major producing countries, Ghana and Nigeria, through innovative agricultural concepts and techniques to stimulate a sustainable increase in the income of yam farmers and contribute to their food security and economic development. YIIFSWA is managed by the International institute of Tropical Agriculture (IITA) and implemented by a syndicate of partners (NGOs, NARs and National institutes) committed to making an impact in the area of Food security and wealth generation through agriculture in Africa.	They engage in - Improved yam variety - Millicent yam technology transfer.
The Adventist Development and Relief Agency (ADRA)	ADRA works with people in poverty and distress to create just and positive change through empowering partnerships and responsible action. It is also interested in value-chain process of food crops linking farmers to competitive markets.	They engage in - Value-chain improvement of crops produced. - Educating farmers in weather prediction
Strengthening Partnership, Results, and Innovations in	SPRING/Ghana aims to reduce stunting by 20 percent in two	- Educating farmers on climate change

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Nutrition Globally (SPRING) Projects	regions—Northern Region and Upper East Region. Working in 15 districts within these two regions, SPRING/Ghana's activities include anemia reduction, infant and young child nutrition; water, sanitation, and hygiene; aflatoxin reduction; community video; and support to the LEAP 1000 cash transfers. SPRING/Ghana defines its activities through the 1,000 Day Household approach, which targets households with pregnant women and children 2 years of age and younger. This approach synthesizes each intervention area into a holistic approach designed to support the ability of the 1000 day household to care for and support the 1,000 day child.	characteristics. - Fertilizer application techniques
Ghana Agricultural Technology Transfer Project (ATTP) – feed the future	The ATTP is seeking to increase the availability and use of agricultural technologies to maximize and sustain productivity in Northern Ghana.	Yet to begin
Community Life Improvement Programme (CLIP)	-The development of coping and adaptation mechanisms to climate change and improving food security situations among smallholder farmers in poor communities in the project area. - advocacy and Micro credit scheme to vulnerable groups and communities in	Working progressively

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	its operational areas in the Northern region - food security/livelihoods - hygiene and sanitation promotion - Provision of portable water	

Source: Field survey, 2017

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Since poverty is generally widespread in the rural areas of Ghana and food security in the Northern region is also threatened, considerable efforts have been made by some NGOs on proper post-harvest management techniques that are implemented and adopted to maintain quality of crops free from pest infestations (MoFA). The three main agricultural priorities of MoFA in the Northern region are; grain storage for human and livestock consumption; post-harvest pest management; improving the income status of farmers through increased produce sales. Based on these, NGOs such as TechnoServe have built storage structures to store yam harvests in some communities in the Mion District. They have also assisted farmers to construct mud silos, which are already known to the local farmers, for the storage of maize and other grains. It has several compartments that can hold different crops and have the capacity to store approximately 1.5 tons of grains. These techniques or strategies have the potential of reducing crop loses to less than 1% not only in Mion district but Ghana at large. Prior to this, many farmers in the north used to store their harvest in woven baskets that do not last and are susceptible to insects and rodents. Other small wooden structures which are also poorly constructed get rotten in no time. As a result of the inadequate storage infrastructures post-harvest loses ranged between 10% - 40% (Innovative Dev't, 2014).

3.3 Research design

The study employed survey research design. According to Kraemer (1993), survey research design was used to quantitatively describe some aspects of a given population where analyses

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were made based on the relationships amongst variables. The rationale was mainly to generalize from a sample to the general population (Creswell, 2014). Apart from the fact that it only provides estimates for the entire population, it can obtain information that are relatively easy for making generalization (Glasow, 2005).

The study employed mixed research methods (qualitative and quantitative). According to Creswell (2014), several published research studies have integrated mixed method research design in the field of social science (Creswell, 2009). Therefore, it is important to apply the mixed method in this study as one approach is used to better understand the results from the other approach.

In this study, the qualitative method was used to gather data on challenges of climate variability adaptation strategies whereas quantitative method was used to generate data on the impact of climate variability adaptation strategies.

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3.4 Sources of Data

Primary and secondary data were used for the study. Primary data was sourced from farmers, extension officers and other stakeholders in the district while Secondary data was obtained from relevant institutions such as Ghana Statistical Service (GSS), Ministry of Food and Agriculture (MOFA), Environmental Protection Agency (EPA), District assemblies.

3.5 Sampling frame

The population from which the sample was selected as the units of analysis covered all maize farmers within the communities in Mion district. The study also included relevant institutions like MOFA, the District Assembly and EPA staff.

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3.5.1 Sample Size

To ensure generalization and a research worth replicating, a sample size of one hundred and forty (140) household respondents was selected, computed with the use of the formula formulated by Fisher (Fisher *et al.*, 1998):

$$n = \frac{pqZ^2}{d^2} \text{ And } \quad n^1 = \frac{1}{\frac{1}{n}+\frac{1}{N}}$$

The Fisher formula is in two folds; the first formula is used for the calculation of sample size for an infinite population. The outcome of the first formula is then fed into the second formula to calculate for the sample size of the known (finite) population.

$$n = \frac{pqZ^2}{d^2}$$

Where;

n = sample size for infinite population

Z = 1.96 (at 95% Confidence level)

p = estimated proportion of maize farmers (0.1)

q = 1-p d = precision of the estimate at 5% (0.05)

The sample size will be;

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$$n = \frac{(1.96)^2 \quad 0.1 \times 0.9}{(0.05)^2}$$

n =138

n = sample size for infinite population n =138

The adjusted sample size for the finite population of 8,143 households in the Mion district is:

$$n^1 = \frac{1}{\left(\frac{1}{n} + \frac{1}{N}\right)}$$

n^1 = adjusted sample size

n = estimated sample size for infinite population

N = Finite population size

$$n^1 = \frac{1}{\left(\frac{1}{138} + \frac{1}{8{,}143}\right)}$$

= 135.7

≈ 136 household respondents will be selected.

However, the sample size was increased to one hundred and forty (140) for easy data collection and analysis

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3.5.2 Sampling Procedure/Techniques

The study employed a multi-stage sampling technique in selecting the farmers for investigation. Mion district was purposively selected mainly for its high production of maize in the Northern region of Ghana. It is also one of the districts that have benefited from farming innovations aimed at enhancing maize yield and also increase household income in the district (GNA, 2014). At the second stage, the entire district was divided into four MOFA operational zones where communities were randomly selected from each zone or strata. Two communities were randomly selected from each zone or strata. At the third stage, farming households in the various communities were randomly selected for investigation. This selection was done using simple random sampling technique. Purposive sampling was used to select stakeholders and staff of institutions for interviews.

A total of one hundred and forty (140) maize farmers were interviewed, comprising 94 male household head farmers and 46 female household head farmers. Analysis was done based on the total sample size of 140 maize farmers in the district, the information given by some key informants via one-on-one interview as well as some of the agricultural extension agents (officers) in the various operational zones. Outcomes of descriptive analyses are shown in Tables from 4.1 – 4.15. The tables present both the results for the categorical data of the demographic characteristics of maize farmers and continuous data.

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Table 3.3: Sample of Adult Households

Operational zones	Selected communities	No of respondents
Sang	1. Kpabia 2. Kulinkpegu 1&2	35
Jimle	3. Jimle 4. Kpalkore	35
Zakpalsi	5. Zakpalsi 6. Sakpei	35
Sambu	7. Sambu 8. warivi	35
Total	8 communities	**140**

3.6 Method of Data Collection

Primary data was obtained using semi-structured questionnaires to solicit data from the local farmers. The questionnaire administered to farmers covered areas such as demographic characteristics of respondents, factors influencing adaptation of climate variability adaptation strategies, the contribution of the strategies to livelihood improvements, as well as the challenges faced by the farmers.

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Key informant interviews were conducted for stakeholders such as community leaders (assembly representatives, leaders of farmers groups, etc.), staff of institutions such as MOFA. These informants have reliable information on the subject matter. It can also serve as a replacement for survey when there are cultural barriers in some communities. Their contribution to this investigation gave more insight or detailed information in reality on the adaptation strategies, the influential factors as well as the challenges. The reason for using them as key informants is because of their depth of knowledge of relevant issues in the communities.

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Focused group discussion were held for maize farmers in the various communities to gather data on common challenges faced by farmers in the district concerning the effects of climate change. One focus group discussion took place in each of the eight (8) communities, comprising twelve participants. These groups constituted maize farmers.

Secondary data was obtained from relevant institutions such as Ghana Statistical Service (GSS), Ministry of Food and Agriculture (MOFA), Environmental Protection Agency (EPA) and the district assembly. The 2010 PHC data for Mion district was provided by GSS while MOFA and the agricultural department of the Mion district assembly provided information on the agricultural activities of farmers in the district. The agricultural department also provided data on the annual rainfall pattern in the district.

3.7 Method of Data Analysis

Quantitative data was processed with the help of Statistical Package for Social Scientists (SPSS Version 20) as well as STATA Version (13) software and presented using tables, figures, frequencies and percentages.

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Objective 1 was analyzed using descriptive statistics (percentages, means and standard deviation). Aside using the descriptive statistics to determine the age, sex, education, religious distribution of respondents, it was also used to categorize various crops cultivated, adaptation strategies and annual yields to discuss how climate variability affects maize production in the district and the world at large.

Objective 2 was analyzed using Ordered Logistic Regression (OLM) model. This regression technique was performed using influential factors such as sex, age, education level, household size of farmers, income from other livelihood activities, membership of Farmer-Based Organizations (FBO), access to credits, farm size and farmland ownership as independent variables while various adaptation strategies such as irrigation, minimum tillage, shifting planting dates, Crop rotation, Diversification of non-farm activities, organic fertilizer application (animal manure), Improved/drought tolerant maize varieties served as dependent variables. These two variables were used in analyzing the factors influencing households' choice of climate change adaptation strategies. According to Osei-Owusu *et al.* (2012), in trying to model the factors that affect the choice of an adaptation strategy, the study used qualitative response regression models because the endogenous variable, which is a set of adaptation strategies, is not measured quantitatively.

Gujarati (2004) explains that qualitative response regression models which are also sometimes referred to as probability models, are a class of models in which the dependent variable is qualitative in nature. It assumes values of only a restricted range of whole numbers. If the dependent variable undertakes only two values, for instance, a farmer is either conscious or unconscious of an adaptation technology, it is known as a binary or dichotomous variable. On the other hand, if the outcomes are more than two then it is a polytomous variable.

When the dependent variable is polytomous and is unordered, then the multinomial logit is appropriate and mostly employed (for example, Hassan and Nhemachena 2008; Gbetibouo 2009; Deressa *et al*., 2010). The multinomial logit is however unsuitable in instances when the dependent variable is ordered. It fails to justify for the ordinal nature of the dependent variable (Greene, 2003). The ordered logit is appropriate in this situation. This study employs the multinomial choice model with logistic distribution to determine the factors that influence the choice of an adaptation strategy. The use of the multinomial logit in this study is justified because the recognized adaptation strategies are not ordinal in nature.

Objective 3 and 4 were analyzed with the help of narrative reports from key informant, focus group discussions and/or other stakeholders. According to Bamberg (2011), narratives can be considered "real world measures" that are appropriate when "real life problems" are investigated. It is a very useful part of the social science investigations, but may not always stand alone for evidence and support for the conclusion of a report (Bamberg, 2011). Based on this, maize farmers were given the free atmosphere to express themselves pertaining to the challenges facing them. Data were gathered in the form of field notes, journal reports and interview transcripts.

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3.8 Econometric Model

Now, based on the nature of data required to achieve the objectives of the current study, standard Logit and Rank-Ordered Logit models were employed. The Logit model was used to analyse factors affecting farmer's decision to adopt any climate change adaptation strategy (the first objective). However, Rank-Ordered Logit model was used to analyse the farmers' preferences for different adaptation strategies (the second objective). The mathematical specifications of these models are given one by one as follows.

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The Logit model considers the relationship between a binary dependent variable and a set of independent variables which can be a binary or a continuous. For such a dichotomous outcome, the Logit model is appropriate. The Logit model is the easiest and most widely used discrete choice model. Its popularity is due to the fact that the formula for the choice probability takes a closed form and is readily interpretable. To identify key determinants of adaptation decision, a dichotomous variable is computed first which indicate whether the farmer is adopted or not. That is,

$Y^* = \beta X_i + E_i$ _ 1

Practically, Y* is unobservable. What we can observe is a dummy variable Yi defined by

Yi = 1, thus if Y* > 0 or (if the farmer adopts)

0, otherwise (if the does not adopt)

This shows that the farmers will choose to adopt (Yi = 1) if Y* > 0, 0 otherwise. Where Y* show the expected benefits of adapting to climate change relative to not adapting, **X** is a vector of variables that affect the decision to adapt or not to adapt to climate change. We then use a logit regression model including 8 explanatory variables, modelled as follows:

$$P_{i=prob(Y_i=1)=} \frac{1}{1+e-(\beta 0-\beta 1x1i+\cdots+\beta 8x8)}$$

$$= \frac{e(\beta 0+\beta 1x1i+\cdots \beta 8x8i)}{1+e(\beta 0+\beta 1x1i+\cdots \beta 8x8i)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots .2$$

Since the estimated coefficients only show the direction of the effects of the independent variables on the dependent variables and show neither the magnitude nor probabilities. Thus, marginal effect is used instead to interpret the effects which are the relative effect of each

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independent variable xi on the probability of the outcome. Marginal effects is calculated by differentiating equation 1 with respect to explanatory variable i.e. x_i.

$$\frac{\partial pi}{\partial xi} = \left[\frac{e^{\beta i' xi}}{1+e^{\beta i' xi}}\right]\beta_i = F(\beta' X)[1 - F(\beta' X)]\beta_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

2.8.1 The Ordered Logit Model

The analytical approaches that are normally used in an adoption decision study involving multiple choices are the multinomial logit (MNL) and multinomial probit (MNP) models. Both the MNL and MNP are significant for analyzing farmer adaptation decisions as these are usually made jointly. These approaches are also suitable for evaluating alternative combinations of adaptation strategies, including individual strategies Hausman and Wise (1978). Both of these models use farmers most preferred choices of adaptation methods from the s*et al*ternatives, not the ranked one. However, according to Hassan & Nhemachena (2008) the most preferred climate change adaptation strategies by African farmers are mainly applied in combination with other strategies and not alone.

In this study, we have used the Ordered Logit model (OLM) to analyze an individual's choice of a set of alternatives. The advantage of this type of data is that, it provides more information about preferences when compared with data in which individuals are asked to illicit their most preferred choice over a set of alternatives or data in which individuals are asked to rate alternatives without comparison (Beggs, *et al*., 1981 and Caplan, *et al*., 2002). In statistical terms, the parameters can then be estimated more efficiently Fok *et al* (2010).

The adaptation strategies employed so far by most farmers in different parts of the country are reviewed from different literatures. In addition, the adaptation mechanisms to climate change in the study area are also observed and the set of alternatives adaptation mechanisms are

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determined. In this study farmers were asked to rank six different climate change adaptation strategies in application to their farm. Farmers rank these climate change adaptation strategies from the one they value most to the one they value least.

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Table 3.4 Measurement of Explanatory Variables

Explanatory Variables	Measurements
Gender of household head	Dummy; 1=female and 0=male
Age of household head	Years
Education Level of household head	Dummy; 1=at least basic education and 0=otherwise
Household Size	Numbers
Non-farm Income status of household head	Ghana cedis
Access to credit	Dummy; 1=Yes and 0=No
Farm ownership	Dummy; 1=Yes and 0=No
Farm size	Hectares

3.9 Review of Methodology

A number of studies or researches have employed models such as the multinomial regression and the Kendall's coefficient of concordance to measure and to identify the factors that influence the choice of adaptation strategies and the challenges to climate change adaptation strategies respectively by smallholder farming households. The justification for the use of these models will be also be discussed

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3.9.1 The Use of Multinomial Logistic Regression to Measure Choice of Adaptation Strategies

Generally, regression is used to analyze the relationship between two variables (dependent and independent). With multinomial logistic regression, a linear regression analysis is conducted based on when the dependent variable is nominal with more than two levels.

Gutu (2014) for instance used the multinomial regression to analyze factors affecting climate change adaptation strategies on maize production by households in Seke District in Zimbabwe. It was deduced from the analysis of this study that different factors have different influences on adaptation strategies adopted by households. It was revealed that the smallholder maize farming households were vulnerable to the effects of climate variability and change because of their low adaptive capacity. Recommendations were that a multidisciplinary extension approach be done to increase and strengthen the adaptation capacity of the households and the promotion of farmer field trainings.

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Obayelu *et al*. (2014) also employed the multinomial regression to ascertain the factors influencing farmers' choice of adaptation strategies in Ekiti State, Nigeria. The multinomial regression analysis revealed that the factors explaining farmer's choices of climate change adaptation included most of the demographic and socio-economic characteristics. The results showed that the most widely used adaptation method by the farmers were soil and water conservation technique measures.

Shongwe *et al*. (2014) also employed the econometric technique to measure the factors influencing the choice of adaptation strategies by households, a case of Mpolonjeni Area Development Programme (ADP) in Swaziland. The empirical results of the analysis showed that perceptions of households towards climate change significantly influenced all adaptation

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strategies practiced by the farming households. However, sex and education level of the household head were insignificant in influencing household choice when adapting to climate change. It was therefore recommended the need to educate households about the negative impact of climate change on cropping systems. The study also recommended that agriculture extension services should be strengthened, agriculture financial institutions should accommodate subsistence farmers on communal land and rural micro-finance institutions should be developed, in order to facilitate farmers to choose effective adaptation strategies.

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3.9.2 Identifying Challenges to Climate Adaptation

Several approaches can be employed in the identification of constraints to climate adaptation strategies. One commonly used approach is the Kendall's coefficient of concordance. The Kendall's ranking technique measures the extent of agreement among numerous quantitative or partial quantitative variables that are measuring a set of objects of interest. The total rank for each variable is computed and the variable with the least score is ranked as the most preferred. This technique has exhibited some similarities with the Friedman's ranking technique. This assertion was supported by Legendre (2005) who reported that there is a close relationship between Kendall's ranking techniques and another technique called the Friedman's ranking which were simultaneously used.

Taylor (2015) employed the Kendall's coefficient of concordance to assess and rank the constraints to climate change adaptation strategies by smallholder faming households in the Brong Ahafo Region of Ghana. The empirical results from the Kendall's rank technique showed that lack of access to credit, lack of ready market for produce, and poor extension service were the three most pressing constraints identified by the respondents.

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CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, the main findings of the study are presented on the effects of climate variability adaptation strategies on the production of maize in the Mion District. Having gathered data based on the objectives of the study, the descriptive statistics of the socio-economic characteristics of the sampled population are presented. This is followed by the results of farming systems and perception of the current climate by maize farmers. The presentation is on the adaptation strategies adopted and practiced by farmers in the District. The results of the factors influencing farmers' choice of adaptation strategies are also discussed. Finally, the results of the constraints that serve as hindrance against farmer households' climate variability adaptation strategies is presented.

4.2 Socio-economic and Demographic Characteristics of Maize Farmers in Mion District

This section discusses the socio-economic and demographic characteristics of respondents. It presents a detailed discussion on characteristics of smallholder maize farmers such as age, gender, marital status, household size, education level to highlight their distribution among the study population to determine how they affect adaptation to climate in the communities.

4.2.1 Age of Respondents

The study findings revealed that the age of households of the sampled respondents ranged from 30 to 75 years with mean age of 42.85 years for the maize farmers (Fig. 4.1). The figure indicates that the majority of household heads in the district were within the age category of 35-44 (39.3%), followed by the category within 44-54 (25%) while the least category fell within 65+

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(6.4%). This implies that the growth and development of the agricultural sector with respect to climate adaptation lies mainly on the youthful age category in the district.

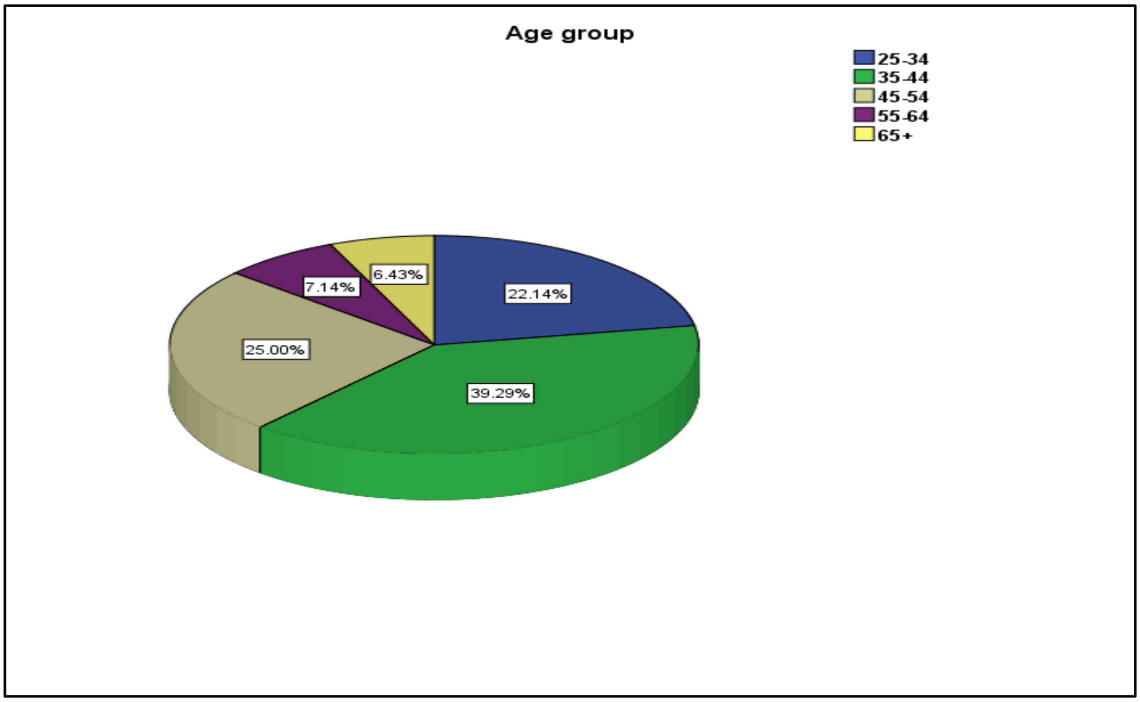

Figure 4.1: Age distribution of respondents Source: Field survey, 2017

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Age distribution is one of the most important demographic characteristics that is used to analyze and interpret the pattern and its impact on the development of agriculture and other sectors of communities in the district. The results in this study conforms with the research findings of Owusu (2015) where over 60% of the labour force (20-40years) were involved in agriculture in the Sisili-Kulpawn Basin of the Northern region of Ghana. Moreover, it is rarely the case that older age-group (55-65+) dominate in the agricultural sector in Northern Ghana (GSS, 2010). The effect of age on the decision to choose an adaptation strategy is varied in the literature. Whereas the findings of Deressa *et al*., (2010) showed that age has a positive influence on the choice of livestock sale as an adaptation strategy by farmers during extreme weather and climatic

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events, other literatures such as Hassan and Nhemachena, (2008); Obayelu *et al.*, (2014), have found age to have no significance in inducing the choice of an adaptation strategy to climate variability.

4.2.2 Gender of Respondents

Both male and female farming households are engaged in agricultural activities in Northern Ghana. However, farming activities are dominated by male households than their female counterparts in the study area. Figure 4.2 represents the distribution of gender among maize farmers in Mion district.

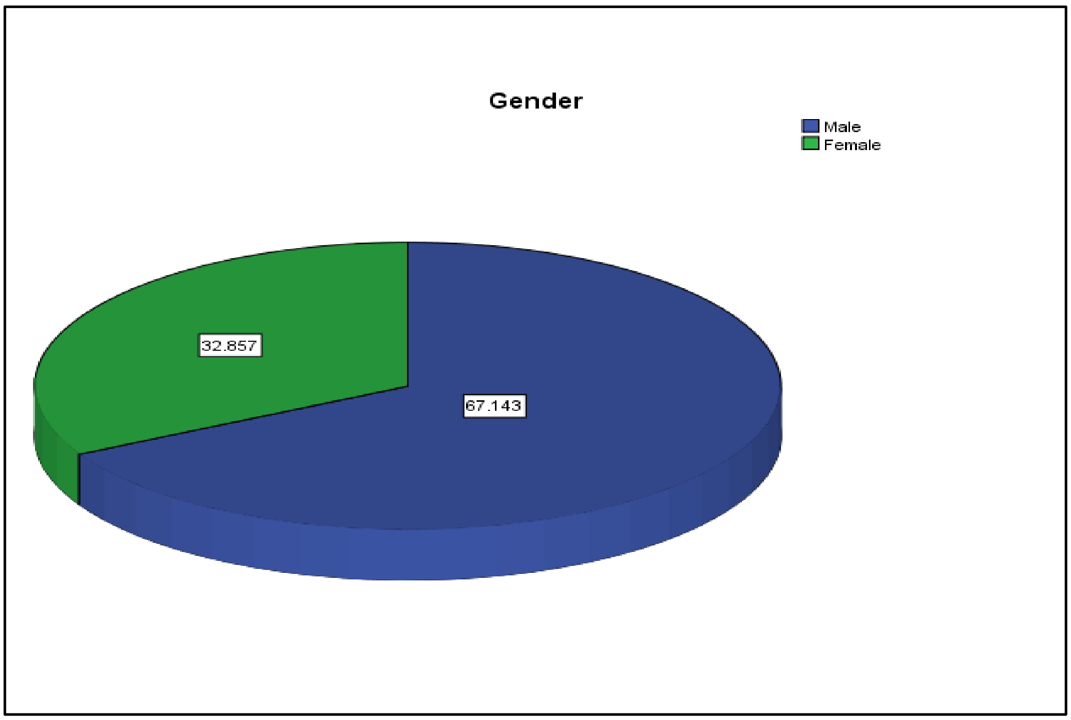

Figure 4.2: Gender distribution of respondents Source: Field survey, 2017

Figure 4.2 indicates that 67.1% of the respondents were males while the female household farmers were 32.9%. This implies that the majority of the respondents engaged in agriculture were males. Several other studies on climate change, agriculture and adaptation strategies have

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shown that the agricultural sector is male dominated especially in Northern Ghana (Owusu, 2015; Jinbaani, 2015). In a study conducted by MoFA in 2011, it was revealed that the economically active population (15 – 49 years) engaged in agriculture in the Northern Region had more males (55.9%) than their female counterparts (MoFA, 2011). Also, observations made by Deressa *et al* (2010) indicated that the gender of a farmer has the potential of influencing his or her choice of an agricultural technology, which implies that male household heads are more likely to adopt agricultural adaptation technique than females

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4.2.3 Marital Status of Respondents

The marital status of farming households is one of the major determinants adoption of some climate variability adaptation strategies. It has the potential of influencing the significance of adoption of these strategies. Table 4.1 shows the distribution of maize farmers by their marital status.

Table 4.1 Distribution of Maize Farmers by Marital Status

Marital status	Married	106	75.7
	Widowed	12	8.6
	Single	22	15.7
	Total	**140**	**100**

Source: Field survey, 2017

Table 4.1 indicates that whereas majority (75.7%) of the household respondents were married, 15.7% of the respondents were not married. Only few (8.6%) of the household respondents were widows. Ideally the statistics indicates that the married majority of the households are relatively

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more active in agricultural activities than the unmarried household farmers, however, the opposite is true. It was observed that most of the unmarried youth traveled out of their communities to seek for other non-farm sources of income to augment sole and inadequate farm income. This study considered all other non-farm income activities by the farmers of Mion district as climate adaptation strategies since climate variability is unfavourably effecting agricultural activities.

The results does not conform with the project findings of Osei-Owusu *et al.* (2012) which indicated that relatively young household heads who are mostly unmarried are actively engaged in agricultural activities than the elderly household heads who are mostly married and not actively engaged in agriculture.

4.2.4 Household Size of Respondents

Household size is one of the household characteristics capable of influencing the farmers' adoption of climate adaptation strategies. It implies that if a household size increases by one person, there is a chance that a farmer will adopt a particular adaptation strategy. Table 4.2 shows the distribution of maize farmers by their household sizes.

Table 4.2 Distribution of Farmers by Household Size

Household size group	Frequency	Percentage (%)	Mean
1 – 5	43	30.71	Mean Household Size =8.06
6 – 10	74	52.86	
11 – 15	13	9.29	
16 – 20	5	3.57	
21 – 25	3	2.14	
26 – 30	2	1.43	
Total	**140**	**100.0**	

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The majority of respondents belonged to the household bracket of 6 – 10 people, followed by the household bracket of 1 – 5, with an average size of 8 people. This implies that the household size is relatively high compared to the national average household size of 4 people in rural communities in Ghana. The results of Teklewold *et al.* (2006) in a study which suggests that household size has an ambiguous effect on adoption of climate adaptation mechanisms, which relates to the findings in this study. If the composition of a household cannot balance labour requirements on the farm, it might unfavourably influence adoption of climate adaptation. However, household size may positively influence adoption of a new innovative technology if considered as a proxy for labour availability (Teklewold *et al*., 2006).

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4.2.5 Distribution of Respondents by Land Ownership

In Northern Ghana, Household heads are usually males and are the custodians of family lands therefore have full control over land use. Table 4.3 below shows ownership of farmlands by maize farmers in the district.

Table 4.3 Distribution of Farmers by Farmland Ownership

Land ownership	Frequency	Percentage (%)
Self (male HHHs)	109	77.86
Family land (female HHHs)	31	22.14
Total	**140**	**100.0**

Source: Field survey, 2017

Inferring from Table 4.3, it could be observed that 77.9% of the farmers who indicated the farmland belonged to them are male household heads engaging in agriculture. The rest (22.1%) were female household heads who either claimed the farmlands are owned by their sons or were family lands. In relative terms, the study observed that the supply of agricultural land in the rural areas is naturally greater that the supply in the urban areas. This indicates that large supply of

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agricultural land could influence how farmers adapt to the challenges of farming by climate variability.

According to Owusu (2015), there are significant disparities between men and women regarding access to and ownership of land, and this is mainly attributed to the patrilineal system of inheritance in the Northern part of Ghana. Climate variability also poses a greater employment challenge to women in the agricultural sector in the form of jobs loses and other social risks such as health and education. This renders them more vulnerable and hence affects their main source of livelihood. The situation explains how it inhibits the participation of women in agriculture.

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4.2.6 Distribution of Respondents by Education Status

The study revealed that the majority of the respondents have no formal education while a handful has attained their education from primary to tertiary. Table 4.4 shows that 67.1% of the respondents had no formal education, 13.6% had primary education, 12.9% had attained up to the junior high level, 5.0% had senior high level of education, and only 1.4% had attained the Tertiary educational level. The data is almost consistent with the 2010 PHC in the Mion district. The census indicated that the literate population was 28.7 percent while 71.1 percent were non-literate for both sexes implying a very high illiteracy rate in the Mion District (GSS, 2012).

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Table 4.4 Distribution of Respondents by Level of Formal Education

Level of Education	Frequency	Percentage
No formal education	94	67.14
Primary	19	13.57
Junior high	18	12.86
Senior high	7	5.00
Tertiary	2	1.43
Total	**140**	**100.00**

Source: Field survey, 2017

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The level of education and age distribution are very important in assessing the effects of climate variability on crop farming. This helps in discovering the extent of farmers' vulnerability and their ability to adapt to climate variability. It was realized that across all the age groups, farmers with no formal education dominates in maize farming, followed by those who attained up to primary and junior high level of education. Only a few (age group 35-44 years) attained up to the tertiary level of education (Table 4.4).

The education of the household head often has a direct and positive influence on the adoption of technology (Hoag *et al*., 1999). This is attributed to the fact that household heads with more years of schooling would be expected to better visualize the benefits of technology. Similarly, education plays a key role for household decision in the adoption of a given adaptation strategy. It creates awareness and helps for better innovation and its consequential benefits (Hoag *et al*., 1999).

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4.2.7 Access to Extension Services

Agricultural extension service is a major agricultural transformation strategy which is aimed at assisting farmers in Ghana who still use the traditional approach in crop production with minimal management technological improvements to increase their productivity and income (Annan, 2012). The study gathered that there is inadequate agricultural extension service in Mion district. The majority (65.0%) of the respondents indicated inadequate or lack of access to extension services while 35.0% had access to services of Agricultural Extension Agents (AEAs) in the district (Table 4.5).

Table 4.5 Access to Extension Services by Farmers

Variable Definition		Frequency	Percentage (%)
Access to Extension Services	Yes	49	35.0
	No	91	65.0
	Total	**140**	**100.0**

Source: Field survey, 2017

The Ministry of Food and Agriculture (MOFA) requires each administrative district to have between 20 to 30 AEAs to provide community-level extension services of bridging the technological gap and the management gap (Annan, 2012). However, the same cannot be said about Mion district in that, the expected impact from the intervention has not been realized due to a number of challenges such as inadequate funding, lack of logistics and insufficient field staffs.

The Mion district Department of Agriculture has divided the district into operational area/stations, but due to inadequate staff only eight (8) have officers manning them. Each zone has a supervisor with Agricultural extension agents (AEA) operating in the zone in carrying out extension services to farmers and serving as linkage between the farmers and Agricultural Research Institutions. The department has twenty (20) staff strength which however is

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inadequate to effectively cover the entire district. The Agricultural Extension Agents (AEAs) farmer ratio in the district is one is to three thousand, five hundred farmers (1: 3,500) (Mion DA, 2017). It is important for MOFA to explore more innovative ways of rendering extension services to farmers such as the use of mass media and mobile services. This is necessary since it is increasingly becoming difficult for MOFA to get new AEAs employed.

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4.2.7 Membership of Farmer-Based Organization

Collective action occurs when more than one individual is required to make an effort in order to achieve an outcome (Francesconi and Wouterse, 2014) directly on their own or through an organization. According to the maize farmers, the formation of Farmer-Based Organizations (FBOs) is based on the interventions of Non-Governmental Organizations (NGOs). Some of the key informants indicated in an interview that FBOs are only active when NGOs or related institutions intend to introduce a technological innovation to farmers.

Table 4.6 Distribution of farmers by Farmer-Based Organization (FBO)

Farmer-Based Organization	Frequency	Percentage (%)
Yes	88	62.86
No	52	37.14
Total	**140**	**100.0**

Source: Field survey, 2017

The survey from the field showed that, 62.9% of the maize farmers belonged to one FBO or the other, while 37.1% were not (Table 4.6). These groups are mostly temporal as they are formed voluntarily and informally, and are therefore dissolved after the completion of a program or task. This conforms with the findings of Salifu & Funk (2012) where the formation and sustainabililty of FBOs in mainly based on the availability of NGOs.

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Successive governments of Ghana viewed the FBOs as a key instrument for agricultural and rural development although the formation of most of these organization were based on agenda and underwent frequent changes in directions (Dadson, 1998; Salifu & Funk, 2012). Despite the growing interest and expectations of FBOs to enhance the livelihood sources of smallholder farmers, maize farmers in Mion District, during a Focused Group Discussion (FGD), indicated that their FBOs are almost functionless since they barely realized its benefits.

Generally, FBOs are formed in Ghana mainly to engage in collective activities such as; planting and harvesting together on the farm land; pooling labour on fields; using a common facility for marketing their products; supporting each other financially through saving and credit schemes to acquire credit from organizations; and procuring agricultural inputs (Salifu & Funk, 2012). Among other farming activities in the district, mutual labour support was indicated by the maize farmers to be common. This is a situation where members of the FBO come together to work on each member's farm in turns. It is referred to as "*Kpariba*" in Dagbani. This is widely practiced not only in the Mion District but among diverse ethnic groups of all Ghanaian FBOs especially at the time seasonal labour is at its peak. It can therefore be deduced that the formation of FBOs in the district could strongly influence the development and adoption of various adaptation strategies in maize farming.

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4.2.8 Access to Credit

The survey result indicated that only 25.0% of the maize farmers had access to credit while the majority (75.0%) of them had no access (Figure 4.4).

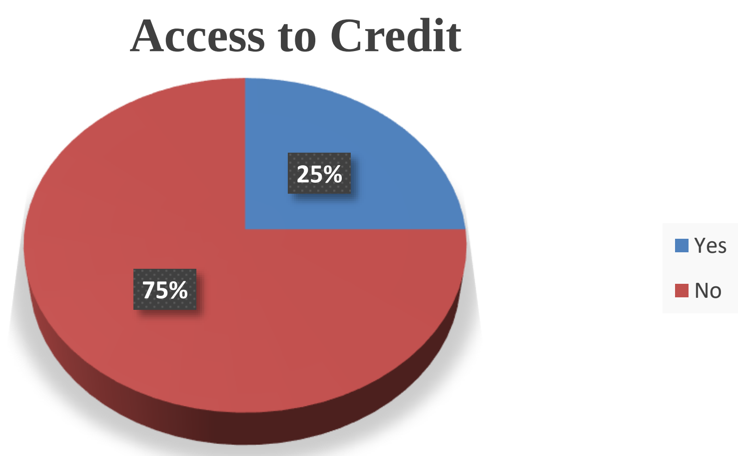

Fig 4.3: Access to Credit of Maize Farmers

Access to credit is an important service to smallholder farmers for input purchase and ultimately encourage them to adopt new technologies for agricultural development. However, while some farmers have access to credit, others may not have due to mainly problems related to lack of collateral and poor access to credit institutions.

According to the AEAs in the district, access to credit can best be facilitated and achieved through the establishment of viable FBOs, whose leadership can lobby to acquire financial credit, farm inputs among others, from stakeholder organizations. In an in-depth interview, both key informants and AEAs noted that farmers in the district sometimes receive credit in kind such as fertilizers, pesticides, herbicides and other equipment to aid them in their farming activities. The 25% of respondents therefore suggests that credit need to be made available, affordable and accessible to farmers for the development of the agricultural sector. The farmers usually have

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challenges in getting access to credit due to the risks involved in farming. It is important for MOFA to intensify insurance education among farmers in order to increase their access to credit.

4.3 Farming Systems

The farming system among communities in Mion district is characterized by mixed farming and other forms of agriculture. Mixed farming, which is the simultaneous household activities of crop farming and rearing of animal make up the main source of livelihood for the farming folks in the district. Table 4.7 indicates the type of farming – crops cultivated and animals reared by farmers in the district.

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Table 4.7: Distribution of farmers by crop cultivated and Animals reared

Crop cultivated	Farmers			Animals Reared	Farmers	
	Freq.	%			Freq.	%
				Goats	55	39.3
Maize	107	76.4		Sheep	39	27.9
Yam	112	80.0		Cattle	11	7.9
Cassava	79	56.4		Poultry	70	50.0
Millet	40	28.6				
Rice	49	21.3				
Groundnut	94	67.1				
Soybean	34	24.3				

Sources: Field survey, 2017

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Maize is one of the major staple crops cultivated in the district. However, unlike groundnut soybeans and other cereal crops, maize is very susceptible to changes in climate and other environmental conditions. As a result, the cultivation of maize is at high risk mainly due to the unfavourable climatic conditions such as temperature and precipitation which is expected to woefully affect maize yield in the near future. From Table 4.7, the survey revealed that 76.4% of the smallholder farmers cultivated maize aside other food crops. In a FGD with the farmers, it was indicated that they are most likely to abandon maize and shift to the production of other food crops provided if the weather pattern continues to worsen with their coping mechanisms not improving accordingly. One of the farmers, popularly known as ‘Zabaga’ from Jimle community stressed that;

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"*I cannot risk cultivating maize any more than two (2) acres from now on. I used to apportion 4 acres of my 8-acre farmland for the production of maize but for the past 3 years I have noticed reduction in maize yield due to variability of the weather pattern. I am demoralized and so my focus is now on other crops.*"

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Animal rearing in the district which include but not limited to the rearing of goats, sheep, cattle and poultry birds are used both for domestic and commercial purposes. The survey revealed that poultry (50.0%) is the dominant animal reared in the district, followed by goats and sheep. This goes to confirm the fact that livestock rearing is the second most important agricultural activity in the savannah agro-ecological zone (GSS, 2014).

Considering the farming system, it can be deduced that the potential of Mion district in agriculture is enormous with the land very suitable for crop production and rearing of animals. These potentials can therefore be sustained if there are adequate measures in place to manage the threat posed by the variability in climate since the main source of feed for the livestock is dependent on rain-fed.

4.4. Farmers' Perception of Climate Variability and Change

During the field survey respondents were asked whether they noticed changes in the weather patterns. With the questionnaire provided for their responses, below indicates the perception of climate variability by the farmers. 45.0% of respondents viewed climate variability as high temperature, erratic rainfall (87.9%), occurrence of flooding (51.4%). The rest included ground dries so fast (drought) (86.4%), low soil fertility (60.0%) and emergence of pests and diseases (50.7%). Table 4.8 presents farmers' perception of climate variability.

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Table 4.8: Perception of Climate Variability

Variable definition			Frequency	Percentage (%)
Climate Change Perception	High temperature	Yes	63	45
		No	77	55
		Total	**140**	**100**
	Erratic rainfall	Yes	123	87.9
		No	17	12.1
		Total	**140**	**100**
	Flooding	Yes	72	51.4
		No	68	48.6
		Total	**140**	**100**
	Drought	Yes	121	86.4
		No	19	13.6
		Total	**140**	**100**
	Low soil fertility	Yes	84	60.0
		No	56	40.0
		Total	**140**	**100**
	Pest and diseases	Yes	71	50.7
		No	69	49.3
		Total	**140**	**100**

Sources: Field survey, 2017

The table above shows that erratic rainfall is highly perceived by the maize farmers as the major cause of climate variability. This is because maize cultivation is highly dependent on the

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availability of adequate water supply for its development to ensure high yields. Again, the issues regarding drought, flooding as well as pest and diseases as causes of climate variability were indicated by maize farmers in the district, which negatively affects crop production in general. Reports from the FGDs indicated farmers are aware of the anthropogenic causes of climate variability and climate change. A 70-year old farmer at Kpalkore community shared his views on the causes of climate variability as;

> "*the change in patterns of the climate is due to some of us farmers trying to proclaim God's attributes of bringing down and distributing rainfall by attempting to call the rains through the use of Juju, and God is punishing us as a result of their sinful actions.*"

Similarly, a 48-year old farmer opined in a narration as;

> "*to my understanding and with my little experience, the cause of the recent unpredictable rainfall pattern is mainly attributable to the way and manner we fell trees for both domestic and commercial use. A friend and a colleague farmer from the south, indicated to me the difference in rainfall pattern is dependent on vegetation.*"

The farmers' perception of climate variability was consistent typically with the data provided by the agricultural department of Mion District in Table 4.9.

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Table 4.9: Mion District Annual Rainfall Figures- 2013-2016

YEAR	AMOUNT OF RAINFALL (MM)	NUMBER OF RAINY DAYS
2012	N/A	N/A
2013	761.5	49
2014	1137	61
2015	772	34
2016	1691	55

Source: Department of Agriculture-Mion District, 2017.

Table 4.9 indicates rainfall distribution between the years of 2012-2016 where the number of rainy days recorded in 2014 was relatively higher than in 2016; however, the relative amounts of rainfall in the respective years or seasons vary differently. This goes to confirm the rainfall variability reported by the smallholder maize farmers in the district. The situation is worrying and implies that MOFA needs to emphasize the promotion of irrigation to reduce over-reliance on rainfall.

Furthermore, respondents expressed diverse opinions on their observations with respect to the climate variability. Respondents were on changes in rainfall pattern. A 47-year old farmer called 'Washiu' from Kulinkpegu (No.1) shared his experience as;

> "*The rainfall pattern in these communities has generally worsened, and it is affecting crop production. The worrying part is that the rainfall delays in the planting season and ceases even earlier than the expected time.*"

This results in unexpectedly low crop yield due to the rainfall erraticism.

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Although most of the respondents agreed on human elements in the occurrence of climate variability, a few still hold the traditional view that climate variability and climate change are caused by God. For instance, a 53-year old farmer in the Sambu community declared that;

> *"the change in the rainfall pattern is attributed to God's way of running His affairs and in doing so, He is testing us to examine our level of faith in Him."*

Respondents also mentioned other causes of climate change during FGD as deforestation, bush burning and use of chemical fertilizers. 'Zabaga' is a 48-year old farmer at Sambu community who has been cultivating maize for the past 20 years. He has expressed his views in the narration below regarding the causes of climate variability.

> "*...to be frank, I am pretty sure I will be speaking for the rest of the group here if I say that we've heard experts on climate and agriculture, forewarning us about the negative effects of felling trees unnecessarily. Most of us have also heard about the dangerous effects of bush fires on the soil fertility of our farmlands, yet we are deeply involved in these negative activities. So, my brother, these are just a few of the issues I think are causing climate variability in this part of the country.*"

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4.5 Effects of Climate Variability on maize production

The maize farmers' perception about the effects of climate variability on the production of maize are discussed in this section. Table 4.10 presents farmers' perception on the effects of climate variability on maize production.

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Table 4.10: Effect on maize production

Effects on maize production	Response	Frequency	Percentage (%)
Seed germination failure	Yes	55	39.3
	No	85	60.7
	Total	**140**	**100**
Stunted maize growth	Yes	137	97.9
	No	3	2.1
	Total	**140**	**100**
Poor maize yield	Yes	133	95.0
	No	7	5.0
	Total	**140**	**100**
Outbreak of pests & diseases	Yes	92	65.7
	No	48	34.3
	Total	**140**	**100**

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From the field survey, some (39.3%) of the farmers attributed failure of maize germination to the variability of climate. The overwhelming majority (97.9%) of the respondents were of the view that irregular rainfall and drought are the resultant cause of stunted maize growth in some planting seasons. Other farmers (65.7%) believed that the emergence of pests and diseases negatively affect maize production in the district which has a negative implication on food security in the Northern part of Ghana.

Ragasa *et al.* (2014) indicated that despite the major investments being made in the past with the aim of improving maize yield, maize yield in Ghana is still one of the lowest in the world. It is also lower than the yield achieved in countries with similar environmental characteristics and rain-fed as well such as Thailand and Southern Mexico (Ragasa *et al.*, 2014). The effects of climate variability are considered a main factor aside the human element such as inadequate farm management due to poverty. This is evident because, in 2012, the average maize yield in Ghana was 1.2 – 1.8 metric tons per hectare (mt/ha) which was far below the expected yield of 4 – 6 mt/ha in on-station trials (Ragasa *et al.*, 2014). The negative outcome could have been as a result of poor management and unpredictable climatic conditions.

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4.6 Adaptation Strategies by Farmers

Adaptation to the adverse effects of climate change and variability is less becoming an option in the agricultural sector, especially when crop farming is very susceptible to these effects (Gutu, 2014). In the communities, it was observed that the majority (86.4%) of the farmers practiced more than one adaptation strategy, and the idea is mainly to maximize productivity amidst the adverse effects of the variability and change of climate. According to Gbetibouo (2009), since any adaptation option or practice fall under the overall framework of utility and profit maximization, a rational farmer would only choose to practice an adaptation if it has greater perceived net benefits. Being aware of the threats posed by these effects, the study found that maize farmers within communities in the Mion district have been practicing the following adaptation strategies to maintain resilience in their production and productivity.

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Table 4.11: Adaptation Strategies Distribution by Farmers (Multiple responses)

Adaptation Strategies	Frequency	percentages
Changing planting dates	138	98.6%
Using improved maize varieties	121	86.4%
Making of ridges/mounds	99	70.7%
Crop rotation	81	57.9%
Application of organic fertilizer	78	55.7%
Diversify into non-farm activities	15	10.7%
Minimum tillage	12	8.6%
Bonding	7	5.0%
Irrigation	2	1.4%

Sources: Field survey, 2017

4.6.1 Changing Planting Dates

In order to cope with the varying trends of the climate system, 98.6% of the maize farmers indicated that they vary their planting calendar with respect to the time rains commence (Table 4.11). Farming systems in Ghana are heavily reliant on the weather and climate characteristics. With respect to crop production, the farming calendar is highly regulated by the two major seasons (rainy and dry seasons) in most parts of West Africa (Obayelu *et al.*, 2014) since crop farming is largely non-mechanized. The weather has become the main predictor for farmers' timing of crop cultivation, planting, harvesting and other activities (Obayelu *et al.*, 2014).

The planting season has been gradually changing and more unpredictable lately. As a result, the farmers in the Mion district had to adapt by changing their planting calendar to suit the actual starting of the rainy season. According to the farmers when engaged in FGD, for the past years

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the rainy season used to start around late March to early April, however, it has changed, because the timing of the rains has shifted to the beginning of May. They also reported that the changes have been accompanied with short season and erratic rainfalls. One of the participants in the FGD, the Assemblyman from the Zakpalsi community offered a couple statements that many focus group participants affirmed to as true;

> *"…we now rely now information provided for us on rain forecast by some of the NGOs such ADRA/AGRA, ADVACE and SPRING. The last message alert I received was on the weather was when I traveled to Savelegu for a ceremony. So, my brother, these are some of the measure we adopt to avoid risks."*

Another 70-year old key informant from Zakpalsi who only gave his name as 'Alhaji' explained that;

> *"those of us in this part of the district are farming on lowland areas and we always experience flooding with two to three consecutive days of heavy rainfall. Based on that we rely on accurate weather information in order to prepare the farmlands to plant especially maize within the first 2 – 3 rainfalls so that the seeds might not fail to germinate as a result of the farmlands becoming muddy and near flooding."*

The implication of the above statement is that, there is the need to attach more importance to the use of mass media such as radio and other mobile devices to facilitate effective extension services. With this, farmers can be well informed about changes in seasonal weather variabilities and adapt to unfavourable outcomes of it.

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4.6.2 Using Improved Maize Varieties

Majority (81.4%) of the maize farmers who were interviewed indicated that maize productivity has been low compared to the past (Table 4.11). They attributed the decline in productivity to the low adoption and patronage of the improved and drought tolerant maize variety for cultivation. According to the Agricultural Extension Agents (AEAs) of the various operational zones within the district, despite having educated as well as demonstrated to the farmers that the newly improved maize varieties yield more than the traditional varieties, only a handful adopt to its use. Some of the newly improved maize varieties such as 'Sanzali sima', 'Abontem' and 'Wang dataa' are the type mainly adopted and used by the few farmers in the district. According to the Agricultural Extension officers' report, as they expressed referring to farmers' adoption of improved maize varieties in farming,

> *"The farmers claim to be poor and cannot afford to bear the costs involved in the adoption of the new innovations we introduce and enlighten them on their practice. Although they buy the improved maize but in small quantities"*

In a discussion with the farmers, they clearly attested to the fact that they are always advised to actively practice the use of improved seeds, however, the cost always deter them. A respondent at Jimle community shared his challenge with respect to the high cost of the inputs as:

> *"the 'agric' improved maize seeds are expensive in that we buy small quantity and add it to our traditional seeds to plant. We have noticed that the yield of the improved varieties is higher than the local varieties."*

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4.6.3 Making of ridges/mounds

Majority (70.7%) of the maize farmers adapted to the adverse effects of climate variability through the making/raising of ridges and mounds (Table 4.11). They believe that the ridges and mounds help to retain moisture in the soil in times of severe drought and at the same time prevent the leaching of soil nutrients. One of the participants of the FGDs in 'Jimle', a farming community in the district explained that, *"with the mounds, it serves as a drainage path for the water that floats during a heavy rainfall to easily drain away without causing damage to our crops."* It implies that the farmers make ridges as a land management practice in order to mitigate the effects flooding which washes off top soil nutrients, and drought which reduces soil moisture.

The Northern part of Ghana is well noted for its characteristically high temperature due to mainly direct sunshine and less vegetation cover (forests). As a result, crop farming (especially maize) can be very susceptible in times of too much evapotranspiration due to drought (Voto, 2015). In order to reduce the adversity of the effect of this climate phenomenon, maize farmers in the Mion district adapted by practicing the raising of mounds and ridges to ensure water retention in the soil in times of drought to prevent the stunted growth of crops in general.

In a publication by CSIR and AGRA (2014) on the topic, 'Recommended Production Practices for Maize in Ghana', it was stated that;

> *"For rapid germination, maize seeds need a soil that is warm, moist and well supplied with air, and fine enough to give good contact between seed and soil. Good seed to soil is very necessary so that the seed can absorb moisture from the soil…."*

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Although this practice is upheld by some of the farmers with the use of tractors to plough their farmlands in order to loosen up the soil, the making of ridges and mounds as well serve the same purpose. It can therefore be deduced from the above that the making of ridges and mounds are effective adaptation mechanism against the adverse effects of climate variability.

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4.6.4 Application of Organic Fertilizers

Farmers in the district have full knowledge about how animal manure can serve as organic fertilizer to help improve the yield of maize crops, however, the field data indicated that 55.7% of the maize farmers applied it as fertilizer on their farms which implies that organic fertilizer application in the district is not encouraging (Table 4.11). The use of organic fertilizers was found to be more common relative to the application of inorganic fertilizers (animal manure) despite the fact that almost every household rear animals implying that there is abundant animal manure from the livestock reared, where it can be applied to supplement the low soil fertility of farmlands, although it might not be sufficient for very large areas of farmlands.

According to one of the AEAs, Mr. Issah, who is in charge of Sang operational area in the district, expressed his opinion about farmers' use of animal dungs as fertilizers as;

> *"Even those who tend to apply organic fertilizers, do so on their backyard farms since it is not far from their homes. Although the farmers are well aware of importance of animal manure to the improvement of soil fertility, but most of them do not spread or apply it on their maize farms, reason being, the farmlands are far from the house and they cannot carry it all the way to the farms. So, they prefer using the chemical fertilizers."*

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The narration implies that distance of farmlands from farmers' homes had created a challenge to the intense application of organic fertilizers as an adaptation strategy to climate variability. In order to boost maize yields, the AEAs reported to have been issuing coupons to farmers who were willing to purchase chemical fertilizers, to purchase at affordable prices at authorized sale points.

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Manure is noted to be largely in the form of crops residues usually from cereals. The use of animal droppings is also common even though the practice is not widespread. The use of animal manure by smallholder farmers is perceived to be effective and less costly in terms of improving soil fertility as a result of erosion originating from floods and other extreme weather events (Obayelu *et at.,* 2014). According to Osei-Owusu *et al.* (2012), the implementation of some introduced strategies has been, however, found to lead to the neglect of certain indigenous climate adaptation strategies. Indigenous strategies which include soil related strategies (for instance, manure application) and other cultural practice related strategies (more commonly, the spacing of planting materials) were found to be substituted by introduced strategies such as soil and plant health strategies (for instance, inorganic fertilizer application) and suggested agricultural management practice (for example, planting in row) respectively.

Even though most farmers prefer the application of chemical fertilizers, if it is not properly or adequately applied could have negative effects on the soil. Ragasa *et al.* (2013a) expressed that, the recommended rates of fertilizer depend on the agro-ecological zone, soil type, and cropping history. It was also shown that, the recommended application rates for starter (basal) or side-dress (top-dress) fertilizer applications range from 50-150kg each per an acre for maize. The application rates recommended by CSIR and MOFA are 26.3 kilogram/acre of nitrogen for rice

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cultivation in the forest zone with less than five years of fallow period and 40.5 kilogram/acre of nitrogen for rice plots that are continuously cropped (Ragasa *et al.*, 2013b).

According to Ragasa *et al*. (2014), inorganic fertilizers are applied to nearly one half of the area planted with maize production in Ghana. On average, 270 kg of fertilizer is applied per ha. Out of this amount, it consists of 47 kg of nitrogen (N), 20 kg of phosphorus (P) and 20 kg of potassium (K). Maize farmers apply only 50% to 60% of the levels of fertilizer application suggested by the Council for Scientific and Industrial Research (CSIR). It is also reported that the national average level of fertilizer applied to maize in Ghana is comparable to levels in Zambia and Malawi, but much lower than those in Kenya and northwestern Ethiopia.

The percentage of maize farmers who apply fertilizers and the amount that they apply varies spatially (Ragasa *et al*., 2014). A higher percentage of producers in the Northern Savannah zone (87%) apply fertilizers, doing so at higher rates – 57 kg of N, 27 kg of P, and 27 kg of K per hectare. Lowest fertilizer adoption levels are pragmatic in the Forest zone, where 17% of the area under maize is fertilized at average rates of 27 kg of N, 16 kg of P, and 16 kg of K per hectare. The fertilizer application rate is also low in the Coastal Savannah zone, where 37% of maize area is fertilized at an average rate of 29 kg of N, 17 kg of P, and 17 kg of K per hectare.

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4.6.5 Diversifying into Non-Farm Activities

The main livelihood activity of farmers in the Mion district is crop farming and other related agricultural activities. It was discovered in the study that the majority of the farmers (68.6%) were engaged in mixed farming (Figure 4.4). Aside the agricultural activities they seem not to have other sustaining livelihood sources. In the questionnaire administered, a question was asked as to which other livelihood they engaged in when they encounter challenges with farming. Most of the farmers (52.9%) indicated that they had no other activity aside farming. About 29.3% of

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them engaged in petty trading, while the other farmers (70%) made mentioned of livelihoods such as building and construction, butchering, carpentry, fitting, tailoring, teaching and weaving (Figure 4.4).

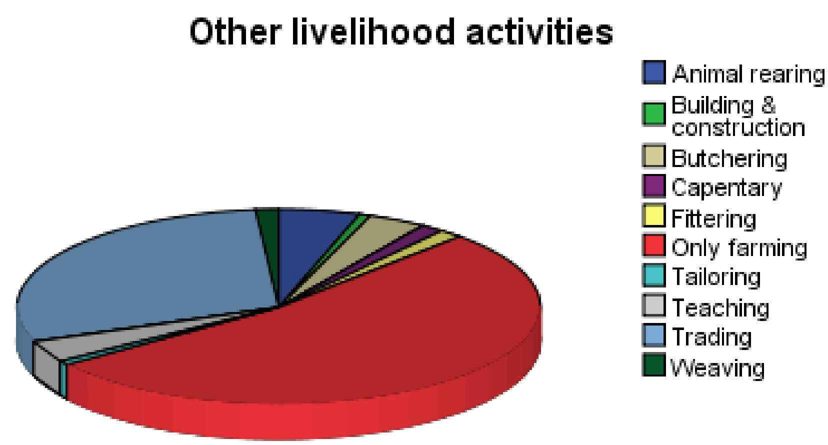

Figure 4.4: Other Livelihood Activities by Farmers

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4.6.6 Minimum Tillage

The practice of minimum tillage as an adaptation strategy is not common among maize farmers in Mion district. This was evidently shown from the field survey where only a few (8.6%) of the farmers indicated to have been practicing it (Table 4.11).

'Magpie' defined minimum tillage as the production system in which soil cultivation is kept to the minimum necessary for crop germination and growth thereby reducing labour, cost of fuel and damage to the structure of the soil (Dave, 2017). The practice aims at ensuring minimum soil manipulation necessary for crop production without turning the soil over (Klutse *et al.*, 2013). According to Buah *et al.* (2017), the most limiting factors affecting the sustainable maize production in smallholder farming systems in sub-Saharan Africa, especially the savanna agro-

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ecological zone, are erratic rainfall pattern and low soil fertility. Soil fertility is typically lost through intense tillage which changes the soil structure through ploughing (Klutse *et al.*, 2013). Minimum tillage has been emphasized in recent years mainly (Klutse *et al*., 2013). There are indications that attempts have been made to deal with this risk during the project implemented by ADVANCE Ghana in 2015, to promote climate-smart agriculture. The project aimed at promoting minimum tillage as one of the practices that can help farmers adjust to climate and improve food security while reducing greenhouse emissions from farming activities (ACDI/VOCA, 2015).

4.6.7 Irrigation

The field survey data indicated that only a handful (1.4%) of the maize farmers are engaged in irrigation farming. According to the respondents, engaging in the practices of irrigation can be a very big challenge as irrigation is capital intensive. It involves a lot more than just the irrigation equipment; sources of water should not be a problem.

Klutse *et al*., (2013) has it that, maize farming practices have seen improvement with the adoption of improved technologies and innovations by farmers which included irrigation. However, in the Mion district, irrigation farming is not common due to the lack of irrigation facilities that will facilitate farming throughout the year (GSS, 2014). There are no rural technology facilities in the district to take care of that. The AEAs in the district projected that if the practice of irrigation and improved land management system were to be highly considered, it would go a long way to increase yields, reduce overall production loses and alleviate child malnutrition. This could help in ensuring food security and reduce poverty levels among smallholder farmers in the district.

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Studies conducted by Owusu (2015) on the impact of climate of climate adaptation strategies in Sisili-Kulpawn Basin of the Northern Region of Ghana indicated that, the adoption rate and practices of irrigation was quite high (57.1%), implying that farmers with access to irrigation had higher yields than those who did not. This therefore means that the practice of irrigation has the potential of increasing maize yields amidst the negative effects of climate variability.

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4.7 Factors influencing the choice of climate variability adaptation strategies

Ordered Logistic Regression (OLM) model was used to analyse factors influencing the farmers' choice of climate variability adaptation strategies. Gender, age, education level, household size of farmers, income from other livelihood activities, membership of Farmer-Based Organizations (FBO), access to credits, farm size and farmland ownership represented the independent variables while the dependent variables included the identified climate adaptation strategies such as improved maize varieties, application of organic fertilizers, crop rotation and minimum tillage. The ordered logit regression model was significant at one percent level signifying that all the independent variables jointly influenced the dependent variables. Also, the likelihood ratio statistics as indicated by Chi-square statistics is highly significant, which is represented by a p-value of 0.0065. This implies that the ordered logit model has a strong explanatory power. The following results were obtained in Table 4.12.

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Table 4.12: OLM regression results

Variable	Coefficient	Robust Standard Error	P-Value
Gender	0.146155	.3709255	0.694
Age	0.0381726**	.018778	0.042
Education level	1.582128***	.4234355	0.000
Household size	-0.0720331**	.0354203	0.042
Farmer Based Organization	0.8181792**	.3689404	0.027
Access to credit	0.2446525	.4000032	0.541
Farm size	0.1993918***	.1187576	0.093
Other Income sources	-0.0038647	.0028097	0.169
Wald chi2(11) = 25.99 Prob > chi2 = 0.0065 Pseudo R2 = 0.0755 Log pseudolikelihood = -141.186			

Note: *, ** and *** are significant levels at 10%, 5% and 1% respectively

From the regression results (Table 4.12), it can be deduced that gender of the household head had a positive influence on the likelihood of the farmers adopting the adaptation strategies, however, it is statistically insignificant with a p-value (0.694). This implies that a male household head had a higher probability of adopting the indigenous strategies as a way of adapting to the variability of climate as compared to their female counterparts. While it does not agree with the findings of Gutu (2014), it is in line with Obayelu *et al* (2014) where gender of the household head had a positive relationship on the likelihood of adopting adaptation strategies. Being a male, a farmer is more likely to adjust by adopting several adaptation strategies with the slightest change in climatic conditions. For instance, the findings of Tenge De Graffe and Heller (2004) indicated that being a female head of household had negative influence on the adoption of adaptation measures such as soil and water conservation measures, because women have restricted access to information, land and other resources due to traditional social barriers.

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Age of the household head tends to be statistically significant to the adaptation strategies and has a positive influence on adaptation to climate variability (Table 4.12). It means that as age of a farmer increases, he is more likely to adopt climate change adaptation strategies. This is consistent with the findings of Gutu (2014) where he explains that the positive relation could be explained that as age of household head increases, the household head will likely acquire more knowledge about weather characteristics and climate pattern and at the end have a weather pattern in mind thus increasing one's chances of adopting different adaptation strategies. In this study, age was found to be insignificant as it would take time for a farmer to note these changes in climate such that an increase in age of the farmer by a year does not imply that one will be well vested with weather patterns but rather it takes more years for one to notice climatic changes.

The level of education (both literate and non-literate) of the household head was shown to have a positive relationship with the various adaptation strategies. It was significant at one percent level, with p-values (p-value >0.000) (Table 4.12). It implies that farmers with higher years of education are more likely to adapt to many and better climate variability adaptation strategies such as the strategies mentioned in Table 4.11, than those with less or no formal education. Evidence from various other sources indicate that there is a positive relationship between the education level of the household head and climate adaptation measure (Maddison, 2006; Obayelu *et al.*, 2014; Deressa *et al., 2010*). On the contrary, Mandleni and Anim (2011), reported that education appears not to have an influence on climate adaptation mechanisms. The implication of this is that increasing the farmers' years of formal education would show less interest in their likelihood of diversifying to non-farm activities, changing of planting period and other related strategies.

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Household size of maize farmers was also found to be statistically significant with an inverse relation to the practices of adaptation strategies to climate (p-value of 0.042). It implies that as the household size increases, farmers would rather increase their farm size accordingly but adopt lesser or no adaptation mechanisms, which will result in the continuing employment of family labour (labour intensive) in order to increase crop yield with less or no adaptation practices at harvest. The results conform to findings of Obayelu *et al.* (2014), that household size had a negative relationship with strategies such as diversification to non-farm activities changing of planting periods. Thus, large family sizes could increase the use of cheap soil and water conservation measures and reduction in farmers' diversification to non-farm activities and adjustment of planting period. According to Teklewold *et al*., (2006), Household size would have a two-way effect on practices of adaptation. On the one hand, if the composition of a household cannot complement labour requirements on the farm, it may have negative influence on adoption. However, household size may positively influence acceptance of a new technology if considered as a proxy for labour availability (Teklewold *et al*., 2006).

Farm size of the household heads had a positive correlation and was statistically significant at one percent for various adaptation strategies with a p-value of (0.093). It conforms partly to the findings of Gutu (2014) which posited that if the farm size was to increase then the probability of adopting some adaptation strategies is likely to increase, holding other unforeseen circumstances constant. Gbetibouo (2009), however, embraces a different view signifying that large scale farmers are relatively more likely to adopt adaptation strategies since they have the capital and resources to easily invest in strategies that calls for a high investment cost. The observations of Deressa *et al*. (2010) which is contrary to the findings of this study indicates that, farmers with larger farm sizes are also wealthier farmers who can rely on savings and are therefore less expected to adopt strategies such as livestock sale and borrowing from relatives as adaptation decisions to climate change and variability.

Membership of a Farmer-Based Organization (FBO) as an influential factor to climate adaptation, had a positive sign showing a direct relation to the practice of various adaptation to climate variability with p-value (0.027) in the Mion district. This implies that being a member to an FBO, a farmer is increasingly exposed to knowledge and skills with respect to innovative technologies to climate variability delivered to them by stakeholder institutions and organizations such as MOFA and other NGOs. The result is consistent with the findings of Singh *et al* (2008) and Sharif Zadeh *et al.* (2008). Sharif Zadeh *et al.* (2008) researched that there is a positive significant relationship between the practices of indigenous climate adaptation strategies by farmers with membership in cooperatives. According to Larbi (2015). FBO training has a significant positive effect on the adoption of a good number of adaptation mechanisms and strategies, implying that a unit increase in FBO training will increase the probability of farmers considering a strategy or two. Moreover, this is accurate because it links the individual to the larger society and exposes them to a variety of ideas on improved farming methods. Members of FBOs are in a privileged position with respect to other farmers, in terms of their access to information on improved agricultural technologies (Larbi, 2015).

Access to credit by maize farmers in the Mion district has a positive effect on the practices of adaptation strategies although it is not significant. This shows that maize farmers with access to credit are less likely to increase the effectiveness of climate adaptation practices. This can be justified mainly by the fact that increase in access to credit enables the purchase of farm inputs by farmers rather than intensifying the adaptation practices. The result conforms to findings of

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Goodwin and Schroeder (1994) and Mugisha *et al* (2004) that as access to credit improves, it does not necessarily indicate an equal improment in adaptation strategies.

The regression results also showed that there is an inverse relation between other livelihood income sources of maize farmers and adaptation strategies. The relationship is not significant with a probability value of (0.169) (Table 4.12). The field survey revealed that, although all the respondents were smallholder farmers, 42.1% of the maize farmers were also engaged in non-farm activities to source income to complement that of farming in order to meet their basic needs. According to Owusu (2015), there may be less or no other dependable sources of income for the majority of the people due to the less or inability of such people to change to the other sectors of the economy such as industry and service to seek for employment, and this will have greater impacts on their livelihood making them poor. This implies that, the Northern Region which has already been noted as one of the poorest regions in Ghana will continue to experience increase in poverty and food insecurity levels if smallholder farmers do not adapt good strategies.

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Shiferaw and Holden (1998) explained that while wealth is believed to reflect past achievement of households and their capability to tolerate risks, thus, households with higher income and greater assets are in a better position to adopt new farming technologies and strategies, non-farm income increased the likelihood of animal rearing and petty trading where there is a certain degree of outcome assurance.

4.7.1 Marginal Effects

According to Green (2000) the marginal effects measure the expected change in probability of particular choice being made with respect to a unit change in an explanatory variable. It also reports the discrete change in the probability for dummy variables. According to Green (2002) for an ordered logit, a unit change in explanatory variable is expected to change by a relative coefficient.

Table 4.13: Marginal Effects of the Factors that Influence the Choice of Climate Adaptation Strategies in Mion District

Variable	Average Marginal Effect	Low Adopter	Medium Adopter	High Adopter
Gender	0.01971458	-0.00776	0.00012	0.00764
Age	0.00517347**	-0.00776	0.00012	0.00764
Education level	0.24294358***	-0.23774	-0.12667	0.364415
Household size	0.00976251**	0.014644	-0.00023	-0.01442
Farmer Based Organization	0.11334813**	-0.15785	-0.01217	0.170022
Project support	0.03350296	-0.04838	-0.00188	0.050254
Farm size	0.0270232***	-0.04053	0.000628	0.039907
Income 2016	0.00052378	0.000786	-0.0001.2	-0.00077

From Table 4.13 above, the marginal effect results for a farmer's gender showed a negative effect for low adopters and a positive effect for high adopters of the adaptation strategies. This implies that there is 0.00764% probability that male household heads are likely to be high adopters, while female household heads have 0.00776% probability of being low adopters of the climate adaptation strategies. The age of a farmer was observed to have an inverse marginal effect for adopting less than four adaptation strategies while it had a positive marginal effect on the likelihood of a farmer adopting more than five adaptation strategies. This implies that as the farmer gets older by one year, there is 0.00776% chance that they will be practicing less than four adaptation strategies, and there is a similar probability 0.00764% that will adopt more than five adaptation strategies on their farmlands. Although the marginal effect is significant, it however takes more than one year to attain a meaning change in the adoption process.

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Primary education had a significant effect on the decision of a farmer to adopt climate change adaptation strategies. This implies that farmers with primary education, had about 0.24% less probability of being lower adopter and 0.36% likelihood to be high adopters of the adaptation strategies compared to those who have not had no form of formal education, ceteris paribus. Also, farmers who have had tertiary education have 0.25% probability of being low adopters and 0.51% probability of being high adopter compared to those farmers who have not had any form of formal education, ceteris paribus. The implication is that as a farmer attained higher levels of education, the farmer is better exposed to the adverse implications of climate change likewise the importance of adaptation strategies. This therefore, influence their decisions to adopt the strategies and the number of these strategies that would maximize their output.

The marginal effect of household size as an explanatory variable was positive for high adopters and negative for low adopters. This implies that if a household increases by one person, there is 0.014644% less probability of the household becoming low adopters that high adopters and a 0.01442% probability of becoming high adopters. This means that as household size increases, farmers become higher adopters than lower adopters, ceteris paribus. Being a member of a Farmer-Based Organization (FBO) had a positive marginal effect for high adopters, implying that a farmer is more likely (0.170022%) to adopt high if they belong to an FBO than if they do not (0.15785%). If a farmer had access to credit, the marginal effect of adopting more than five adaptation strategies is 0.050254% as compared to farmers without access to credit, with marginal effect (0.04838%) of adopting less than three strategies. Farm size has a positive marginal effect for adopting high number of strategies and low number of strategies respectively. It implies that if a farm size increases by one hectare, the marginal effect of adopting high number of adaptation strategies was positive at 0.039907% as compared to negative marginal

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effect of adopting less number of strategies 0.04053% if farm size increases by one hectare. An increase in farm income is not likely to encourage the adoption of high number of adaptation strategies, implying that if the farm income increases, there is negative marginal effect of adopting more adaptation strategies at 0.00077%. this indicates that the marginal effect is not significant. However, an increase in farm income has a marginal effect (0.000786%) of adopting less than three adaptation strategies.

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4.8: Contribution of Adaptation Strategies to Maize Farmers Livelihoods Activities

Since rainfall patterns have been unpredictable in the recent decades and the fact that crop production in Ghana especially in the Northern region depends heavily on weather conditions (temperature and rainfall), crop (maize) yields have been dwindling and in some cases declining as compared to previous years. In the study area, observations were that farmer households with only crop and livestock farming being their main livelihood activity were seen to be more vulnerable to the effects of climate variability especially on food insecurity due to the fact that their adaptive capacity was low. As indicated earlier, 125 maize farmers (89.3%) were engaged only in crop farming and livestock rearing (Figure 4.5). Based on this, it is rational for maize farmers to adapt and enhance their livelihood through engaging in petty crop and animal trading, as well as diversifying into other non-farm income sources as a way of risk management in times of crop failure attributable to climate variability.

At the end of the day, the idea behind adaptation is for the farmer household heads to be able to cater for the household needs and still be able to save money for future. Income loss can have essential negative effects on the livelihoods of farmers due to mainly bad weather conditions. However, this varies with the number of household size. Response by the farmers in the questionnaire provided for them indicated that the majority (75.5%) believe that the use of

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improved maize varieties can increase maize yield. Some (53.2%) of them believe that the application of herbicides and pesticides help in the reduction of pest infestation. Diversifying into non-farm livelihood activities were believed by over 61% of the farmers as increasing their incomes. However, less than half (30.5%) of the total respondents thought that crop rotation and other soil management techniques help to increase soil nutrients.

During a FGDs with the farmers, they described how the planting of improved maize varieties had increased their farm yields although those varieties were not planted in their entire farmlands. One of the farmers, referring to how he had realized an increase in his income status, stated that,

> *"I used to harvest nine bags of maize from my four and half acre farm but honestly I have since realized an increased to ten or sometimes more when I was advised to buy the 'Pannar' maize variety. Its costly so I bought small quantity otherwise I believe I could have gained more than this. But you see, my brother, we don't have money. That's the problem."*

Another farmer, 'Mba Machele' explained, concerning the effects of pest infestation, that;

> *"it's been quite a while since my maize crops were severely infested by those worms and caterpillars. In fact, our harvests could not be sold in the market because of the holes bored through them by the pests. Thanks to the pesticides and other post-harvest management practices that the NGOs and the AEAs taught us"*.

Yet another 50-year old farmer, whose opinion seemed to represent the entire participants, was quick to add that;

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"…and having narrated all these to you, nothing beneficial is gotten from it. I think that we always appreciate the presence of the agricultural officers who normally visit us in our farms and sometimes after we have harvested our crops to continue to teach us how to properly manage it and derive maximum profit out of our sweat. Particularly me, I perceived them to be those who wanted to cheat us. On the contrary their technology transfers are worth emulating just that I can't afford to practice all for now due to financial and other challenges."

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Table 4.14: Annual Yield of Maize Farmers in Mion District

NO.	YEAR	NO. OF FARMERS	AVERAGE YIELD (Tons/hectare)	QUANTITY PRODUCED (Metric Tons)	NO. OF HECTARES	Average Qty produced per farmer (Qty/farmers) metric tons	Farmer average income (price* X qty)
1	2012	35,008	0.53	5,163.7	8,903	6.9 ≈ 7	Ghc 560
2	2013	36,509	0.50	5,060	10,120	7.2 ≈ 7	Ghc 560
3	2014	39,541	1.03	5,913.23	5,741	6.7 ≈ 7	Ghc 560
4	2015	38,387	0.90	5,688	6,320	6.7 ≈ 7	Ghc 560
5	2016	35,638	0.60	5,164.8	8,608	6.7 ≈ 7	Ghc 560

*Current (2016) maize bag is priced at Ghc80
Source: Department of Agriculture, Mion District.

The data acquired from the department of agriculture of the Mion district (Table 4.14) shows a slightly high-income status of the maize farmers. The data confirms the response of the famers and indicates a steady maize yield for the past five years, which is likely to decrease if adaptation strategies are not at its best amidst the adverse effects of climate variability.

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4.9 Challenges of Climate Variability and Change Adaptation Strategies

During the study, it was discovered that several challenges confront the famers when it comes to the practices of climate adaptation strategies. Some of these challenges have been identified from already existing literatures on climate adaptation. They are as follows; financial constraints, constraints relating to lack of information on climate change characteristics, socio-cultural constraints, institutional and political constraints, lack of infrastructural development, technological constraints, inadequate extension services, lack of access to improved crop varieties, as well as constraints pertaining to lack of climate change adaptation policy. Table 4.15 presents the various challenges mentioned in the district.

Table 4.15: Challenges of climate adaptation strategies

Challenges	Frequency	Percentage (%)
Lack of access to credit	137	97.9%
High input prices	138	98.6%
Inadequate extension officers	84	60.0%
inadequate information on climate change characteristics	139	99.3%
Other challenges		Lack of tractors to plough Herdsmen and their cattle

4.9.1 Lack of Access to credit

Farmers' access to credit is one of the main drivers that influence the adoption of an adaptation strategy (Table 4.15). The study gathered that the majority (97.9%) of farmers do not have access

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to credit institutions in the district, not because they are not available, but because the farmers do not have security to access them. A farmer and a key informant in Kulinkpegu community, reported during a FGDs that;

> "*our financial background is not strong and based on that we are afraid to go in for any financial assistance whereby we are most likely to divert the use of these supports into other unrelated programmes that may not yield any returns for us to payback in due time."*

Therefore, they prefer to rely on the 'small' capital they have for farming. However, the AEAs in the district see the issue of financial constraints differently. They see it as the farmers' perception of poverty, since the farmers rear animals and mainly use them for domestic purposes. The AEAs argued that farmers can sell some of their livestock and use the amount gained to buy the necessary farm inputs for the preparation and cultivation of crops. An AEA in charge of Sang zone/operational area explained that;

> "*These farmers' lifestyle is very strange and interesting; most of them consider the rearing of animals as a traditional culture rather than business. So, they prefer to keep them, and however sell or eat them only when the circumstance is critical or demanding."*

This implies that farmers need to be intensively educated on economic and resource management in order to maximize the benefits of the limited resources at their disposure.

4.9.2 High Input Prices

The study also observed that due to the farmers' poor financial background, they cannot afford to buy some of the farm inputs such as early maturing and drought resistant maize varieties,

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insecticides and pesticides to apply to their farmlands. The survey results showed that the overwhelming majority (98.6%) of the farmers believed the prices of farm input to be high (Table 4.15). In order to adapt to the low soil fertility of their farmlands, there is the need to apply inorganic fertilizers to improve yield. According to the AEAs, sometimes they had to issue coupons to some of the farmers who are willing to apply the fertilizers to buy at affordable prices at prescribed sale points. Mr. Issah, an AEA for the Sang operational zone in the district indicated that;

> "*I believe the problem of soil fertility complained by the farmers would have been minimal if they had adhered to the use of animal manure as organic fertilizer. That is even the best kind of manure that is not harmful to the soil and therefore does not cause any environmental degradation.*"

The implication is that it is economically wise and environmentally friendly to use organic fertilizer from animal dungs rather than farmers' preference of inorganic chemical fertilizers to improve soil fertility.

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4.9.3 Inadequate Extension Contacts

One of the main duties of the Agricultural Extension Agents (AEAs) is to educate the rural farmers on various ways of adapting to the adverse effects of climate variability and change within the operational zones in the district. The Department of Agriculture is one of the core departments of the district assemblies. It has units that are involved in delivering the needed agricultural developmental technologies to farmers which include crops, livestock, veterinary, monitoring and evaluation, engineering, extension and Women in Agricultural Development (WIAD) units. The department is also administratively sub - divided into four zones to enhance

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technologies dissemination namely Sang, Sambu, Zakpalsi and Jimle zones. The Department has also divided the district into twenty (20) operational areas/stations. However, due to inadequate staff, only eight (8) officers are covering the zones. Each zone has a supervisor with one AEA operating in the zone to carry out extension services to farmers. and serving as linkage between the farmers and Agricultural Research Institutions. Two of the AEAs on separate interviews, expressed their challenges which were the same. Mr. Issah, the AEA in charge of Sang operational expressed their challenges as;

> *"Our challenges are numerous; our motor bikes are weak and cannot be used on these deplorable road as you can see; no fuel allowances to enable us visit the villages regularly; the attitude of the farmers is also a problem sometimes in that it is difficult for them to understand that you are trying to help them."*

Mr. Ali, who is responsible for Zakpalsi area, also mentioned similar challenges such as farmer-extension agent relationship, fuel allowances and lack of good roads linking to communities. These challenges can affect the delivery of innovative technologies negatively.

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4.9.4 Inadequate Information on Climate Change Characteristics

According to the agriculture department of the Mion district, the AEA to farmer ratio stands at one is to three thousand, five hundred (1: 3,500). Obviously the limited AEA staff cannot cover all the farming communities effectively and efficiently. The overwhelming majority (99.3%) (Table 4.15) of the respondents attested to the fact that there is inadequate information on the current climate variability. At the end of the weekly visits only selected farmers get access to the extension agent. According to FAO (2008), risk exists when there is uncertainty about future outcomes of ongoing processes or about the occurrence of future events. Providing farmers with

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valuable information such as weather and flood prediction coupled with finest agronomic practices can assistance reduce the impact of climate change on farmers. The AEAs indicated during an interview concerning the challenges on information transfer that;

> *"Having educated the few farmers who can reach at a given time, education and technology dissemination between farmers is not encouraging since they might not properly relay or defuse the right information for the benefit of their colleague farmers."*

This narration implies that there are distortions with respect to farmer-to-farmer technology of information transfer. The extension agents stressed that if information delivery and information relay between farmers on good agronomic practice were to be effective, challenges related to agricultural extension could have reduced.

4.9.5 Lack of Tractors to Plough

Farmers in the Mion District, especially those in the Sambu, Zakpalsi and Kulinkpegu (1&2), indicated emphatically that the lack of tractors to plough to their farm fields during the farming (planting) seasons has been a bane to early and effective farming. It is also one of the factors hindering the effectiveness of adaptation strategies and the consequent hindrance to food security in the area. According to the farmers, they usually hire the services of tractor owners from other districts to get their farms ploughed, and sometimes at unfavourable price negotiations. One of the key informants explained that;

> *"There are no tractors. Few people own tractors in this district to plough for all us. So, by the time most of us will plough and plant, either flooding or drought affects the germination and development of our crops."*

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Based on that one of the AEAs even described in a one-on-one interview that,

> "…*in order to improve on that situation, I personally would go into contract with some private tractor owners elsewhere to assist farmers in the district to plough their fields on time for effective farming.*"

The implication of the narration suggests the need for more tractors to be made available for farmers to easily access them, and for tractors to be sold at affordable prices for farmers to be able to buy them for agricultural purposes.

In conclusion, the findings of the study shows maize farmers' perceived causes and effects of climate variability and climate change. Data on these perceptions were used to establish the adaptation strategies and mechanisms that were mainly stated in the results analyses. The adoption and effective practices of these adaptation strategies were not without challenges that impeded their smooth applications. Several factors contribute/influence the decision of farmers' choice of their adaptation strategies, most of them include the demographic characteristics. The benefits of strong adaptive capacity was also documented to ascertain how it improved the livelihood strengths of farmers in the district.

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CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

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

5.2 Summary and Conclusion of the Study

The results showed that majority of the maize farmer respondents in the district mainly practiced adaptation strategies such as changing planting dates, using improved maize varieties, making of ridges, crop rotation and crop diversification, and application of inorganic fertilizers. The choice of strategies was justified based on their perception of what climate variability is. Most of the maize farmers attributed it to erratic rainfall, high temperature, flooding, drought, low soil fertility and others. It can therefore be established that the type of climate adaptation mechanisms that are adopted by farmers are mainly based on their perception or believe of the climate variability.

The findings in the study showed that maize farming households were still vulnerable to the variability of climate as majority (95%) of them indicated that the perceived climate variability affects maize production through crop (maize) germination failure, stunted maize growth and eventually poor maize yield. Some of the respondents (65.7%) were able to connect climate variability to the outbreak of diseases, with recent attack on maize crops by the 'fall armyworms' being a typical example. Based on this, the study concludes that the collective notion of climate risks, arising out of experience confronting the farmers over a long period now, have given them the edge to adapt to the adverse effects of climate variability.

Ordered Logistic Regression (OLM) model was employed to compute and analyse the factors influencing the choice of adaptation strategies to climate variability. Since the farmers in the study area practice more than one adaptation strategies in their farms, farmers were categorized or grouped into low, moderate and high adopters, where by farmers who adopted up to three strategies were considered low adopters, farmers adopting between 4 – 5 were moderate adopters, while those who adopted more than five strategies were high adopters. Based on this, 30% and 30.7% of the farmers were categorized as low and high adopters respectively, while 39.3% of them were moderate adopters.

The results of the regression showed that gender of the household head, age of household head, farm size, level of education, household size, membership to FBO, farm income, access to credit were factors that effected the adoption and practices various adaptation strategies. The farmers therefore need develop the desire to attain higher level of education since education was shown as one of the significant factors that affect the practice of climate adaptation strategies. It means that as they attain high education, access to information on both farming and climate can be easily and comprehensively obtained. Farmers also stand the chance to easily access credit to improve on their farming activities.

Although the adaptive capacity of the farming households is very weak amidst the education and practical demonstrations embarked by the AEAs and some NGOs, this may be attributed to low AEA-farmer ratio, farmer attitudes towards the adoption of new and advanced agricultural technologies, and poverty. To this end, E–extension model can play a great role in overcoming the challenge. The study revealed several challenges facing smallholder maize farming households in the Mion District. These include the lack of access to credit facilities, high input prices, inadequate extension services, lack of tractors to plough and others. These challenges can

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be minimized if farmers improve or change their adaptive capacities through cooperating with AEAs.

5.3 Recommendations

Based on the findings obtained from the study, it can be deduced that smallholder farming households (not only maize farmers) are very vulnerable to the effects of climate variability and change. However, their practice of adaptation strategies is still faced with challenges. Therefore, there is the need for stakeholder institutions and organizations such as MOFA and other agricultural related NGOs to address these challenges to increase adaptive capacity of farming households through sensitizations and policy reforms.

The local farmers in the district need to be provided with adequate and affordable access to credit in the form of loans by relevant government institutions such as ADB, MASLOG, NBSSI, among others, to increase their ability and flexibility to change production strategies in response to forewarned climate conditions. This would enable them overcome the major challenges of climate variability adaptations.

The identified adaptation strategies in the study should be promoted and supported by government, Non-Governmental Organizations (NGOs) and civil society organizations if households in the district are to be resilient and improve adaptive capacity to climate variability and climate change impacts. Factors influencing households' decisions to adopt climate variability adaptation strategies point the need for government support households and ensure sustainability of agricultural activities and enhance food security. Agriculture extension services need to be strengthened by increasing the interaction between households and extension officers by providing enough transport to ensure they conduct adequate field visits to farmers.

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The study revealed that the AEA – farmer ratio is very worrying since ratio stands at one is to three thousand, five hundred (1: 3,500). Based on that, there has been inadequate agricultural technology transfer in the district. Therefore. more qualified AEAs should be employed by government to offer extension services in terms of sensitizations about the impact of climate variability and change, demonstrations of good agronomic practices. Alternatively, e-extension services such as the use of mobile phones should be encouraged.

Smallholder maize farmers in the district have the potential to increase their farm size since there are sufficient lands available for cultivation. The study therefore recommends that farmers should increase their farm lands under cultivation and with the adaptation of improved technologies; this will transform into higher yields and returns thereby improving the peoples' livelihood sources.

The study revealed that the smallholder farmers rear a lot of animals. This implies that there is sufficient animal dung which can be used as organic fertilizer to replace the chemical fertilizer farmers have been struggling to acquire for their farms. Farmers are therefore encouraged to rather focus their attention towards the use of animal manure as organic fertilizer, since it is considered be environmentally friendly. The use of compost by farmers need to be intensified since compost helps to improve both soil structure and soil fertility after periods of droughts and floods in Northern Ghana.

Moreover, policy makers need to formulate more specific climate adaptation policies and programmes that are linked to enhancing livelihood diversification, building from the positive activities being taken to manage climate variability. This is based on the report by the AEAs that most farmers abandon the innovative technologies as soon as the extension programmes are over.

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For instance, programmes that are geared towards assets building such as skills training and craftsmanship should be integrated into national climate adaption strategies to enable farming households to venture into non-farm activities. Rearing of livestock is one of the principal livelihood opportunities for farming households in communities in the Mion District. Therefore, efforts need to be made to develop local expertise aimed at promoting the production of livestock through regular workshops on livestock production and credit supply.

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5.4 Area for Further Study

Adaptation strategies employed by farmers in the Mion District have been identified, and analyses of the factors that influence the major strategies or techniques have been done. It is strongly recommended that research studies be done on climate adaptation strategies in other districts not only in the Northern part of Ghana, but in other parts of the country. It might be interesting to discover that the findings will not be the same for other districts. The study on the effectiveness of E-extension on adoption of climate adaptation is also worth researching.

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APPENDICES

Appendix A

Questionnaire to Households on the "**Effects of Climate Variability Adaptation Strategies on Maize Production in Mion District**"

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SECTION 1: QUESTIONAIRE FOR HOUSEHOLD

A. Background and Personal Information

✓ Please tick [ ] in one of the boxes where appropriate.

1. Your Sex: male [ ] Female [ ]

2. Your Age: 0-14 [ ] 15-24 [ ] 25-34 [ ] 35-44 [ ] 45-54 [ ] 55-64 [ ] 65+ [ ]

3. Your education level: No formal education [ ] Basic [ ] High school [ ] Tertiary [ ]

4. What is your religion? Islam [ ] Christianity [ ] African Traditional [ ]

5. Your Marital status: married [ ] Single [ ] divorced [ ]

Occupation: Please specify ____

SECTION 2

6. Is maize the main crop you cultivate?

   Yes ☐ No ☐

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7. What other crops do you cultivate other than maize?

____

8. How has your maize production been for the past five years?

   High ☐ Low ☐ Steady ☐ Don't know ☐

9. In your opinion, what factors are responsible for the high/low production of your maize? *Please tick all that apply*

   Erratic rainfall Drought

   High temperature poverty,

   Low soil fertility Maize variety

10. What measures have you been putting in place to ensure improvements in the yield of your maize farm?

    a) Changing planting dates
    b) Using improved maize varieties
    c) Application of inorganic fertilizers
    d) Others please specify____

11. Which one of the above mentioned do you commonly practice?

____

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12. Have any institution or organization educated you or a group of you on a particular adaptation strategy to improve on maize production?

Yes ☐ No ☐

13. If yes, please mention the organization and the education that was provided

____

14. Has it been effective? Or to what extent has the intervention improved on your production of maize?

____

15. What then is your perception on Climate variability?

____

____

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SECTION 3

16. What factors influence the choice of your adaptation strategy (ies)?

	Improved/drought tolerant maize varieties	Shifting planting dates	Inorganic fertilizer application	Irrigation	Minimum tillage	Diversification of non-farm activities	Crop rotation
Sex							
Age							
Education level							
Occupation							

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Membership of social group							
Land category							
Access to credit							
Access to extension services and training							
High incidences of crop pest and disease							
High input prices							
High food prices							
Perceptions of households towards climate change							

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SECTION 4

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17. What is the size of your farm? ________________________________

18. On average how many bags of maize have you harvested in the past five (5) years? ____

19. With the adaptation how many bags of maize do you harvest?_____________

20. Are you encouraged to increase your farm size based on the adaptation strategies you have adopted? Yes ☐ No ☐

21. What other livelihood activity would you want to engage in aside farming? ____

SECTION 5

22. What difficulties do you experience in the practice of this/these adaptation strategies?

____
____
____

23. In your opinion, how can these challenges be improved?____
____
____

24. Would you switch to other livelihood activities if these challenges are not improving are expected? Yes ☐ No ☐ Don't know A☐DIX B

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Questions for Focus Group Discussion on adaptation strategies in maize production

1. What changes have you noticed about the current weather conditions in relation to the past (10 – 20 years ago)?
2. What have you noticed about your maize yields?
   a. Has the yield been low or high?
3. What factors, in your individual opinions, are responsible for these unstable yields?
   a. Do you think the weather is a factor?
   b. What other factors can you mention to be responsible?
4. What various measures have you put in place to ensure your maize yield increases?
5. Has any organization visited and educated you on how to adapt to the effects of the climate change?
   a. What exactly was the intervention based on?
6. Do extension officers come to educate and guide you on ways of adapting to the climate change?
7. How have these strategies improved your maize farms and yields?
8. Do you have access to credit?
   a. How often? Annually?
   b. How sufficient and sustainable was it?
9. What challenges do you face in the adaptation of your maize farms?

Thank you very much for your time

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Checklist

1. Identifying farmers' perception of climate variability and change (temperature and rainfall patterns)
2. Farming systems in the communities
3. How climate variability affects maize production
4. Adaptation strategies
5. How these strategies improve maize farms?
6. What are the influential factors affecting your choice of adaptation strategies?
7. Challenges faced by maize farmers

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APPENDIX C

Three: List of Tables

Table 1: Demographic Characteristics of Maize Farmers in Mion District

Variable Definition		Frequency	Percentage (%)
Gender	Male	94	67.1
	Female	46	32.9
	Total	**140**	**100**
Level of Education	No formal education	94	67.1
	Primary	19	13.6
	Junior high	18	12.9
	Senior high	7	5.0
	Tertiary	2	1.4
	Total	**140**	**100**
Marital status	Married	106	75.7
	Widowed	12	8.6
	Single	22	15.7
	Total	**140**	**100**

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Farmer-Based Organization	Yes	88	62.9
	No	52	37.1
	Total	**140**	**100**
Trip to the city	Yes	105	75
	No	35	25
	Total	**140**	**100**
Access to credit	Yes	35	25.0
	No	105	75.0
	Total	**140**	**100.0**
Access to extension services	Yes	91	65
	No	49	35
	Total	**140**	**100.0**

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Table 2: Demographic characteristics of maize farmers

Variable Definition		**Frequency**	**Percentage (%)**	**Mean = 42.85** **Std dev = 10.708**
Age group	25-34	31	22.1	
	35-44	55	39.3	
	45-54	35	25.0	
	55-64	10	7.1	
	65+	9	6.4	
	Total	**140**	**100.0**	
Household size				**Mean = 8.06** **Std dev = 4.756**
Duration of travel to city				**Mean = 2.35** **Std dev = 2.881**
Maize farm size				**Mean = 4.87** **Std dev = 1.674**

Table 4.5: Type of Farming System

Variable definition		**Frequency**	**Percentage (%)**
Farming type	Crops only	44	31.4
	Mixed farming	96	68.6
	Total	**140**	**100**

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Animals reared	Goats	55	39.3
	Sheep	39	27.9
	Cattle	11	7.9
	poultry	70	50
Crops cultivated aside maize	Yam	112	80
	Cassava	79	56.4
	Millet	40	28.6
	Rice	41	29.3
	Groundnut	94	67.1
	Soybean	34	24.3
Farmland ownership	Self	108	77.1
	Family land	31	22.1
	Rented	1	0.7
	Total	**140**	**100**

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