CHIRSTIAN SERVICE UNIVERSITY COLLEGE

THE PERCIEVED IMPACT OF CLIMATE CHANGE AND ADAPTATION ON SMALLHOLDER FARMERS IN THE SEVELUGU NANTON DISTRICT IN THE NORTHERN REGION OF GHANA.

BY

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DECLARATION

Candidate's Declaration

I hereby declare that this dissertation is the result of my own original research and that no part of it has been presented for another degree in this University or any other University.

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

Name: Patience Frimpomaa Nyame

Supervisor's Declaration

I hereby declare that the preparation and presentation of the dissertation were supervised in accordance with the guidelines on supervision of the dissertation laid down by Christian Service University College.

Supervisor's Signature ……. Date …….

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ABSTRACT

This study assessed Smallholder farmers' perceived impact of climate change and adaptation on agriculture in the Savelugu Nanton district in the Northern Region of Ghana. A non-probability sampling technique was used to obtain a sample size of 123 smallholder farmers and a structured questionnaire was used to elicit data from the respondents. The data collected from the farmers were analyzed using descriptive statistics. The results of the study showed that majority of the smallholder farmers' perceived decreasing precipitation and increasing temperature. Farmers' level of adaptation was found to be relatively high with majority of the farmers using irrigation, changing crops, changing planting dates and planting short season varieties as the major adaptation measures to decreasing precipitation and increasing temperature. Findings of the study also indicate that the major barriers to climate change adaptation by smallholder farmers in the district are lack of information about climate change, lack of knowledge about adaptation, lack of credits, no access to irrigation water and poor soil fertility. The study concludes that smallholder farmers in the district perceived changes in climate and employ adaptation strategies and socio-economic characteristics are important in determining farmers' adaptation to climate change.

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DEDICATION

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CHAPTER ONE

INTRODUCTION

Background to the study

The Intergovernmental Panel on Climate Change (IPCC) has defined climate change as a fluctuation between normally experienced climate conditions (rainfall, temperature, wind) and a different but recurrent set of climate conditions over a given region of the world. It is brought about by the increase in emission of Green House Gases (GHGs) in the atmosphere that destabilize the ozone layer, leading to global warming (IPCC, 2007). Over the past few decades, climate change has adversely affected both physical and biological systems in most continents across the globe (Rosenzweig et al., 2007). It estimates that the global temperature will increase between 1.8C and 4C above the levels observed from 1980-1999 during the time frame of 2090-2099, depending on how human societies continue to develop (IPCC 2007) the report also states that changes in climate are not restricted to the rise in temperature, but can also be detected in events such as heavier, more frequent precipitation, an increase in the number of areas affected by droughts, a greater number of tropical cyclones forming with higher intensity, and sea-level rising, among others(IPCC 2007) The agriculture sector is the backbone of the economies of most of the developing world, employing about 60 percent of the workforce and contributing an average of 30 percent of Gross Domestic Product (GDP) in Sub-Saharan Africa (World Bank, 2011).

Climate change is a serious problem worldwide as it affects agriculture. This challenge is composed of the likely impacts on ecosystem services, agricultural production, and livelihoods. Generally, losses in the agriculture sector due to climate change has economy wide consequences, like loss in gross domestic output, a decline in the income/consumption of the most vulnerable population; hence, a general

deterioration in households' welfare Food and Agricultural Organization [FAO], (2007).

Perceptions are influenced not only by actual conditions and changes, but are also influenced by other factors. A study by Gbetibouo (2009) found that having fertile soil and access to water for irrigation decrease the likelihood that farmers will perceive climate change; however, education, experience, access to extension services increase the likelihood that farmers perceived climate change. According to Trenberth et al., (2007), many developing countries have already experienced weather events in terms of floods, droughts, heat waves and tropical cyclones that are more frequent or intense than previous experiences and the resulting impacts point to the consequences on the environment, production system and livelihoods from future climate variability and change, hence to minimize the impacts of climate change requires a knowledge of the perception and adaptation of climate change strategies to deal with the phenomenon.

Adaptation to climate change is not a scenario for the future; it is an existing reality, already underway in many parts of the world. As mentioned, the contrasts between adaptation in the developed and developing world are striking and in the short-term at least, climate change is creating winners and losers, not surprisingly, the winners are primarily rich, industrially developed countries (Bals, Christoph et al. 2008). According to Porter et al. (2014), in the past 30 years climate change has contributed to global agricultural production declining by 1-5% per decade. Its effects are also predicted to manifest in severe consequences for the global agricultural sector, especially in tropical and sub-tropical regions (Dewi, 2009; Thornton, 2012). Where the economies of a majority of countries are largely driven by the agricultural sector, such as in sub-Saharan Africa, the impacts of climate change are particularly severe. Higher temperatures affect yields of crops, and encourage weed and pest proliferation.

Studies by the International Food Policy Research institute (IFPRI) have showed that increased floods and droughts increase the likelihood of short-run crop failures and long-run production declines in both crops and animals (IFPRI, 2009). If left unchecked, the climate change is expected to lower global per capita Gross Domestic Product (GDP) by 20% in 2020, threatening global food security *Stern, 2006). The African continent is perceived as particularly vulnerable to climate change impacts due to its nearness to the equator as well as high poverty levels and low adaptive capacity (Pidwirny, 2006 and IPCC, 2007).

As anticipated, the rise in temperatures would greatly affect regions where temperatures are already high, leading to high evaporation losses that would impact on sectors like agriculture (IPCC, 2007 and Mertz et al. 2009). The semi-arid region of Africa is an area already characterized by climatic variability on both inter-annual and multi-decadal scales and prone to droughts, represents one region that is particularly vulnerable to climate change (Nassef et al., 2009). The smallholder farmers' population in West Africa mostly in arid and semi-arid regions whose livelihoods circle around crop production and livestock rearing are thus perceived to be significantly at risk as climate change would impact on the availability of the water, vegetation growth and critical inputs for agricultural production (Nori et al., 2008)

Agriculture remains at the heart of Ghana's economy and society. It is estimated that over 50% of the working population is engaged directly in agriculture, and that the sector historically contributes to approximately 40% of the county's gross domestic product (Government of Ghana 2007). According to ISSER (2013), agriculture continues to be the main contributor to the economy of Ghana. Agriculture contributed 22.7% to the GDP and it was the biggest source of foreign exchange, accounting for about 40% of Ghana's foreign currency earnings; and the main producer of two-thirds

of the domestic food need in 2012(ISSER, 2013). Also, the bulk of agricultural production remains concentrated in the hands of smallholders, approximately with 2.75 million households engaged in the sector and approximately 90% of landholdings less than 2 hectares in size. The country is classified as generally food secure (although pockets of food insecurity exist in each of Ghana's regions), producing 51% of its cereal needs, 60 % of fish requirements, 50% of meat needs and relying on imports to cater for the deficit (Government of Ghana 2007). However, despite all the importance agriculture offers to the economy, the sector is bedeviled by the adverse impacts of climate change and extreme weather events (Akudugu, 2012). The Northern region of Ghana is one of the driest savannah regions of Ghana, where an increasing number of droughts, floods and bushfires heavily affect nature and humans (Daze, 2013). It is found to be one of the most vulnerable and exposed regions to climate change and variability in Ghana (Etwire et al., 2013; Stanturf et al., 2011). Farmers' willingness to accept and use prescribed measures could be enhanced if their perceptions and understanding are considered in designing such measures. By contrast, current models used in predictions of climate change and adaptation practices are at a global scale and need to be downscaled to accommodate realities at the community level (Nhamo, N.;Daniel, M.; Fritz, O. T 2014). This study seeks to add on exiting knowledge to help smallholder farmers mitigate the impact of climate change on agriculture.

Statement of Problem

Ghana's economy can be best described as agrarian, with the agricultural sector contributing 21.3 percent of GDP and employing 55 percent of the work force, as mainly smallholder farmers (Ghana Statistical Service [GSS], 2013). Agriculture is predominantly rain fed and exposes agricultural production to the effects of present climate variability and the risks of future climate change. In the Savelugu Nanton

district of Ghana, agriculture production is the dominant source of food and household incomes for the vast majority of rural households.

Agriculture production is largely rain-fed. Farmers' dependence on an annual mono-modal rainfall pattern coupled with farm resource constraints make agriculture very vulnerable due to the impact of climate change.

Climate change has had significant impacts on agriculture in Ghana which has led to the initiation of several initiatives to address and mitigate these challenges. This includes the Climate Smart Agriculture (CSA) which involve sustainable and resilient agricultural techniques including crop diversification. Weather Information Services are provided for farmers and Irrigation Systems has increased to reduce vulnerability of rain dependent agriculture. Also, research and extension services have been made to develop and disseminate crop varieties and techniques that are more resilient to changing climatic conditions. Several research have been conducted on the effect of climate change on agriculture in Ghana. This include a report published by the United Nations Development Programme (UNDP) on the topic "Climate Change and Food Security in Ghana: A Review of Climate Change Impacts on Food Security and Livelihoods". This report provided an overview of the impact of climate change on food security and livelihoods in Ghana. In addition, a research paper published on the topic "Farmers' Perceptions and Adaptation to Climate Change: A Case Study of the Sekere-Afram Plains in Ghana" which investigated farmers perception and adaptation strategies regarding climate in a specific region in Ghana. There has not been much research conducted in the Savelugu Nantom District in the Northern Region of Ghana to find out the impact of climate change on agriculture considering the climatic condition of the area.

Research Objectives

The main research objective for this study is to assess the perceived impact of climate change adaptation on smallholder farmers in the Savelugu Nantom District in the Northern Region of Ghana.

Specifically, the study seeks to

- Find out perceived long term temperature and rainfall change (climate trend) in the District
- Identify smallholder farmers' perceived adaptations to climate change impacts.
- Find out smallholder farmers' perceived constraints to adaptation to climate change

Research Questions

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

- What are smallholder farmers' perceptions of long-term temperature and rainfall change (trend)?
- What are smallholder farmers' adaptations to climate change impacts?
- What are the perceived constraints to adaptation to climate change by smallholder farmers?

Significance of Study

In order to enhance policy towards tackling the challenges climate change poses to farmers, it is important to have knowledge of farmers' perception on climate change, their choice of adaptation methods and the barriers affecting adaptation to climate change.

Current knowledge of adaptation and adaptive capacity on climate change in the Northern Region is insufficient for prediction of adaptations considering the regions climatic condition. It is also insufficient for rigorous evaluation of planned adaptation options, measures and policies of the government since many research have not been conducted in the study area.

Adaptation to climate change has the potential to substantially reduce many of the adverse impacts of climate change, reduce vulnerabilities and promotes sustainable development through enhancing the welfare of the poorest members of society (Acquah, 2011). Farmers in the Savelugu Nanton District in the Northern Region are no exception as they also experience the challenges of climate change. Therefore, there is a need for farmers to adapt to climate change in order to improve their agricultural production.

This work will provide vital information on strategies smallholder farmers in the Savelugu Nanton District are using to adapt their farming to climate change in order to reduce losses, to improve their livelihood resources obtained from agricultural production activities. Again, the findings of this study will be relevant to the farmers, the researchers, policy makers, the government and international organizations for information and policy formulation like the National Climate Change Policy to guide actions in addressing climate change and its effect on agriculture. .

Delimitation of the Study

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

Limitations of the Study

The inability of the student researcher to interact with the respondents directly to have firsthand information served as a limitation to data collection. Most of the farmers are not educated and they do not keep adequate records of the challenges climate poses, so much of the study relied on farmers' ability to recall climate change situation in the area. In addition, most of the farmers do not keep records of their farming activities and it was difficult getting actual and accurate data; the study therefore relied heavily on the ability of the respondents to recall their farming activities. The results of the study may not be generalized since the study was carried out in one community in the district.

Organization of the Study

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

Key Terms

Smallholder Farmers: Smallholder farmers are individuals or households who own or manage small plots of land and engage in agricultural activities for their livelihoods. They typically have limited resources, including land, capital, and technology, and rely on subsistence farming or small-scale production.

Perception: Perception refers to the process by which individuals or groups interpret and make sense of information received from their environment or experiences. In the context of climate change, it involves how people understand and mentally process changes in weather patterns, temperature, and other environmental factors.

Climate Change: Climate change refers to long-term alterations in temperature, weather patterns, and other climatic variables on Earth. It can result from natural processes or human activities, such as the emission of greenhouse gases. Climate change encompasses both gradual shifts in climate (e.g., global warming) and more immediate changes (e.g., extreme weather events).

Adaptation: Adaptation, in the context of climate change, involves making adjustments or changes in response to the impacts or anticipated impacts of changing climatic conditions. It includes strategies, practices, and measures designed to reduce vulnerabilities and enhance resilience to the effects of climate change, such as altered rainfall patterns, increased temperatures, or more frequent droughts

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This chapter presents review of relevant literature on the major issues of climate change, empirical review and theoretical review.

Concept of Climate Change

In everyday life, climate plays important role in shaping natural ecosystems, human economies, and cultures which all depend on its elements in diverse ways. However, Department of Ecology, State of Washington (2015) notes that current state of various climatic elements is not what it used to be, and hence the past is no longer a reliable predictor of future occurrences. Climate is the average weather conditions of a particular geographical area, measured over a longer period (National Aeronautics and Space Agency, 2008).

Generally, climate refers to the patterns of variation in variables such as temperature, rainfall, humidity, wind, atmospheric pressure and precipitation. Climate change is a long-term continued change, either increase or decrease, in the average weather condition. According to the Intergovernmental Panel on Climate Change (IPCC, 2012), climate change is the changes in the climate condition as a result of the changes in the mean and/ or the variability of its properties and that which persists for an extended period, typically decades or longer. Climate change is known to be caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. However certain human activities have also been identified as significant causes of recent climate change, often referred to as "global warming" (National Research Council, 2010).

The United Nations Framework Convention on Climate Change (UNFCCC, 1992) defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes. According to De Chavez and Tauli-Corpus (2008), global warming is the average increase of the earth's surface temperature and oceans as compared to previous centuries. This is a result of the continuous trapping of heat within the earth's atmosphere due to increased quantity of greenhouse gases. Global warming is one of the key aspects of climate change, and it can lead to the rise in sea levels, warm oceans and melt the glaciers thereby threatening agricultural productivity and human settlements. Other impacts may include; changes in rainfall patterns and increase in soil erosion, storms, floods and drought. The ultimate result at the end would be a deepening food crisis, as well as worsening weather, energy crisis and general environmental breakdown throughout the world.

Causes of Climate Change

The factors that can cause a change in climate are called climate forcing or forcing mechanisms. This include processes such as variations in solar radiation, variations in the Earth's orbit, variations in the albedo or reflectivity of the continents and oceans, mountain-building and continental drift and changes in greenhouse gas concentrations (NASA2010). Additionally, forcing mechanisms can be either "internal" or "external". Internal forcing mechanisms are natural processes within the climate system itself (for example, the thermohaline circulation). External forcing mechanisms

can be either natural (e.g., changes in solar output) or anthropogenic (for example, increased emissions of greenhouse gases).

The Royal Society 2010 concluded that Greenhouse gases such as carbon dioxide absorbs heat emitted from Earth's surface and the increases in the atmospheric concentrations of these gases cause Earth to warm by tapping more of this heat. Human activities especially the burning of fossil fuels since the start of the Industrial Revolution have increased atmospheric Carbon dioxide concentration by about 40%, with more than half of the increase occurring since 1970.Despite a strengthening consensus that the increase in anthropogenic emissions of greenhouse gases is partially responsible for the observed increase in global temperatures since the mid-20th century, scientific debates continues on several issues, including the relative size of individual causes of climate change such as sulfate aerosols(Kaufmann et al. 2011). The magnitude and timing of these changes will depend on many factors, and slowdowns and accelerations in warming lasting a decade or more will continue to occur. However, long term climate change over many decades will depend mainly on the total amount of Carbon dioxide and other greenhouse gasses emitted as a result of human activities.

Climate change is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (Smit and Pilifosova, 2003). Various activities carried out by human beings have varying contributions to the changes in the climate systems. The burning of coal, oil, and natural gas, as well as deforestation and various agricultural and industrial practices, are altering the composition of the atmosphere and contributing to climate change. These human activities have led to increased atmospheric concentrations of a number of greenhouse gases.

Impact of Climate Change

Climate is rapidly changing with disruptive impacts in many ways in all parts of the world (Karl & Trenberth, 2003). The changes being experienced appear faster than any seen in the last 2,000 years, climate change and variability thus present additional obstacles to ending poverty and improving standards of living (Department of Ecology, State of Washington, 2015). Karl & Trenberth (2003) describe climate change as a global issue which may prove to be humanity's greatest challenge. This could be true considering its significant consequences to livelihoods of many people around the world (Boyd et al., 2009). Although climate change is a global phenomenon, its effects and impacts on people are varied across different parts of the world, with the developing world being much exposed (Adger et al., 2003).

In developing countries, a greater proportion of people engage in livelihood activities pertaining to primary production, making the impact of climate change more intense than in developed areas where secondary activities dominate (IPCC, 2007: 2012). Besides, a greater proportion of peoples' livelihoods in the developing world is predominantly dependent on natural resources, which predisposes them to the negative impact of climate change (Mawunya and Adiku, 2013). In Africa, climate change is a major challenge and a threat to agricultural livelihoods and food security of many rural people living in the region Agriculture is the most vulnerable sector to climate change due to the sensitivity of its activities to weather and because people engaged in it tend to be poorer compared with other sectors (Aniah et al., 2014). Therefore, variations in rainfall patterns and temperature adversely impact their economic and social survival. The main long-term key impacts include significant changes in rainfall patterns and temperature which affect agriculture, which invariables lead to a projected significant reduction in food security; worsening water security; decreasing fishing resources in

large lakes due to rising temperature; increasing vector-borne diseases; rising sea level affecting low-lying coastal areas with large populations; and rising water stress (APF, 2007). Ghana's economy relies heavily on rain-fed agriculture, energy, and forestry. About 70% of the population depend on agriculture and forestry. Climate change modeling projections indicate that the country is very vulnerable to climate variability and change with projected rises in temperature, declines in rainfall, and shifts in the timing and intensity of weather events (Smith et al. 2002).

Trends of Climate Change in Africa

According to Juana et al., (2013), the historical climate trend in Africa shows warming temperature of approximately 0.7°C and over most of the continent during the twentieth century, a decrease in rainfall over large portions of the semi-arid region south of the Sahara and an increase in rainfall in east and central Africa. Over the twenty first century, these trends are expected to continue and be accompanied by a rise in sea level and an increased frequency of droughts and floods (IPPC, 2001). The same study conveyed that in all the regions of sub-Sahara Africa the temperature has shown an increasing trend and the precipitation pattern showed a 2% increase in West Africa and 7% increase in East Africa, but a 4% decrease in southern Africa. Other studies have predicted a general decrease in precipitation and water availability. Between 1970 and 1995, Africa has experienced a 2.8 times decrease in water availability, and since 1970, average discharge of West African rivers has dropped by 40-60% (Shiklomanov, 1997). Arnell (2004) predicted that about 370 million African people will experience increases in water stress by the year 2025, while about 100 million people are likely to experience a decrease in water stress by the year 2055 as a result of a likely decrease in precipitation. In the Nile region, many studies on water availability estimate a decrease

in river flow up to more than 75% by the year 2100, with implications for agriculture, conflict and livelihoods of the poor (Nyong, 2005).

In addition, a study conducted by Seid (2016) in western Ethiopia indicated that the average annual temperature increases by about 0.096oC each year. The same study witnessed that the total amount of annual rainfall in the study area decreases by about 46.75 mm each year. Severe droughts have been recorded for southern Africa. Over parts of southern Zimbabwe and south-eastern Botswana, rainfall amounts were as low as 10 percent of the average value during the rainy season of 1991/92.

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

Trends of Climate Change in Ghana

Ghana is located in West Africa on the guinea coast and has a tropical climate. Agriculture constitutes the mainstay of Ghana's economy, accounting for 21.3 percent of GDP and employing 55 percent of the economically active population (GSS, 2013). Agriculture is predominantly rain fed, which exposes it to the effects of climate variability and the risks of future climate change. The rainforest zone may experience an increase rain fall but this may have implications for erosion and floods coupled with drifting of climate induced migrants from the north to this zone in search of better

livelihoods and serving as source of farm labour for an increased encroachment into forest reserves for extensification of cocoa, palm and other crops. This certainly will aggravate deforestation rates.

Increased climate variability reflected in changing climate regimes on agriculture is evident (World Bank, 2011). Annual rainfall in Ghana is highly variable on inter-annual and inter-decadal timescales and long-term trends are difficult to identify. Rainfall over Ghana was particularly high in the 1960s, and decreased to particularly low levels in the late 1970s and early 1980s, producing an overall decreasing trend in the period 1960 to 2006, with an average precipitation of 2.3 mm per month (2.4 percent) per decade (UNDP & NDPC, 2010). Projections for precipitation indicate a cyclical pattern over the period 2010-2050 for all regions, with high rainfall levels followed by a drought every decade or so (UNDP, 2000; World Bank, 2010b). According to (UNDP and NDPC, 2010), temperature data since 1960 indicates that mean annual temperature has increased by 1.0˚c, at an average rate of 0.21˚c per decade. The rate of increase has been higher in the Northern Region of the country than in the South. Daily temperature data indicate that the frequency of 'hot' days has increased extensively in all seasons except for December, January, and February, and the frequency of 'hot nights' has increased considerably in all seasons (UNDP & NDPC, 2010). The mean annual temperature is projected to increase by 1.0 to 3.0°c by the 2060s, and 1.5 to 5.2°c by the 2090s (UNDP, 2000; World Bank, 2010b). The projected rate of warming is most rapid in the northern inland regions of Ghana. When considering the Ghana dry climate scenario, temperatures in the three regions of the north are projected to increase by 2.12.4°c, in the western, western-central, and Volta regions by 1.7-2.0°c, and in the Brong Ahafo region by 1.3-1.6°c. UNDP and NDPC, (2010) further indicated that most projections show substantial increases in the

frequency of days and nights that are considered 'hot' in current climate, but the range of projections between different models is large.

Smallholder Farmers' Perceptions of Long-Term Temperature and Rainfall Change

Climate change is real but there is uncertainty on the exact nature and consequences of decision making on how to respond (Rao 2013). Smallholder farmers' adaptation decisions are guided by their perception of climate change and variability, and climate related risks. The vulnerability, resilience, coping and adaptive capacity of farmers to climate change and variability in semi-arid systems could be addressed through different adaptation strategies. Smallholder farmers need to be able to identify the changes already taking place in their areas and institute appropriate coping and adaptation strategies. A farmer's ability to perceive climate is a prerequisite for their choice to cope and adapt (Moyo et al., 2012; Kihupi et al., 2015).

The coping and adaptation strategies of smallholder farmers depend, to a large extent, on their perception knowledge level on climate change (Kihupi et al., 2015). In essence, adaptation to climate change and variability requires farmers to first notice that the climate has changed, and then need to identify and implement potential useful adaptations (Adger et al., 2005). According to Acquah & Onumah (2011), rural farmers, whose livelihoods depend on the use of natural resources, are likely to bear the brunt of adverse consequences and their perception of climate change is crucial in reducing their vulnerability and increasing resilience to the negative impacts of climate change. Recent studies suggest that climate change is happening faster than had been reported by the IPCC assessment of 2007.

The temperatures are expected to increase by 1.1 – 2.9 under low emission and 2.4 – 6.4 under high emission by the end of the century. The global South, notably the African continent is perceived as particularly vulnerable to climate change impacts due to its nearness to the equator as well as high poverty levels and low adaptive capacity (IPCC, 2007). Boko et al. (2007) assert that Africa is one of the most vulnerable continents to climate variability and climate change as a number of African countries are already facing semi-arid conditions that are challenging to agriculture productivity. The smallholder farmers' population in West Africa mostly in arid and semi-arid regions whose livelihoods circle around crop production and livestock rearing are thus perceived to be significantly at risk as climate change would impact on the availability of water, vegetation growth and critical inputs for agricultural production (Nori et al., 2008)

Ghana is a tropical country which experiences changes in weather elements. Ghana was documented to have completed its first National Communications to the United Nations Framework on Climate Change (UNFCCC) in 2000, which predicted the impacts of climate change. In this respect, Ghana is not an exception. The Ministry of Environment, Science and Technology (MEST) of Ghana (2010) alerted the public that climate change is a threat to Ghana's development prospects. The ministry also identified various types of climate change phenomena which Ghana has encountered such as clear signals of warming, uncertainty of rainfall, increasing frequency, intensity and duration of extreme weather events (e.g, floods, droughts, storms), among others. The global – level complexity of these phenomena can be clearly observed in the semi-arid regions of Ghana, particularly in the Northern, Upper East and Upper West Regions.

The devastating effects of climate change in the northern part of the country where poverty persists, have become an increasing concern. Various manifestations of climatic instability and change can be observed in northern Ghana, including floods that devastate large areas of near-ready grain fields, several episodes of late rains during planting seasons, persistent droughts affecting large portions of the region, increasing temperatures and declining precipitation. The Savelugu-Nanton District is located at the northern part of the Northern Region of Ghana. The area receives an average annual rainfall of 600mm which is considered enough for a single farming season. The annual rainfall pattern is erratic at the beginning of the raining season, starting in April and intensifying as the season advances, raising the average from 600mm to 1000mm sometimes.The district is characterized by high temperatures with an average of 34oC. The maximum temperature could rise to as high as 42oC and the minimum as low as 16oC. The low temperatures are experienced from December to late February, during which the North-East Trade winds (harmattan) greatly influence the Municipality.

Smallholder Farmers Perception of Climate Change

In the area of climate change, studies about farmers' perceptions of climate change have increasingly been regarded as important globally particularly in Africa. Studies have been used to understand how climate change is perceived at local levels and to recommend plausible adaptation strategies and public policies that match farmers' experiences and capacities to adapt. These perceptions of smallholder farmers on climate change is very important in the sense that it accord them the opportunity to adapt and minimize its effect on agricultural production. It has been said that awareness or knowledge about climate change is a precondition for mitigating or adapting to its adverse effects (Maddison, 2006).

There has been a lot of research on perception on climate change in the developed countries where the relationship between scientists and indigenous people is very high (Jan and Anja, 2007). Different empirical studies indicated farmers' perception about climate change. Ishaya and Abaje (2008) and Fosu-Mensah et al. (2012) have examined the indigenous people's perception on climate change and adaptation strategies in Kaduna State of Nigeria and the Sekyere District of the Ashanti Region of Ghana respectively. The result of their study revealed that indigenous people perceived that climate had changed and still continues to change due to human activities. Centre for Environmental Economics and Policy in Africa (CEEPA, 2006) highlighted that a high percentage of farmers in Africa have realized that the climate has changed significantly. Acquah (2011), assessed farmers' perceptions and adaptation to climate change as well as the socioeconomic determinants of willingness to pay for climate mitigation policies in Ghana. Through the using of descriptive statistics and the logit model the study results indicated that 60 percent reported that there had been a noticeable increase in temperature and 49 percent reported a decrease in rainfall. Other barriers included lack of credit and lack of information about climate change, high cost of adaptation and insecure property rights. Acquah and Onumah (2011), analyzed information collected from 185 farmers from Western Region of Ghana about their perceptions on, and adaptations to climate change in the region. While the majority of the farmers interviewed perceived increase in temperature and decreased precipitation as the climate change variables experienced in that region, only 18 percent of the respondents did not perceive any changes in the two climatic variables. While about 60 percent of the respondents reported the use of one or more adaptation methods, 40 percent did not adopt any adaptation measures. In Osun State, Nigeria, Sofoluwe, Tijani, and Baruwa (2011), surveyed 100 farmers to gather information on their

perceptions about changes in temperature and precipitation. The study used the multinomial logit model to analyze the factors that determine farmers' adoption of various climate change adaptation measures. The results showed that more than 75 percent of the respondents were aware of increase in temperature and decreasing precipitation in the region. The farmers reported that late planting, irrigation, soil conservation, planting different crop varieties are the common adaptation strategies used, and that lack of information on climate change impacts and access to credit, labour shortages, shortage of land and poor potential for irrigation are the barriers to adapting to the perceived changes in climatic conditions. The regression results showed that livestock ownership, access to loans, off farm income generation, gender and household size were the significant determinants of adapting to climate change impacts.

Maddison (2006) conducted a survey covering seven African countries and reported that significant numbers of farmers believe that temperature has already increased and that precipitation has declined in the countries. According to Maddison (2007), as experience increases, farmers are more likely to perceive changes in rainfall. To him, frequency of drought changes in the timing of rains increase with the number of years in farming. Consequently, without adaptation, the vulnerability of communal households that depend on agriculture would increase with climate variability and change. However, these smallholder farming communities have coped and adapted to the effects of climate change and variability over the years (Li et al., 2013). This creates the need for understanding the perception of the smallholder farmers to the impacts of climate change and variability at the local level (Kassie et al., 2013).

Smallholder Farmers Adaptation to Climate Change

Many functional definitions of adaptation to climate change have been fronted. Among these, Antle (2008) defines adaptation to climate as the adoption practices that

are relatively less vulnerable under the changed climate; while Wannasai et al (2013) call it the process through which societies are taking measures to reduce the negative effects of climate change. It has been referred to by IPCC report (2001) as adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects which moderates harm or exploits beneficial opportunities. Adaptation in agriculture is identified as one of the policy options to reduce the negative impact of climate change on agricultural productions (Kurukulasuriya & Mendelson, 2006).

Rural areas are characterized by the presence of diverse economic activities in order to cope with risky events and achieve a sustainable income stream over time (Lopez, 2008). Some are farm related and others are not. Various researches have shown that non-farm activities were growing in importance especially in Africa accounting for 40-45 percent of average household income (Barret et al., 2001). Adaptation in agriculture occurs at two main scales: household-level (micro) and national level (macro). Micro-level analysis of adaptation in agriculture focuses on tactical decisions that farmers make in response to seasonal variations in climatic, economic and other factors. These micro-level tactical decisions of households in agriculture include using different adaptation options. The most common micro-level adaptation options in crop agriculture include crop diversification, using irrigation, mixed crop-livestock farming systems, using different and new crop varieties that are better suited to drier conditions, changing planting and harvesting dates, and mixing less productive, drought-resistant varieties and high-yield water sensitive crops (Temesegen et al., 2008).

On the other hand, national level or macro-level analysis is concerned with agricultural production at the national and regional scales and its relationships with domestic and international policy (Bradshaw et al., 2004). For example, crop adaptation

measures can be supply-side measures (such as providing more water), demand side measures (such as reuse of water) and combinations of both. Deressa et al. (2009) identified changing crop variety, soil and water conservation, water harvesting, planting of trees, changing planting and harvesting periods as some of the methods employed by food crop farmers in Ethiopia. Among these, tree planting was dominant method adopted by most of the farmers.

The Ghanaian economy is agricultural driven with about 60 per cent of the population involved in the growing of crops and rearing of animals at the subsistence level as a means of survival (Alhassan & Dio, 2007). This implies that the majority of land in the country is mainly used for agricultural cultivation (MoFA, 2008). Agricultural production in Ghana is still highly dependent on rainfall although initiatives have been put in place with the introduction of irrigation farming in recent years (MoFA, 2008). T. Wheeler et al, 2009 asserts that the key to the ability of farmers to adapt to climate change and variability will be access to relevant knowledge and information but other studies such as (Wannasai et al., 2013) further suggest that adaptive capacities should be established earlier on. He suggested land size, cropping intensity, poverty incidence and literacy rate as indicators of vulnerability of this process.

Characterizing Adaptation and Determinant of Adaptation Choice Strategies

The Intergovernmental Panel on Climate Change is a useful starting point, defining adaptation as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities' (IPCC, 2001). Adaptation can be categorized more specifically into various types and forms: in terms of timing it can be 'anticipatory' or 'reactive', and on the level of preparation and outside intervention, it can be either 'planned' or

'autonomous' (Tol, Klein, Richard., Nicholls, & Robert, 2009). In practice, adaptation actions tend to constitute 'on-going processes, reflecting many factors or stresses, rather than discrete measures to address climate change specifically' (IPCC, 2007a). As to Maddison (2006) finding, educated and experienced farmers are expected to have more knowledge and information about climate change and the agronomic practices that they can use in response. In addition, the same study found that farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making.

Factors that affect the decision of farm households to use/choose among crop adaptation strategies can include access to information, household financial capacity, lobar, education, age, marital status, gender, farm (plot) characteristics, and access to extension and credit, and input and output markets (Veronesi, & Yesuf, 2011). Large-scale farmers are more likely to adapt to climate change because they have more capital and resources (Hassan and Nhemachena, 2008). Productive resources such as capital, land and labor serve as important factors for coping with and adapting to climate change. The choice of the suitable adaptation measure depends on factor endowments (i.e. family size, land area and capital resources) at the disposal of farming households (Hassan and Nhemachena, 2008).

Temesgen et al. (2008) found that farm income of the households has a positive and significant impact on conserving soil, using different crop varieties, and changing planting dates. In addition to farm income, nonfarm income also significantly increases the likelihood of planting trees, changing planting dates, and using irrigation as adaptation options. Availability of better climate and agricultural information helps farmers make informed and comparative decisions among alternative crop management

practices and this allows them to choose a better strategy that makes them cope well with changes in climatic conditions (Nhemachena & Hassan, 2007).

Lack of information (about seasonal and long-term climate changes and agricultural production) can constraint farmers from adopting different climate change adaptation strategies thereby increasing high downside risks arising from failures associated with non-uptake of new technologies and adaptation measures. Farmers who lack capital and other resources will fail to cover costs necessary to take up adaptation measures and thus may not make beneficial use of the information they might have.

The availability and quality of labour can affect the involvement of households in other income (money) generating activities. Farm households with more available and quality labour can have higher probability to get involved in other income generating activities (Kandlinkar & Risbey, 2000). On the other hand, education is an important source of information for farm-level management activities. Many studies have confirmed that having better access to extension services increases the probability of adopting different adaptation measures (Aymone, 2009; Temesgen et al., 2009). Farmers with better extension services access are more likely to be aware of changing climatic conditions and expected to have good knowledge about different types of adaptation measures in order to reduce climate change impact or to exploit the advantages. Information on climate change impact also increases the likelihood of using different crop varieties as an adaptation measure. Having access to farmer-to-farmer extension increases the likelihood of using different crop varieties and planting trees (Temesgen et al., 2008). Similarly, age can also affect the quality of labour as it is connected with experience. Elder household heads are expected to have more experience in farm practices and management (Nhemachena & Hassan, 2007).

Limited market access also can negatively affect the potential for farm-level adaptation. Farmers with access to both input and output markets are likely to have more chances to use adaptation measures. Input markets allow farmers to acquire the necessary inputs required to take adaptation measures. On the other hand, access to output markets provide farmers with positive incentives to produce cash crops that can help improve their resource base and hence their ability to respond to changes in climatic conditions (Mano et al., 2003). Generally, the determinants of adaptation and choice of adaptation strategies differ from region to region as well as from time to time.

Smallholder Farmers' Perceived Importance of Adaptation practices

In regard to adaptation to climate change, Singh et al (2014) suggests that adaptation measures should be evaluated continuously, and learning should be complemented by experience gained from micro-level (households/ village/ community). Profitability is a key factor affecting farmers adaptation decisions besides their perceptions of and capability to adapt to climate change (Antle 2010). They will choose crop varieties for their resilience to stresses or plant according to site specific conditions but working together with the enabling household characteristics in ways that take advantage of the changed conditions.

In general, subsistence farmers have a low tolerance for risk because they are close to the borderline (FAO 1995) in terms of savings and liquid assets and would not risk their family welfare on untrusted technologies. Naess et al. (2010) indicate that understanding local perceptions of climate change is helpful because this understanding can help identify more precisely what is required to strengthen local climate resilience, aids in identifying specific constraints that different actors and groups face, uncovers a more holistic appreciation of adaptation in relation to particular socio-economic, political or historical contexts and provides policy makers with data about how climate

change impacts are felt at the local level, the challenges and opportunities that people face in adjusting their livelihoods and the assistance that should be provided.

Dinar et al., (2008) highlighted that yields could fall quite dramatically in the absence of costly adaptation measures. Moreover, Kurukulasuriya and Mendelsohn (2008) stated that the negative impacts of climate change can be significantly reduced through adaptation strategies. Therefore, there is a need for investments to improve agricultural productivity under the risk of climate change (Schlenker and Lobell, 2010).

Perceived Constraints to Adaptation to Climate Change by Smallholder Farmers

Constraints is defined as something that could reduce the willingness or capacity of individuals, business or other organizations to adapt to the impacts of climate change Productivity Commission (2011). This means that the existence of barriers is likely to make farmers in particular and communities in general not to effectively adapt to climate change impacts. A study by Jones (2010), identified three broad categories of barriers to adaptation. Ecological and physical limits which comprise the natural limitations to adaptation, associated largely with the natural environment, ranging from ecosystem thresholds to geographical and geological limitations. Human and informational resource-based limits relating to knowledge, technological and economical restrictions. Social barriers are made up of various processes relating to cognitive and normative restrictions that prevent individuals or groups from seeking the most appropriate forms of adaptation.

A perception analysis performed by Bunting et al. (2013) illustrates how a household's ability to create more resilient livelihood outcomes is influenced by environmental conditions and socio-economic institutions. Studies of climate change scenarios of future impacts (until 2050) such as by IFPRI (2010) have concluded that,

families with higher incomes are better able to experiment with new technologies and management systems that might be costly upfront but offer big productivity and resilience pay offs in the future. Many researchers have indicated that access to credit increases the likelihood of adaptation (O'Brien et al., 2000; Temesgen et al., 2008; Aymone, 2009; Temesgen et al., 2009). O'Brien et al. (2000) also pointed out that, despite numerous adaptation options that farmers are aware of and willing to apply, the inadequate access to financial resources to purchase the necessary inputs and other associated equipment (e.g., purchasing seeds, acquiring transportation, hiring temporary workers) is one of the significant constraints to adaptation. According to Chiotti et al 1997, constrains to adaptation of climate change include a number of climatic factors such as (temperature, rainfall, seasonal frequency and climate variability), social factors (socio-economic, demographic characteristic, market factor, suitability of technology) and economic factors (financial resources, product price and investment, the support from government agency).

As to Gandure et al., (2012) finding, lack of access to adequate cropland was a barrier for farmers to adapt to climate change. The rural area generally has high vulnerability or less capacity for adaptation. Also, Information on climate change, social capital, age of household head, wealth and agro ecological settings have a significant impact on farmers' perception of climate change (Deressa et al; 2009). Madison (2006) showed that access to information through extension increases the chance of adapting to climate change whereas lack of information on choice of adaptation options, lack of financial resources, shortage of land, poor potential irrigation and labour constraints are factors inhibiting climate adaptation (Deressa et al., 2008).

Empirical Review

Wheeler (2013) examined the impacts of climate change on water availability for agricultural purposes and its implications for agricultural water management. They examined the potential effects of irrigation water supply, soil moisture and crop water requirement. The researchers combined climate models and hydrological simulations to project changes in water resources and the study concluded that climate change would lead to changes in water availability, intensity of drought, shift in precipitation patterns and changes in the timing of snowmelt. The study emphase the need for adaptive water management strategies like improved irrigation, water harvesting techniques and the development of drought tolerant crop varieties.

DaMatta (2016) assessed the long-term impact of climate change on coffee production in Brazil and explore adaptation strategies. The study considered historical climate data, coffee yield data, and statistical models to analyze the relationship between climate variables and coffee productivity. The study concluded that increasing temperatures and changing rainfall patterns posed significant challenges to coffee production in Brazil. It emphasized the need for implementing climate-smart agricultural practices, such as shade management and water conservation techniques, to mitigate the adverse effects of climate change on coffee yields. Tis study recommended that the development and promotion of heat-tolerant coffee varieties, improved water management practices, and the establishment of early warning systems to support coffee farmers in adapting to climate change.

Deressa (2011) assessed the vulnerability of smallholder farmers in Sub-Saharan Africa to climate change impacts on agricultural food production. A household survey among smallholder farmers in multiple regions of Sub-Saharan Africa was conducted and it gathered data on climate change perceptions, farming practices,

adaptive capacity, and food security. The study found that smallholder farmers were highly vulnerable to climate change impacts, with increased temperature, changing rainfall patterns, and extreme weather events leading to reduced crop yields and income instability. Limited access to resources, lack of information, and weak institutional support were identified as key barriers to adaptation. The study emphasizes the need for targeted interventions to enhance adaptive capacity among smallholder farmers, including the provision of climate information services, access to climate resilient technologies and strengthening social safety nets to address food security concerns.

Nguyen (2017) examined the effects of climate change on rice production in Vietnam and identified the adaptation strategies. This study utilized historical climate data, crop yield data, and statistical modeling techniques to assess the relationship between climate variables and rice productivity. The study concluded that increasing temperatures and changes in rainfall patterns negatively impacted rice yields in Vietnam. The findings highlighted the importance of implementing adaptive measures such as the development of heat-tolerant rice varieties and improved water management practices and recommends the adoption of climate-resilient rice varieties, improved irrigation systems, and enhanced farmer education on climate-smart agricultural practices.

Fosu-Mensah (2012) examined the impact of climate change on maize production in Ghana and identified adaptation strategies for farmers. This study involved field surveys, data collection, and interviews with maize farmers. Statistical analysis and regression models were employed to analyze the relationship between climate variables and maize yields. The research revealed that rising temperatures and changes in rainfall patterns adversely affected maize production in Ghana and explained the importance of implementing climate-smart agricultural practices, such as

conservation agriculture and improved irrigation systems, to enhance resilience and mitigate the negative impacts of climate change. The study recommended that the provision of climate information services to farmers, the promotion of drought-tolerant maize varieties, and the development of supportive policies and programs to enhance climate change adaptation in the maize sector.

Theoretical Framework

Several theories can help us understand the impact of climate change on smallholder farmers and their adaptation strategies. Here are some key theories and perspectives.

Vulnerability and Resilience Framework

García Avila (2007), defines vulnerability as the process by which human population and ecosystems are subject to damage or threat due to social and biophysical factors. Water itself can be one factor of vulnerability**.** To address these concerns about vulnerability, we focus on the concept of resilience. Resilience has a robust history in ecology, beginning with Holling (1973); Folke (2006) describes the evolution of the term in ecology and in social-ecological systems analysis. The term's meaning has evolved over time. Originally, resilience most often meant a return to a previous state**.** This framework views smallholder farmers as vulnerable to climate change due to their dependence on climate-sensitive sectors like agriculture. It examines factors that contribute to vulnerability (e.g., socio-economic status, access to resources) and explores strategies to enhance resilience (e.g., diversification, community-based adaptation).

Theory of Ecological Modernization

This theory was originally developed by scholars like Joseph Huber, the theory of Ecological Modernization revolves around the idea that economic development and environmental protection can go hand in hand (Mol, Spaargaren, & Sonnenfeld, 2014). In the context of climate change impact on agricultural food production, this theory suggests that innovative, sustainable farming practices can improve food production while mitigating environmental impact. It emphasizes the role of technology, policy, and social innovation in addressing climate-induced challenges in agriculture (Mol & Spaargaren, 2016).

Commons Dilemma Theory

This theory explores how smallholder farmers collectively manage shared resources (e.g., water, forests). It examines the challenges of overexploitation and offers insights into community-based adaptation approaches, such as cooperative resource management. According to Milinski et al.(2006), participants are required to decide how much to give for climate change mitigation, which is called a give-some game, as opposed to a take some game. However, when climate change is framed within the context of policy making and policy preferences, climate action is often framed as forgoing the short term benefit of economic growth and employment for the global public good. It is not giving but more akin to restraining oneself from taking more from public pool (Dawes 1980)

Cultural Ecology

Cultural ecology considers how cultural beliefs, practices, and indigenous knowledge influence smallholder farmers' interactions with their environment. It sheds light on the role of traditional wisdom in climate adaptation. Cultural ecology is the human interaction with the environment (Sutton & Anderson, 2010). Also, Frake

(1962) described Cultural ecology as the study of "the role of culture as a dynamic component of any ecosystem of which humans are a part". As a field of study, cultural ecology examines the relationship between a given society and its natural environment. The study of the culture, examining the discourses and practices that shape the relationships between individual and environment, provides insight about the factors affecting the development of self within socio- cultural contexts (Chabal & Daloz, 1999; Zachary, 2000).

Asare (2015) investigated the long-term impact of climate change on cocoa production in Ghana and explored the adaptation strategies for cocoa farmers. This study involved historical climate data analysis, interviews with cocoa farmers, and statistical modeling techniques used to analyze the relationship between climate variables and cocoa yields. The study revealed that rising temperatures and changing rainfall patterns posed significant challenges to cocoa production in Ghana. It highlighted the importance of implementing adaptation measures such as shade management, improved pest and disease management, and the promotion of climate-resilient cocoa varieties. The research recommended that the provision of extension services to educate cocoa farmers on climate-smart practices, the development of early warning systems for pest and disease outbreaks, and the establishment of financial support mechanisms to facilitate farmers' adoption of climate change adaptation strategies.

CHAPTER THREE

METHODOLOGY

Introduction

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

Study Area

The Savelugu/Nanton district is one of the districts carved out of West Dagomba in 1988. The District is located at the northern part of the Northern Region of Ghana. It shares boundaries with West Mamprusi to the North, Karaga to the East, Kumbungu to the West and Tamale Metropolitan Assembly to the South. The altitude of the district ranges between 400 and 800 feet above sea level. The district also has a total land area of about 2022.6 sq. km. with a population density of 68.9 persons per sq. km. The population of 106,284 is mostly rural and resides in 136 communities. This population is predominantly made of the youth and less than 15 years of age constitute as high as 49% of residents (UNICEF 2000).

Climate

The area receives an average annual rainfall of 600mm which is considered enough for a single farming season. The annual rainfall pattern is erratic at the beginning of the rainy season, starting in April and intensifying as the season advances, raising the average from 600mm to 1000mm sometimes. The district is characterized by high temperatures with an average of 34oC. The maximum temperature could rise to as high as 42oC and the minimum as low as 16oC. The low temperatures are experienced from December to late February, during which the North-East Trade winds (harmattan) greatly influence the Municipality.

Vegetation

The district is located in the Savanna woodland which could sustain large scale livestock farming, as well as the cultivation of food crops such as rice, groundnuts, yams, cassava, maize, cowpea and sorghum. The trees found in the area are drought resistant and hardly shed their leaves completely during the long dry season. Most of these are of economic value and serve as important means of livelihood, especially for women. Notable among these are shea trees (the nuts which are used for making shea butter) and dawadawa that provides seeds used for condimental purposes.

Natural Resources

The district is blessed with vast arable land with potential for both livestock and crop production. Tourism potentials in the district include the Saakpuli Slave Market, Tuunaayili, the former seat of the Dagomba Kingdom, Yoggu, which is said to be where the chief priest settled long ago, and an Oxbow Lake at Zonchangni. The district is, however, faced with unfavorable natural environmental conditions. There is little tree-cover, resulting in harsh harmattan seasons and its attendant bushfires resulting from the activities of farmers and hunters. The greatest threat however is the rate at which the tree vegetation is being cut down for fuel wood.

Geography

Two major rivers, the Volta and Nasia run through the district with numerous streams feeding into these rivers. Most of these streams dry up after the rainy season making it difficult for the inhabitants to have water for their activities. The vegetation is Savannah Grassland and the land is low-lying. There are two seasons, which characterize the climate in the district and these are the rainy season, which is from May to October and the dry season is from December to March when the North Westerly Harmattan Winds are most prominent.

Road/Transport

A greater portion of the district is accessible to transport throughout the year except the Kudanali area in the Pong Tamale sub-district due to flooding from the Volta river and some streams. Telephone and postal facilities exist between Savelugu and other parts of the country.

Economy

Majority of the people engaged in the production of food crops at a subsistence level. Cash crop production is very minimal and includes shea nut, soybeans and cotton. Food crops produced include groundnuts, maize, millet, guinea corn, cassava, yam and cowpea. Agro Processing is generally carried out by traditional methods on a very small-scale. There is also a large plantation of grafted mangoes at Gushie, cultivated by ITFC which provides employment for a number of people in the area. Livestock reared on a small scale in the district include animals such as cattle, sheep, goat and fowls.

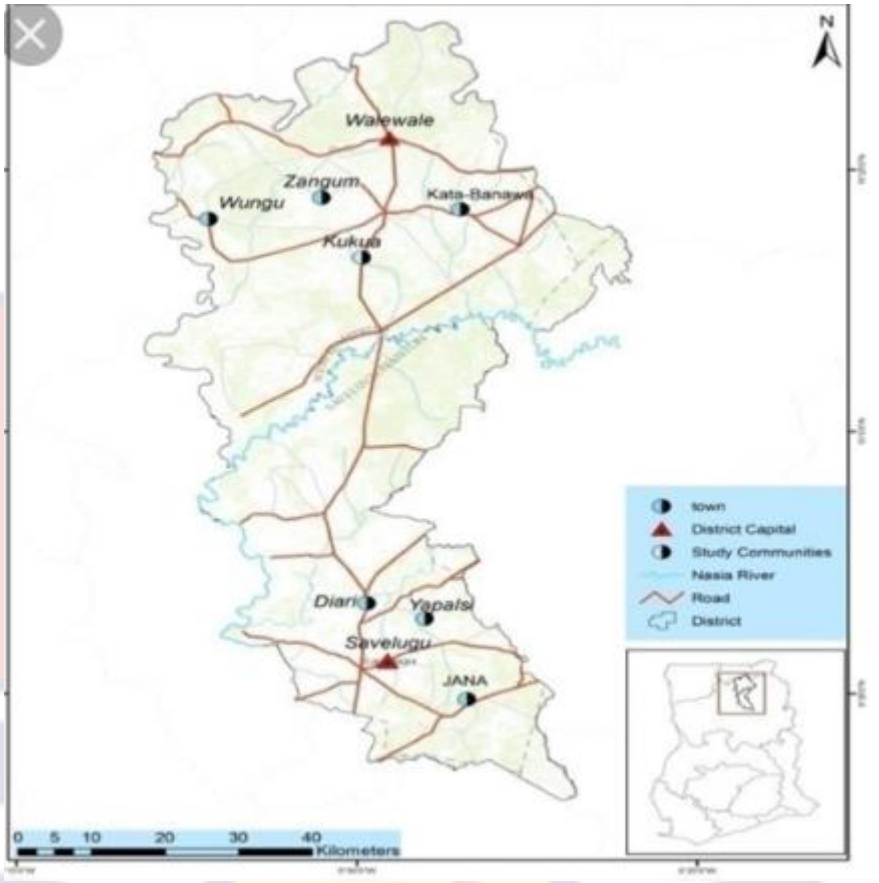

Figure 1 Savelugu Nanton District Map

Source : http://images.app.goo.gl/KLiuyn1NEMR5Lf9

Research Design

The study used quantitative methods to collect data in the study. The design was survey using questionnaires to compare responses across the respondents. Also, to seek understanding of the farmer's perspective or situation by regarding the respondents as experts of their situation. The questionnaire was divided into sections to collect data on the respondents' demographic characteristics, access to essential assets and adaptation strategies. In this study, demographic and socioeconomic data were summarized and presented using descriptive statistics such as frequency, percentage, graphs, figures, and tables.

This methodology was found appropriate for this study because the study aimed to investigate experiences of farmers with regards to the impacts of climate change and adaptation on smallholder farmers. A representative population of 123 smallholder farmers in Savelugu participated in this study farmers' perception of climate change and adaptation strategies in the study area.

The Study Population

The target population for the study includes all farmers producing crops in the Savalugu Nanton district.

Sample and Sampling Procedure

Non-Probability sampling technique was used to sample 123 participants for the household questionnaire administration during the survey. The sample size "n" where n is the sample size of the study, "N" is the total population and "e" is the margin of error. Collection and analysis of data for the study was derived from the Gomez and Jones (2010) formulae below;

n=N/ (1 + N(e)2)

From the 2010 Ghana Statistical Service Population and Housing Census, the total number of working populations between the 15 and 65+ engaged in Agriculture, Forestry and Fishery work is 44, 330. With a 0.09 margin of error.

n= 44,330/ (1 + 44, 330(0.09)2)

n = 44,330/ (1+ 44,330(0.0081))

n = 44,330/ (1+359.073)

n = 44,330/360.073

n = 123

Instruments

The primary data was collected through the use of self-administered questionnaires. The questionnaire were specifically designed to measure variables of the study. The variables were broadly categorized into socio-demographic characteristics, production activities, climate change information, adaptation measures in response to climate change and barriers to adaptation measures. The questionnaire for the farmers was grouped into 34 items with five sections, A-E. Section A extracted information on the socio-demographic characteristics of sampled population. Section B was on the production activities, Section C on climate change information, section D was on adaptation measures in response to climate change and finally section E, which was on barriers to adaptation measures.

Data Collection

One research assistant was selected from the district who understands the local dialect and is familiar with the study area and also a colleague from Accra who understands the local dialect. The research assistant was trained on how to administer the instrument. It involves the meaning and interpretation of the items on the interview schedule to the respondents. Data was collected by convenient sampling and snowball sampling where the nearest individual that can be included in the study was conveniently chosen to serve as respondent and was led to other smallholder farmers. It took almost two (2) days for the administration. Monitoring of the process of administration was also undertaken. Data was collected in March 2019.

Data Analysis

The study utilizes descriptive statistics. Descriptive statistics such as frequencies, charts, cross tabulations and percentages were used to present smallholder farmers' perception on climate change, farmers' decision to adapt to climate change

and the barriers to adaptation. Frequencies and percentages were used to describe farmers' sociodemographic characteristics depicted in objective one (1). Objective two (2) is to identify farmers' choice of adaptation measures in response to climate, thus frequencies and percentages were used to identify their choice of adaptation measures. For objective three (3), to investigate the determinants of farmers' adaptation to decreasing precipitation and increasing temperature. Objective four (4) was to identify barriers to farmers' adaptation measures in response to climate change. Descriptive statistics was used to illustrate the barriers affecting farmers. Statistical Package for Social Sciences (SPSS version 21.0) was used for all the analysis.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

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

Socio-economic Characteristics of the Respondents

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

Age Distribution of the Respondents

Table 1 presents the age distribution of the respondents. The study revealed that younger people are involved in the farming than the aged in the study area. The result implies that the older the farmer, the more experienced he/she is in farming and the more exposure he/she has had to past and present climatic conditions over longer periods of time. Furthermore, mature farmers are better able to access the characteristics of modern technology than younger farmers, who might be more concerned about profit than the long-term sustainability of their operations. As shown in Table 1 below, ages of the farmers ranged from 20 to 60and above years. The mean age of all the respondents is 36.65years with a standard deviation of 12.143.

Table 1: Frequency Distribution of Age of Respondents

Age	Frequency	Percent
16 - 20	15	12.2
21 - 25	11	9.8
26 - 30	15	12.2
31 - 35	17	13.8
36 - 40	18	14.6
41 - 45	18	13
46 - 50	14	11.3
51 - 55	5	4
56 - 60	9	7.3
61 And Above	3	2.4

Source: Field survey data, 2019

Cross-tabulation between Marital Status and Sex of Smallholder Farmers

The marital status and sex of the respondents were investigated and presented in Table 2. The number of male respondents who were married was more than that of the females.

Table 2: Cross Tabulation Between Marital Status and Sex of Respondents

Sex	Marital Status of Farmers			
	Single	Married	Widowed	Co-habitating/consensual relationship
Male	23	70	3	4
Female	0	21	2	0
Total	23	91	5	4

Source: Field survey data, 2019

It could be attributed to the fact that because some males marry more than one wife, they could only become widowed if and only if all the wives are dead. Thus, the

probability of men becoming widowed is less than that of the women. Also, it is tangible to adopt the reason given by Ducan and Brants (2004), who found similar results in the Volta Region that this could be related to differences in remarriage patterns between widowed men and widowed women. Also, traditionally, most of the household heads in the study area should always be a male or the husband rather than the female or the wife unless the man is debilitated due to accident or illness.

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

Educational Levels of the Respondents

Education is extremely important in that it facilitates individuals to make informed decisions that impact their health and wellbeing. Education also provides people with the knowledge and skills that can lead to a better quality of life. Literacy is widely acknowledged as benefiting both the individual and society and, in particular among women. Table 3 presents the distribution of male and female rice farmers according to their educational background characteristics.

Table 3: Frequency Distribution of Educational status of Smallholder Farmers

Educational Level	Frequency	Percentage
No formal education	22	17.9
Primary School	49	39.8
Middle School leaver/ Junior high	52	42.3
Total	123	100

Source: Field survey data, 2019

Majority 82.1 percent of the smallholder farmers in Table 3 had some formal levels of education, whilst 17.9percent did not have any form of formal education. With respect to formal education, majority 42.3 percent of the respondents acquired middle school or junior high education, whilst 49 percent of the respondents also had primary education. In Ghana, it is generally believed that education standard up to JSS or Middle School level is enough to make one literate (GSS, 2004). The impact of the level of education on agriculture stems from the fact that farmers who are literate, generally tend to adapt innovations quickly which increase total factor productivity of agricultural development in general (Adesina & Djato, 1996). The 89.7 percent

The Experience of the Respondents

Farming experience plays an extremely important role in decision making of what to produce, when to produce, how to produce and how much to produce to satisfy the demands of the prevailing markets. Farm households with more available and quality labour can have higher probability to get involved in other income generating activities (Kandlinkar & Risbey). The smallholder farmers farming experience of respondents is shown in Table 4. Out of the 123 respondents interviewed, 35.9 percent of them had been engaged in farming between ten to eighteen years and 33.5 percent had farming experience between twenty to forty years.

Table 4: Farmers Experience

Years Involved in crop Production	Frequency	Percentage
1 - 10	49	40
11 - 20	45	36.9
21 - 30	11	18.5
31 - 40	10	7.2
41 - 50	1	0.8

Source: Field survey data, 2019

The farmers had farming experience ranging from 1 to 50 years with a mean experience of 20 years and a mode of 20. Majority 95.4 percent of the farmers had farming experience less than 31 years. The average years of farming experience revealed that virtually all farmers have wealth of experience. These results confirm Gbetibouo (2009) that experienced farmers have diverse skills in farming techniques and management and are able to spread risk when faced with climate variability. Highly experienced farmers tend to have more knowledge of changes in climatic conditions and the relevant response measures to be applied.

Farm sizes of the Respondents

The farm sizes of the smallholder farmers under cultivation are small with an average of 2.2 acres. Finding indicates that 43.1 percent of the smallholder farmers interviewed had farm size of two (2) acres. This is followed by a farm size of three (3) acres with 29.3 percent whereas 13. 8 percent of smallholder farmers had farm lands less than one (1) acre and more than three (3) acres each from table 5. This result clearly reveals that the farm sizes under cultivation are small; with a minimum farm size in acre of 1 and maximum of 3 acres

Table 5: Farm Size

Farm Size	Frequency	Percentage
Less than 1 acre	17	13.8
1 acre - 2.0 acres	53	43.1
2.1 acres - 3.0 acres	36	29.3
Above 3.0 acres	17	13.3

Source: Field survey data, 2019

This finding is consistent with Aryeety & Nyanteng (as cited by Owusu, 2011) that food crop producers are predominantly small-scale in terms of the area cultivated. The small land areas under cultivation may be attributed to the land tenure system pertaining in the production area.As indicated by Hassan and Nhemachena, 2008, Large-scale farmers are more likely to adapt to climate change because they have more capital and resources. Small scale farmers on the other hand are less likely to adapt to climate change due to lack of capital and resources.

Financial Resources available for Production

Finance plays a very important role in smallholder farmers since it determines farmers' ability to secure farm inputs for the establishment and maintenance of farms. Access to credit for productive purpose can effectively reduce the vulnerability and improve their household welfare. This therefore necessitates investigating access to finance and financial credits. From the findings of the study, money lenders form a major source of financial capital for establishing smallholder farms in the study area with 56.9 percent, with 22 percent of means of funding from personal savings. Family and friends and Farming organizations formed 9.8 percent and 10.8 percent respectively being the least source of finance for smallholder farmers in the study area. These findings coincides with O'Brien et al. (2000) also pointed out that, despite numerous adaptation options that farmers are aware of and willing to apply, the inadequate access

to financial resources to purchase the necessary inputs and other associated equipment (e.g., purchasing seeds, acquiring transportation, hiring temporary workers) is one of the significant constraints to adaptation.

Table 6: Source of Finance

Source of Finance	Frequency	Percentage
Money Lenders	71	57.8
Family and Friends	12	9.8
Farming Organisation	12	9.8
Own Savings	28	22.8

Source: Field survey data, 2019

Farmers access to Extension Services

The results of the analysis in Table 7 showed that majority 53.8 percent of the respondents had access to extension services while 46.7 percent of smallholder farmers did not have access to extension services shown in Table 7.

Table 7: Extension Service

Access to Service	Frequency	Percentage
Yes	66	53.8
No	57	46.7
Total	123	100

Source: Field survey data, 2019

The main source of technical knowledge for the farmers is the District Agricultural Extension within the District Assembly and other Non-governmental organizations. Findings of the study is consistent with Gbetibouo (2009), who argued that farmers with access to extension services are likely to perceive changes in the climate because extension services provide information about climate and weather.

Also, Madison (2006) showed that access to information through extension increases the chance of adapting to climate change.

Consequently, awareness and perceptions of changes in climatic conditions shape action or inaction on the problem of climate change. Furthermore, access to extension services increases the likelihood of perceiving changes in climate, as well as the likelihood of adapting to such changes through the creation of opportunities for the farmer to adapt suitable strategies that better suit the changed climatic conditions. This suggests that extension services assist farmers to take climate changes and weather patterns into consideration, through advice on how to deal with climatic variability and change.

Monthly Incomes of the Respondents

Income is an important factor in household economies and therefore also in food security, since it allows greater access to food. The average income derived from production by the farmers in the Savelugu Nanton in the Northern Region of Ghana is 433 Ghana Cedis, with 11 percent earning below 200 Ghana Cedis, 27.6 percent earning between 200-400 Ghana Cedis, 45 percent earning between 401-600, 12.2 percent earning between Ghana Cedis 601-800, 8.1 percent of the respondents earning between Ghana Cedis 801-1000 while 4.1 percent earning above 1000 Ghana Cedis as presentenced in Table 8.

Table 8: Monthly income

Monthly Income	Frequency	Percentage
Below Gh200	14	11.5
Gh200 - Gh400	34	27.6
Gh401 - Gh600	45	36.6
Gh601 - Gh800	15	12.2
Gh801 - Gh1000	10	8.1
Above 100	5	4.1

Source: Field survey data, 2019

Smallholder Farmers Perception of Changes in Precipitation and Temperature

In an effort to examine whether the farmers' perceived changes in climate, the farmers were asked questions relating to their perception of temperature and rainfall pattern. Results revealed that 73 percent of small holder farmers identified decrease in rainfall or precipitation. Findings of this study is consistent with Sofoluwe, Tijani, and Baruwa (2011), who surveyed 100 farmers to gather information on their perceptions about changes in temperature and precipitation in Osun State, Nigeria. Their results showed that more than 75 percent of the respondents were aware of increase in temperature and decrease in precipitation in the region. Similarly, Maddison (2006), also reports that perceptions about climate change showed in a study that a significant number of farmers believe that temperature has already increased and that precipitation has declined for eleven African countries. Small holder farmers perception of changes in precipitation and temperature in Figure 1 revealed that 73 percent perceived a decrease in rainfall, 2 percent of the farmers did not see any change in rainfall pattern and 25 percent perceived an irregular rainfall pattern.

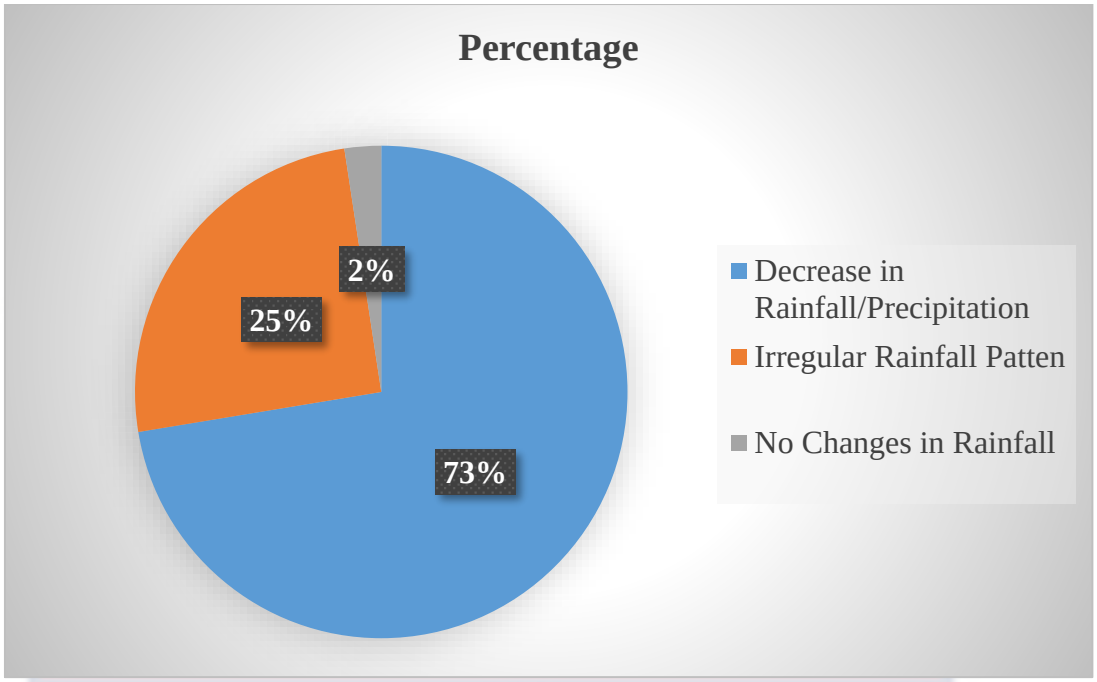

Figure 2: Changes in Rainfall

Source: Field survey data, 2019

Smallholder farmers Perception of Changes in Temperature

The study analyzed smallholder farmers' perception of changes in temperature. From the Figure 2 below, majority of 60 percent of the farmers' perceived increasing temperature and 3 percent of the farmer's perceived decreasing temperature. In addition, 17 percent of the farmers perceived no change in temperature, whilst 20 percent of the farmers perceived irregular pattern of temperature. Findings of this study is consistent with Maddison (2006) In a survey conducted covering seven African countries and reported that significant numbers of farmers believe that temperature has already increased and that precipitation has declined in the countries.

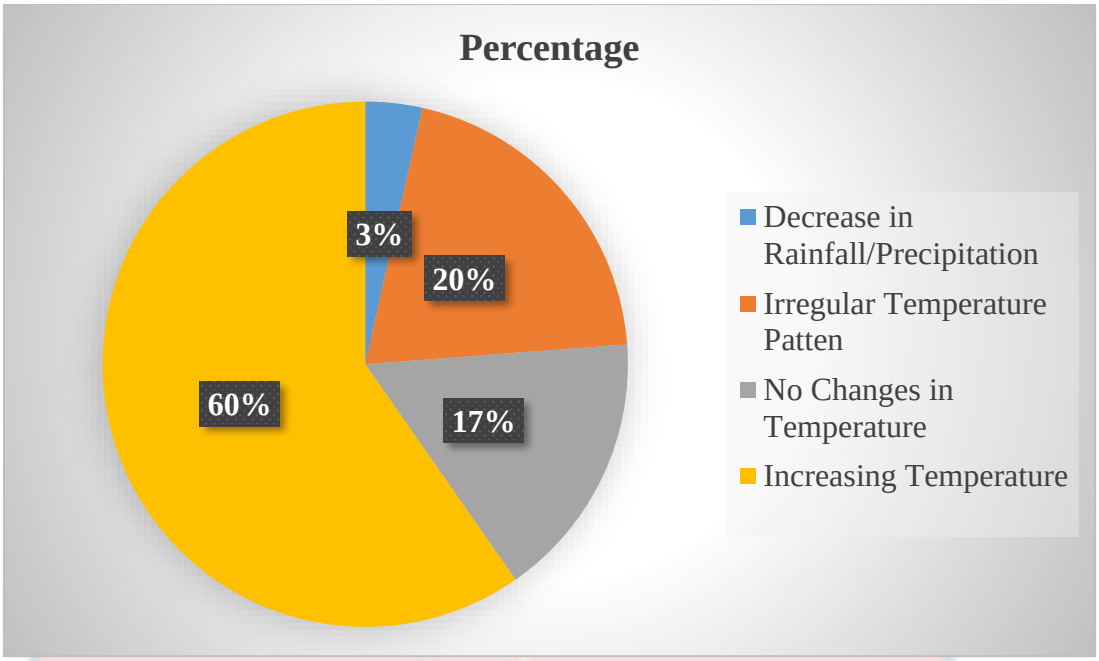

Figure 3: Changes in Temperature

Source: Field survey data, 2019

Farmers' Choice of Adaptation Measures in Response to Changes in Precipitation and Temperature

Smallholder farmers were asked if they employ some adaptation measures due to decreasing precipitation and increasing temperature in Table 9. Majority of 37.4 percent of smallholder farmers adapted changing planting dates as their main adaptation measures and 7.3 percent adapted planting short season variety as the adaptation strategies to changes precipitation and temperature.

Table 9: Major Adaptation Strategy

Adaptation Strategy	Frequency	Percentage
Changing planting dates	46	37.4
Crop diversification	26	21.1
Change in crops	20	16.3
Find off farm jobs	6	4.9
Plant short season variety	9	7.3
No adaptation	16	13

Source: Field survey data, 2019

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

Also, Fosu-Mensah, Vlek and Manscheadi (2010), investigated how farmers perceive long-term changes in temperature, rainfall and vegetation cover over the past twenty years. The main adaptation strategies reported by the farmers were crop diversification and changing planting dates. These studies are consistent with the findings of this study where 38 percent of smallholder farmers resorted to changing planting dates as their adaptation strategy, 21 percent engaged in crop diversification, 16 percent adapted change in crops and 7.4 percent planted short season varieties. Whereas 5.0 percent found off farm jobs and 11.6 percent did not engage in any adaptation strategy.

Barriers to Adaptation Strategies

The study also investigated barriers preventing farmers from adapting to climate change in Figure 3. The results of the study indicate lack of information about climate change, lack of knowledge about adaptation options, lack of access to credit, no access to irrigation water, expensive changes, poor soil fertility and insufficient access to inputs are the major barriers inhibiting farmers' ability to adapt to climate change impacts.

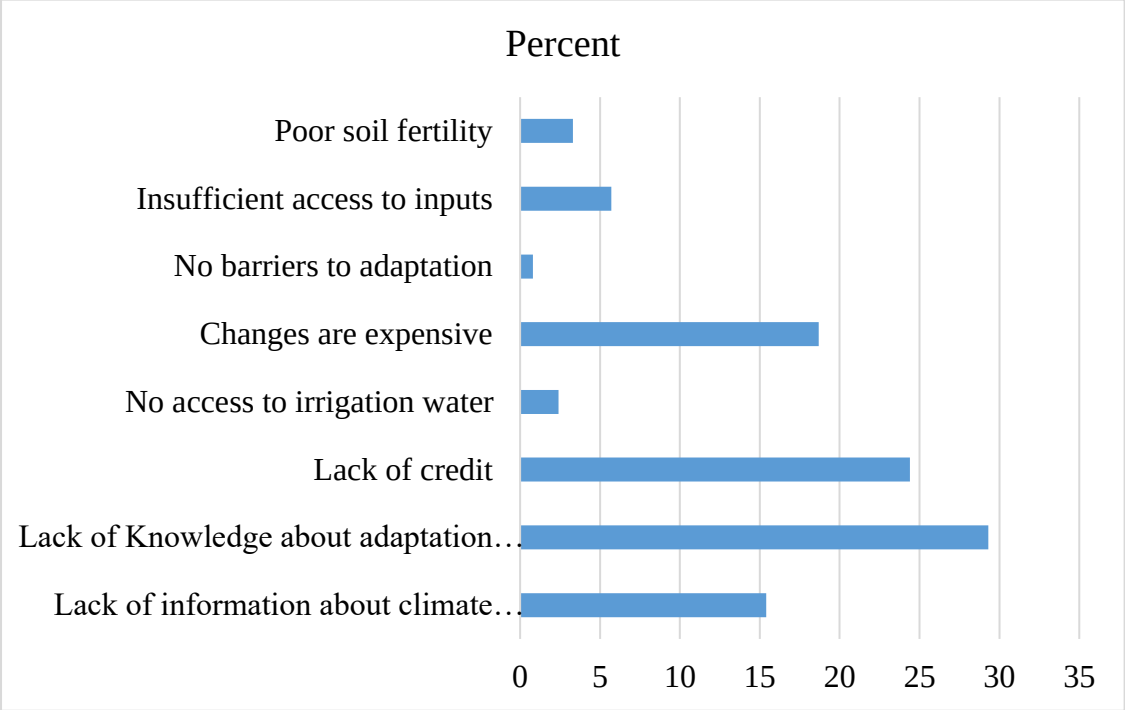

Figure 4: Barriers to Adaptation Strategies

Source: Field survey data, 2019

Result shows 24.4 percent of the farmers identified lack of access to credit as the main barrier to effective adaptation to climate change while 0.8 percent did not experience any barriers to adaptation. Finding indicates 15.4 percent identified lack of information regarding climate change measures. Majority of 29.3 percent of farmers identified lack of knowledge about adaptation options. Findings also indicate 2.4

percent of small holder farmers did not have access to irrigation. Also, 18.7 percent of the farmers' think that changes are expensive. Finding revealed that 5.7 percent identified insufficient access to inputs while 3.3 percent of the small holder farmers identified poor soil fertility as constraints to adaptation.

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

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

General Overview

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

Summary

Climate change and weather patterns have been experienced as negative impacts on food production, food security and natural resources all over the globe. Farmers' adaption to climate change is crucial to combating food insecurity and related problems. This study sought to empirically understand the Perceived Impact of climate change and adaptation on smallholder farmers in the Savelugu Nanton district in the Northern Region of Ghana.

Specifically, the study sought to achieve the following objectives: 1. Find out long term temperature and rainfall change (climate trend) in the District 2. Identify smallholder farmers' perceived causes of climate change on agriculture 3. Identify smallholder farmers' adaptations to climate change impacts. 4 Identify smallholder farmers' perceived importance of adaptation practices. 4. Find out smallholder farmers' perceived constraints to adaptation to climate change

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

Smallholder Farmers Perception of Changes in Precipitation and Temperature Patterns

Farmers in the study area were aware of climate change situation on their production, with majority 84.4 percent perceived changes in climate as a severe trend

whilst 15.6 percent did not perceive any changes. With respect to precipitation, the study revealed that majority 54.1 percent of the farmers perceived a decrease in precipitation; 3.2 percent perceived an increase in precipitation; 27.4 percent of the smallholder farmers perceived an irregular precipitation and 15.3 percent of the farmers did not see any change in precipitation. Similarly, majority 59.7 percent of the smallholder farmer's perceived increases in temperature, 3.5 percent of the smallholder farmer's perceived decrease in temperature, 20.3 percent of the farmers perceived irregular pattern in temperature and 16.5 percent of the farmers perceived no change in temperature.

Smallholder Farmers Choice of Adaptation measures in response to Climate Change

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

Determinants of Smallholder farmers Adaptation to decreasing Precipitation and increasing Temperature

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

Constraints to Smallholder Farmers' Adaptations Measures.

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

Conclusions

The perceived impact of climate change on smallholder farmers crop production have provided valuable insights into the challenges and potential adaptation strategies for various agricultural sectors. From the findings of the study, the following conclusions are drawn: Majority of the Smallholder farmers perceived a decrease in precipitation and increasing temperature. Also, smallholder farmers' used variety of measures to adapt to decreasing precipitation and increasing temperature. These measures include: irrigation, change in crops, changing planting dates and plant short season variety as the major adaptation measures to climate change impacts. In addition, findings from the analysis indicate education level, farming experience, and financial support are significant predictors of the probability to adaptation to decreasing precipitation and increasing temperature respectively. And lastly lack of information about climate change, lack of knowledge on adaptation and lack of credits were identified as the major barriers to adaptation.

Conclusion of the study that highlight the contribution to practice and policy. Enhancing collaborations between climate scientists, agronomists, economists, and social scientists to increase the understanding of complex interactions between climate change and agricultural system which will contribute to the development of comprehensive theories and models that capture the multidimensional aspects of the impact of climate change on agricultural food production.

Facilitating the exchange of best practices, experiences, and lessons learned among farmers, agricultural extension services, and relevant stakeholders that will help enhance the dissemination of climate-smart agricultural techniques, including the adoption of resilient crop varieties, efficient water management practices, and sustainable farming methods.

The implementation of climate resilient agricultural policies. That is to integrate climate change considerations into agricultural policies and support the development and implementation of climate adaptation plans which involves providing incentives and financial support for farmers.

Recommendations of the Study

Recommendations Based on the Findings of Study, the following recommendations are made.

1. From the findings of the study, smallholder farmers do not have adequate information on climate change. Therefore, The Ghana Meteorological Agency should provide information on climate related issues through the District Directorate of Agriculture to Enhance the accessibility and reliability of climate information, including weather forecasts, seasonal outlooks, and long-term projections, to support informed decision-making by farmers and policymakers. This will enable proactive planning and the timely implementation of adaptation measures
2. The Ministry of Food and Agriculture (MoFA) should educate farmers on specific adaptation options to enable them adapt to climate change situation in the district since majority of the smallholder farmers resulted to cultivating different varieties as the traditional means of adaption. Integrate

climate change considerations into agricultural policies and support the development and implementation of climate adaptation plans which involves providing incentives and financial support for farmers to adopt climate-smart practices, promoting risk management strategies, and investing in research and development for climate-resilient crop varieties and technologies.

3. The study found out that majority of small holder farmers used personal savings as their major means of financial support. The Banks and Microfinance institutions should therefore provide financial support to Smallholder farmers since it improves adaptation to climate change.

Recommendations for Further Studies

Studies on climate change have mostly focused on the northern part of Ghana due to its arid nature. However, the non and semi-arid regions of the country could be experiencing dynamics worth studying. Future studies should therefore focus on these areas.

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APPENDIX

APPENDIX A: STRUCTURED UESTIONNAIRES

MSC. MONITORING AND EVALUATION

DEPARTMENT OF PLANNING AND DEVELOPMENT

FACULTY OF HUMANITIES

CHRISTIAN SERVICE UNIVERSITY COLLEGE

Introduction

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

Date of interview: Day: _____ Month: _____ Year: _____

SECTION A: SOCIO ECOMOMIC CHARACTERISTICS OF RESPONDENTS

1. Sex (a) Male [ ] (b) [ ]
2. Age of farmer at last birthday. (a) Below 18yrs [ ] (b) 18yrs – 30yrs[ ] (c) 31yrs – 60yrs[ ] (d) above 60yrs[ ]
3. Marital status of farmers: (a) single [ ] (b) Married [ ] (c) Divorced [ ] (d) Widowed [ ] (e) Co-habiting/consensual relationship
4. Are you the head of the household? (a) Yes [ ] (b) No [ ]
5. Educational level of respondents (a) No formal education [ ] (b) Primary school [ ] (c) Middle school leaver/Junior high school [ ] (d) O'level/senior high school [ ] (e) Tertiary level [ ]
6. How many years have you been engaged in crop production? _____ years.
7. What is your monthly income? (a) Below Gh200[ ] (b) Gh200 – Gh600[ ] (c) Gh601 – Gh1000[ ] (d) Above Gh1000
8. Which income source is your main source of income (a) Pension [ ] (b) Farming[ ] (c) Part time Job[ ] (d) Remittances[ ] (e) Social Grant

SECTION B: PRODUCTION ACTIVITIES

9. Means of Land Ownership (a) Allocated/Communal [ ] (b) Inherited [ ] (c) Borrowed [ ] (d) Rented [ ] (e) Bought [ ]
10. What is the size of your farm in acres? (a) less than 1 ha [ ] (b) 1 ha - 2.5 ha[ ] (c) above2.5 ha [ ]
11. How do you perceive your land's fertility? (a) very fertile [ ] (b) Fertile [ ] (c) Infertile [ ] (d) Don't Know [ ]
12. What crop do you produce at present? _____
13. What changes in yields do you perceive? (a) Increase [ ] (b) Decrease [ ] (c) No change [ ]
14. What do you think is contributing to this change? _____
15. Do you have access to credits? (a) Yes [ ] (b) No [ ]
16. Do you irrigate your farm? (a) Yes [ ] (b) No [ ], if no why? _____
17. Do you have access to extension services? (a) Yes [ ] (b) No [ ] If yes, how many times_____
18. Do you get financial support from any quarters for production? (a) Yes [ ] (b) No [ ] if yes from where?_____
19. Do you use fertilizer on your farm? (a) Yes [ ] (b) No [ ]
20. Do you apply manure on your farm? (a) Yes [ ] (b) No [ ]
21. Source of manure: (a) Own farm [ ] (b) Farmers in the same community [ ] (c) Farmers in another community [ ] (d) others [ ]

SECTION C: CLIMATE CHANGE INFORMATION

22. Do you perceive changes in climate? (a) yes [ ] (b) No [ ]
23. If yes, in question 22, is climate change a serious condition? (a) yes [ ] (b) No [ ]
24. What are your perceptions of the changes in temperature? (a) Increase in temperature [ ] (b) Decrease in temperature [ ] (c) No change in temperature [ ] (d) Irregular temperature pattern [ ]
25. What are your perception of the changes in rainfall? (a) Increase in rainfall/precipitation [ ] (b) Decrease in rainfall/ precipitation [ ] (c) Irregular rainfall pattern [ ] (d) No change in rainfall pattern [ ]

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

26. Do you adapt to climate change? (a) Yes [ ] (b) No [ ]
27. Do you adapt to decreasing precipitation? (a) Yes [ ] (b) No [ ]
28. If yes, what major adaptation strategy do you usually use? (a) Changing planting dates [ ] (b) Crop diversification [ ] (c) Reduce farm size [ ] (d) Change in crops [ ] (e) Find off farm jobs [ ] (f) Plant short season variety [ ] (g) No adaptation ([ ] (i)Others (specify) _____
29. Why do you prefer your choice of adaptation strategy in question 28 to other strategies? (a) It improves the land (make land fertile, add nutrients) [ ] (b) It prevents erosion [ ] (c) It is more economical [ ] (d) It reduces the direct impact of climate change (drought, flood etc) [ ] (e) Others (specify) _____
30. Do you adapt to increasing temperature? (a) Yes [ ] (b) No [ ]
31. If yes, what major adaptation strategy do you usually use? (a) Changing planting dates [ ] (b) Crop diversification [ ] (c) Reduce farm size [ ] (d) Change in crops [ ] (e) Find off farm jobs [ ] (f) Plant short season variety [ ] (g) No adaptation [ ] (g) Others (specify) _____
32. Why do you prefer your choice of adaptation strategy in question 31 to other strategies? (a) It improves the land (make land fertile, add nutrients) [ ] (b) It prevents erosion [ ] (c) It is more economical [ ] (d) It reduces the direct impact of climate change (drought, flood etc) [ ] (e) It is environmentally friendly [ ] (f) Others (specify) _____

SECTION E: BARRIERS TO ADAPTATION MEASURES

33. Do the following under listed factors constrain you from using adaptation strategies? (a) Lack of information about climate change [ ] (b) Lack of knowledge about adaptation options [ ] (c) Lack of credit [ ] (d) No access to irrigation water [ ] (e) Changes are expensive[ ] (f) No barriers to adaptation [ ] (g) Insecure property rights[ ] (h) Insufficient access to inputs [ ] (i) Shortage of land [ ] (j) Poor soil fertility [ ] (k) Others barriers (specify)_____

34. How do you feel about dealing with climate change challenges? (a) Fearful/afraid [ ] (b)Helpless[ ] (c) Assured [ ] (d)Powerless[ ] (e)Encouraged[ ]