UNIVERSITY FOR DEVELOPMENT STUDIES

SMALLHOLDER FARMER ADAPTATION STRATEGIES TO CLIMATE VARIABILITY IN MAIZE AND YAM PRODUCTION, THE PERSPECTIVE OF SMALLHOLDER FARMERS IN THE SAVELUGU-NANTON MUNICIPALITY

IDDRISU INUSAH TIJANI

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BY:

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THESIS SUBMITTED TO THE DEPARTMENT OF ENVIRONMENT AND RESOURCE STUDIES, FACULTY OF INTEGRATED DEVELOPMENT STUDIES, UNIVERSITY FOR DEVELOPMENT STUDIES, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PHILOSOPHY (MPHIL) IN ENVIRONMENT AND RESOURCE MANAGEMENT

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DECLARATION

Student

I Iddrisu Inusah Tijani, do hereby declare that except for reference to other peoples' work which has been respectfully acknowledged, this thesis is the result of my own effort under the supervision of Dr. Kenneth Peprah and Mr. Anthony Mwinilanaa Tampa-Naa and that no part of it has been presented for another degree in this university or elsewhere:

Candidate's Signature: …….Date: ……

Supervisors'

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

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

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Co-Supervisor's Signature……..Date……..

Name: Mr. Anthony Mwinilanaa Tampah-Naah

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DEDICATION

This work is dedicated to my son Arif Kasi Ahmed Tijani, my ever supportive and dependable Mother, Iddrisu Mariyah and to my wife, Alhassan Alima Elizabeth. It is also dedicated to all my friends.

ABSTRACT

One of the greatest threats to agriculture and global food security today is climate variability. Various studies have shown how both human and environmental systems are adapting to the adverse impacts of climate variability. However, most of these studies failed to recognize indigenous knowledge of smallholder farmers and how this could influence conventional scientific adaptation strategies. Recent adaptation studies have either concentrated on indigenous strategies or conventional scientific strategies. This study adds to what has been done in determine the level of synergy between these two knowledge streams. The study assessed the integration and use of indigenous and conventional scientific adaptation strategies in the cultivation of maize and yam. Both qualitative and quantitative techniques were employed. Interviews, questionnaires, focus group discussions, key informant interviews were the major methods of data collected for the study. These techniques were used to assess smallholder farmers' perception of climate variability, strategies of adaptation and the various determinants of adaptation as well as challenges of both strategies. The results show that, smallholder farmers perceived the climate as changing with erratic and reducing rainfall as well as increasing length and frequency of drought as its main manifestations. It was revealed that, smallholder farmers used both indigenous and conventional strategies and that no one strategy is exclusively preferred to the other. Inadequate finance and low capacity to adopt conventional improved technologies of adaptation are the major determinants of adaptation. The study finally brought to light, the challenges of both indigenous and conventional strategies and specific areas where synergies between the two has enhanced smallholder farmer adaptation. The study concludes that, certain aspects of both strategies can properly be developed and this will lead to a reduction in the cost of adaptation while increasing farmer output.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

AIACC- Assessment of Impact of Adaptation to Climate Change

AIPP- Asian Indigenous Peoples' Pact

CCCCD- Canadian Coalition on Climate Change and Development

CFTC- Canadian Feed the Children

COP- Conference of Parties

CRI-Crop Research Institute

CSK- Climate-Seed Knowledge

DIRTS- Disseminating Information Resource Technologies System

DOP- Department of Agriculture

EPA- Environmental Protection Authority

FAO- Food and Agriculture Organization

FASDEP- Food and Agricultural Development Policy

FBOs- Farmer Base Organisations

GDP- Gross Domestic Product

GSS- Ghana Statistical Service

IFPRI- International Food Policy Research Institute

INC- Initial National Communication

IPCC- Intergovernmental Panel on Climate Change

IUCN- International Conservation Union

MADO- Municipal Agricultural Development Office

MESTI- Ministry of Environment Science, Technology and Innovation

MiDA- Millennium Development Authority

MMDAs- Metropolitan, Municipal and District Assemblies

MOFA- Ministry of Food and Agriculture

NCCAS- National Climate Change Adaptation Strategy

NDPC- National Development Planning Commission

OECD- Organization of Economic Cooperation and Development

REDD+- Reduce Emission from Deforestation and Forest Degradation Enhanced

RTIMP- Root and Tuber Improvement Marketing Programme

SADA- Savannahh Accelerated Development Authority

SAP- Systemic Adaptation Strategy

SNC- Second National Communication

SNMA- Savelugu-Nanton Municipal Assembly

SSA- Sub-Saharan Africa

UNDP- United Nations Development Program

UNEP- United Nations Environmental Program

UNFCCC- United Nations Framework Convention on Climate Change

WMO- World Meteorological Organization

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

One of the greatest threats to agriculture and global food security today is climate variability. The bane of this phenomenon is felt mostly by smallholder farmers whose rate of adaptation is hindered by inadequate technology, finance and climate related information (Antwi-Agyei et al, 2013 & IPCC, 2014). It is predicted that, these variations in climate will continue and much of its effects will weigh heavily on smallholder farmers. While most adaptation strategies by smallholder farmers are developed through observations and experiences, recent conventional adaptation strategies are mostly imported from external development agents. However food crop production which is the focus smallholder farmer activities, is the most climate dependent activity and yet smallholders will struggle to adapt to these predicted continuous variations (Smit & Pilifosova, 2007:IPCC, 2007). However, most of the indigenous strategies of which smallholder farmers are accustom to, are gradually fading in areas where they are mostly practiced (Ajani et al., 2013).

Climate variability is defined by the World Meteorological Organization (WMO) as the "variation in the mean state and the statistics of the elements climate on both temporal and spatial scales beyond individual weather events. It is often used to denote deviations of climate statistics within a shorter to a relatively longer time frame". Schipper (2007) defined adaptation as the "process through which people reduce the adverse effects of climate on their health and well-being and take advantage of the opportunities that the climatic environment provides". Basically, four types of adaptation are identified and they include anticipatory, autonomous,

planned and maladaptation. Anticipatory adaptation is usually meant to reduce exposure and is initiated before the manifestations of the impact of climate variability (Burton et al., 2006). Autonomous adaptation on the other hand refers to those that take place in reactive response usually without the influence of a recognized public agency (Smit & Pilifosova, 2007). The IPCC (2007) described planned adaptation as the policy response designed to maintain system or realize a desired outcome. Also, maladaptation refers to those types of adaptation which tends to increase vulnerability rather than reduce it (Barnett & O'Neil, 2010). Indigenous knowledge however is described as "knowledge generated from a particular place among a specific group of people which is grounded in local custom and usually linked with communities which have strong ties to their natural environment" (Orlove et al., 2009).

Globally, the 21st Century has witnessed a continuous variations and fluctuations in the world's climate, impacting negatively on agriculture (IPCC, 2007). Africa is projected to be among the most affected, although the continent's contribution to these variations is found to be minimal (Burton et al.; IPCC, 2007). Countries in Sub-Saharan Africa are most likely to suffer severely from these variations due to the over dependents on rainfall for agriculture (Kurukulasuriya & Rosenthal, 2003;IPCC, 2014). These changes have a greater tendency to affect crop yields negatively, thereby putting pressure on scarce resources in a region that are already overburdened with numerous challenges (IFAD, 2012). Adaptation therefore remains the surest solution to these impending adverse impacts. This will however be greatly influenced by the environmental and local conditions since climatic conditions are location specific (Codjoe, 2011).

Adaptation to climate variability has a long history in Africa (Burton et al., 2006). A lot of adaptation strategies have already been proposed mostly from international organizations.

However, these adaptation strategies fail to yield the desired outcome adding pressure on the resources of the smallholder farmer which is already challenged. Strategies such as crop and weather insurance, the use of chemical fertilizers, agro-forestry, integrated pest and disease management and weedicides have particularly not yielded the desired results either due to poor adoption by smallholders or poor conceptualization in the sub region. This will therefore result in increased risk for the farmer and other livelihood difficulties leading to severe consequences. This situation is however exacerbated by the direct dependence on only rainfall and poverty (UNDP, 2007).

Adaptation has become important in Sub-Saharan Africa (SSA) because of the impacts of climate variability on livelihoods, as evidenced by recent floods, droughts, heat waves and warmer temperatures. Agricultural production and food security is expected to be placed under stress by climate variability with 16% of people in Africa and 27% in Sub-Saharan Africa been undernourished (FAO, 2007). While the issue of adaptation in the developed world has been mostly successful, that of Africa and for that matter Ghana is still bedevilled with so many barriers such as finance, technology, socio-cultural among others (Antwi-Agyei et al, 2013). While the developed world have advanced in the technology and more scientific adaptation strategies, the acquisition of this data on weather and climate is still somewhat rudimentary in Sub-Saharan Africa. Weather stations used for the provision of basic climate information are dwindling. Research shows that there were more weather stations 20 years ago than it is now in Sub-Saharan Africa (Ziervogel et al, 2008). This is one of the reasons why Africa is relying on imported strategies which normally fail because of lack of adequate local information in the process (Codjoe, 2011).

In Ghana, the evidence of the increasing existence of climate variability is becoming apparent. The general shift in the pattern of rainfall is accompanied by reducing rainfall amounts and increases in average surface temperature as well as heat waves. Coastal Ghana is being inundated by increasing tidal waves while the forest belt is also going through rapid loss of moisture than ever experienced. This has impacted negatively mostly on food crop production with maize being the most affected among the category of cereals and yam among tubers.

Even though the repercussions of climate variability are felt in all the regions, its effects in the Northern Region including the other two Northern Regions are much more pronounced. This is because the region is already physically and economically vulnerable by virtue of its geography. The Guinea Savannah Ecological Zone, on which the Northern Region falls, is blessed with a single maxima rainfall season (April-September) with a prolonged dry season spanning over six months (October-March). The Guinea Savannah Ecological Zone is also among the warmest in the country with an annual mean temperature of about 30^0C. The inhabitants, who are mainly smallholders, meanwhile depend on crop farming as a source of livelihood and this is determined heavily by these climatic factors (Yaro, 2010).

Additionally, the usual April-May commencement of rainfall in the northern Region has also being shifting making the onset of the season highly unpredictable and this has the tendency to affect crop yield (Tachie-Obengi et al., 2010). This presents a range of uncertainties in the livelihoods and sustenance of smallholder farmers due to the heavy dependence of rainfall for agriculture (Etwire et al., 2013). Temperature and the frequency of drought have been in the rise and smallholder farmers believe the phenomena will only persist. Additionally winds in the northern region have been much stronger with a greater tendency of destroying upright crops like maize (Samaddar et al., 2014).

Adaptation is not new to smallholder farmers in the Savelugu-Nanton Municipality because farmers in the region have been modifying their strategies and practices in the wake of these challenges. These strategies consist of both indigenous climate related practices and the introduced strategies. (Kuwornu & Ramatu, 2013). Research has shown that, the onset of the rainy season, farmers' expenditure, farmer's income, access to weather and climate information, soil and plant health technology play influential role in determining adaptation choice in the region (Mabe et al. 2014). Decreasing and erratic rainfall As well as temperature increases are among the major determinants of adaptation strategies (Ramatu et al. 2013).

The continuous fluctuation of rainfall in the municipality has resulted in innovative means by which smallholder farmers either utilizes the increases in water or result in the development of effective water management strategies in time of reduction (Ramatu et al., 2013). Decreasing rainfall in the area is however hindered by low irrigation infrastructure (SADA, 2010). Effective and workable adaptation strategies rely on the smallholder farmer perception and how these strategies are in sync with relevant scientific knowledge practices. The choice of adaptation strategy is not limited to only the experience of the farmer but also attributable to some local non-scientific explanations in the district. For instance, farmers in the Savelugu-Nanton district struggle to contain the effects of drought and mostly attribute this to curses and this mirror the weaknesses of smallholder farmers in the district (Jarawura, 2014).

Of the total arable land in the municipality, more than 50% is under maize production with about 21% used for the production of yam. However most of these lands are in the hands of the smallholder farmers. In a municipality where about 97% of the work force are into agricultural and are mostly smallholder farmers, it is imperative to examine how these groups of people are

adapting to these adverse climatic impacts. This is ideal especially when projections point to increases in the current adverse spade of climate.

1.2 Problem Statement

Over the years, smallholder farmers have been challenged in the use of some indigenous adaptation strategies due to the increasing complexity of climate variability. Evidence shows that, the climate is changing at rate beyond the capacity of most indigenous systems (FAO, 2013 & IPCC, 2014). Conventional scientific adaptation strategies therefore gained a lot of attention than the indigenous strategies. However, the adoption and use of these conventional adaptation strategies by smallholder farmers is increasingly becoming unsuccessful. There is generally lack of involvement of indigenous knowledge of the smallholder farmers in the overall adaptation planning process in Ghana as most of these strategies are even borrowed from external development agents. As climate variability is increasingly undermining the ability to realize adequate food needs, smallholder farmers are at the forefront of dealing with the impacts but are not first in line for both international planning and finance for adaptation programs and strategies (Pettengell, 2015).

In most instances, adaptation to climate variability and agricultural development activities have been mobilized in response to foreign aid which fail to consider local climatic conditions and other related factors at the community level. This probably is the reason why only few related programs are conceived and planned in Ghana and accounts for the reason why it is difficult implementing some adaptation strategies in the country (IFPRI, 2009). Access to climate information and utilization is therefore vital for smallholder farmer adaptation and this can influence greatly, the choice and success of adaptation strategies (Mabe et al., 2014). Meanwhile,

in a municipality where 69.2% of its inhabitants cannot read and write, interpreting and utilizing conventional adaptation strategies by smallholder farmers remains an illusion (GSS, 2014).

Several adaptation strategies have been proposed for the Northern Region and in Ghana for that matter in documents such as the National Adaptation Policy and Second National Communication Reports to the United Nations Framework Convention on Climate Change (UNFCCC), but these proposals are often over generalized (Adger et al, 2003) and lacking in terms of empirical data on indigenous knowledge on adaptation. Forgetting that adaptation is greatly determined by the existing conditions and characteristics that are peculiar to particular location (Huq et al. 2003; Adger et al. 2003; Smith & Wandel, 2006; Burton et al., 2006). Recognizing and utilizing indigenous knowledge in adaptation will enhance the design and success of adaptation strategies (Codjoe et al., 2013).

Several adaptation strategies have been used by farmers and are highlighted in existing literature. Some of the conventional scientific adaptation strategies include tolerant crop and livestock varieties, application of chemical fertilizers, improved meteorological forecast, integrated pest and disease management, integrated soil fertility management and agro forestry (Antwi-Agyei et al, 2013; Kuwornu & Ramatu, 2013). However, the implementation of some of these strategies has not been without difficulty due to lack of localised information on climate, finance, as well as technology. For instance, although a lot has been achieved in modern hybrids, the question of optimum population of a variety across different environmental setting is still a challenge.

Northern Region accounts for a greater proportion of grains produced in Ghana with maize commanding the largest share followed by yam in terms of tuber crops. Of all the regions producing maize and yam, northern Ghana is predicted to be worse affected in terms of output. The region belongs to the highest class of yam producers in Ghana attaining over 300,000 Metric

tonnes (Mt) annually but remain the most vulnerable after the Brong Ahafo and Eastern Regions (Sagoe, 2006).

The Canadian Coalition on Climate Change and Development (CCCCD) identified that, smallholder farmers in the Savelugu-Nanton municipality still prefer the use of indigenous varieties through its Climate-Seed-Knowledge (CSK) program. Smallholder farmers believe that, the indigenous varieties are more resistant than the improved seeds especially during times of fluctuation in the predicted outcome of the climate. The introduction of improved seeds sometimes leads to the extinction of some indigenous varieties; they contended (CFTC, 2012).

These strategies usually do not recognize in much detail, indigenous ecological knowledge practices which are vital to the overall adaptation strategy since indigenous experiences can contribute to a large extent the success of these adaptation strategies. Various studies have either concentrated more on conventional adaptation strategies (Tachie-Obengi et al., 2010;Etwire et al., 2013;Mabe et al., 2014) or indigenous adaptation strategies (Gyampoh et al., 2009; Ajani et al., 2013;Codjoe et al., 2013). However, these studies fail to consider the possible areas through which both strategies can complement each other. Again such studies often fail to recognize the fact that, northern Ghana falls in two distinct ecological zones and this could play a key role in adaptation planning.

As time has ran out in achieving food security under the Millennium Development Goals one and achieving food security seems to be eluding Northern Region and for that matter Ghana, the Sustainable Development Goals presents yet another great opportunity. Global agenda is gradually shifting towards adaptation to climate variability which must take cognizance of the existing indigenous strategies of adapting to climate change variability.

As the climate is expected to continuously vary for at least the next two to three decades, smallholder farmers in the Savelugu-Nanton municipality will have to embrace themselves for more adverse impacts. However, sustained increase in food production including maize and yam hinges on effective and workable adaptation strategies. And yet with the success of both conventional and indigenous adaptation strategies being questioned, it is therefore imperative to assess how both strategies could complement each order in the adaptation of maize and yam in the Savelugu-Nanton municipality.

1.3 Main Research Question

The main research question is: How can indigenous adaptation strategies complement the conventional adaptation strategies in order to increase maize and yam crop production in the Savelugu-Nanton Municipality in Northern Ghana?

1.3.1 Specific Research Questions

The specific research questions are:

i. How do smallholder farmers perceive climate fluctuations in the Savelugu-Nanton Municipality?
ii. How are smallholder farmers adapting their livelihoods to the impacts of climate variability in the Savelugu-Nanton Municipality?
iii. What are the determinants of adaptation among smallholder maize and yam farmers?
iv. How is conventional and indigenous adaptation strategies challenged in maize and yam production in the Savelugu-Nnaton municipality?

1.4 Main Research Objective

The main objective of the study is to assess the synergies between indigenous adaptation strategies and conventional adaptation strategies to climate variability among maize and yam smallholder farmers in the Savelugu-Nantong Municipality.

1.4.1 Specific Research Objectives

The specific research objectives of this study are to:

i. Assess manifestations of climate fluctuations in relation to maize and yam in the Savelugu-Nanton Municipality.
ii. Assess smallholder farmers' adaptation strategies in maize and yam cultivation.
iii. Examine the determinants of adaptation among maize and yam smallholder farmers.
iv. Examine the challenges of both conventional and indigenous adaptation strategies in maize and yam production.

1.5 Significance of the Study

The study aimed at assessing the synergies between indigenous and conventional adaptation strategies to climate variability by smallholder maize and yam farmers in the Savelugu-Nanton Municipality. This study provides information on indigenous and conventional adaptation strategies with respect to maize and yam. The outcome of this research work will be more beneficial to policy makers, environmentalist, development workers and the global research community. In the first place, the study will assist policy makers including the Ministry of Food and Agriculture (MoFA) and related government agencies with relevant information necessary for policy guideline formulation. It will also bring to light some approaches and procedures regarding climate variability adaptation.

Climate variability is now the focus of the state and international community. The study will also be of significance to stakeholders in the agricultural sector including Non-governmental Organizations (NGOs) by making available indigenous adaptation procedures that could enhance their operation. It will also be relevant in planning adaptation programs in order to enhance food security of the study area and beyond.

Lastly, adaptation to climate variability has recently received wide audience in global literature and this study seeks to add meaningful and relevant literature to the already existing pool. It therefore contribute to the on-going discourse on climate variability and provide useful benchmarks for further research in academia as well as provide useful insights on gaps concerning food security.

1.6 Scope of the Study

This study covered smallholder maize and yam farmers in the Savelugu-Nanton Municipality of the Northern Region of Ghana. The municipality has a large arable farm land and the inhabitants are mostly smallholder farmers. In terms of food crop cultivation, maize remains the number cereal crop and yam the most popular tuber crop cultivated by almost all households in the municipality. However, recent variability in the climate is hampering efforts of smallholder farmers to realise good yield among these crops.

Contextually, the study focused on indigenous and the conventional adaptation strategies to climate variability that have existed and are practiced in the municipality. This was done in order to determine the level of synergies between these two strategies and how both can be used concurrently in order to impact positively on productivity.

The study spanned six months across the farming season within the study area. This created the opportunity to collect data during farming season and as well validate the data within the same period from the respondents.

1.7 Organization of Study

This study is organized into five chapters. Chapter one deals with the general introduction of the study. Chapter two looks at the review of relevant literature on the topic of study. Chapter three focuses on the profile of the study area and methodology. Chapter four looked at the analyses, presentation of findings and as well as discussions of results. Finally, chapter five dealt with the summary of the major findings, conclusion and recommendations.

1.8 Limitations of the Study

Limitations are unavoidable in any social research situation and therefore this study is not an exception. The first challenge was with the access to secondary data especially with departments of the state like the Meteorological Service Department and Ministry of Food and Agriculture. After several appeals to these two organizations and several other return visits, the data was finally gotten. The second challenge was with language of communication on the study topic. Translating climate information directly to the respondents' local language was a problem. In order to address this challenge, the research team developed a list of the most widely used words with agreed translation which were used by all to avoid ambiguity. Finally, some respondents were sometimes unwilling to be contacted. This was mainly because several researchers have used their knowledge and expertise without any benefit coming to the respondents. The goal of the research was made very clear to them as it was purely academic and that there will be no direct benefit coming from the team.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter seeks to discuss the theoretical and conceptual framework on the topic of study. It also reviews relevant literature from the global, regional, national and at the Savelugu-Nanton municipality related to indigenous and conventional adaptation strategies. The review is to determine the level of work that has been achieved in relation to the topic of study. The review provides grounds for in-depth discussions of issues arising from indigenous ecological knowledge and adaptation to climate variability. The review covered areas such as climate variability, conventional and indigenous adaptation strategies, barriers to adaptation and strategies in maize and yam adaptation.

2.2 Theoretical Framework

The study made use of two distinct theories namely: the Solar Variability Theory and The Planetary Motion Theory.

2.2.1 The Solar Variability Theory

The solar variability theory contends that, solar variability in the solar system is the main reason for the current changes being experienced in the climatic system. According to the theory, the brightness of the sun results in the formation of sunspots and these sunspots varies in frequency and in cycle of 11, 87 and 210 years. These changes result directly in the amount of solar radiation known as solar wind. This solar wind eventually reaches the earth surface with some effects. According to the proponents of the theory, there is a positive feedback that occurs with either a process involving the solar wind on cosmic rays or the ocean thermohaline circulation.

On the one hand when the influence is felt on the cosmic rays, the situation affects cloud formation considerably. On the other hand, the sea surface temperature and the wind pattern are affected when the influence is on the ocean thermohaline circulation. The electrons that are mostly released by the cosmic rays stimulate the formation of ultra-small clusters of sulphuric acid and water molecules that constitute the building blocks of clouds condensation nuclei. In periods of greater solar magnetic activity, the stronger solar winds blocks some cosmic rays from penetrating the lower atmosphere resulting in fewer cloud condensation nuclei being produced.

2.2.2 The Planetary Motion theory

The Planetary Motion theory of climate change contends that most of the warming of the latter part of the twentieth century can be explained by natural gravitational and magnetic oscillations of the solar system induced by the planet's movement through space. These oscillations modulate solar variations and/or other extra-terrestrial influences of Earth, which then drive climate change. An extra-terrestrial influence on climate on a multi-millennial time-scale associated with planetary motion was first suggested by a Serbian astrophysicist, Milutin Milankovitch, and published in 1941.

Earth's orbit around the sun takes the form of an ellipse, not a circle, with the planet passing farther away from the sun at one end of the orbit than at the other end. The closest approach of the planet to the sun is called "perihelion" and the farthest is called "aphelion." Perihelion now occurs in January, making northern hemisphere winters slightly milder. The change in timing of perihelion is known as the precession of the equinoxes, and it occurs every 22,000 years.

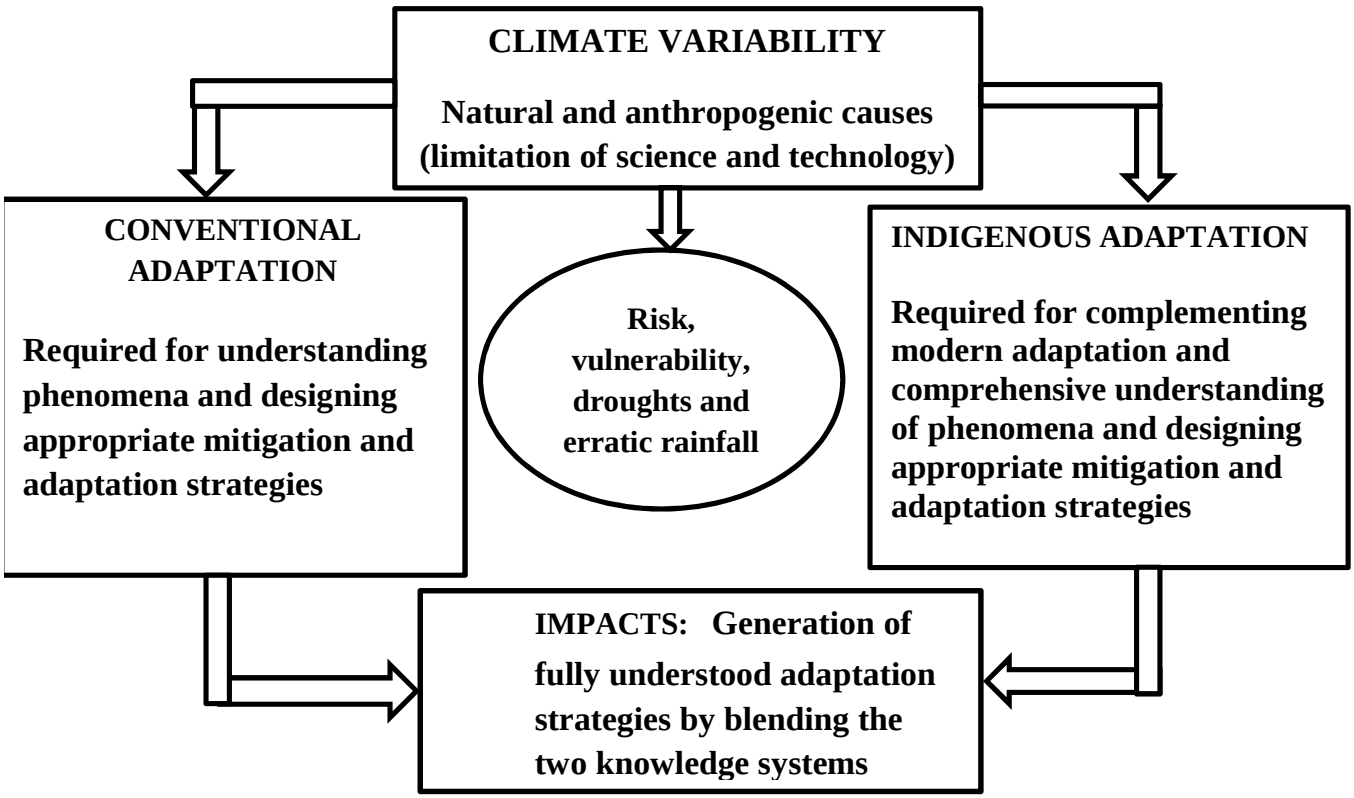
The shape or "eccentricity" of Earth's orbit also varies on cycles of 100,000 and 400,000 years due to the tug of other planets, specifically Jupiter and Saturn, on Earth. It shifts from a short broad ellipse that keeps Earth closer to the sun, to a long flat ellipse that allows it to move farther

from the sun and back again. Earth also spins around an axis that tilts lower and then higher during a 41,000-year cycle. More "tilt" roughly means warmer northern hemisphere summers and colder winters; less "tilt" means cooler summers and milder winters.

The coincidence of these cycles is known to lead, with the help of positive climatic feedbacks such as water vapour, to the cooling and warming periods.

2.3 Conceptual Framework

This study intends to proceed by utilizing the framework on indigenous knowledge and conventional science by Chanza and De Wit (2013:206) as seen in Figure 2.1.



Adapted from Chanza and De Wit (2013:206)

Figure 2.1: Framework on Building Climate Change Knowledge

In Figure 2.1, the central issue is climate variability and this is caused by anthropogenic activities and natural occurrences. In order to adapt to the impacts of this variability, two main approaches are identified and knowledge from these two approaches sterns from indigenous and conventional knowledge streams. While knowledge on conventional is required for understanding phenomena and building appropriate mitigation and adaptation strategies, that of the indigenous is needed to complement conventional approaches to adaptation by providing in-depth indigenous knowledge in the design of these approaches. This could impact on generating fully comprehensive adaptation strategies. Based on this concept, the following operational definitions are adopted.

Climate Variability: Climate variability refers to the "Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events" (FAO, 2013).

Adaptation: Adaptation refers to "adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change" (Smit & Pilifosova, 2007).

This adjustment can be imposed on the basis of premeditated planning or it can take place without specific policy frameworks or tools to implement it" (Schipper et al, 2010). Adaptation in effect can be technological, behavioural, policy based and managerial (AIPP, 2012).

Adaptive capacity: This is the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change or variability. Improvement of adaptive capacity represents a potent means of coping with climate variations and uncertainties (Adger et al., 2007).

Autonomous Adaptation: Autonomous or spontaneous adaptations are considered to be those that take place in reactive response (after initial impacts are manifest) to climatic variations without the involvement directed of any public agency. Autonomous adaptations describe initiatives by private actors rather than by governments, and mostly a consequence of market forces or changes in welfare services (Smit & Pilifosova, 2007).

Planned Adaptation: Planned adaptation often is as the result of a deliberate or conscious policy decision on the part of a public agency, usually induced by a notion of a change or likely variations in climatic conditions which requires minimizing losses or benefiting from opportunities. Planned adaptation is sometimes known as intervention strategies or anticipatory adaptation (Smit & Pilifosova, 2007). "Planned Adaptation is a deliberate policy initiative based on awareness that conditions have changed or are about to change and that action is required to return to, maintain or achieve a desired state" (IPCC, 2007).

Anticipatory Adaptation: refers to that type of adaptation usually initiated right before the manifestations of the impacts of climate variability of climate change. The main aim is to reduce sensitivity to exposure or to harness benefits that come with such changes or variations (Burton et al. 2006).

Maladaptation: this is the type of adaptation that increases vulnerability rather than reduce it. This take place when a particular development context is not well analysed to fit well into the climate system. The aim of the strategies of adaptation is usually expected to impact positively but consequently result into a negative or advice situation (Barnett & O'Neil, 2010). Maladaptation could result from the improper application of technologies of adaptation and poor conceptualization of the concept of adaptation.

Indigenous Knowledge: "Indigenous Knowledge is defined as the established knowledge of Indigenous nations, their worldviews, and the customs and traditions that direct them" (De La Torre, 2004).

Indigenous Adaptation: These are the methods or adjustments, employed by indigenous societies in the face of actual or potential shift in the ecological system and the elements of climate so as to cope with the expected or actual stress in the climate system.

Indigenous Adaptation Strategies: These include all the indigenous methods, mechanisms and measures that were employed and are still being used by indigenous smallholder farmers in response to the manifestations of climate variability.

Vulnerability: Vulnerability to climate change refers to "the propensity of human and ecological systems to suffer harm and their ability to respond to stresses imposed as a result of climate change effects". The vulnerability of a society is influenced by its development path, physical exposures, the distribution of resources, prior stresses and social and government institutions (Adger et al., 2007)

Risk: "The combination of the probability of an event and its negative consequences" (FAO, 2013).

Drought: "The phenomenon that exists when precipitation is significantly below normal recorded levels, causing serious hydrological imbalances that often adversely affect land resources and production systems" (FAO, 2013).

2.4 Climate Variability and Global Adaptation Experience

The concept of adaptation to climate variability has seen a lot of development in the 21st Century. This is mainly due to the unprecedented adverse impacts predicted on human and natural systems (IPCC, 2012). Adaptation in climate literature is traceable to the natural sciences

in evolutionary studies. It describes the development of features and mechanisms by human and natural systems to cope with stress pose by environmental and climate variability (Smit & Wandel, 2006). Adaptation to climate variability has long being in existence in both human and natural systems. People and societies all over the world have adjusted to climate variations and extremes with different levels of achievements. While some have been very beneficial others have failed leading to irreparable consequences on human and the environment. Climate variations are expected to heighten climate related risk and bring forth new adjoining risk factors for both human and the natural system (IPCC, 2014). Regardless of the interventions that are already in place, people all over the world have to face the reality of climate variability in a world where it is still in the ascendency (Kreft, 2015).

Just as the impacts of climate variability are not evenly distributed, the adaptive capacities to climate variability are also different with respect to different locations. A study to review the concept of adaptation in human communities to global changes in the climate in the context of adaptive capacity and vulnerability finds that, adaptations are merely base on prediction of outcomes and its effects on the environmental systems as well as estimated impacts. The study concludes that adaptation in any human system is linked and reflects adaptive capacity as well as vulnerability. Issues of adaptation are local and begin at the community level (Smit & Wandel, 2006).

Literature (IPCC, 2007) has it that, as adverse impacts of climate variability keeps increasing and adaptation alone is not expected to cope with all the negative impacts. Smit and Skinner (2002) in a study to determine the adaptation option of agriculture to climate change identified the characteristics of adaptation to include the following; intent and purposefulness, timing and duration, scale and responsibility and the form (Smit & Skinner, 2002). Poor communities are particularly going to be hard hit because of the vulnerability and their low adaptive capacity

(Huq & Reid, 2007). As the climate keeps varying with the passage of time, impacts from these variations keeps exerting pressure on the natural environment systems. This has been highlighted by the IPCC (2007) report which recommends urgent response from both national and regional for effective and rapid adaptation alternatives. Livelihoods will increasingly be challenged in the wake of increasing variation in temperature and precipitation, frequent droughts and floods, strenuous hurricane activity and ocean acidification (Jones et. al, 2012).

Adapting to climate variability requires integrated facets of potential actions. Parry (2009) categorized adaptation into two: soft and hard approaches. The soft approaches include information, policy capacity building and institutional functioning and these soft approaches are less vigorous. They emphasize on behavioural changes, measure of reducing the spread of risk and measures that will enhance the overall resilience to a range of variable climatic factors. The hard approaches on the other hand rely on the use of technology and infrastructural interventions that will assist in reducing the risk to hazardous climatic factors and variation (Parry, 2009).

Adger and others identified risk to climate variability adaptation in three stages. This include response to current variability which reflects past and historic experiences, observed and long term trends in climate fluctuations and anticipatory response. These three responses are interwoven and might form a continuum with no clear cut boundaries. Predicting future impacts of climate variability and improvement in climate monitoring and better early warning signs is fast growing in the developed world. The adaptive capacity to climate variability is increasingly widening across and within societies. As indicated in the IPPC forth Assessment Report (2007), human and social capabilities are vital determinants to adaptive capacity at all levels and this is the challenges faced by the developing world. These determinants at national and local levels coupled with technology and policy will enhance and increase the range of opportunities and lower risk (Eriksen, 2007). Climate does not vary uniformly in all regions of the world hence

adaptation to climate variability is expected to be specific to a particular context locality (IPCC, 2014).

In recent times, the relevance of indigenous knowledge in adaptation is increasingly becoming vivid among international organization (UNFCCC, 2013). This highlight the important role it could potentially play in the adaptation process. All over the world there exist a diverse set of social groups across continents, countries and communities. These diversities are reflected in the culture and other livelihoods approaches to the on-going variations in the climate. While the impact of global climate variability is felt across so many segments of the society, its impact on vulnerable indigenous people are much heavier. Indigenous people in the world have a long standing adaptation experience to climate variability. Indigenous people are very close to the natural biophysical system and have accumulated knowledge and practices that play a major role in reducing risk and improving disaster preparedness (Hiwasaki et. al., 2014).

Effective adaptation process is vital and relies basically on effective communication of weather and climate and this hinges on indigenous knowledge of indigenous people who are close to the natural environment (MoSTE, 2015). The Asian Indigenous Peoples' Pact (AIPP) noted that marginal lands which are inhabited by indigenous communities depend directly on the natural resources putting them at risk to adverse climate variability. There exist even greater risks for indigenous and traditional people who have been pushed by climate extremes to least fertile lands. This has been a direct consequence of historical, social, economic and political neglect. Despite the exposure to these adversities, indigenous people have developed strategies for coping with these phenomena (IUCN, 2008).

Fekadu (2014) noted that for indigenous knowledge to be meaningfully effective in adaptation then a proper methodology for its practice must be put in place and this is grounded in the wealth of knowledge of indigenous people. The failure to realize this could result in the loss of

knowledge or even underutilized. The study concludes that given the risk associated with climate variability will require a context specific strategies of adaptation and this is rooted in indigenous knowledge.

To a large extent climate variability has already impacted on agriculture and it is expected further to exacerbate the already deteriorating livelihoods and food crop production (Lobell et al, 2011). Temperature and rainfall variations as well as shifting patterns of rainfall, sea level rise and salinization are expected to erode environmental stability leading to lower crop yields. The level of these impacts will not only depend on the timing but also the overall combination of these factors and other localized conditions. Appropriate prediction of variable climatic impacts on agriculture will demand data, tools and models that will reflect all of these localized conditions (FAO, 2013).

A wide range of regional studies have shown that, climate variability is expected to impact adversely on agriculture than it will do positively. Few studies have indicated pockets of favourable benefit to agricultural yields in the regions of high latitude. Almost all dimensions of food security are affected by the on-going climate variability and these include access to food, its utilization and price fluctuation. This has a greater tendency of triggering other related stresses such as unemployment and income levels (IPCC, 2014). According to the OECD, by the year 2050 an additional 26 million people in Latin America and 132 million people in Asia will risk suffering from hunger. Maize harvests by smallholders in Latin America are expected to fall by an average of 10% (Fechter, 2009).

A study by Ray and others (2015) found that, crop yields in relation to climate change have mostly relied on national and regional data to the neglect of small isolated communities mostly inhabited by smallholder farmers. Global studies are always focused on country level data which mostly does not reflect local community experience thereby leaving out a lot of impacts at the

community level (Ray et. al., 2015). The food and Agriculture (FAO) identified low and fluctuating crop yield in Brazil that is linked to the three factors outlined above. Additionally to these findings, increased in global evapotranspiration also exacerbate the plight of the already affected people. In the same vein, a study by Qun (2011) in the Huang-Huai-Hai Plains in China is highly susceptible to high temperatures and reducing rainfall and this affects agriculture output (Qun, 2011).

2.5 Barriers to Adaptation

There is a wide popular acclamation in literature on the positive role adaptation could play in reducing adverse impacts of climate variability (IPCC, 2007; 2012; 2014; Adger et al., 2007). In recent times however, there exist a gap between the actual existing climatic impacts and the on-going adaptation process (UNEP, 2014). The IPCC (2014) acknowledged that, risk to climate variability will be intensified regardless of the reduction in emission of greenhouse gases from the current levels even if that will exactly be in line with the goal of the United Nations Framework Convention on Climate Change (UNFCCC). The overall impacts are predicted to be very acute in developing countries with impacts on poorer communities likely to worsen.

These arguments amplify what can be described as limitations to adaptation. The limits to adaptation are inextricably linked to the rate and magnitude of climate variability which are usually subjective among various communal settings. The likelihood of variation in the limits to adaptation is therefore obvious (Adger et. al., 2007). The United Nation Environmental Program (2014) described limits to adaptation as ‘adaptation gap’. Most literature has identified the limitations to adaptation to consist of physical, funding, technology and the knowledge gap or limit (Burton et al., 2006; Smit & Pilifosova, 2007 & UNEP, 2014). Generally however, the limits to adaptation as in most literature will discussed under the following captions.

2.5.1 Physical and Ecological Barriers

Various ecological studies have predicted that, the magnitude and rate of climate variability will alter ecological systems considerably. Some physical and ecological system will exceed their thresholds which will affect the normal functioning of the system. Climate variability is predicted to alter the physical conditions of key environmental systems in certain regions and this has the potential to limit the adaptation possibilities. For instance, rising sea level is likely to affect coastal and island settlements in terms of adaptation (IPCC, 2007; Tol, 2006).

2.5.2 Technological Barriers

Technology has proven to be the solution to most humanly identified challenges with regards to climate variability. Technologies for climate adaptation have been those that are worthy of providing adaptation needs and benefits through proper dissemination channels. Technology can be rooted in socio-cultural settings based on the institutional context of the location. The best form of technology for adaptation may be the one that serves variety of purposes in a varying climatic environment (UNEP, 2014). Technologies that will enhance adaptation could be developed and transfers are made among nations especially to the developing world where adaptation needs are very high (Adger et al., 2007).

2.5.3 Financial Barriers

The intergovernmental Panel on Climate Change (2014) estimated between $70 billion to $100 billion global costs of adaptation by 2050 (Nelson, 2009 & IPCC, 2014). However, there are concerns that such figures could be underestimated because, national level adaptation estimates

are usually far higher than that of global estimates. Estimates from the World Bank however indicate a total of $10 billion to $40 billion for the same estimated period (World Bank, 2006). These figures probably are just mere estimates which may not have meaning in themselves.

Adaptation to climate variability is limited financially especially in developing countries where smallholder farmers struggle to meet adaptation needs. Adequate financial resources for simple farm implements and inputs are difficult to come by and this limits their adaptive capacity. Financial considerations in mostly developing world are usually the reason why certain adaptation strategies are limited. These include irrigation, improved new varieties as well as diversification of farm operations are constraint in developing countries.

2.5.4 Information and Knowledge Barriers

The United Nation Environmental Program (UNEP), identified knowledge limitation in three phases, that is missing or incomplete knowledge, inadequate linkage between different bodies of knowledge and limited diffusion and translation of knowledge to decision makers. This could be described explicitly as gap in the production of knowledge in adaptation, integration and transfer (UNEP, 2014). The uncertainty which clouds climate variability together with individualized perception of risk pose to these variations influences decisions taken at both the local and national level. Dangers posed by climate and weather extremes are dependent on the interpretation and the existing context (Adger et. al., 2007).

2.5.5 Social and cultural barriers

Adaptation to climate variability across the world take place among groups of people with varied interpretations, experience and response base on their respective worldviews and believes systems (Fekadu, 2014). Adaptation could therefore be hindered by conflicting world views and

interpretation. Varied and diverse understanding of adaptation across several groups places limits on adaptation (Ford, 2004). Studies have shown that traditional practices especially for ecosystem management do exist in forms of beliefs and taboos and in most cases very effective at the community level (Agrawal, 2003). Research on social and cultural limits to the adaptation process do not get the required attention in the realms of research (Jamieson, 2006).

2.6 Adaptation to Climate Variability in Africa

It is widely acknowledged in literature that, Africa's share in the causes of climate variability is minimal and yet predictions suggest that the region will be hardest hit in terms of impacts (IPCC, 2007 & Ager, 2006). It is projected that, climatic factors in Africa will continue to vary in most parts of the 21st century. The only safe haven that could probably lessen the negative impacts of this variability is adaptation. Although adaptation to climate variability is one of the feasible responses to mitigating the impacts of the varying climate, it is projected to however come at a great cost (IPCC, 2014) to a region which is already struggling to meet its socioeconomic demands.

Significantly, the 21st century is expected to experience a lot of variation in the climate and weather pattern in Sub-Saharan Africa. A study (Adejuwon, 2006) to assess intended range of climate forecast to enhance farmer output efficiency concludes that, inter annual variability in temperature is relatively low compared to that of rainfall. The variation in rainfall is much more pronounced than in temperature. For instance, a wet season in March-April- May does not mean that the next wet season will follow the same pattern. There are wide regional disparities in Sub-Saharan Africa in rainfall amounts resulting in localized droughts in some instances. The study also identified weather forecasting as the basic form of effective way of adaptation which is particularly challenged in Sub-Saharan Africa as pointed out clearly in literature.

Literature has it that, there were so many monitoring and weather forecasting stations in Africa in the 20th century as compared to the current trends. Currently, there are less weather monitoring system as existed about 20 to 30 years back and this has made weather prediction in Sub-Saharan Africa less precise (Patt, 2007). Unlike the developed world, there is no clear cut direction on how weather and climate monitoring is done in Africa. Although there are some weather stations doted round major cities and towns in Africa, there is generally lack of cohesion among these stations and this has made it difficult to develop a comprehensive monitoring scheme that will be meaningful to the whole adaptation process. The study noted that producing reliable climate information remains a challenge in Sub-Saharan Africa (Ziervogel, 2008). This lack of uncertain data in Africa makes resilient building very difficult (FAO, 2012).

Although agriculture has been identified as one of the contributory factors to the variations in the climate, it could as well be a meaningful solution to reducing and mitigating emissions and carbon sequestration (Ngigi, 2009). This argument in literature is a further justification of the relevance of the UNFCCC REDD+ program which has the potential to maintain and improve ecosystem services by restoring and conserving forest cover as well as effective soil management. The REDD+ program is a major form of improving the adaptive capacity to the climate variability (Mant, 2014). Considering the relationship between adaptation and the REDD+, it means that mitigating climate variability will vary along the line. Mant (2014) identified that climate variability is an on-going process of variation and therefore adaptation strategies will as well vary will rely on local conditions.

Bishaw (2013) argued that mitigation and adaptation to climate variability in Africa had to do more with land and improve natural resource processes that could reduce emission through agroforestry. The land as the study identified in Africa consists of multiple layers and perform multiple functions and this when managed well could be a major source of adaptation. Some

societies are closely dependent and connected to natural resources and this makes their livelihoods very sensitive to these resources. The study further stated that, the ease with which adaptation strategies will be implemented will largely vary in location. What has proven to be an effective strategy in one location has the tendency to fail in another location. Ribot (2010) found that climate variability also has feminine connotation as adaptive capacity are linked to things that women already are disadvantage of. These include money, technology, education and information. Already marginalized and disadvantage groups are likely to face further deteriorating consequences and this could influence the sustainability adaptation strategies (Ribot, 2010).

A wide range of policy has been focused on adaptation to climate variability leading to resource dedication in the sector, their adoptions are generally poor and this has led to poor yields in certain communities (Asfaw, 2014). This literature contends that, household adaptive capacity is a major determinant of farm practices selection. However, inconsistent policies in Africa have been one of the contributory failures to adaptation in Africa. The study identified weak infrastructure and inconsistent governmental policies as a major barrier in adaptation. This agrees with the findings of Amusa (2010) that, inconsistent policy adoption results in the growing indifference among Nigerian Farmer regarding attitude towards governmental (Amusa, 2010).

Regardless of current mitigation levels, impacts of climate variability will generally be negative but this does not mean that the process of mitigation should be halted. Mitigation will however lower the risk to these impacts thereby enabling effective adaptation strategies to be implemented. Literature confirms that, adaptation will be needed to protect livelihoods and increase food crop production in mostly developing countries including Sub-Saharan Africa (Tubiello, 2012).

The concept of adaptation as literature identified is still growing especially in Africa where comprehensive baseline for adaptation is still a challenge (Ziervogel, 2008). There is the likely tendency of separating climate adaptation from the broader development spectrum. In some instances, low crop yields and others impacts have been blamed on climate variability which in reality is not the case as in the case of the Machakos municipality in Kenya. A study (Clements, 2011) finds that, climate variability is a developing challenge with an uncertain end point and therefore adaptation needs should be made more understandable and a focal responds for communities to gain access to information, knowledge and skills so that a formidable responds scheme will be harness to avert livelihood challenges. It is obvious that, pattern of climate variability experienced every year could be a useful benchmark to future trends that will enhance adaptation strategies (Meybeck et al., 2012).

What is making the Sub-Saharan African situation more vulnerable is the fact that, majority of the farmers in this region relies directly on the natural system and only rainfall for farming purposes. Over 80% of land used for crop farming worldwide is rain-fed with more than half of this population in Sub-Saharan Africa (Ajani et al., 2013). The situation with Sub Sahran Africa is that of the adaptive capacity which is very low compared to that of Asia. This is as a result of poverty resulting from lack of infrastructure, socioeconomic and political difficulties (IFPRI, 2010).

Studies have shown that, climate variability is expected to hinder the growth of most smallholder farmers in Africa. In Ethiopia, where agricultural remain central to the economy contributing 24% of the country's GDP and employing over 70% of the work force (2009-2010), climate variability is expected to hinder this progress (Bishaw, 2013). In a related study which was meant to assess farmer's incentives and conditioning factors promoting adaptation and increasing crop productivity, identified that, wealthier farmers are more adaptive to climate stress than poor

resourced farmers. It further found out that, household status is related positively to the choice of risk reduction methods. This means that poor householders who are mostly peasants command fewer resources necessary for reducing risk. This is expected to hinder growth of the sector since most farmers in the sub region are smallholder farmers with limited resources (Asfaw, 2014). Building capacities on adaptive capacity should be focused on smallholder farmers since about 65% of agriculture is practiced by the smallholders whose resources are already challenged (IFPRI, 2004).

The Assessment of Impact and Adaptation to Climate Change (AIACC, 2006), identified that crop yield in the short to medium term will respond adversely to interannual variability in rainfall than in temperature in Sub-Saharan Africa.Variability in temperature is expected to be minimal in the short to medium term and this may affect fewer crops. In general, yields with regards to staples are expect to reduce with the reduction in rice very little as compared to maize which is predicted to reduce. The study further identified temperture as a major determinant in developing resistant pest and this could increase the total cost of production (Adejuwon, 2006). This is similar to findings that, the pattern of of temperature response among existing pest and insects may result in the emergence of new pest and insects capable of being more resistant (Meybeck et al., 2012). This could affect smallholder farmers whose resource awareness to climate variability is very low (Adewale, 2013).

The perceived inability of the smallholder farmers to adapt favourably to agriculture is a direct result of poor conceptualisation of climate variability (Ziervogel, 2008). The study found that, in reality some areas in Sub-Saharan Africa are blessed with a wide range of forecasting and early warning signs but the difficulty has to do with the end users who are mostly illiterate smallholders. These people finds it difficult to interpret such complex models. It further noted that, recent literature has unearted a wide range of methodologies necessary for the peasant

farmer but these are not tied to the end users. The study concludes by identifying three issues that hinder the use of climate information in Africa. Firstly, climate information is not readily available to the farmers and this affects the reliability of farmers on projected climate information. Climate projections are more future driven while the smallholder farmer finds this irrelevant to the current impacts. Lastly, effectively interpreting climate information is difficult and only a hand full of experts exist in Africa (Ziervogel, 2008).

Smallholder farmers who are the majority (over 50%, UNDP) of producers in Sub-Saharan Africa are particularly at risk. Adaptation is therefore critical and of concern in developing countries, particularly in Africa where vulnerability is high because ability to adapt is low (Hassan & Nhemachena, 2008). Evidence (IPCC, 2014) suggests that, Sub-Saharan Africa is the most vulnerable to climate variability and this could be reflected mostly in livelihood difficulties with manifestations in the agricultural sector. Losses could be as high as between 2% to 7% of gross domestic product.

2.7 Indigenous Adaptation Strategies and Experiences in Africa

Indigenous knowledge has been proven to be effective in the organization and implementation of sustainable development projects but however, its relevance is yet to be felt in formal adaptation strategies (Ajani et al., 2013). Indigenous knowledge dates back to periods of antiquities and as result accumulated vast body of knowledge and experiences which has been used to manage the environmental systems for a considerably longer period of time (Pareck & Trived, 2011). In Africa, communities have amassed a great deal of knowldege about the environmental sysyems and its interaction. This makes the smallholder farmer in Africa a resourceful farmer base on an excellent observation and interpretation of the environment (Berkes & Jolly, 2001).

In Sub-Saharan Africa, indigenous adaptation strategies are built on traditional or indigenous knowledge acquired through experiences with nature and the daily interactions as well as perceptions of the environment (Fabiyi & Oloukoi, 2013). Indigenous knowledge is an integral part of local belief system and culture. There exist a great deal of indigenous knowledge and strategies among traditional communities to climate variability (FAO, 2013).

Studies (Ajani et al., 2013) highlighted the importance of integrating indigenous knowledge in the policies relating to climate variability. The objective of the study was to examine the use of indigenous knowledge as a strategy for adapting to climate variability. The study identified that; climate variability cannot be separated from sustainable development just as sustainable development will be meaningless without indigenous knowledge. Indigenous adaptation knowledge is beneficial and provides a sustained medium through which smallholder farmers can adapt to climate variability. The study concludes on the integration of indigenous knowledge into the mainstream adaptation policy. The study however cautioned that, such integration must be done with caution (Ajani et al., 2013).

In a related study meant to identify the types of traditional and indigenous knowledge on adaptation system, relates that indigenous knowledge systems are built on religious and cultural beliefs and this makes it an integral part of the people (Fabiyi & Oloukoi, 2013). In coastal Nigeria where the study was conducted, established taboos and believed system proved vital to the adaptation process. The study concludes that, indigenous knowledge in among the communities in Nigeria is mostly oral and depends largely on observation (Fabiyi & Oloukoi, 2013).

Literature has it that, adaptation to climate variability is not new among traditional and indigenous people (Theodory, 2014 and IPCC, 2007:2014). Studies (Theodory, 2014) of analyses of climate variability impacts in selected communities in Ngono River Basin also found

that, indigenous knowledge is mostly oral, holistic and relies heavily on accumulated experience. It is base on the custom of the communities and provide fertile grounds for problem solving and sustainability. The study however laments that, the role of indigenous knowledge is not been given the aproppriate recognition by policy and conventional science which could be a good complement to scientific knowledge. It reckoned that, most indigenous knowledge practices have scientific bases and yet, majority of these is yet to be recognized by formal scientific knowledge (Theodory, 2014).

Indigenous knowledge in Sub-Saharan Africa has chalked some successes even before the advent of scientifically proven adaptation strategies. For instance, before the advent of chemical fertilizers, farmers in Sub-Saharan Africa have relied on organic farming which is a major source of mitigation and sustainably soil management practice. Its bases are embeded in tradition, culture, customs and the holistic believe and value system and this make it unique. Adaptation to climate variability as indicated earlier is unique and context specific (Clements, 2011) and as such indigenous knowledge will be vital to this process since it is also unique to communities.

2.8 Climate Variability and Adaptation in Ghana

Ghana is experiencing its share of climate related extremes. It is estimated that countries in Sub-Saharan Africa including Ghana will suffer from climate related shocks by virtue of the geography and location (IPCC, 2007). According to the Ghana's Second National Communication to the UNFCCC (2011), the discernible impacts of climate variability include variable and erratic rainfall, temperature fluctuation, floods and sea inundation. These climatic conditions are expected to stretch livelihoods especially the smallholder farmer whose resources

base is already challenged. Climate variability will affect human activity that depends directly on the environmental and climatic system (Yaro, 2010).

It is evident in literature that, Sub-Saharan Africa as well as Ghana is already vulnerable to climate and environmental conditions due to low adaptive capacity, sensitivity to adverse climatic conditions and poverty in Sub-Saharan Africa (SSA) and the heavily dependence on the environmental system for both economic and livelihood gains (Boko, 2007). Variation and reduction as well as erratic in rainfall distribution in Ghana will adversely affect the country's agricultural sector more than other sectors. This is because, the economy of the country still rest heavily on agriculture which employs about 50% of labour and contributes about 40% averagely in the past five years to the GDP. It is estimated also that over 90% of agriculture land are in the hands of the smallholder farmers whose average cultivable area is less than two hectors in size (Sova, 2014). Climate variability will pesist for some time regardless of current efforts to reduce the adverse impacts (IPCC, 2012). This therefore reinforces adaptation as the surest solution to the ongoing climate variability.

Several adaptation strategies have been available in literature. Codjoe (2011) identified series of adaptation strategies in Ghana to include crop diversification, mulching, fallowing, land rotation and migration among others. Similarly, (Antwi-Agyei et al., 2013) identify strategies of adaptation to climate variabilty to include livelihoods diversification, planting drought tolerant crops as well as irrigation. The study also revealed that, the timing of planting is another strategy employed by smallholder farmers in the Sekyre-Dumasi municipality. Yield of crops are affected greatly in Ghana due to high temperature and inadequate water availability. Extreme heat has been found to affect most crops nationwide making several crops' pest and diseases more resistant than before. These conditions create additional stress situations worsening the already vulnerable situations of the smallholder farmer.

Adaptation to climate variability in Ghana is embedded in other socioeconomic systems. Differential priorities exist in adaptation and these influences the adaptive capacity of rural farmers in Ghana (Antwi-Agyei et al., 2013). This study further revealed that, there are gendered differentiated outcomes in adaptation as men are found to be more adaptive than women. Although rural householders in Ghana are found to share some similarity, a lot of differences do exist due to social and cultural differences as well as other environmental interactions. As such research in to adaptation should be designed for specific communities (Codjoe et al., 2011). Almost all sectors in Ghana are found to be vulnerable to climate variability including environmental systems and socioeconomic pillars. Even though droughts are not so much pronounced in Ghana, northern Ghana in the last two to three decades has experience drought than other parts of the country. In recent years, southern Ghana has also began experiencing drought situations especially in the transitional zone where rainfall amounts are continuously reducing and becoming dispersed (Yaro, 2010).

What is making Ghana's vulnerability to climate variability more serious is the fact that, poverty levels are increasing, production and export base are still in their primary form, over dependence on rainfall as well as increasing population (Nelson & Agbey, 2005). The relation between climate variability and poverty in Ghana is so strong especially in northern Ghana. This is partly the reason why the nation's economy keeps fluctuating with no consistency in growth (IFAD, 2012). Even though records show that Ghana's agricultural sector has been growing, this growth is linked to increases in cultivable area instead of mechanization. For instance, food production index rose from 74.8 in 1990-1999 to 137.6 from 2005-2009. These increases are however not sustainable because it is only linked to increases in land which is limited.

Kemausuor and others in their assessment of farmer perception of climate change in the Ejura-Sekyedumasi municipality found that 80% of the farmers believe that there is an on-going

increase in temperature while over 90% believe that rainfall amounts are shifting (Kemausuor et. al., 2011).

Codjoe in his study assessed the perception, experience and indigenous knowledge of climate change and variability in Accra and notes that, the experiences of people in metropolitan Accra in floods, heats waves have shaped their knowledge on adaptation. Participants in the study were quick to suggest some adaptation measure to climate variability (Codjoe, 2013).

The volatility of Ghana's agriculture to climate variability is as a result of its dependence on rainfall especially in the savannah areas. This has the tendency to widen the north-south disparity in both socio-economic and livelihood gains (IFPRI, 2012). Climate variability is estimated to exacerbate inter seasonal variability in rainfall and temperature (Challinor, 2007). This will create difficulties for the water system increased incidence of pest and diseases. The consequences of this are yield reduction, food security situations and other forms of disasters like floods (Vermeulen, 2010). Most global studies have predicted reduction in yields especially staples unless stringent adaptation efforts are made to reverse this predicted situations. Effective adaptation can reverse and even sustain increases in the food systems (IFPRI, 2012).

2.9 Ghana's Second National Communication to the UNFCCC (SNC)

Ghana joined the United Nations Framework Convention on Climate Change (UNFCCC) in September 1995. Since then, the country has come out with policies and programs to aid its implementation. As part of its implementation which has been recognized under Article 4 and 12, member nations are mandated to publish periodic activities in relation to the convention and to communicate effectively activities regarding adaptation and mitigation. Ghana is categorized under the non-annex 1 countries and per decision 17/CP.8 of the UNFCCC, guidelines for both

the Initial National Communication (INC) and the Second National Communication (SNC) have been submitted accordingly. The INC was submitted to the conference of parties (COP) in December 2000 and covered the period 1996 to 2000. This current SNC covers the period 2000 to 2006 and this is in fulfilment of the country's obligation to the UNFCCC. The essence of this current document is meant to further update and report additional new findings, policies and effort made within the said period towards enhancing adaptation and mitigation.

The main objective of SNC is to communicate to the Conference of Parties the extent to which Ghana has been implementing the convention with emphasis on prospects, constraints and gaps. One key area that makes the SNC unique is the new methodology for calculating emission for the entire period of ratification (1996-2006). This highlights Ghana's contribution to the mitigation and adaptation drive. Issues of finance, technology, capacity building remains gaps constraining the achievements of adaptation and mitigation goals. On the new estimate alone, the agricultural sector alone is responsible for 36% of total emissions in Ghana. The main sources of these greenhouse emissions from the sector have been mainly nitrogen and other chemical fertilizers. It has been estimated that, the cost of adaptation to climate variability and change in the agriculture sector alone is US$ 334.24 by the year 2020 and by 2050; the figure could increase to US$ 336.30 (NCCP, 2014).

Climate change and variability is taking centre stage in both the political land scape and in policy drive. At the policy level, climate change and variability is being mainstreamed into the nation's development agenda by the National Development Planning Commission (NDPC). In furthering the goal of the convention, Ghana has also ratified the Kyoto Protocol upon which the Green Development Mechanism (GDM) has been in operation in Ghana since 2005. This is to ensure and promote quality environmental standards. The SNC was also quick to report on major climate change enabling institution in the country that is underway. This consists of the National

Climate Change Policy (NCCP) and the National Climate Change Adaptation Strategy (NCCAS). Substantial part of the Third National Communication (TNC) according to SNC will highlight the achievement of these two documents. Finally, the SNC to the UNFCCC identified the vulnerable sectors and the manifestations of climate change to include floods, drought, Bush fires, unpredictable rainfall patterns, sea level rise along the eastern coast, increased desertification/land degradation, consistent loss of forest cover and loss of some biodiversity

2.10 National Climate Change Adaptation Strategy (NCCAS)

Evidence of climate change and variability in the climatic system has become vivid in Ghana with the passage of time. This calls for the developing strategies and mechanisms that could assist human and the natural system adapt to the looming impacts of these changes and variations. The lack of a comprehensive national strategy towards adapting and addressing these eminent climatic challenges has been of concern over the years. Base on this, the National Climate Change Adaptation Strategy (NCCAS) was adopted in partnership with the United Nations Environment Program (UNEP) and United Nations Development Program (UNDP) in conjunction with the Climate Change and Development- Adapting by Reducing Vulnerability (CC-DARE) program. The strategy was finally published in 2012 with funding from the Danish Ministry of Foreign Affairs.

The main objective of the strategy is to “enhance Ghana’s current future development to climate change impacts by strengthening its adaptive capacity and building resilience to society and ecosystem. The specific objectives of the strategy is to improve societal awareness and preparedness for future climate change, enhance and mainstreaming climate change into national development to reduce climate change risks, increase the robustness of infrastructure

development and long-term investments, enhance the adaptability of vulnerable ecological and social systems by increasing the flexibility and resilience of these systems and finally to foster competitiveness and promote technological innovation".

One of the influential factors that paved the way for the adoption of this strategy is the United Nation Framework Convention on Climate Change (UNFCCC) which tasked all member states to make climate change central to development planning process. The adoption of the strategy was equally informed by the volatility of the country's economy and it's over reliance on the natural environmental system which is being affected much by the climate extremes. Studies shows that, about 70% of the country's population depends either directly or indirectly on agriculture and forest resources (IFAD, 2012). The main approach adopted by the NCCAS is the participatory approach intended to use sectorial vulnerability and adaptation assessment carried out by experts and stakeholders.

The National Climate Change Adaptation Strategy is to span for an initial period of 10 years before a review by the relevant stakeholders. The strategy identified mainly two implementing bodies which consist of the institutional framework and decentralized units. The institutional bodies rely heavily on the Ministry of Environment, Science, Technology and Innovation, the national Climate Change Committee and related non-governmental and civil society organizations. It also covers on-going projects and programs related to climate change. The decentralized bodies consist of the Metropolitan, Municipal and district assemblies (MMDAs). These organizations will be tasked through consistent capacity building and monitoring and evaluation so as to realize the overall goal and objectives.

Five key criteria for adaptation option selection is also a major component of this strategy and this was developed by a committee to oversee the integration of over 75 sectors prioritize by the committee. The main aim of the committee was to come out with adaptation option that will

cover sensitive areas of ecology, vulnerability and the economy. This committee was dubbed the "Akropong Approach". Although the National Climate Change Adaptation Strategy has clearly outlined various strategies for implementation including but not limited to livelihoods, energy, agriculture, health, fisheries and early warning mechanisms, little is mentioned of the contribution of the informal sector to the achievement of these goals. A good percentage of smallholder farmers are illiterates and are found in the informal sector where smallholder agriculture is dominant. Mention is not also made on the role of indigenous knowledge and how it can be used in together with the conventional strategies outlined in this document.

2.11 National Climate Change Adaptation Policy in Ghana (NCCAP)

The Ghana's climate change adaptation policy was adopted in 2014 by a team of researchers within the Systematic Adaptation Project (SAP). Its main focus is on agriculture which is touted as the bedrock of the nation's growth. This is largely related to the sector's inconsistent growth trend experienced in the last two to three decades and in the wake of climate change and variability, more challenges for the sector are expected. The policy identified poor soil fertility, heavy dependence on rainfall, high post-harvest losses as well as climate variability to be the main factors militating against the achievement of food security in Ghana. The country has experience a mean increase in temperature of 1^0 C in the last 30 years with the northern sector alone accounting for about 1.7^0 C and this figure is predicted to reach 2.04^0 C by 2030 (SNC-UNFCCC, 2011).

The climate change adaptation policy document composed of a comprehensive compilation of key national policy documents that have been implemented and relates mainly to agriculture and climate change resilient building. These policy documents include the Ministry of Food and

Agriculture (MoFA) and its related agencies including the Ghana Food and Agricultural Sector Development Policy I and II (2002 and 2007), ECOWAS Agricultural Policy (ECOWAP) and Comprehensive Africa Agricultural Development Program and many others including the Food and Agriculture Development Policy (FASDEP). These policies are used mainly for content analysis and as such the objectives of the policy centred on various thematic areas that are common to these policy documents.

There are also climate change related institutions such as the Environmental Protection Agency (EPA) under the technical implementing agency of the Ministry of Environment Science and Technology and Innovation (MESTI). This became Ghana's focal point for regional and international conventions of which Ghana has signed to. Based on all these policy documents, the policy carved out its objectives to include the sectors related directly to climate change and variability in relation to agriculture. These objectives are to: awareness creation and capacity building, improve land management, develop drought, flood, pest and diseases tolerant varieties and climate resistant livestock breeds, promote research into climate smart agriculture, establish environmental sanitation strategies, improve water resource management, Promote agricultural diversification, Promote fisheries resource management, invest in post-harvest storage systems and promotion of alternative livelihoods

The National Climate Change Policy identified five major areas relevant to the achievement of its objective and these areas are agriculture and food security, disaster preparedness and response, natural resource management, equitable social development and energy and infrastructural development. With the area concerning agriculture and food security, the NCCP further identifies eight focus areas to include the objectives stated above. The main body responsible for the monitoring of the implementation of the NCCP is the Ministry of Environment, Science, Technology and Innovation and its affiliated organizations.

From the above, it is clear that Ghana has all it is in terms of policies to prepare adequately for climate change and variability. The NCCP tries to draw experiences from past similar policies in order to come out with a comprehensive solution towards reaping benefits instead of always been at the receiving end of climate related stresses. Climate change and variability take place in a wider spectrum and affects almost all activities that are linked to the natural environmental system (IPCC, 2007). One key area of concern for policies in general has always been the implementation. In reference to this research work, indigenous knowledge on adaptation is completely missing in the policy. The Intergovernmental Panel on Climate Change (IPCC, 2007) highlighted the need to include indigenous knowledge in policies related to adaptation (Nyantachie-Frimpong, 2013). This is subtly missing in the policy document.

2.12 Adaptation, Climate Variability and Food Crop Production in Northern Ghana

Northern Ghana geographically covers three administrative regions in the Guinea and Sudan savannah ecological zones as well as the fringes of Brong-Ahafo and the Volta Regions. Historically, this part of Ghana has been exposed to an avalanche of pessimistic connotations such as being poor, underdeveloped, food insecure; conflict prone and in the last two decades climate variability has set in as well. As noted by Yaro (2013), some of these difficulties are as a result of the geography of the region which is particularly exposed to the vagaries of the weather in the mist of other socioeconomic and political struggles that have also bedevilled the region. Climate variability in recent times is particularly eroding past and present efforts in making the region the food crop hub of Ghana. The region's vulnerability to climate variability stems more from its single rainfall season which is increasingly becoming erratic in the face of high and fluctuating temperatures (Akudugu et al., 2012).

Climate variability in northern Ghana generally manifest itself in terms of drought, short but intense rainfall pattern, high temperatures, floods and these manifestations affect the natural systems adversely. Literature has it that, while rainfall amounts is predicted to even depreciate by 2020 through to 2050, temperatures are going to be risen instead (Amuako-Mensah & Asante, 2014).

A study by Yaro (2013b) identified that, farming is becoming more expensive than earlier envisage and this leads to fluctuations in farmer welfare and livelihoods. Farming is determined primarily by climatic and non-climatic factors and this determines the adaptation mechanism in response to these factors and this particularly is becoming difficult for the northern farmer (Yaro, 2013b). The choice of adaptation strategy is dependent on the perception of the farmer to climate change as well as its peceived impacts. Smallholder farmers are more prone to adverse climatic impacts due to low infrastructure, poor technology and lack of credit facilities and this significantly affects household income (Nkegbe & Kuunibe, 2014). Erratic and flauctuating rainfall trends pose a serious threat to household welfare in northern Ghana and this has the tendency to affect their adaptive capacity. This findings is similar to that of Amikuzuno (2013) which found that the level of adaptive capacity of the smallholder farmer is determine by income status and the rate of vulnerability to climate extremes (Amikuzuno, 2013).

Climate variability in northern Ghana affects communities differently but the recent spade of variabilty has resulted in the alternating sequence of drought and floods which Akudugu and Ditoh (2012) describe as the “double tragedy”. Livleihoods in the region are highly insecure due to the adverse climatic impacts on the natural environment and this intend determines agricultural productivity. It therefore erodes efforts of sustainable investments since households consume whatever is produced (Akudugu et al., 2012).

Studies show that, farmers in Northern Ghana perceives short dry spell at various times in the year as being normal. To them, some of the crops such as maize during a cerain period requires high temerature with minimal water. But the recent droughts that are experienced is beyong what has originally been taken place about three decades back. Additionally, times of droughts are increasingly shifting fast beyond the comprehension of the small farmer (Jarawura, 2014). In a similar vein, a study to assess how climate variability affects yields of staple crops in northern Ghana relates that, rainfall and temperature variability are among the most influencing factors in crop yield (Amikuzuno & Donko, 2012). Irrigation has been tooted as one of the feasible adaptation measures that could lift northern Ghana's agriculture. However, surface water is increasingly becoming scarce coupled with increasing variability in rainfall and temperature affects crop yield (Amikuzuno, 2013).

2.13 Indigenous Adaptation Strategies in Savelugu-Nanton Municipality

Adaptations to climate variability at the local level have historically been developed around local ecological knowledge. Studies on indigenous farmer adaptation have shown some admirable qualities that consist of innovative process that can enhance the whole adaptation process. Local perception on indigenous adaptation to climate variability has been found to be very crucial to the total adaptation process (Weber, 2010). There have been so many calls for mainstreaming indigenous adaptation knowledge into policy but this is yet to receive full attention by policy (Yaro, 2013b). These works have focused on the pattern of change however, and less have been done to aspects of the reactions of indigenous farmers to the total climate variation process.

In most studies (Amikuzono, 2012: Codjoe, 2011: Jarawura, 2014) related to climate change and variability, the perception of farmers on the elements of climate do not usually depart so much

from conventional science knowledge. The only difference between indigenous and conventional scientific knowledge on adaptation has to do more with the causal factors. Where as conventional adaptation believe anthropogenic activities causes fluctuations in the climatic system, indigenous adaptation knowledge blame socio-cultural and moral factors as the main causes of climate variability (Jarawura, 2014). In many cases, indigenous adaptation practices do not usually reflect conventional scientific logic but however they both have the common goal of ensuring increases in food crop production. A study with the goal of examining evidences of adaptation strategies of smallholder farmers in northern Ghana, revealed that indigenous adaptation practices include other forms of conventional adaptation strategies (Kuwornu & Ramatu, 2013).

Smallholder indigenous farmers generally have accumulated clear ideas of trends in the parametres of climate variability through long time observation of natural environmental and climatic process (Yaro, 2013b). Smallholder indigenous farmers have long relied on obsevation as a useful tool in determining climate fluctuations in the municipality. Jarawura (2014) identifies that, through observation, smallholder indigenous farmers in the Savelugu-Nanton municipality have easily identified rainfall and drought by observing clearly the climatic factors. A similar study by Eguavoen (2013) revealed that, most indigenous adaptations practices are short term and this is a clear indication of lack of documentation of these practices. Knowledge on the observation of variations in climate is accumulated with long term observation and the knowledge increases with age and experience. These long term observation when transformed into models becomes part of the adaptation process (Eguavoen, 2013). This is similar to findings that is fast growing in literature that, top-down engeneered base models are not enough to reduce climate risk to the smallhoder farmer (Samadder, 2014). Smallholder farmers in northern Ghana prefer local indigenous varieties of certain crops to the conventional hydrid varieties. The believe

is that, the local varieties are best suited for their local conditions. A study revealed that, 85% of smallholder farmers still rely of local variety of maize. The believe is that it taste better and more resistant than the hybrid which necessarily require a lot of imputs to cultivate (Agrawal, 2003).

Indigenous ecological knowledge system in northern Ghana is essential for the survival of most adaptation needs. As noted by Yaro (2014) in his study of the role of institutions in adapting to climate variability in northern Ghana, traditional institutions are vital for the success of adaptation programs. The study recognized the importance of local institutions especially in rural Ghana where smallholder farmers abounds (Yaro, 2014). The seeming difference between indigenous and conventional scientific knowledge show that both have their limitations and require some level of synergy building. Nyantachie-Frimpong (2013) noted in his study of indigenous knowledge and climate change adaptation in northern Ghana, smallholder farmers over the years have developed workable strategies of adapting to climate variability. The study notes that, indigenous knowledge are embeded in culture and this could affect the idea of shared knowledge.

2.14 Maize and Yam Cultivation in Savelugu-Nanton Municipality

Maize and yam remain one of the most important food crops in Ghana and is used for both human and industrial purposes, occupying a central position in the fight against hunger (EPA, 2000). As climatic elements keeps fluctuating with increasing rate of droughts and floods, maize production systems are constantly in danger. This coupled with losses resulting from production and climate induced pest and diseases have already exerted pressure on smallholder farmers in Sub-Saharan Africa (SSA) (Wiredu et al., 2010).

However, recent dynamics in the climate assessment on food crop production conducted by the Environmental Protection Agency revealed that, maize is highly susceptible to changes in the

climate than other cereal crops and this requires a major attention (Tachie-Obeng et. al., 2010). In terms of the total arable land for crop production in Ghana, maize alone accounts between 50%-60% (MiDA, 2010: MoFA, 2012). Maize is produced in almost all the agro-ecological zones in Ghana with annual output of 1,470,000 metric tonnes (MoFA-SRID, 2009). However, there has been a series of fluctuations in its production in the past three decades.

Maize is a utility crop capable of thriving in several ranges of agro climatic zones. This includes areas with 250mm to 5000mm of annual rainfall. Globally however, the major maize production areas are within the temperate zone (DOA, 2003 and MEF & DBT). Maize is mostly grown in warm weather with the mean daily temperature of not less than 19^0 C. The minimum temperature for germination is 10^0 C even though recent studies revealed that germination will be faster and more uniform with soil temperature of 16 to 18^0 C (MEF & DBT). Sunlight is effectively used by maize crop than any other cereal resulting in the highest yield per hector compared to other cereals. It needs more than 50% of its total water requirements in about 30 to 35 days after tasseling. Therefore inadequate soil moisture at grain filling stage results in a poor yield and shrivelled grains (MEF & DBT).

In maize production, even though a lot has been achieved in grain yield per area, conventional hybrids are yet to achieve certain heights in Sub-Saharan Africa. The study further indicates that, maize varies according to environmental conditions and it is season or location specific. To achieve maximum grain yield for maize as the study conclude, the higher the potential yield, the higher the due population (Tokatlidis, 2012).

A study conducted to unearth farmers' adaptation scenarios of climate change for maize production in semi-arid regions of Ghana found that, cereals including yield of maize are predicted to reduce in Ghana mainly due to temperature increases and reducing rainfall amounts. For areas within latitude 0-15^0 N of which Ghana is part, temperature is predicted to increase by

1-2^0 C by the year 2020. Yields from crops that are mostly rain-fed including maize are expected to reduce by about 50% for the same period (Tachie-Obeng et. al., 2010).

According to the Ghana Living Standard Survey (GLSS), maize is the most cultivated crop in Ghana with 63% of the total households engage in farming cultivates maize. Recent efforts to increase the production of maize in Ghana have seen increases in the application of fertilizers and other inputs. These inputs application is however not sustainable due to high cost involved especially in the northern sector where poverty rate is high (Diao, 2010).

Yam on the other hand is a root tuber crop occupying a vital position in the Ghanaian economy. For this reason, it is produced throughout the country especially in the transitional zone, the Guinea savannah belt and some parts of the Sudan savannah around the Upper West region (MiDA, 2010;Anaadumba, 2013). Ghana is the third largest producer of yam in the world but remains the number one exporter of the product to the international market with 94% of exports from West Africa coming from Ghana. It is also the third most cultivated crop in Ghana behind maize and cassava and consequently the third provider of energy in Ghanaian diet (MiDA, 2010). Additionally, about 6.3% of cultivable land area in Ghana is used for yam cultivation. The commodity alone accounts for 16% of GDP resulting from the agricultural sector. Despite the enviable position occupied by this crop, the yam industry in Ghana is dominated by smallholder farmers spread throughout the production areas in the country. Yam production in Ghana's agricultural sector is one of the promising industries growing steadily from about 877,000 tonnes in the 1990s to about 5,960,490 tonnes in 2010 and this was done by mainly smallholder farmers (Anaadumba, 2013). But the industry is also at risk to climate variability due to fluctuating weather events.

Yam is mostly grown by smallholder farmers who use indigenous and traditional methods of generating yam seeds over the years and this remains one of the major problems of the sector

(Dramani, 2013). The ideal rainfall requirement for yam is about 1000mm annual rainfall evenly spread over five to six months with a fertile and less leached soil (MiDA, 2010). Northern region alone accounts for about 12% of the total yam produced in Ghana (Anaadumba, 2013). The Savelugu-Nanton municipality is among the five intervention zone of the Millennium Development Authority (MiDA) due to its potential for expansion and increase production of the crop in the northern savannah zone (MiDA, 2010).

The future of Ghana's yam is mixed with the expected opportunities interlaced with some challenges. A major challenge for the sector has been the unavailability of yam seeds as well the prevalence of diseases for the crop. Postharvest losses for yam in the 2012 alone accounted for 24.4% of total national produced. High temperatures make it difficult to store both yam seeds and the product itself after harvest although the ministry targeted reduction of postharvest losses by 12% (MOFA, 2007).

2.15 Summary

The above review reveals that adaptation remains the focal point in responding to adverse impacts of climate variability. Climate variability will affect both human and natural environmental system and could derail the already existing efforts in building resilience unless properly curbed. The agricultural sector is particularly expected to be affected negatively and this is mainly because of its direct reliance on rainfall and other natural systems. In Ghana, the northern savannah belt remains the hardest hit. The agriculture sector in Ghana is dominated by smallholder indigenous farmers who depend directly on the natural environmental system for their livelihood needs. With the current spade of seasonal variability in rainfall and temperature, adaptation is becoming difficult and expensive for these smallholders. Again, majority of these smallholders are illiterates and finds it difficult to adequately apply the current conventional

adaptation strategies. It is advocated that for adaptation strategies to be effective, sustainable and cost effective, it must be blend with the indigenous adaptation strategies of these farmers.

CHAPTER THREE

PROFILE OF STUDY AREA AND METHODOLOGY

3.1 Introduction

This section provides information of characteristics of the study area. The study was done in the Savelugu-Nanton Municipality and consisted of ten (10) study communities. The communities are Tampion, Nyolugu, Zoggu, Zieng, Fazihini, Balshie, Kpachelo, Zosali, Nabogu and Dipale. The ten communities were selected from ten agricultural development zones out of the fifteen operational zones of which the municipality is divided into. The purpose of this was to ensure an even distribution of study communities so as to increase representativeness. It also brings to light the research design employed for the study.

3.2 The Geography of Savelugu-Nanton

3.2.1 Location

The Savelugu-Nanton Municipality 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 municipality ranges between 400 and 800 feet above sea level. The municipality also has a total land area of 2022.6 sq. km. with a population density of 68.9 persons per sq. km (GSS 2014). The study communities are shown in Figure 3.1.

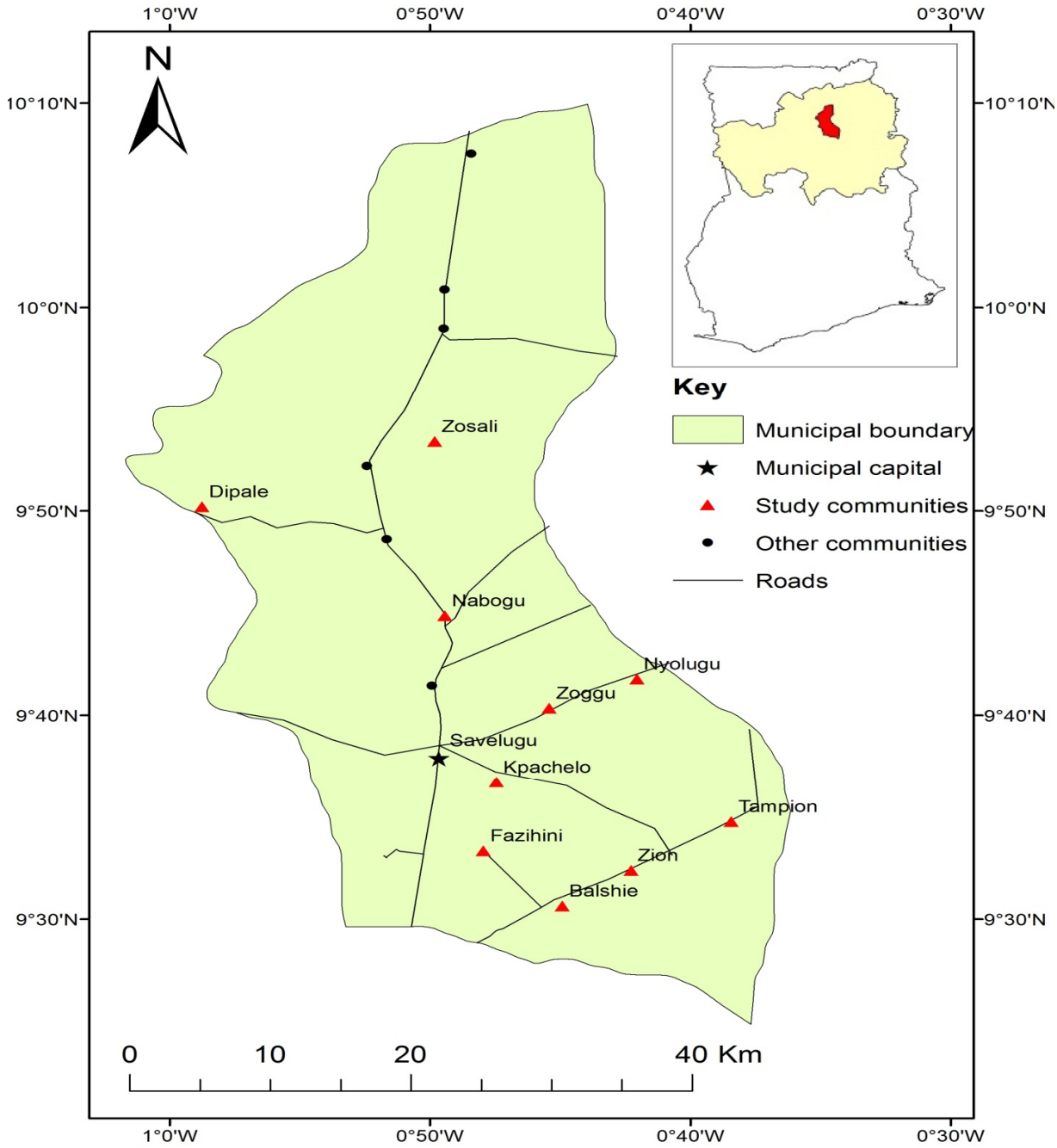


Figure 3.1: Map of Savelugu-Nanton Municipality showing Study Communities

3.2.2 Relief and Drainage

The Savelugu-Nanton Municipality is evenly flat with gentle undulating low land. The altitude ranges between 400 to 800 ft. above sea level with the southern part being slightly hilly and sloping gently towards the North.

The Municipality can boast of the White Volta and its tributaries as well as some dams. The White Volta is drained through Kukuobilla and Nabogu with some tributaries around Gushei. These areas are prone to flooding during the wet season, thus making the area suitable for the cultivation of water loving crops like rice. One of the tributaries of the White Volta, Kuldalnali, flows in between the Municipality and Tolon/Kumbumgu District (DAR 2014).

3.2.3 Climate and Vegetation

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 (Jarawura, 2014).

The municipality is characterized by high temperatures with an average of 34^{o}C. The maximum temperature could rise to as high as 42^{o}C and the minimum as low as 16^{o}C. The low temperatures are experienced from December to late February, during which the North-East Trade winds (harmattan) greatly influence the municipality (DMO, 2014).

The municipality is located in the Savannah 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 have 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 sheabutter) and dawadawa that provides seeds used to enhance cooking (DAR 2014).

3.2.4 Population Characteristics

The Municipality has a total population of 139,283 comprising 67,531 males (48.5%) and 71,752 females (51.5%). The Municipality has a sex ratio of 94.1 males per 100 females. About 7 out of every 10 persons in the Municipality reside in the rural areas (60.3%) which mean that the Municipality is predominantly rural (GSS, 2010).

3.2.5 Economic Characteristics

About 77.6 percent of the population 15 years and older in the Municipal are economically active. About 79.5 percent are male and 20.5 percent are female. Approximately 90 percent of are employed in agricultural, forestry and fisheries. Majority (96.5%) of this economically active population are into agriculture.

Nine out of ten households (89.3%) in the Municipality are engaged in one agricultural activity or the other. Agricultural households account for 83.3 percent of the total households in urban areas and constitute a higher proportion of 93.3 percent in the rural areas. Crop farming dominates the types of agricultural activities engaged in by households in the Municipality (97.0%) of all households followed by livestock farming (68.7%).

Data on the employment status reveal that majority of the people (54.6%) in the Municipal are self-employed, thus giving rise to a large private informal sector, which provides employment

for 96.4 percent of the economically active people in the Municipality, with the public (government) sector constituting only 1.9 percent.

Crop farming is the most dominant activity engaged by 96.5 percent of the work force. In all agricultural activities remains the dominant activity. Livestock farming is the next most important agricultural activity. The Municipal has a total of 365,890 livestock and 19,193 keepers. Chicken constitute 5,185, goats are 5,599 and sheep 64,441. The most scarcely found livestock in the Municipal are snails which are only three for one keeper. The average number of livestock per keeper is 19 for the Municipal. In terms of keepers, the numbers of keepers who rear cattle are 638 and that of goats are 5,599 (pg. 48 DAR 2014).

3.3 Methodology

This section is on the methods applied in gathering data for the study. It also examines the various methods used in the data analyses and presentation.

3.3.1 Research Design

The study employed the concurrent mixed study design approach. The design was chosen because it offered the researcher the opportunity to conduct detailed and comprehensive analyses on the data collected. Issues of climate variability and indigenous smallholder knowledge influencing their practices is quite complex and to offer a detailed analyses of the findings, the concurrent mixed design was used. Therefore both quantitative and qualitative data was collected for the study at the same time. The qualitative data was used to add more meaning into the figures being presented.

3.3.2 Operationalization of Study Variables

The study variables consist of climate variability, indigenous adaptation and conventional adaptation. Climate variability describes the changes in the normal occurrence of weather and its elements beyond what is previously known or observed. Indigenous adaptation strategies are the methods or adjustments, employed by indigenous societies in the face of actual or potential shift in the ecological system and the elements of climate so as to cope with the expected or actual stress in the climate system. Also, conventional adaptation strategies are the strategies that are external to the communities and have been introduced by external development agents such as the government, nongovernmental organization and farmer based organizations

3.3.3 Sources of Data

Both primary and secondary data sources were used for the study.

3.3.3.1 Primary Data

Primary data was collected using a variety of methods such as interviews, questionnaires, key informant interviews, focus group discussions and observation. The use of different tools for data collection assisted the researcher to identify inconsistencies in the responses (Twumasi, 2001).

Interviews

On the use of interviews, three hundred and thirty seven (337) interviews were conducted. Three Hundred and Thirty Two (332) were smallholder farmers and five (5) extension officers. With regards to the smallholder farmers, interviews were conducted directly since most of them could read and write. For the extension officers, arranging for interviews were not possible due to their busy schedules. The questionnaires were therefore left for them to respond at their own time. The questions covered perceptions of smallholder farmers on climate variability, adaptation

experience, determinants of adaptation and the various challenges of adaptation. Questions on perceptions and conventional adaptation strategies were mostly close ended while questions on indigenous adaptation strategies and the challenges of adaptation were mostly open ended. This was done in order to unearth indigenous adaptation practices of the study area since most indigenous practices are specific to location. Close ended were also used for the mostly on conventional adaptation strategies and this was because, so much has been done on conventional strategies which existed in literature. Once the time and location of interviews were agreed, the research observed all the customary protocols before the actual interviewing process. Interviews were conducted in relaxed atmosphere and this gave respondents the room to express themselves. Responses that appeared contradictory were accompanied by follow up questions for clarification. There were situations when respondents spend too much time on a question but when that questions were finally answered, the researcher intelligently put in the next questions. This was to avoid destabilizing the atmosphere. There were times the team leader will have to monitor the research assistants in order to ensure that the right procedures were followed. With respect to the five extension officers, it was impossible to arrange a schedule interview but the fact that they could read and write the questionnaires were handed over to them to complete at their own time. All the five questions were returned within two weeks.

Key Informant Interviews

With regards to key informant interviews, eight key informants were interviewed. The eight respondents were purposefully selected from the eight out of the ten communities visited with only two communities not represented due to the absence of respondents. These communities are Kpachelo, Zieng, Fazihini, Nyolugu, Zosali, Balishei, Depale and Nabogu. The respondents for the key informant interviews were selected were selected during the individual interviews.

Special consideration were given to respondents who were observed to be very knowledgeable and experienced in farming. The key informant interviews covered broad areas of perception on climate variability, indigenous adaptation strategies and the challenges of adaptation. Questions on key informant interviews were open ended. In conducting these interviews, specific arrangement with regards to the scheduled time were agreed. Respondents consent was also sought for the interviews to be recorded. The main aim of these key informant interviews were to access additional information to support the individual interviews. In conducting the interviews, the researcher was very cautious on the norms and mannerism of putting the questions through. This was because; all the key informants were the elderly with some of them having chieftaincy titles. Follow up questions were ask in order to clarify issues that were vague. Also indigenous terms used to describe certain aspects on the topic were reinforced for clarity. Each of the eight key informant interviews lasted approximately one hour each. Plate 3.1 shows a key Informant Interview session.

Plate 3.1: Key Informant Interview in Zieng

Observation

The researcher made some observations in the field. Although the timing of the data collection did not cover all the processes involved in the adapting maize and yam, categories such as the method of storage of maize and yam, making of yam mounds and the storage of seeds were particularly observed. The researcher there employed photography in order to give pictorial accounts of some important events from the field. Some of the pictures took included indigenous storage facilities, yam mounds, ridges, interview sessions and focus group discussions.

Focus Group Discussion

With respect to focus group discussions, Five (5) focus group discussions were held in five different communities and they are Zieng, Fazihini, Nyolugu, Kachelo and Zoggu. The minimum number of participants was seven and the maximum number of participant was ten. Although all the participants in the focus group discussions were intended to be mixed, it was difficult finding women respondents for the discussion. This was because; maize and yam cultivation is dominated by men smallholder farmers. In all the five (5) discussions, only three women participated in the mixed group discussions in two separate groups. Two women took part in Fazihini while the men were eight and one from Nyolugu among eight men also. The less involvement of women was because of the selected crops for the study. Maize and yam cultivation is dominated by male smallholder farmers. On the discussions, the questions covered smallholder farmer perception on climate variability, adaptation experiences of smallholder farmers, determinants of adaptation and challenges of climate variability adaptation. The participants composed of mostly middle age men and some few others in their early seventies. The youngest participant was twenty eight. Initially, it appeared the vast differences in age could result in the nonparticipation of some others but this was not the case however. One of the

problems encounter on the facilitation was initially how to moderate the questioning. The emotions that accompanied some of the responses were great and nearly caused a complete digression in some cases. Plate 3.2 shows a focus group discussion session at Nyolugu.

Plate 3.2: Focus Group Discussion, Nyolugu

3.3.3.2 Secondary Data

Secondary data sources were not left out of the study. The Municipal Agricultural Development Office (MADO) provided data on annual production of maize and yam as well as some conventional adaptation strategies. The Ghana Meteorological Agency (GMET) was also a source of rainfall and temperature information. Other sources included journals, books and reports were particularly helpful in this study.

3.4 Sampling Techniques

Under the probability sampling techniques, Simple random sampling was used to select ten (10) communities from the study area. The municipality comprises of fifteen (15) agricultural operational zones. In order to ensure representativeness of the sample communities, ten (10) communities were selected from ten operation zones. Four out of the ten sampled communities consisted of farmer groups and these communities are Kpachelo, Fazihini, Nabogu and Zosali. The lottery technique was therefore used to select the study sample. Again, simple random sampling was use to select smallholder farmers respondents from each of these communities. Table 1 is the breakdown of smallholder farmers interviewed.

Table 3.1: List of Sampled Communities and Respondents

S/N	Community	Number of respondents
1	Tampion	32
2	Nyolugu	40
3	Zoggu	40
4	Zieng	40
5	Balishei	35
6	Kpachelo	28
7	Fazihini	39
8	Nabogu	30
9	Zosali	26
10	Dipale	22
	Total	**332**

Source: Author, 2015. (S/N-Serial Number)

Purposive sampling was also use to select key informants for the study. Smallholder farmers with expert knowledge and experience were selected purposively for purposes of interview. These key informants were selected from the smallholder farmers interviewed. Also, smallholder farmers were selected purposively for focus group discussions. In two of the communities, existing farmer groups were used and the other three communities made use of smallholder

farmers belonging to no group. Five Agricultural Extension Agents were also selected using purposive sampling.

3.5 Sample Size Determination

In all three hundred and thirty seven (337) respondents were used for the study. Respondents consisted of smallholder farmers and agricultural extension officers. The minimum age of respondents was eighteen (18) years. The sample was determined based on the Taro Yamane's formula (1967) $n=\frac{N}{1+N(\infty)2}$ (Puopiel, 2014) at 95% confidence level. Where n is the sample size to be determined and N is the sample frame.

3.6 Techniques of Data Analyses

The study employed both quantitative and qualitative analytical methods in the interpretation of results from the study.

3.6.1 Quantitative Data

Data from the study was analysed using the Statistical Product and Service Solutions (SPSS). This software was used to facilitate the quantitative analyses by producing descriptive statistics such as frequencies and percentages as well as establishing the relationship between variables. The software was also used to produce graphical figures and table. The tables and graphs were used to depict trends and pictorial diagrams for easy analyses. This helped in accuracy analysis that will help to check the consistency of given responses. Data was also be transformed into descriptive statistics for purposes of analyses and interpretation.

The Kendall's coefficient of concordance was used to rank the determinants of adaptation. The Kendall's *W* is a measure of the degree of agreements level among several respondents whose rate of adaptation are influence by a given set of n determinants (Legendre, 2005). Where *W*

denotes an index that measures the ratio of the observed variance of the sum of ranks to the maximum possible variance of the ranks. The idea behind this index is to find the sum of the ranks for each determinant been ranked. If the ranking is in perfect agreement, the variability among this sum will be high (Tanko et al., 2016).

3.5.2 Qualitative Data

Qualitative data was analysed by the use of content analysis and intuitive interpretation of responses. Audio data from focus group discussions were transcribed for analyses and interpretation. Discourse analysis technique was also employed for the purposes of key informant interviews and focus group discussion (FGD) analyses and interpretation.

3.7 Validations of Findings

Validation of findings which is a necessary component of this research was done through data triangulation, use of member checking, use of peer debriefing and external auditors. The researcher engaged in member checking of various responses from the respondents in order to ensure that the right information is captured. This was done by engaging in return visits to the respondents before, during and after the analyses. Independent colleague researchers were also engaged to offer some professional review of the analysed data through some debriefing process.

CHAPTER FOUR

DATA PRESENTATION, ANALYSES AND DISCUSSIONS

4.1 Introduction

This chapter presents and analyses the results of data acquired from the study area. The results are presented and discussed based on the itemized specific objectives of the study. Commencement of these results and discussions begin with the background characteristics of respondents, smallholder farmers' perception of climate variability, adaptation experiences of smallholder farmers, the key determinants of adaptation and the challenges of both conventional and indigenous adaptation strategies.

4.2 Background Characteristics of Respondents

The background characteristics of respondents considered for the purpose of this study are the age of respondents, sex, and educational background. It also considers access and source of farm credit as well as access and number of extension visits.

4.2.1 Age of Respondents

This section discusses the age categories of respondents. The study covers smallholder farmers eighteen (18) years and above. The study as seen in Figure 4.1 revealed that, 27.7% of the respondents are aged between 36 and 45. This is closely followed by respondents aged between 46 and 55 (22.3%) and those aged between 26 and 35 (21.1%). This category of people falls within the economically active population. This means that crop cultivation in the municipality is mostly practiced by the economically active population who fall in the middle age group. However, only 13.9% of the respondents aged above 56 years are still engaged in farming. This means that, the aged are less likely to be engaged in active crop cultivation. However, the aged

possess a lot of experience through the observation of the climate over time as a result of prolong engagement in farming. This agrees with Eguavoen (2013:12) that "observation of long term changes in climate increases with age"

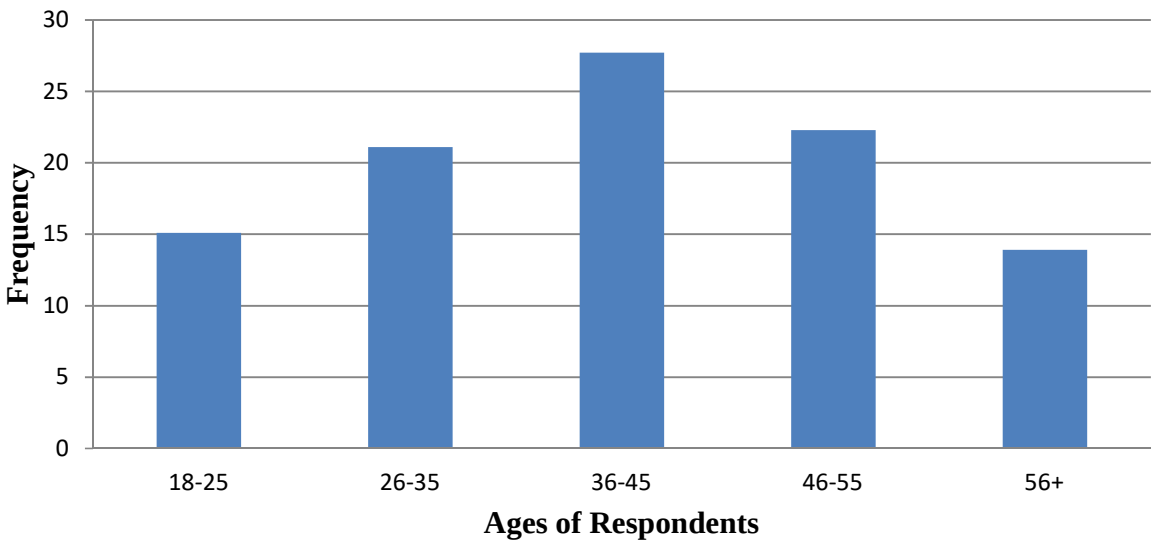


Figure 4.1: Age of Respondents

Source: Field Survey, 2015

4.2.2 Sex of Respondents

This section discusses the sex composition of the respondents for the study. Figure 4.2 illustrate the composition of respondents by sex. Majority of the respondents (84%) are male while the remaining 16% are female. This means that maize and yam cultivation is dominated by the male. The cultivation of these crops in the municipality is seen to be the preserve of the male with the female counterparts engaged in the cultivation of other crops. Land holding is also the preserve of the male except in some few cases women do own land. Additionally, the male is always recognized as the household heads. All other persons in the household are expected to serve the

head both in labour and other house duties. This means that, women can contribute their labour to the farm but do not actually own the farm. Their role is normally supportive to that of the male.

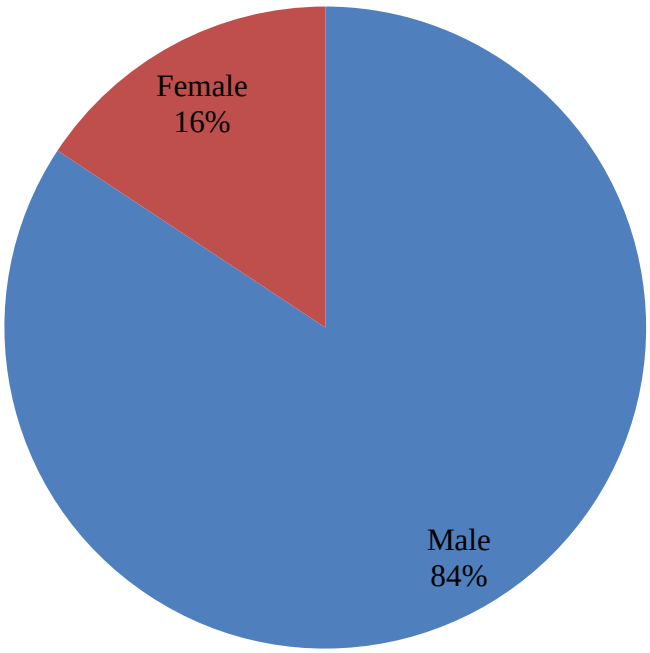


Figure 4.2: Sex of Respondents

Source: Field Survey, 2015

4.2.3 Educational Background of respondents

Ones level of education is vital in determining the level of adaptation. The study therefore sought to identify the educational background of the respondents. Figure 4.3 shows the results of the study show that majority of the respondents (226) representing 68.1% of the respondents have not been to school. This means that, majority of the respondents could find it difficult to adopt adaptation strategies requiring some level of literacy and technology. The complex nature of recent climate variability requires some basic education to adopt strategies that could best fit the situation. These categories of respondents are more likely to adopt indigenous adaptation

strategies than conventional strategies as a result of lack of formal education. Only 3% of the respondents are educated up to the tertiary level with 22 of the respondents representing 6.6% in the senior high school level. These respondents are more likely to adopt conventional adaptation strategies than indigenous strategies.

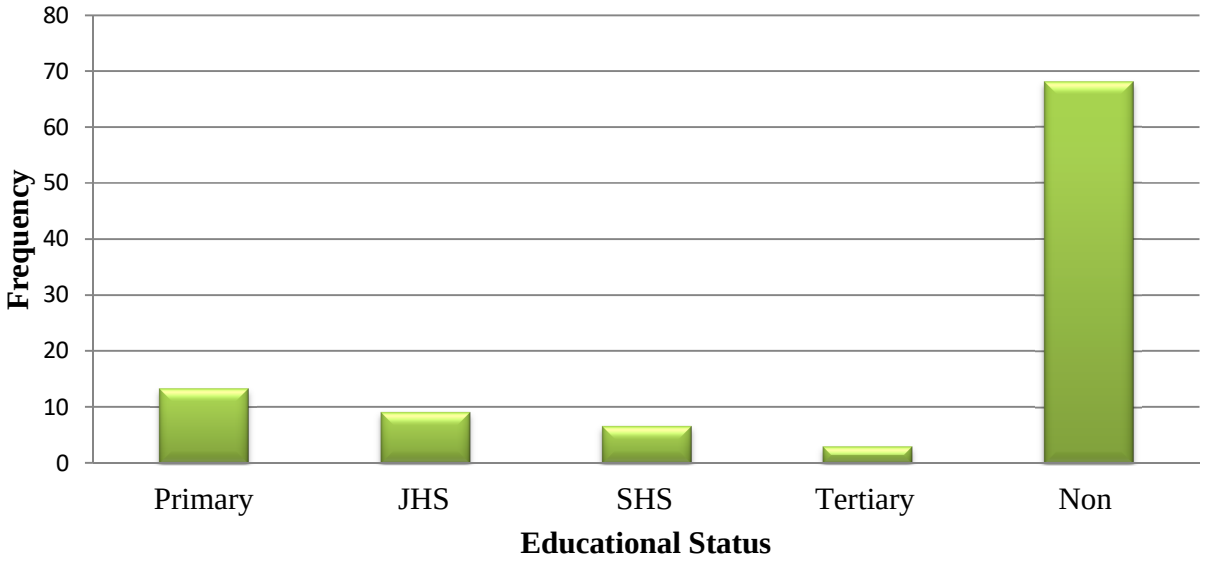


Figure 4.3: Educational Status of Respondents

Source: Author, 2015

4.2.4 Crop Category of Respondents

The study also identified the major crops grown in the study area. Table 4.1 shows the crops cultivated by respondents. In Table 4.1, it is seen that all the (100%) respondents cultivates maize. This means that maize is the predominant food crop cultivated in the municipality and this shows why maize is regarded as the staple crop in the municipality. The large number of respondents into maize cultivation is also as a result of the climate of the study area which favours maize crop production. With regards to yam production, 84.3% engage in yam cultivation as well. The high percentage of respondents engaged in yam production also indicates

that, the climate in the areas favours the growth of yam as well. Again, yam is considered a cash crop among smallholder farmers in the municipality and is usually the first crop to be cultivated during the beginning of the season. A large (91%) percentage of the respondents also cultivate other crops which imply that, each of the respondents cultivates at least more than one food crop.

Table 4.1: Crop Category of Respondents

Crop	Yes (Percentage)	No (Percentage)	Totals
Maize	100.0	0.0	100.0
Yam	84.3	15.7	100.0
Other Crops	91.0	9.0	100.0

Source: Author, 2015

4.2.5 Access to Credit

The study also considered the credit support to farmers. This section highlights the credit sources of respondents in the Savelugu-Nanton Municipality. In Table 4.2, the study reveals that majority (252) of the respondents representing 75.9% do not have access to credit facilities. This means that, the level of adoption of strategies that are relatively expensive cannot be adopted by these respondents. It therefore suggests that 75.9% of the respondents are more likely to adopt less expensive strategies which are mostly the indigenous strategies. This conforms to the work of Hassan and Nhemachena (2008:94.) that "access to credit has a positive effect on smallholder farmers' strategy adoption. Farmers with access to credit have higher chance of adapting to climatic conditions". Only 80 (16+64) of the respondents representing 24.1% (4.8%+19.3%) have access to credit. However, 64 of these are from nongovernmental organization and 16 are from private sources. This suggests that, these respondents are more likely to adopt conventional strategies than indigenous strategies.

Table 4.2: Source of Credit of Respondent

Accessibility to Credit	Frequency	Percentage
No Access	252	75.9
Private	16	4.8
NGO	64	19.3
Total	**332**	**100.0**

Source: Author, 2015

4.2.6 Access to Extension Services

The result shows that 248 of the respondents representing 74.7% have no access to extension services with 84 of the respondents also representing 25.3% having access to extension services. This is presented in Table 4.3. The study revealed that, 74.7% of respondents are not visited by extension agents. This could impact on respondents' level of adoption of newly improved strategies since extension agents are a major source of knowledge on adaptation. About 25.3% of respondents have access to extension service. This means that, respondents could possess a higher capacity to adapt to new strategies. On the average, 16 of the respondents with access to extension visits have been visited on two occasions with majority (26) receiving three visits per season. For the respondents who received 5 and 6 visits, are 4 respondents each respectively. This means that respondents with regular access to extension services are more likely to adapt to new and improved conventional adaptation strategies. This could make them better adaptors to new technology than majority (74.7%) of the respondents without access to extension visits.

Table 4.3: Access and Number of Extension Visits

Extension Visits	Frequency	Percentage
No Extension visits	248	74.7
1	10	3.0
2	16	4.8
3	26	7.8
4	24	7.2
5	4	1.2
6	4	1.2
Total	**332**	**100.0**

Source: Author, 2015

4.3 Perception of Trends and Fluctuations in Climate

Perceptions are very important in determining how people react to situations. Most human actions are guided by how the said situation is perceived. In accessing smallholder adaptation to climate variability, it is necessary to identify the various forms of perceptions they hold towards the phenomena.

4.3.1 Nature of Rainfall in the Savelugu-Nanton Municipality

Smallholder farmers were required to indicate their perception of rainfall in the municipality. The nature of rainfall was categorized as being stable, changing, and erratic as well as indifference. The study revealed that, majority (198) of the respondents representing 59.6% believe that rainfall in the municipality is reducing. This is reflected in reducing the quantity of rainfall with frequent droughts. This means that respondents do not get enough rainfall as it used to and this has serious implications for crop productivity in the municipality since agricultural activities are rain fed. As indicated in Table 4.4, about 188 respondents representing 35.5% of the respondents perceived the rainfall has been erratic. This presents a situation of unpredictability and hence could result in to serious risk to smallholder farmers with irreparable consequence. The inconsistency in the amount of rainfall has implications for planning by smallholder farmers thereby increases the risk to climate variability. The nature of rainfall was

also examined in reference to the sex of respondents, access to extension services and the background of respondents. On the reduction of rainfall, about 152 male smallholder farmers perceive the rainfall as reducing with 38 female respondents also agreeing to the reduction in rainfall amounts. As many as 108 male respondents and 10 female respondents perceive rainfall as being erratic. This means that majority of both male and female respondents perceive rainfall as either reducing or erratic.

With regards to access to extension services and rainfall, about 38 respondents who have access to extension services perceive reduction in rainfall amounts and 152 of the respondents without access also perceiving a trend of reducing rainfall. However, 40 of the respondents with access to extension services think the rainfall is erratic and 78 of those without access to extension services also perceive rainfall occurrence as erratic. This means that, there is no much difference in the perception of smallholder farmers with or without access to extension services in the way rainfall is perceived. On education, about 100 (66+34) of the respondents who are educated perceived changes in rainfall. About 208 (124+84) of the respondents who have not being to school also perceive the rainfall as reducing and erratic. This means that both the educated smallholder farmers and the uneducated perceive changes in the amount of rainfall.

Table 4.4: Nature of Rainfall in the Savelugu-Nanton Municipality

		Nature of Rainfall				
Variable	**Category**	**Stable**	**Reducing**	**Erratic**	**Don't Know**	**Total**
Sex	Male	6	152	108	14	280
	Female	2	38	10	2	52
Access to Extension	Yes	2	38	40	4	84
	No	6	152	78	12	248
Education	Educated	0	66	34	6	106
	Not Educated	8	124	84	10	226

Source: Author, 2015

Most of the changes in the climate are manifested in reducing rainfall amounts, increasing length and frequency of drought and shifting farming seasons. This is captured in the words of a participant in a focus group discussion:

"*These days, the rains normally deceive us. It usually starts as if it will rain for some time and then when you come preparing to farm, it will stop. When it stop this way whatever you have already sewn, then goes to waste. But later it will come very heavy for a short period and those who were waiting for the rains now begin rushing to the farms"* (FGD, Zieng).

The amount and nature of rainfall has become a concern to the smallholder farmers. The rain is not only reducing in amounts but also the number of rainy days. This leads to poor development of crops as the water requirement both in quantity and duration are not met. In a focus group discussion, this was what came up from a middle aged participant:

"*For me what I see about the occurrence of rain regarding our farming is that the rain has been mistaken in the last four years, the crops don't grow the way they want. The rain will just be there waiting and start at once and rain for days. It will continue raining and at the time the crops will need water, then it will stop. In that case, the crop will fail because it rained at a time we don't need rain. When the crops need rain, it will make a mistake and not come and rather come at a time we don't need it."* (FGD, Fazihini).

As a result of the rainfall reduction, farming has become increasingly difficult and risky. Because of the short duration of rainfall experienced now, smallholder farmers are not able to fully cultivate all the crops they used to cultivate. All the crops have their respective periods of planting which is different from each other. If the duration of the rain is longer, the more time available to cultivate all these crops. Ones the time period of cultivating particular crops elapses,

then such a crop is more likely not to thrive well due to wrong timing. This confirms the findings of Antwi-Adjei et al. (2013:15) that timing of planting is an important strategy employed by smallholder farmers. In a key informant interview, a respondent contended that farming was a year round activity. Each particular part of the year has the exact farming activity they will be engaged in. During the ending part of the season when the rains are stopping, usually marks the beginning of preparing the land for first yam cultivation:

"We used to cultivate yam as the first crop. Thereafter it will be followed by groundnut, cassava and maize. By the time your maize gets to maturity you are already eating your first yam. The ground nut too will be ready at this time. My son, so as you can see we now have to cultivate all these in just one period which is not possible and all these is because of the rain"(KII, Kpachelo).

This means that, the wet season is increasingly becoming shorter and confirms Tetteh-Annang et al. (2015) assertion that, "the wet season is becoming shorter over the last three decades".

4.3.2 Effects of Climate Variability

Various groups of people are affected by climate variability differently. Smallholder farmers in the Savelugu-Nanton Municipality were asked to state how climate variability affects them. In Table 4.5, majority (172) of the respondents representing 51.8% are affected by reducing rainfall. The quantity of rainfall received has reduced drastically thereby affecting the yields of most food crops. This means that, smallholder farmers will have to devise strategies to take advantage of this decreasing rainfall. Such strategies could include cultivating shorter duration crops and irrigation schemes to help arrest this situation. This is similar to the findings of Nkegbe and Kuunibe (2014:8) that there is decreasing trends in rainfall in northern Ghana and this could adversely affect livelihood. Also, 18.7% of the respondents are affected by increasing

drought. The number and frequency of drought has been rising as well. The increasing drought situation will require strategies for effective management of water for use in the farms during times of need. Some of the respondents (1.2%) experience other form of effects. These respondents are affected by low crop yield, emergence of new weeds and pest as well as strong winds. The less amount of rainfall received provide ground for survival of certain diseases and pests.

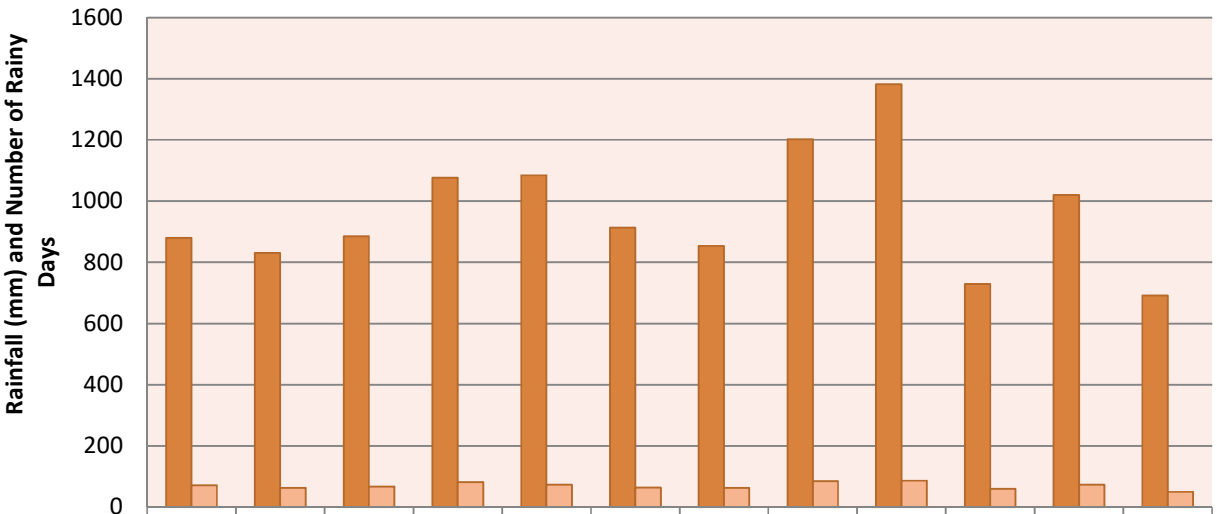
Table 4.5. Effects of Climate Variability

Effect of Variability	Frequency	Percentage
Shifting farming season	58	17.5
Increased temperature	36	10.8
Reducing rainfall amount	172	51.8
Increasing droughts	62	18.7
Other	4	1.2
Total	**332**	**100.0**

Source: Author, 2015

The Savelugu-Nanton municipality has gone through a series of irregular rainfall pattern. The effects of these phenomena are tremendous and pose a greater threat to crops and the livelihoods of smallholder farmers. Figure 4.4 shows the rainfall figure as well as the number of rainy day from the year 2000 – 2013. The amount of rainfall received has been fluctuating over the last 14 years. This phenomenon has a tendency of affecting crop productivity especially crops requiring longer duration. Such crops are more likely to be indigenous varieties since most indigenous varieties have longer duration. This means that crops such as yam and some maize varieties that take longer time to mature are more likely to fail. Between 2000 and 2002, the total amount of rainfall received in the municipality was relatively small compared to the 2003 and 2004 figures. In 2011 also, there was a sharp fall from the 2010 figures both in amounts and the number of days. The sharp decline in rainfall amounts has implications on food crop production and development in general. These continuous fluctuations are more likely to affect the overall planning and consequently reduce crop output there by putting livelihoods in danger. In some

cases the disparities are very huge. Between 2010 and 2011, the number of rainy days were reduced by 24 days and increased by 10 days in the following year with another 7 days reduction in the preceding year also.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
RAINFALL	879.8	830.8	885.2	1,075.	1,084.	913.2	853.4	1,202.	1,381.	729.2	1,020.	691
DAYS	72	63	67	82	74	64	63	85	87	60	74	50

Figure 4.4: Rainfall and the Number of Rainy Days

Source: Municipal Metrological Department, Savelugu-Nanton (2015)

In a focus group discussion at Kpachelo, a 62 years participant retorted that, seasonal change in the onset of rain never exceeded two to three weeks. If the season started in a particular month, then based on the experience and calculation, the next season will delay between two to three weeks.

"*We used to add two to three weeks to the days the rain started in the previous season then we begin farming. These days if you do that you will not get anything. The rains either come early or delay more than we are expecting. Sometimes even if we get the first rains we are afraid to farm because you cannot tell what will happen next*" (KII, Zieng).

This therefore means that the season has been shifting at a pace more than earlier experienced. This agrees with the IPCC findings that, indigenous systems are going to experience greater changes in the climate system. This shift unlike the one explains by one participant earlier, is much greater and irregular. From Table 4.6, the first rains in the municipality for a year have not been regular. From 2000 to 2008, there have been some disparities in the first rains. The only consistency experienced was from 2004 to 2006. This first rain as explained through a Focus Group Discussion is called *Salun Saa or Sigli saa*. The *Salun Saa* is very important for the planting of yam. Farmers at this time would have finished making their mounds and waiting for the first rain to begin the planting. Therefore the delay in the onset of the rains, affects first, the planting of yam and subsequently maize and other crops. Yam has a long gestation period spanning over four months. The reduction in rainfall has a greater tendency to affect yam growth since it requires water over a long period. This agrees with the work of MiDA (2010:4) that, yam requires water not less than 1000mm evenly spread over five to six months. For maize, it was revealed that, there used to be two periods of maize cultivated. The first period is the *Shein Kawana* and the other is the *Wuu Kawana*. The *shein Kawana* is the early planted maize which is mostly the indigenous yellow maize and the *Wuu Kawana* is the late planted maize usually a late maturing variety.

Table 4.6: Month of Start of Rain

Year	Month of start of rain
2000	January
2001	March
2002	April
2003	February
2004	January
2005	January
2006	January
2007	February
2008	March

Source: Municipal Meteorological Department, Savelugu (2015)

4.3.3 Nature of Temperature in the Savelugu-Nanton Municipality

The study also sought to determine how temperature is perceived among respondents. The responses are described as increasing, decreasing, fluctuating and stable. In Table 4.7, approximately 56% of the respondents perceive temperature as increasing. This means that, average temperature in the district has been rising and this could be attributed to the reduction in both rainfall amounts and the reduction in the number of rainy days. This reduction in rainy days in particular translates into longer dry seasons which are often noted for high temperatures in the municipality. As noted in a focus group discussion "*the length of hamattan has increased in this last few years and this affects our planting time (FGD, Nyolugu).* Increases in rainfall and the number of rainy days reduce surface temperature. Also, 6.1% of the respondents perceive temperature as reducing. About 29.5% of the respondents also see temperature as being stable. According to these respondents, certain periods which were noted for high temperature still experience high temperatures and the periods noted for low temperatures also experiences lower temperatures.

Table 4.7: Nature of Temperature

Temperature	Response/Frequency	Percentage
Increasing	186	56
Decreasing	20	6.1
Fluctuating	28	8.4
Stable	98	29.5
Total	**332**	**100.0**

Source: Author, 2015

This assertion is reflected in the mean monthly temperatures recorded from 2005 to 2014 in Figure 4.5. From the graph, it is seen that average monthly temperatures usually start increasing from the month of October and travels through March to April in some cases. Lower average

temperatures are experienced mostly from May to September. However, there has been some inconsistency in both minimum and maximum mean temperatures for these periods. Between 2006 and 2008, the minimum mean temperature recorded was 15^0C while for the same period between 2009 and 2011, it was 18^0C.

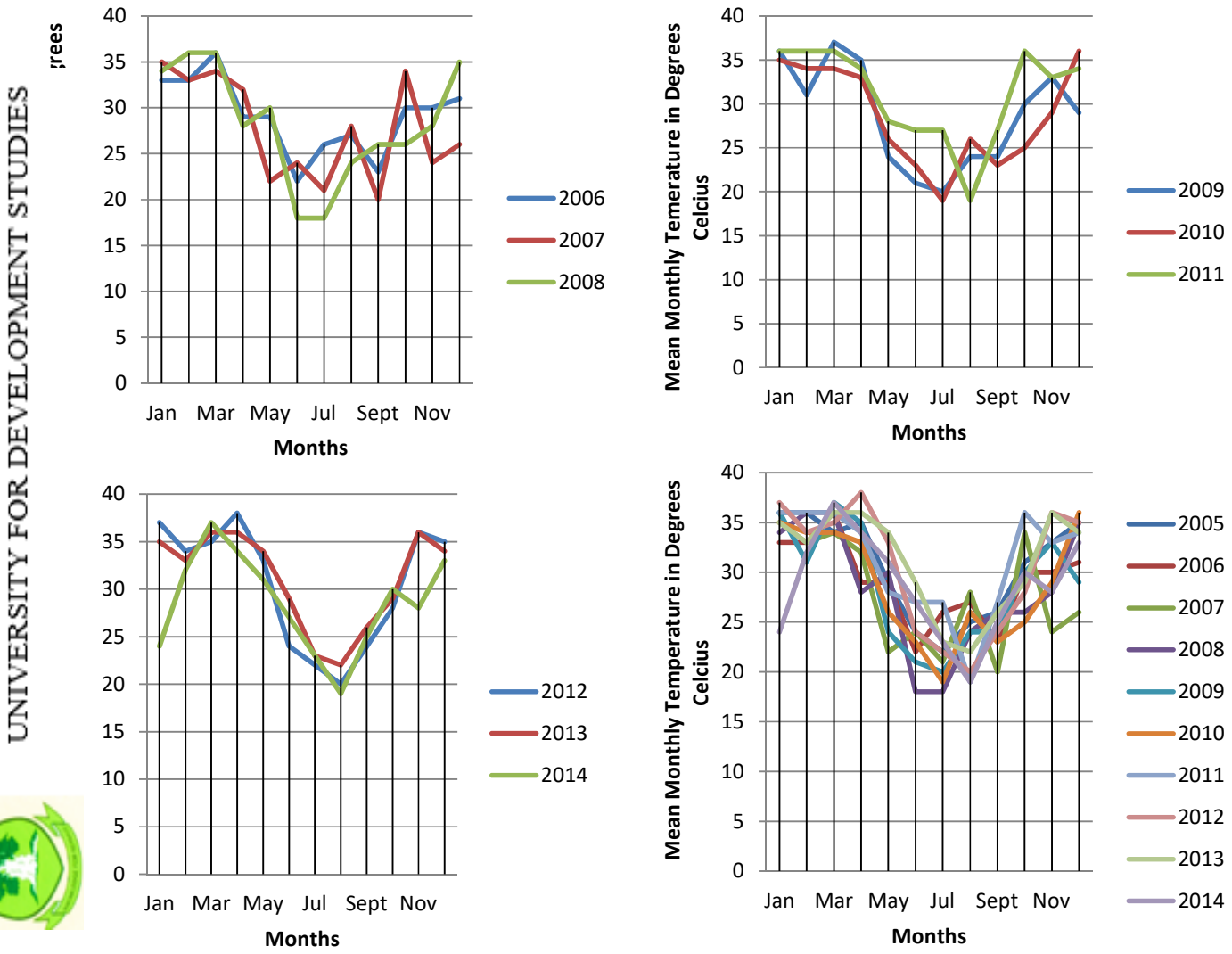


Figure 4.5: Mean Monthly Temperature

Source: Municipal Meteorological Department, Savelugu (2015)

4.3.3 Notice of Variability in Rainfall and Temperature

The study also revealed when various categories of the respondents started noticing the onset of climate variability as illustrated in Table 4.8. The study revealed that, 50.6% of the respondents noticed the effect of climate variability for the past 5 years. To them, the amount of rainfall has been reducing with an increase in the frequency of dry spells. Also, 21.7% of the respondents noticed these effects only 2 years ago. The category of respondents is more likely the young population since the older generation has the higher probability of witnessing climate changes over time. As many as 3% of respondents said they noticed climate variation for more than two decades. The occurrence of these variations was however not as pronounced as the recent phenomena.

Table 4.8: Notice of Variability in Rainfall and Temperature

Period (Years)	Frequency	Percentage
Two	72	21.7
Five	168	50.6
Ten	68	20.5
Twenty	14	4.2
More than Twenty	10	3.0
Total	**332**	**100.0**

Source: Author, 2015

4.3.4 Frequency of Occurrence of Some Climate Variables

Respondent indicated the level of frequency with which erratic rainfall, floods, high temperatures and drought occurs in the municipality. Respondents indicated whether a particular parameter is less frequent (LF), frequent (FQ) and highly frequent (HF). For erratic rainfall, the study shows that 50.6% of the respondents indicated that it is highly frequent. This means that the rate of reduction and inconsistent occurrence of rainfall has been dominant. This therefore has the tendency to reduce crop yield and increase crop failure since the municipality's agriculture is rain-fed. In the same way, 48.8% of the respondents indicated that drought in the municipality

has been highly frequent. Floods and high temperatures are less frequent as revealed by the study of 68.8% and 38.6% respectively. This means that floods and temperature change impacts little on food crop production. This agrees with the findings of Adejowon (2006:36) which found that "inter annual variability in temperature does not affect crop productivity compared to rainfall".

On the average, 34.4% of the study result shows that erratic rainfall, floods, high temperatures and drought are frequent in the municipality. This means that, the municipality has been experiencing erratic rainfall, floods, high temperatures and drought more often. However, much of the effects are with erratic and reducing rainfall.

Table 4.9: Elements of Climate and Frequency of Occurrence

Climate Variable	Frequency			
	LF	**FQ**	**HF**	**Totals**
Erratic Rainfall	7.2	42.2	50.6	**100**
Floods	68.7	16.9	14.5	**100**
High Temperatures	38.6	49.4	12	**100**
Drought	22.3	28.9	48.8	**100**
Average percent	**34.2**	**34.35**	**31.475**	**100**

Source: Author, 2015. (LF=Less Frequent, FQ=Frequent and HF=Highly Frequent)

In all the focus group discussions, there was a greater agreement on how erratic rainfall and drought situations have caused havoc to food crops. This is what a participant had to say at Zieng:

"The current rainfall does not just come the way we want. When we were children, rainfall used to come in greater amounts. By then, the season begins with at least three heavy rains. Those who were ready to do yam mounds begin preparing. Others who are into groundnut also start tilling the land. But these days, we receive the rains all at once putting pressure on us the farmers and at the time you need it most, it will stop".

In a similar situation, respondents made it clear that, the intermittent rainfall has resulted in to frequent droughts as well. A middle aged participant complained that:

"My son, because you are from the city you can't even understand this very well. The situation with drought is serious than what you Karachi people (educated) think. Follow me to veranda and see the quantity of maize I harvested from a two acre land. In fact, if we have done something against God, I just hope he will show us his mercies otherwise….hmmm"(KII, Tampion)

4.3.5 Causes of Climate Variability

Respondents were also giving the chance to state the causes of climate variability. The results of the study show that 48.2% attributed the causes of climate variability to the will of God. It is seen as the punishment to the world as a result of increasing disobedience and immoral acts. This is in line with finding of Yaro (2013b:1265) that, small scale peasant farmers attribute social and religious and moral reasons for the changing climate. A good percentage (28.9%) of the study results also attributed the causes of climate variability to the removal of tree cover. To them, trees do not only provide shade but also play a key role in rain formation.

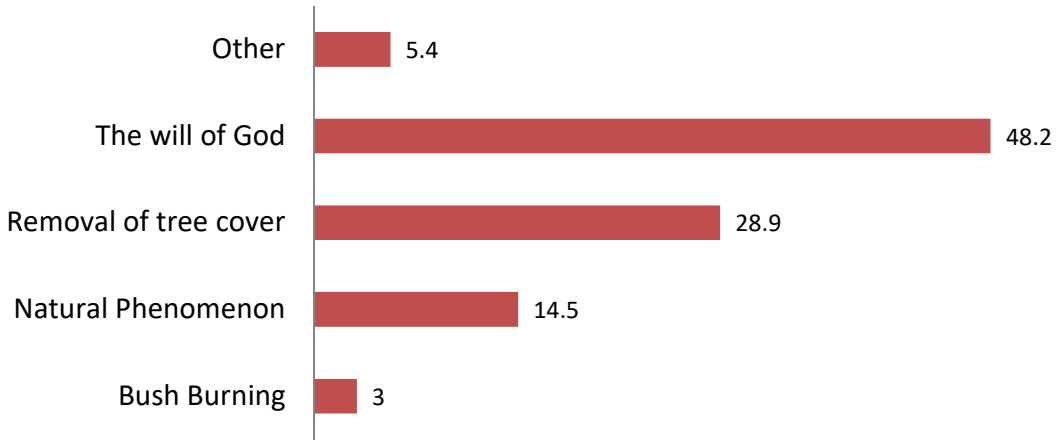


Figure 4.6: Causes of Climate Variability

Sources: Author, 2015

In a key informant interview, a respondent indicated that:

"*When we were children, it was not all trees that were fell for fire wood. It was a taboo to cut certain trees and this was good and provided 'darkness' (Zimsim) necessary for rainfall formation. These days you can stand and even see the next village"*.

The removal of trees therefore reduces the quantity of rain water that will be received. Certain trees were preserved for traditional purposes and were not cut for any purpose. This confirms Eguavoen (2013:15) that, some indigenous trees were not cut without a reason and this helps to preserve the forest. As little as 3% of the respondents see bush burning as the main cause of climate variability. Bush burning destroys the forest cover while increasing the environmental temperature. This low percentage of respondents also indicates that, respondent may be guilty of talking about bush burning as a cause. It was observed that, some of the respondents shy away mentioning bush burning because they are guilty of the practice. Respondents engage in burn bushes to hunt for game during the off season and by this practice, a lot of trees are burnt as well leading to depleting the tree cover in the municipality. In an interview with an Agriculture Extension Agent, it was confirmed that, some respondents engage in both bush burning and deforestation during the off season. Others (5.4%) within the study also attributed the causes of climate variability to include curses by the gods of the land as a result of immoral activities, serial killing, teenage pregnancies among others. The increasing prevalence of these activities affects the amounts of rainfall as these acts are seen as sin against the gods of the land.

4.3.6 Past Existence of Causes of Climate Variability

Respondents' views as to whether the causes of climate variability as experienced now existed in the past was also sought and this is seen in Figure 4.7. About 178 of the respondents representing

53.6% accepted that, climate variability existed in the past. Climate variability is not recent but has been in existence in the past. They contend that, the recent variations in the climate is only extreme compared to those experiences in the past. This means that, the current spade of climate variability is much more pronounced as compared to those they experienced in the past.

In a key informant interview, a respondent made it clear that:

"*Drought and rainfall failures have been there. During Acheampong's government, the whole country was in trouble. The drought was serious and we as young men then had to even queue for government food. What is difficult about the current situation is that, it is not changing like those days. It is even worsening and that is a major cause of worry* (KII, Nabogu).

The study result also shows that, 46.4% of the respondents believe climate variability is a recent phenomenon. To them, what is going on now has never been experienced before. This means that the conditions surrounding the current changes in the climate has never happened. These respondents are more likely to be young farmers whose farming experience is not that much.

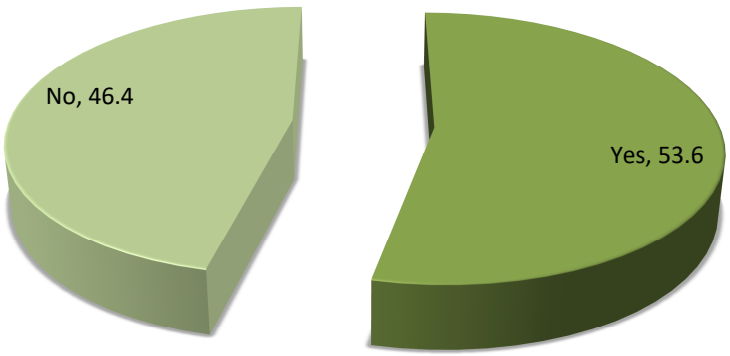


Figure 4.7: Existence of Causes in the Past

Source: Author, 2015

4.3.7 Future Stability of the Climate

The views of respondents as to whether the current trends in climate will become stable in future was also taken and presented in Figure 4.8. The study shows that as many as 206 of the respondents representing 62.0% think that, the variations in the climate will one day assume normalcy. This means that, the on-going variation is only a natural phenomenon and is more likely to become stable. Therefore as and when the cycle of stable climate comes, the situation now will be reversed. However, 38% of the respondents do not think the current variability will become stable. This means that, the changes experienced now is expected to only get worse or continue.

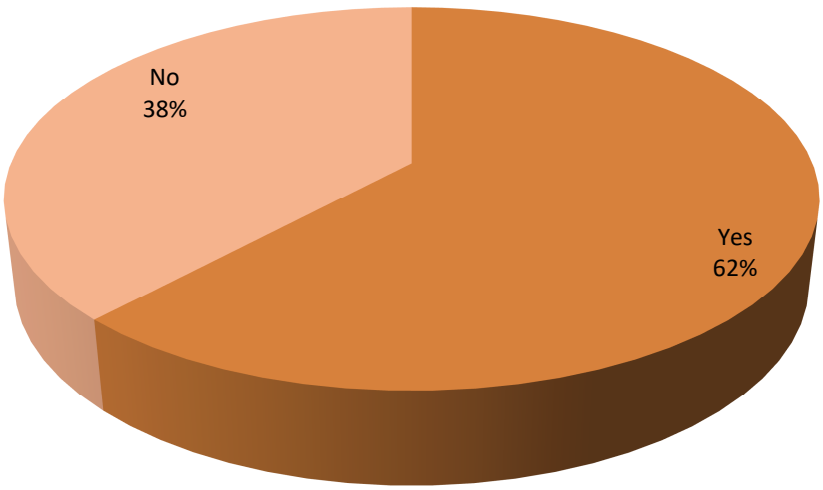


Figure 4.8: Future Stability of Climate

Source: Author, 2015

4.3.8. Methods of Rainfall Determination

The result in Figure 4.9 shows methods of rainfall determination. The study revealed that, about 45.8% of the respondents determine the onset of rain by observing the clouds. During off season, clouds are generally very clear but in the middle of harmattan, it becomes very dirty with thick dust. Once this dust finally fades away, it signifies that the rain could come any time sooner. This means that it is not the only the thick black cover of clouds that is observed at this point but the white/blue like clouds that precede it. In the same way, the study established that, 27.7% of the respondents rely on radio broadcast as the main source of determining the onset of rains.

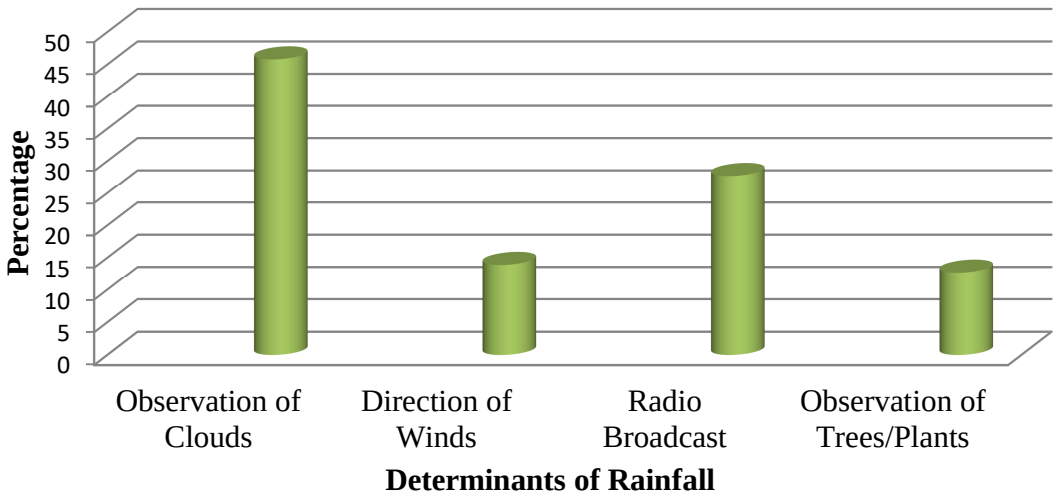


Figure 4.9: Determination of Rainfall

Source: Author, 2015

These respondents rely on the activities of Farm Radio International together with Might F.M. (Savelugu) for broadcasting weather information to farmers. This therefore means that, farmers with access to radio set are more likely to have more adaptive capacity. This is not different from Asfaw (2014:30) finding that, “wealthier farmers are more adaptive than others”.

About 13.9% of the respondents also use the direction of winds to determine the onset of rain while 12.7% of the respondents rely on other forms of observations such as trees and plants at certain stage, cry of some birds, observation of stars and the movement of black ant off valleys. The use of tree and ants as well as cry of birds is purely indigenous. These methods can be categorized in to two. It was observed that, the use of trees to determine weather is more or less long term. The trees are used to determine overall seasonal changes as in changing from the dry season to rainy season. For instance the *dawadawa* and the baobab bears fruit usually a month to the beginning of the first rains. The other methods such as the use of the ants and birds are more specific to rainfall determination. For instance, when ants move their eggs up a hill on a hot sunny afternoon, give the indication that there will be rains. The visa versa signifies a drought situation as well. This finding conforms to Hiwasaki et al. (2014:18) findings that indigenous people rely on the movement of celestial bodies like stars and living things like trees and ants to determine the weather situation.

4.3.9 Causes of Drought

On drought, respondents established poor farming methods, bush burning, curses, application of chemical fertilizers and others as the causes of drought as seen in Figure 4.10. On the causes of drought, 35.5% of the respondents attributed the causes of drought to bush burning. This means that, the burning of bush reduces the tree cover which plays a key role in transpiration and consequently rainfall. Also, 7.2% of the respondents think that, the application of chemical fertilizer is the cause of drought. This means that, continuous use of chemical fertilizers weakens the soil thereby affecting both trees and plants growth. As many as 17.5% of the respondents think drought is just a normal phenomenon. It occurs naturally and to some extent is also a

necessary condition during the growth process of maize and yam including other crops. Poor farming methods are also attributable to the cause of drought according to 10.2% of the respondents. Slush and burn, improper application of chemicals are some of the causes of drought. Other respondents representing 29.5% think drought is a punishment for the immoral acts and sins against the land and God. When gods of the land are dissatisfied with the way things are going on, such a punishment becomes eminent.

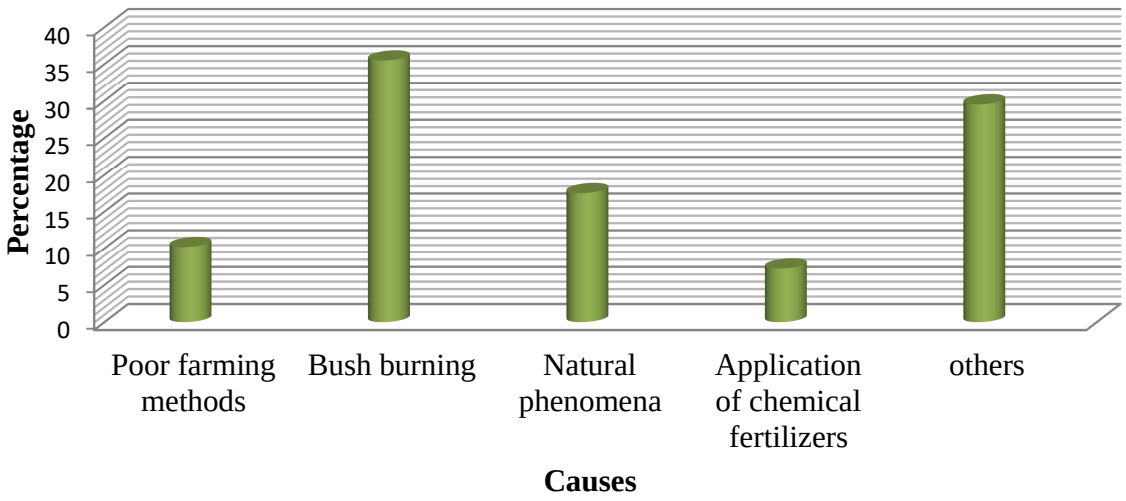


Figure 4.10: Causes of Drought

Source: Author, 2015

A participant in a focus group has this to say about the causes of climate variability and drought (*sanzali*).

Yes, there was "Sanzali" in the past but the "Sanzali" has increased. We have such practices, yes, we have a lot of such practices but they are all concerning our relations with God. I am saying this because we do things that God brings the "Sanzali" in our communities. For instance, certain killing of people was not part of our lives, other bad practices that are abound were all not part of society. Don't we know Almighty God does not like those things? For

instance, the cutting of trees, these days the number of trees we cut is unimaginable. The existence of trees used to make rain and water in general to come. But these days we have cut the trees that could help bring back uninterrupted rainfall. That is it (FDG, Nyolugu).

In the study area, it is common to speak of drought (*sanzali*) as a form of punishment from God for the immoral life style people now live. Among these immoral activities include the cutting of trees for fuel wood. Similar to the findings of Jarawura (2014:112), reasons assigned to the causes of drought are mostly socio cultural and moral factors. It was forbidden to cut certain tree but now all these taboos are not being adhered to. Focus groups explained that, *rainfall favors darkness (Zimsim) as a result of tree cover. This explains why southern Ghana gets more rain than northern Ghana where the area looks clearer* (FGDs, Nyolugu).

It was also realised in a focus group discussion that, respondents categorized drought in to three main types. They are the *Dakuyaayi Sanzali* (two weeks drought), *Biewu pihinahi* or *Gburugu Sanzali* (40 days drought) and *Chima Sanzali* (this is a long grass use in roofing thatch houses). The *Dakuyaayi Sanzali* is the first drought and it last approximately two weeks and take place during periods of planting. The longest and most dangerous of all is the *Gburugu Sanzali* which may last up to 40 days. In a normal farming season, this drought starts when maize is about three to four weeks. Around this time, maize needs some amount of heat to be able to grow well. By the time rains opens up again, the maize will begin tasseling. At this point any fluctuation in rainfall will affect the growth of the cob. The *Chima Sanzali* is normally not recognized by most farmers. This is because it happens at the end of the season when most people are harvesting. This ushers us into the dry season and mostly recognized by yam farmers because this is the right time to begin preparing the land.

However, the above situation of drought is the ideal but of late, the experience has been different as a participant recounts in a focus group discussion:

Sanzali" is explained in a way that, even though we are children but we are aware of it but these days it delays more than we used to know. For instance, since I was a child and old people have been talking and we are listening, we were told that, "Sanzali" was for say 40days which we were told is called "Gbirigu Sanzali", and then we have two weeks "Sanzali". But these days, the rain sometimes stops and exceeds these two types we were told about in the past that is the 40days "Sanzali" and the two weeks "Sanzali" which affects us greatly. That is how it is, the "Sanzali" is there but these days it delays beyond our imagination and it sometimes affects us beyond like I said what we used to know about "Sanzali".(FGD, Zieng)

4.3.10 Number of Drought Occurrence

The study as shown in Table 4.10 illustrates smallholder farmers' experience of drought in the Savelugu Municipality. According to the survey, majority (152) of the respondents representing 45.8% indicate that drought takes place three times a season. According to them, there is usually a short spell at the beginning of the season immediately after sewing followed by a prolong drought mostly exceeding six weeks. At the end of the season, there is also another short drought. As little as 3.0% of the respondent think that drought only happens once a season. This means that, the usually long spell of drought is the only form of drought recognized by these respondents as its effects weigh heavier than the other two. Also, 8.4% of the respondents think that, the number of drought cannot be predicted. This is as a result of the increasing complexity in the weather. What is certain is that the usually occurrence will always happen including other forms of drought that are difficult to notice.

Table 4.10: Number of Drought in a season

Period	Frequency	Percentage
Once	10	3.0
Twice	142	42.8
Thrice	152	45.8
Not Predictable	28	8.4
Total	**332**	**100.0**

Source: Field Author, 2015

4.3.11 Effects of Climate Variability on Agriculture

On agriculture, the effects of climate variability were also determined by the respondents. Table 4.11 shows the effects of climate variability on agriculture. Table 4.11, shows the effects climate variability on agriculture. As many as 59.0% of the respondents, attribute reducing yields of crops to climate variability. This means that crops do not get the required necessary condition to thrive well. With the increasing variation in climate, food crop production will therefore be worsened since reducing yield is associated with climate variability. This will aggravate the plight of smallholder farmers as agriculture in the municipality is on rain-fed. Also, 27.7% of the respondents think the effect of climate variability on agriculture is not predictable. This means that, different crops may be affected differently with regards to climate variability. While some crops could be experiencing higher yield, some crops may be reducing in yield. It was however observed that, the latter rather occurs more in recent years than the former. This mixed outcome has a higher probability to affect smallholder farmers.

As little as 1.2% of the respondent attribute increasing yields to effects of climate variability on agriculture. This is more likely to be as a result of increasing farm sizes or effective use of adaptation strategies leading to increasing yields.

Table 4.11: Effect of Climate Variability on Agriculture

Effect	Frequency	Percentage
Reducing yield	196	59.0
Increasing yield	4	1.2
Not predictable	92	27.7
Don't know	28	8.4
Others	12	3.6
Total	**332**	**100.0**

Source: Field survey, 2015

In Figure 4.11, it is seen that, between 2010 and 2013 the total yam produced in the whole municipality has been increasing. Ironically however, total production for maize for that same period has been reducing. The reduction in the yield of maize is largely as a result of climate variability and this confirms Fitch's (2009) and Tachie-Obeng et al. (2010) findings that maize harvest by smallholder farmers are predicted to reduce as a result of climate variability. The increased in the yields of yam may be attributed to factors such as increasing farm size, better adaptation of yam farmers to the variability in climate and increases in the number of farmers who are into yam production as these factors are positively related to increase in yield. It was also noted from an interview with agricultural extension agents that, winds have grown much stronger and disastrous especially to maize crop. The continuous felling of tree has resulted in stronger winds which affect maize crops more than others. This agrees with the findings of Sammadar et al. (2014) that winds in northern Ghana has been much stronger with greater tendency of destroying maize.

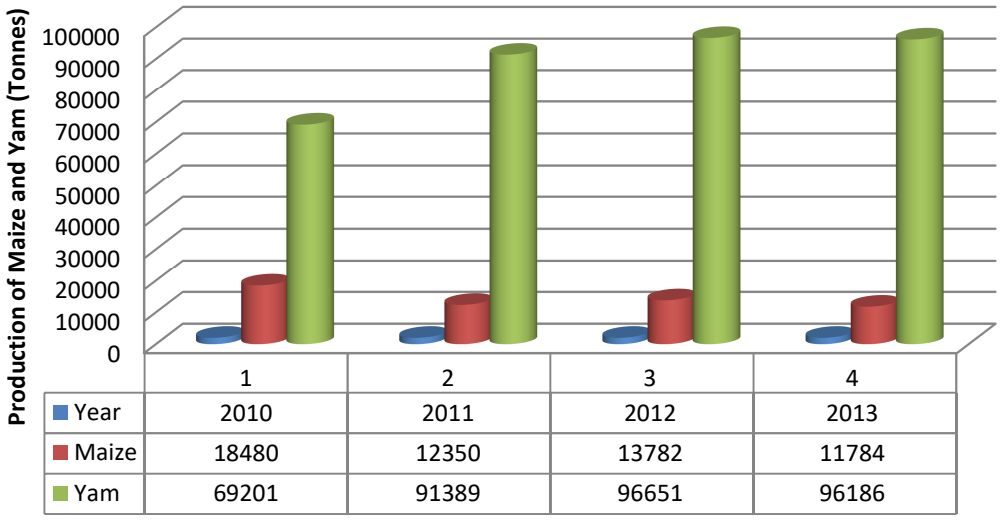


Figure: 4.11: Annual Production of Maize and Yam

Source: Municipal Agriculture Development Unit, Savelugu-Nanton

4.3.12 Effects of Climate Variability on Maize and Yam

The study found out that, climate variability affects maize and yam at various stages. Table 4.12 shows the views of respondents on the effects of climate variability on maize and yam cultivation. The study as seen in Table 4.12 found that, 134 of the respondents representing 40.4% experience reducing yield in maize and yam as a result of climate variability. This means, the quantity of output has been reducing and this is attributed to climate variability and respondent will have to adopt strategies that will ensure output increases. About 22.3% of the respondents say the effect of climate variability on maize and yam is not predictable. To them, there are times when the yield increases beyond the previous output. This could also be attributed to the choice and use of some adaptation strategies and the effectiveness of some strategies over others. Effective and timely use of adaptation strategies leads to increases in output. It was further established that, 17.5% are affected by total crop failure resulting from the effects of

climate variability. This means respondents will have adopt more effective strategies that could lead to more crop survival as well increase in output. A few (3.6%) others accepted that, they experience yield increases in maize and yam output. This could be attributed to the adoption of a improved adaptation strategies or increases in farm size. This means that, those respondents are better adaptors since better adaptation leads to increases in yields.

Table 4.12: Effects of Climate Variability on Maize and Yam

Effect	Frequency	Percentage
Reducing yield	134	40.4
Total crop failure	58	17.5
Affects the storage of crop	44	13.3
Increasing yield	12	3.6
Not predictable	74	22.3
Other	10	3.0
Total	**332**	**100.0**

Source: Author, 2015

4.3.11 Causes of Flood

The study revealed that, floods do take place in the Savelugu Municipality and the various responses are shown in Table 4.13. Majority (162) of the respondents representing 48.8% think excessive rainfall is the cause of floods in the municipality. This means that, when it rains beyond the normal required rate, the possibility of flood is eminent. The general low amounts of rainfall received in the municipality in recent years suggest that, the likelihood of floods is less. In the same vein, the study revealed that 18.7% of the respondents attribute floods to lack of good drainage system. The low level of land in the municipality could be one of the reasons for lack of drainage system. Again, 25.9% of the respondents blame the existence of flood on low vegetation cover. The continuous felling of trees and bush burning, affects the soil structure which reduces the soil capacity to hold more water and increases the rate of erosion.

A few (22) other respondents representing 6.6% of the respondents attribute floods to the use of tractors for farming. The use of tractors does not create furrows that will naturally regulate water in to the farm as in the case of ridges.

Table 4.13: Causes of Floods in the Savelugu Municipality

Effect	Frequency	Percentage
Excessive rainfall	162	48.8
Lack of drainage system	62	18.7
Low vegetation cover	86	25.9
Others	22	6.6
Total	**332**	**100.0**

Source: Field Survey, 2015

On floods, respondents perceived flood in two main ways. The first is called *Kokpegu* (invasion of water) and *Kodilli* (destruction of water). The first flood situation is usually not caused by excessive rainfall but by poor farming practices which traps water into a farm without an outlet. The use of tractors to plough is a major cause of this as the land is left evenly flat without channels through which water will flow out. This first situation is necessarily not bad because it makes water available to the crops as and when the need arise. The second flood situation is dependent on excess water resulting from continuous down pour. The first flood situation is mostly controlled if the farmer used ridges. With this the water is left in between the furrows as shown in Plate 4.1.

Plate 4.1: A maize farm soaked in flood

Source: Author, 2015

The perception of smallholder farmers on climate variability is greatly influenced by economic and sociocultural circumstances of respondents. Generally, respondents are fully aware of the risk posed by climate variability. This is translated in low crop yield experienced over the years. In effect, the perception of climate variability is much more influenced by scientific observations which is mostly proclaimed through the media and by nongovernmental organizations. In a bid to conceptualize the phenomenon, respondents still attribute some unscientific explanations. In some cases respondents fail to offer scientific explanation not because of ignorance but because they apart of the cause. For instance, in a focus group at Kpachelo, a participant refuted the claim of deforestation being one of the causes of drought only to be exposed by a colleague that, he vends with firewood all year round. Although some perceptions realized from the study are largely cultural, a lot of them conform to general logic and science.

4.4 Adaptation Experiences of Smallholder Farmers

This section is devoted to the experience of adaptation strategies employed by smallholder farmers. The results indicate that, various strategies are employed by smallholder farmers. The strategies consist of both indigenous strategies and conventional strategies.

4.4.1 Broad Adaptation Strategies used in Maize and Yam Cultivation

The section examines broad adaptation strategies used by smallholder farmers in tackling the adverse impacts of climate variability. The study as shown in Table 4.14 indicate that, majority (118) of the respondent representing 35.5% rely on effective use of weather prediction. This means that, weather prediction is seen as the most important step in climate variability adaptation because no serious planning can be made without proper understanding of the weather. This finding is similar to the one obtained by Adejuwon (2006) and Ziervogel (2008), that, weather forecasting has been recognized as the first basic step in adapting to climate variability and is by far the most challenge in Sub-Saharan Africa.

Table 4.14: Broad Adaptation Strategies used in Maize and Yam

Major Strategy	Frequency	Percentage
Changing planting time	78	23.5
Soil Management/Cultural Practices	66	19.9
Effective use of weather prediction	118	35.5
Use of chemical fertilizers	62	18.7
Other	8	2.4
Total	**332**	**100.0**

Source: Author, 2015

On weather prediction, respondents recounted most of the indigenous weather prediction scenarios to include using certain trees, sound of birds, movement of ants up a hill, the position of stars and the natural direction of winds. These indigenous strategies are used to determine the onset of rain. It was however observed that, most of the indigenous weather prediction mechanisms are more or less short term weather forecast strategies. This finding is in tandem

with Eguavoen (2013) that, indigenous adaptation strategies are short term and there is the reason for lack of documentation. For instance it is not clear using the indigenous strategies how to forecast rainfall in the next one to two seasons. Again, using the indigenous prediction strategies, one cannot rely on it to determine the quantity of rainfall. These indigenous strategies are short term notice on weather rather than long term predictions. In a key informant interaction, a respondent laments on how the continuous failure of rain has cost them:

"*Our main problem is the rain. If it comes like it used to, one may not even need fertilizers for his crops but this is not the case. There were some spiritual men in charge of rain but you can't find even one now. These days we listen to radio for information on weather but sometimes it doesn't happen as they say. They will tell us to expects rain in a particular day only to realized that other places have received some rain and we are just sitting*"

This deliberation reflects the narrow view respondents even have on meteorological forecast. Although respondents still use indigenous weather predictions, it is not all that reliable and therefore they have also relied on the improved meteorological forecast usually broadcast on Might F.M. but have failed to conceptualize the average weather conditions. Ones it is announced that, rain is to be expected in the municipality, respondents think that, all other areas will receive rain.

As many as 78 of the respondents, representing 23.5% changes their planting time in line with shifting rainfall pattern. This means that, smallholder farmers respond to climate variability by changing periods of planting. This agrees with the assertion of Gbetibouo (2009) that "decreasing rainfall is likely to increase the probability of smallholder farmers adopting delay in planting as an adaptation option to climate variability". It was also evident from the study that, 19.9% of the respondents use cultural practices as their major form of adaptation. This means

that, they rely on weeding, right method of sewing, mulching, stalking and others to contain the negative impacts of climate variability. The use of chemical fertilizers was also popular among 18.7% of the respondents. As little as 8 of the respondent rely on the methods other than those mentioned above.

4.4.2 Commonly Used Adaptation Strategies in Maize and Yam Adaptation

In Figure 4.15 the study revealed that, the most popular strategy adopted by smallholder farmers in the Savelugu Municipality is chemical fertilizer application. Of the total respondents, 66.9% use chemical fertilizer in adapting to climate variability. This could be attributed to the effectiveness of chemical fertilizers in addressing soil fertility needs. Continuous cultivation on the same piece of land has led to the soil losing its fertility. Approximately half (55.4%) of the respondents also use organic manure as well. The greater number of respondents using chemical fertilizers and manure suggest that, climate variability impacts negatively on soil fertility. For those using organic manure, it was indicated that organic manure when used properly improves the soil much better.

The use of mulching although has been very useful, is gradually becoming less used. This could be attributed to reducing amount of rainfall and increasing surface temperatures leads to loss of soil moisture thereby making the practice of mulching unsuccessful. Other strategies such as crop insurance, agroforestry, and other were also found to be unpopular among the respondents. On the average, the respondents are poor in adapting to climate variability as 60.9% do not use any form of adaptation. This could be as a result of inadequate finance and technology among others.

Table 4.15: Commonly used Adaptation Strategies

Strategy	Adoption		
	Yes	**No**	**Totals**
Chemical Fertilizer	66.9	33.1	100
Organic manure	55.4	44.6	100
weedicides	44.6	55.4	100
Shifting cultivation	35.5	64.5	100
Integrated Pest and Disease Management	13.9	86.1	100
Mulching	20.5	79.5	100
Ridging	62.7	37.3	100
Mixed Farming	13.3	86.7	100
Average	**39.1**	**60.9**	**100**

Source: Author, 2015

4.4.3 Conventional Adaptation Strategies in Maize Cultivation

The level of satisfaction of smallholder farmers to the use of adaptation strategies is very vital to its rate of adoption. The study therefore revealed the level of satisfaction of respondents to some conventional adaptation strategies. Respondents were required to indicate as to whether they are very satisfied, satisfied, indifferent or even unsatisfied with the use of some conventional adaptation strategies. In Table 4.16, about 60.2% of the respondents are very satisfied with the use of chemical fertilizers as an adaptation strategy. The use of chemical fertilizers leads to increases in crop output and reducing the risk of crop failure. For early maturing crop varieties, 51.2% of the respondents were satisfied with the use as strategy for adverse climatic impacts. This means the short spell of rainfall does not favour longer crop varieties. A respondent in a focus group discussion indicated that;

"Times have changed so we should also change to suit the time if not we will fail as farmers. Last year for instance we were told not to farm late of used longer varieties and those who listened benefited. I think what the extension agents have been telling us is good especially with regard to the rain and the use of improved varieties (FGD, Zieng).

For crop insurance and integrated pest and disease management (IPDM) 16.3% of the respondents were not satisfied with the use of these strategies. However, the level of indifference of crop insurance among respondents was very high. This means that the strategy is not popular among respondents in the Savelugu Municipality. In an interview with an Agricultural extension agent, it was clear that only Nabogu community among the study communities, have been exposed to crop insurance. This is through the collaboration with Innovations for Poverty Action (IPA) Disseminating Information Resource Technology System (DIRTS) programme. On the average, a large (37.8%) percentage of the respondents are satisfied with the use of conventional strategies of adaptation. This means that, a good percentage of the respondents are comfortable with the use of conventional strategies of adaptation.

About 46.4% of the respondents are very satisfied with improved weather forecast technology. The presence of Might F.M. has helped in this regard. Respondents enjoy through their radio set weekly broadcast on weather in the municipality. On the average, 37.8% of respondents are satisfied with conventional strategies and 31.2% are indifferent to the satisfaction of conventional strategies. This could result from poor communication of these conventional strategies as climate communication is cumbersome and could affect the rate of adoption of strategies. This is in tandem with Eguavoen (2013:9) that climate communication is difficult especially when concepts between indigenous knowledge and conventional scientific knowledge differ.

Table 4.16: Conventional Adaptation Strategies in Maize Cultivation

	Level of Satisfaction				
Conventional Strategy	**VS**	**SA**	**ID**	**US**	**Totals**
Improved Meteorological Forecast	46.4	34.9	11.4	7.2	100
Fertilizer/Weedicides	60.2	31.3	4.8	3.6	100
Early Maturing crops	9	51.2	28.3	11.4	100
Crop Insurance	0	17.5	66.3	16.3	100
Integrated Pest and Disease Management	4.2	38	41.6	16.3	100
Integrated Soil Fertility Management	4.8	53.6	34.9	6.6	100
Average	**20.8**	**37.8**	**31.2**	**10.2**	**100**

(Where VS=Very Satisfied, SA=Satisfied, ID=Indifferent and US=Unsatisfied)
Source: Author, 2015

4.4.4 Conventional Adaptation Strategies in Yam Cultivation

The study also examined conventional adaptation strategies with respect to yam. Again, the responses were measured based on the level of satisfaction of smallholder farmers to each strategy. The level of satisfaction of the use of improved meteorological forecast was very high. As many as 46.4% of the respondents were very satisfied with the use of improved meteorological services with only 7.2% of respondents not satisfied with the use of improved meteorological forecast. This means that smallholder farmers are very satisfied with the used of new technologies in weather prediction. In most focus group interactions, it was noted that the challenge with the inconsistency in the amount of rainfall received is a bane of smallholder farmers. Unlike the level of satisfaction in the use of improved meteorological forecast, the use of weedicides by respondents was unsatisfactory. About 40.3% of the respondents were not satisfied with 31.5% indifferent to the use of weedicides in the cultivation of yam. The reason for the dissatisfaction of the use of weedicides was common among respondents. It was realised that the use of weedicides affects the length of storage of yam as it easily get rotting. It was also alleged by a middle aged key informant that, the use of weedicides does not only affect yam in

terms of storage but also destroys the land on which it used. They explained that such lands easily dry up as it loses it natural ability to retain water for some time. In an interview with an extension agent, it came up that, the use of weedicides is still a major problem to some smallholder farmers. According to this respondent, generally weedicides are in to two categories. There is the pre-emergency treatment and post emergency treatment. The pre-emergency weedicides are used before the plant germinates and the post-treatment is used during the growth of the plant. In most instances, some respondents tend to apply the wrong weedicides leading to some difficulties. Also some weedicides meant for maize could also be used for yam by some farmers and this is wrong. For instance, the commonest yam weedicides are the Athrazine and the Agrazine. As many as 34.3% of respondents appeared indifferent to the use of crop insurance. This is because most of the respondents are yet to experience the strategy. As illustrated in Table 4.17, about 30.2% of the respondents are very satisfied with the use of integrated pest and disease management. This means that, the use of this technology reduce risk in yam farming especially after harvest.

Table 4.17: Conventional Adaptation Strategies in Yam Cultivation

Conventional Strategy	Level of Satisfaction				
	VS	SA	ID	US	Total
Improved Meteorological Forecast	48.3	26.7	20.6	4.4	100
Weedicides	8.5	19.7	31.5	40.3	100
Integrated Pest and Disease Management	30.2	25.6	27.9	16.3	100
Crop Insurance	6.2	13.6	34.3	45.9	100
Average	23.3	21.4	28.6	26.7	100

(Where VS=Very Satisfied, SA=Satisfied, ID=Indifferent and US=Unsatisfied)
Source: Author, 2015

4.4.5 Indigenous Adaptation Strategies in Maize Farming

On some indigenous adaptation strategies, respondents again rated their level of satisfaction on the use of these strategies. Respondents indicated as to whether they were very satisfied, satisfied, indifferent or unsatisfied in the use of these indigenous strategies. In Table 4.18, the study revealed that 72.9% of the respondents are very satisfied with the use of crop rotation. This means that, there is high probability of increase in productivity in using crop rotation. Respondents are very comfortable rotating maize and yam. In a focus group discussion, it came up that, the rotation of maize and yam has some advantages for both crops:

"*For maize and yam, we rotate them every year. If you don't do that, it will not do well. You can't cultivate yam on a particular land two or more years in succession. My son it will not do well. You need to cultivate the Batandalli and Kukuagu in turns. This method helps we those who cannot buy fertilizers*".

The word *Batandali* refers to a practice of spreading old yam mound for the cultivation of maize. That of *Kukuagu* is an old maize farm ready to be used for yam mounds. The effectiveness of indigenous mounds and ridges conforms to the findings of Kuwornu and Ramatu (2013) that, mounds and ridges are effective indigenous soil management practices. The study further found that, crop rotation serve as a means of controlling some disease and pests. An agricultural extension agent points out that, smallholder farmers rely on crop rotation as a means of controlling *Striga Hermonthica* in maize farms. About 63.9% of the respondents were satisfied with indigenous variety's use. This means that, respondent still use indigenous varieties of maize and yam for planting. It was however observed that, respondents do not know exactly the difference between improved varieties and indigenous varieties. For some of the maize varieties, the repeated use of some improved varieties is eventually described as indigenous since it is not bought from a recognized certified dealer. For maize, the most notable indigenous variety now is

the yellow maize. The study revealed three reasons for the high adoption of indigenous varieties. Firstly, Indigenous varieties have a greater chance to survive without fertilizers. Secondly, it does well in terms of resistance to drought stress and finally it is good for the preparation of some local dishes due a better taste. This is in agreement with FAO (2010) and Wiredu et al. (2010) assertion that, smallholder farmers prefer indigenous grains to hybrid which is perceived to be more resistant to stress and use mostly for food preparation.

A good number (52.4%) of the respondents are satisfied with the use of ridging in maize and mounds in yam cultivation. These two strategies help in water conservation and flood control as well as controlling erosion when doing terracing. The furrow in between the mounds and the ridges serve two main purposes. It regulates the amount of water that gets to the plant by storing excess water. It also reduces the effect of flooding on the crop. In a similar outcome, the study shows that indigenous weather prediction is still popular among respondents as 52.4% were satisfied with its use. The high confidence in the indigenous weather prediction suggests a lack of access to improved weather forecast. These indigenous strategies range from the observance of the traditional calendar, movement of and sound of birds and certain development of trees and plant. It was realized that certain tree like the *Dawadawa* tree and Baobab tree are major source of rain information. These trees according to the respondents start fruition two months before the rains set in. Therefore any time it is observed that the trees are bearing fruit, it signifies that the rains are preparing to come. There is also a tree called *Puhuri Wuuni* which shares its leaves during the rainy season and in the offseason, it begins to form new leave. The observations of these trees guide smallholder farmers to prepare for the season. It was also realized that, the sound and cry of certain birds at particular time was also a sign of rainfall. The cry of a bird known as *Kumpuu* at midday was a sign of rainfall. Other such as ants moving with their eggs up a hill also is a sign of rain and the reverse was a sign of drought.

It was further established from the study that, 37.3% of the respondents were indifferent to the use of bush fallowing as a strategy. To them, population increases today has limited the practice of farming to some few areas. The practice of fallowing leads to continuous removal of trees which is necessary for rain formation. On average, 41.5% of the respondents are satisfied with the use of indigenous adaptation strategies with 15.5% unsatisfied with the use of indigenous adaptation strategies.

Table 4.18: Indigenous Adaptation Strategies in Maize Cultivation

Indigenous Strategy	Level of Satisfaction				Totals
	VS	SA	ID	US	
Crop rotation	72.9	21.1	3	3	100
Mixed cropping	43.4	30.1	4.2	22.3	100
Indigenous variety	6.0	63.9	19.3	10.8	100
Mulching	15.1	41.6	30.7	12.6	100
Ridging/mounds	23.5	52.4	11.4	12.7	100
Fallowing	6.0	28.9	37.3	27.7	100
Indigenous weather prediction	12.0	52.4	16.3	19.3	100
Average	**25.6**	**41.5**	**17.5**	**15.5**	**100**

(Where VS=Very Satisfied, SA=Satisfied, ID=Indifferent and US=Unsatisfied)
Source: Author, 2015

4.4.6 Indigenous Adaptation Strategies in Yam Farming

In Table 4.19, about 48.1% of the respondents are satisfied in the use of crop rotation in the cultivation of yam. As explained by respondents in focus discussions, crop rotation is very important in the cultivation of yam. The rotation of yam maize has being an old age practice among smallholder maize and yam farmers. With mixed cropping however, respondents were unsatisfied with its use with respect to yam cultivation. It was explained that, the amount of nutrients in soil giving the current challenges is not enough to support two or more crops on the land as this could affect the yield of both crops. On the use of mulching, 42.3% of the respondents were very satisfied with its use in yam cultivation. This underscored the need for

constant moisture in yam cultivation. A young yam farmer explained that, the cultivation of yam usually starts at times when there are no rains. Mulching is therefore used to conserve moisture for use by the sewn yam sett. Also, about 46.45% of the respondents were very satisfied with the use of traditional mounds in cultivating yam. The importance of the use of mounds was clearly seen in the words of a respondent in a focus group discussion:

"When we use mounds to cultivate yam it enables the tuber to grow very well. The mounds are usually very soft thereby given chance for the growing tuber to expand to its fullest. Also, in between the mounds are spaces that help to conserve water for use by the plant…(FDG, Nyolugu)

It was very established that, 40.1% of the respondents are satisfied in the use of climbing sticks. It was explained that, the use of climbing sticks enables provide shade for the tubers while also ensuring the free growth of the creeping plant. An old farm explain that, the use of trees as climbers is even more beneficial to the growth of the yam than even the normal climbing sticks.

Table 4.19: Indigenous Adaptation Strategies in Yam Farming

Indigenous Strategy	Level of Satisfaction				Total
	VS	SA	ID	US	
Crop rotation	35.4	48.1	16.5	0	100
Mixed cropping	15.2	20.3	18.7	45.8	100
Mulching	42.3	40.6	17.1	0	100
Mounds	46.4	40.2	13.4	0	100
Indigenous weather prediction	20.3	25.9	30.1	23.7	100
Climbing Sticks	33.2	40.1	10.5	16.2	100
Total	**30.5**	**35.8**	**17.7**	**14.3**	**100**

(Where VS=Very Satisfied, SA=Satisfied, ID=Indifferent and US=Unsatisfied)
Source: Author, 2015

4.4.7 Comparing Conventional and Indigenous Strategies in Maize and Yam

The study again demanded respondents to determine their level of agreement to statements on both indigenous and conventional adaptation strategies. In Table 4.20 respondents' level of

agreement on the uncertainty of the onset of rain was sought. About 47.6% of the respondents disagreed with the decision not to farm as a result the uncertainty of the rainfall. This means that, the risk posed by the unpredictability of the rain does not deter smallholder farmers from engaging in farming. This is because smallholder farmers are readily adopting some measures in reducing associated risk. This agrees with Asfaw (2013) that exposure to climate variability and climate inconsistency is associated with the choice of risk-reduction method. Again, 36.1% of the respondents agreed to the preference of indigenous strategies to conventional strategies. This means that, smallholder farmers still hold some attachment to indigenous strategies as these strategies are mostly culturally driven. Even though 52.4% of the respondents agreed that, indigenous strategies and more sustainable, the same number (52.4%) of respondents equally agrees that conventional strategies are more effective in responding to climate variability. This explains why 50.8% of the respondents agreed that conventional strategies require a lot of money to practice. This also explains why 45.2% of the respondents strongly agreed that chemical fertilizers are very effective but expensive. A participant has this to say in a focus group discussion:

I don't have money to buy chemical fertilizer. I use animal droppings with rice chaff. It's very good and support plants to produces higher yield. When the maize plant matures, you would look at the maize with happiness (FDG, Kpachelo).

This means that, finance is a major barrier to conventional adaptation strategies among the respondents. On the level of understanding of the conventional strategies, 40.4% agreed that they find it difficult to understand. The high percentage of agreement confirm that, majority (68.1%) of the respondents did not get any formal education and could find it difficult adopting some conventional strategies. While 56% of the respondents agreed that they use both indigenous and conventional strategies, 51.2% also agreed that, they tend to use indigenous strategies only when

they cannot afford conventional strategies. This could explain why some indigenous strategies fail as it is use as a backup to conventional strategies. There is therefore no time and space to plan effectively for the use of these strategies. It was further established that, 45.2% of the respondents disagreed that, conventional strategies is the only answer to current changes in the climate. This level of disagreement could partly be explained by about 33.1% of the respondents agreeing that, indigenous strategies is not archaic and can still be used effectively today. It is however, clear from the study that, there is high (42.4%) agreement on the combination of both indigenous and conventional strategies.

Table 4.20: Comparing Conventional and Indigenous Strategies

Statement	Level of Agreement					Totals (%)
	SA	A	ID	DA	SD	
1. I have decide not farm this year because I don't know when the rain will come	7.8	24.7	12.7	47.6	7.2	100
2. I prefer indigenous adaptation strategies to conventional strategies	17.5	36.1	5.4	33.7	7.2	100
3. Chemical fertilizers are very expensive but very effective for farming	45.2	41.6	1.2	10.8	1.2	100
4. Conventional strategies requires demand more capital than indigenous strategies	24.1	51.8	5.4	18.1	0.6	100
5. Indigenous strategies are more sustainable than conventional strategies	7.8	52.4	11.4	27.1	1.2	100
6. Conventional strategies are effective than the indigenous strategies	13.3	52.4	8.4	25.3	0.6	100
7. I don't easily understand most of the conventional strategies very well	22.3	40.4	7.2	25.3	4.8	100
8. I have been using the conventional strategies alongside the indigenous strategies	27.1	56	4.8	10.8	1.2	100
9. I use indigenous strategies only when I cannot afford to use conventional strategies	23.5	51.2	3.6	20.5	1.2	100
10. Conventional strategies is the only answer to the changing climate	10.2	27.1	15.1	45.2	2.4	100
11. Indigenous strategies is not archaic and can respond effectively to climate variability	18.7	33.1	10.2	30.1	7.8	100
Averages	**19.8**	**42.4**	**7.8**	**26.8**	**3.2**	**100.0**

Source: Author, 2015 (SA=Strongly Agreed, A=Agreed, ID=Indifferent, DA=Disagree and SD=Strongly Disagree)

4.4.8 Conventional Strategies during Pre-planting of Maize

Some adaptation strategies which are used at the pre-planting stage of were also revealed from the study. From Table 4.21, it is clear that, the proportion of respondents using tractors to plough their farm land is greater (42.8%). This means almost half of the respondents use the services of tractors in terms of land preparation for maize cultivation. Respondents attributed erratic rainfall as been the reason why the use of tractors is very high.

Table 4.21: Pre-Planting Strategies of Maize

Strategy	Frequency	Percentage
Bullock	40	12.1
Weedicides	102	30.7
Farm Tractors	190	57.2
Total	**332**	**100**

Source: Author, 2015

This is what a participant has to say in a focus group.

"The rains come for a short period and stop. So within this period if you are not able to do your plough, you will not have enough water in the soil that will help till the land when doing ridges. This is why ridges are not common again. Ridges are very good but the rain will not give you enough time for it to be constructed".

A good percentage (24.7%) of respondents also use weedicides to spray on the weeds before planting and other (12.0%) also rely on bullock to help plough the land. The least usage of bullock suggests that, most of the respondents do not have access to bullocks except those engage in mixed farming. As such bullock are rarely use for commercial ploughing in the municipality. Although the use of weedicides is effective, respondents prefer tractors to the use of weedicides in land preparing for fear of the land being affected negatively by producing tougher weeds.

4.4.9 Indigenous Pre-Planting Strategies in Maize Cultivation

At the pre-planting stage of maize, smallholder farmers in the study area rely on two main strategies and these are ridging and hand ploughing. The study revealed that, ridging is the most preferred indigenous strategy used by smallholder farmers. In most of the focus discussions, respondents made it clear that ridging is the best strategy during the pre-planting of maize. Respondents' preference of ridging is as a result of the advantages that come with it. Ridges according to the respondents are good for conserving water and controlling erosion and leaching of plant nutrients. A respondent in focus group discussion made it clear that:

"*The use of ridges is even more beneficial to us than the use of tractors. When you are able to used ridges, you may not even use fertilizers. The only problem with ridges now is that it cannot be used and this is as a result of the rain. Because it does not rain enough these days, it is difficult to use ridges because of lack of moisture in the soil (FGD, Fazihini)*"

Aside the use of indigenous ridges, smallholder farmers also use hand weeding with hoe. The use of the hand weeding with hoe is done on the surface of the soil in order to loosen it for sewing. This process is called *Jaribu* meaning hand ploughing by the respondents. The use of these two strategies is usually preceded by a practice called *Vala nyobu*. An agricultural extension agent underscored the importance of this strategy in an interview. The process of *vala nyobu* is practiced such that, a farmer will gather all dried plants on to the land prior to ridging or hand ploughing *(Jaribu*). The dried plants are ploughed to mix with the soil and this adds more nutrients to the soil. However, annual bush burning by respondents has rendered this practice useless.

4.4.10 Conventional Strategies used During Maize Planting

Strategies of adaptation in maize cultivation start with pre-planting. The study revealed two main strategies use for planting maize and they are the use of planters and row planting. In Figure 4.12, the study revealed that majority (94%) of the respondents are familiar with the use of row planting. This means that, the row planting is well known among respondents. This could be attributed to the influence of extension service to respondents. Although row planting is popular among respondents, it is however rarely used. This was explained in a key informant interview where the respondent indicated the importance of row planting:

"It improves yield more than the indigenous sewing method. The spacing allows for enough space for each plant to thrive very well; the line sewing is good. I used it about two times and I realized that it is better than how our people do it. It gives each crop some space to 'breath' there increasing the growth. The roots develop very early and when there are strong winds, the maize plant does not fall".

The study further revealed that, about 6% of the respondents are familiar with the use of planters. These respondents are mostly smallholder farmers belonging to farmer groups with direct contact with some non-governmental organisations. A young farmer indicated that, the only time he experienced using planters was with the Adventist Development Relief Agency (ADRA) where it was use for new variety trials.

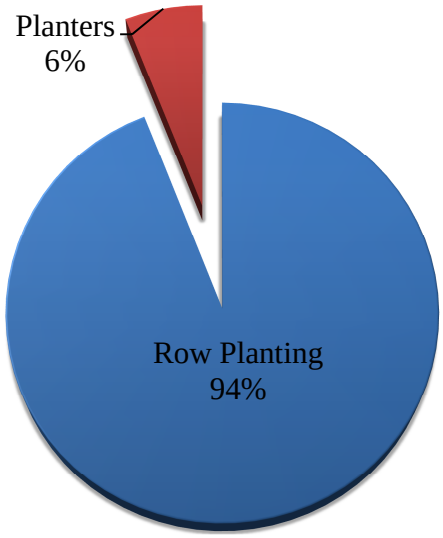


Figure 4.12: Conventional Strategies used in Planting of Maize

4.4.11 Indigenous Strategies used for Planting Maize

With indigenous strategies of planting maize, respondents are familiar with the indigenous broadcast sewing. According to respondents, the use of this method is by far the most preferred sewing method since it is very fast to practice. The indigenous broadcast sewing is done without any predetermined measurement but at the discretion of the farmer. Usually practice in groups, the lead person moves uses a pointed stick to create hole at intervals for sewing. Depending on the interval spacing, between one to three maize seeds are placed in a hole. Generally, respondents made it known that there is usually a practice of soaking maize seeds in some concoctions before sewing. However, this does not depend on either the type of sewing. An old yam farmer in a key informant interview explained that:

"It is not everybody who likes to see your progress. There are bad people who can destroy your crops by merely speaking about it. Therefore we usually soak the seeds in some concoction before planting in order to prevent such situations".

4.4.12 Strategies at the Growth of Maize

The study results as shown in Table 4.22, indicate that, chemical fertilizer usage is the most (64.7%) patronized by respondents. Continuous cultivation coupled with other factors such as bush burning has led to the deterioration of soil fertility. The need to support the soil with fertilizers is therefore a prudent adaptive strategy since it will lead to increases in output. This conforms to the findings of Diao (2010) that, "increases in the output of maize is directly related to the application of chemical fertilizers". It was established further that, 33.4% of the respondents also use weedicides. The high percentage of respondents signifies that, the weeds are becoming tougher than before. There was a high agreement on the way weeds are becoming resistant and other new weeds are coming up. A respondent identified a particular weed called *Bochaa* which is found to be very destructive. The *Bochaa* also known as witch weed colonizes the whole farm and take away all the nutrients from the maize. The name *Bochaa* according to an extension agent is use to describe a parasitic weed known commonly as Striga *(Striga Hermonthica)*. *Striga Hermonthica* is commonly found in maize farms and succeeds in sapping all nutrients leaving the plant weak. As a result of its destructive nature, respondents also referred to soil acidity as a form of *Bochaa.* According to an agricultural extension officer, continuous cultivation and the regular use of chemical fertilizers like NPK results in soil acidification and this alters the pH of the soil. As little as 1.8% of the respondents use compost. The low percentage of the respondents using compost suggests that, the technology is not popular among smallholder maize farmers. It is important to state that, these strategies are not mutually exclusive and can therefore be use concurrently.

Table 4.22: Strategies During the Growth of Maize

Strategy	Frequency	Percentage
Weedicides	111	33.4
Chemical Fertilizers	215	64.7
Compost	6	1.8
Total	**332**	**100**

Source: Author, 2015

4.4.13 Indigenous Strategies during the Growth Stage of Maize

The study identified the use of organic manure and hand weeding with hoe as the most important strategies at this stage. In a focus group discussion, it came out that respondents are generally involved in using the faeces of animals to fertilize the land. This suggests that respondents engage in mixed farming. Two main ways of organic manure procedures were realised. In the first instance, respondents who owned cattle use the cow dung by tying cattle on the land during the off season. The dung is therefore ploughed along with the soil. Respondents who also own other forms of livestock also gather the faeces and it is later spread on to the farms. A respondent has this to say about organic fertilizers:

"The organic manure is very good and some trust it even better than the fertilizers we are so used to. The organic manure is very good for the land than the fertilizers we apply. Some prefer it to the fertilizers we apply".

On the other hand, the use of hand weeding as a means of controlling weeds has been an old age phenomenon among smallholder farmers. A key informant indicated that, a maize farm must be weeded at least two times in order to realise good yield. The study further realised that, respondents used to do hand weeding in groups known as *Kpariba* or communal farming. This came up in a focus group discussion when an old farmer explained the process:

"*We used to come together to work on each other's' farms. It was of good help to us all since there are times your effort alone is not enough to work against the time. These days because of modernity we have failed. When you call people to help, nobody shows up and it is all because of these weedicides".*

4.4.14 Strategies for Storing Maize

After harvesting, storage becomes another issue of concerned. Post-harvest losses over the years have been a major problem. Study therefore sought to examine the strategies use in the storage of maize. Table 4.23 shows both indigenous and conventional strategies use for storing maize. The indigenous strategies are *Kambong, Buli, Kpagrigu* and the use of *Monyoma. Kambon* is made from dried grass constructed with sticks at the base to prevent direct contact with the ground. *Kpachagriga* is also very similar to *Kambon* only that the back of the grasses is usually smeared with cow dung as a local disinfectant. Also, *Buli* describes an upright structure made from clay mixed with rice chaff. All the three facilities are roofed with a conical shaped woven grass and are shown in Plate 4.2 (A and B). *Monyoma* refers to a particular scented grass which is used to deter insects from infesting maize grains. The use of *Kambong* is popular among respondents as 38.7% uses it. According to a key informant, the use of *Kambong* is popular because it is easy to construct using locally materials.

Table 4.23: Indigenous Adaptation Strategies for Storing Maize

Indigenous Strategies	Percentage	Conventional Strategies	Percentage
Buli	18.1	Sacks (jute, makola and triple sacks)	63.6
Kpagrigu	36.3	Silo	13.3
Kambong	38.7	Chemicals	23.1
Monyoma	6.9		
Total	**100**		**100**

Source: Author, 2015

"When I harvest my maize, it is stored in a "Kambong" you saw it in front of my house behind there. When it is stored, it stays there till the time I need it without pest destroying it. It can even stay up to the time rains will start at the off-season. There are also Buli which is also good for storing maize but it is difficult to construct" (FGD, Fazihini).

As little as 6.9% of the respondents, uses Moynoma for storing maize. It was realised from a focus group discussion that, *Monyoma* cannot be used alone but along with other methods as mentioned above. It was observed from the study communities that, different names were assigned to the *Kambon* in different communities. The other names for the *Kambon* are *Kpachagrigu, Leenga, Pupuri and Chenchenku.* It was also realised that, the storage of maize seeds for replanting was different from those to be consumed. Usually, respondents hang some pieces of selected healthy cobs from the harvested ones. In the selection of the cobs, an old maize farmer explained that, big cobs are selected from the middle of the farms are selected. This is to avoid selecting a disease infested cob.

(A)

(B)

Plate 4.2: A picture of Buli and Kambon

On the use of the conventional strategies, the study identified the use of sacks, silos and the use of chemicals. Majority of the respondents representing 63.6% use sacks for storing maize. Three types of sacks were identified and include jute, *makola* and the triple sacks. Among the three types, the use of the jute and *makola* sacks was more than the triple sack. This was because most of them acquired the triple sacks as part of support from nongovernmental organisations. A female maize farmer indicated that, sacks are mostly used because it allows for easy transportation.

The study further found that the use of sacks and chemical for storage of maize was also very popular. About 23.1% of the respondents use chemicals to threat maize. After the chemicals treatment of the maize, the grains are bagged in sacks. About 13.3% of the respondents also use silos for the storage maize. This is because, the acquisition of silos compared to the other method is found to be expensive for the respondents. Therefore all the respondents who uses silos either used the community silos or those provided by some non-governmental organizations.

4.4.15 Indigenous Strategies during the Pre-Planting of Yam

It was realised from the study that, there is only one dominant strategy used in the pre-planting of yam and this is the hand weeding with hoe. In most focus groups, it became clear that the use of the hoe weeding is the only indigenous strategy use at this stage. The importance of this strategy is reflected in the words of a respondent in a focus group discussion:

"Traditionally we prefer the use of the hoe to any other method. The weeding is done at the end of the season when the grasses are fully grown. Towards the end of the rains, these grasses are

cleared with a hoe and left on to the field which serve as a mulch. This will keep the ground moist until it is time for making of the mounds"

This means that, the cultivation of yam starts right at the end of the rainy season suggesting that the crop is a long gestation crop. Therefore preparation for farming starts early and the need for moisture availability becomes crucial. In most focus groups, it became clear that the conserved moisture will be used in the constructing of the mounds.

4.4.16 Conventional Strategies during Pre-Planting of Yam

The study revealed that, the use of weedicides and tractor plough are the most common conventional strategies. In Figure 4.13, majority of the respondents representing 56% uses tractors to plough the land while 44% of the respondents use weedicides. The high percentage of respondents using tractor plough at this stage suggests the level of confidence on the strategy. The common weedicides for yam farms are the Athrazine and the Agrazine.

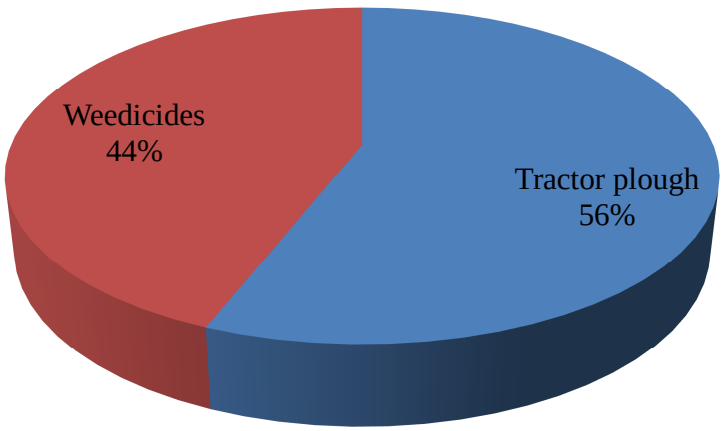


Figure 4.13: Conventional Strategies at the Pre-Planting of Yam

Although the percentage of respondents using weedicides is quite substantial, most focus groups complain of the effects of these weedicides to yam farmers. Respondents observed that, yam farmers who use this method find it difficult to store their produce for a long time. The tubers easily get rotting and this is attributable to the use of weedicides. However respondents were quick to acknowledge that, the use of weedicides and tractor plough fastens their work but does not lead to high yield compared to the use of hand weeding with hoe. A key informant explained that:

"*Using the weedicides and tractors to plough is very fast and so a farmer can cultivate two or more acres but the produce easily gets rotting. When the weedicides are used it makes the soil very hard, making mounds construction difficult. It is just that we are becoming lazy otherwise the hand weeding is the best for preparing land for yam farming*"

It must be emphasised that, irrespective of either indigenous or conventional land preparation, the indigenous yam mounds are used by respondents after this initial land preparation.

4.4.17 Strategies for Yam Planting

The study revealed that, the planting of yam is predominantly indigenous. The main strategies used at this stage include yam sett selection, mulching and timing of planting. With the sett selection, respondents explained that, yam setts are selected into various varieties in order to assist in planting. Similar varieties are planted in either rows or columns in order to allow for easy monitoring and subsequent milking. In order to avoid pest infestation after planting, neem seeds are grind into powder and then applied into the planting hole before covering. With mulching respondents explained that, it is use because of the role it plays in the germination of the yam setts. When a yam mound is mulch during planting, the yam sett is protected from the direct heat from the sun while preventing moisture loss in the mound. The use of mulching

therefore contributes to the survival and germination of the yam setts. According to key informant in *Zoggu*, the growth of yam is very sensitive to high temperature and because it is usually planted during the dry season, mulching is used by the majority of the respondents to conserve moisture for use by the yam setts. The practice of mulching the mound is called *Bugbu*. The process of *Bugbu* involves covering the tip of the mound where the sett is sewn with fresh leaves while placing a muzzle of sand on it. Additionally, timing of planting of setts is as crucial as the handling of the setts. A key informant explained that, the planting of yam is done early in the morning. Ones the sun shine enough to produce heat, yam planting ceases.

4.4.18 Strategies at the Growth Stage of Yam

From Table 4.24, about 54.2% of the respondents use staking and hand weeding with hoe at this stage. The use of stalking and hand weeding with hoe is popular among the respondents because, it enables the yam crop to develop very well. While stalking ensures the healthy growth of the plant, hand weeding with hoe reduces competition between weeds and the yam plant.

Table 4.24: Cultural Practices for Yam Cultivation

Strategy	Frequency	Percentage
Staking/weeding	180	54.2
Hand weeding	124	37.3
Weedicides/Chemical fertilizer	28	8.4
Total	**332**	**100.0**

Source: Author, 2015

The importance of staking is reflected in the argument of a participant in a focus group discussion.

"The reason for doing the staking is to protect the yam from dying and to prevent it from lying on the floor and the leaves falling off. When you don't stake and it rains, the yams will die. When

this happens, the yams will not do well, either than that the staking makes it do well. Snake and other reptile could even begin to take over the farm" (FGD, Fazihini).

Aside the normal staking, respondents also sometimes allows the yam plant to creep on trees closer to a group of mounds and the process is known as *Tivuligu*. The use of *Tivuligu* is found to be better than even the normal staking. Respondents testified that on a land where many trees abound to be used as *Tivulisi,* produces bigger tubers than even the normal staking. This means that, the cultivation of yam could determine the number of trees on the land and this could prevent deforestation. It must be emphasised that staking is not an alternative to hand weeding. The results of the study further show that, 37.3% of the respondents' use only weeding. The difficulty in getting sticks to be used in farms has forced some of them to resort to only weeding. According to respondent in a focus discussion, ideally a yam farm (*boggu*) goes through a series of three time of weeding before harvesting. Plate 4.3 shows a new yam farm at Kpachelo.

Plate 4.3: Newly Constructed Yam Mounds

Conventionally, some yam farmers now use weedicides in place of hand weeding. About 5.4% of the respondents were found to be using weedicides in yam farms. This method is adopted

because it is less laborious compared to ordinary weeding. Although it is the quickest means of clearing weeds, respondents also noticed it effects on tubers after harvesting. The commonly used weedicides for yam are the Athrazine and the Agrazine while the Bootx-etra is still the common yam fertilizer used.

4.4.19 Strategies for Storing Yam

The study revealed that, yam farmers store their produce with the use of only indigenous strategies. The three strategies are the use of the local hut locally called *Dede* and the burying method. It was evidenced from the study that, 53.6% of the respondents store yam in the hut (*Dede*). The hut (*Dede)* is the use of dried yam climbers (*Nyu-kalinsi*) to form a carefully constructed hut arranged with some supporting sticks in a circular form while the yam lies in the middle. The use of the hut regulates the amount of heat entering the yam. Other respondents accounting for about 37% store yam in a *Kambong* as shown in Figure 4.1. Plate 4.3 shows a picture of *Dede method*.

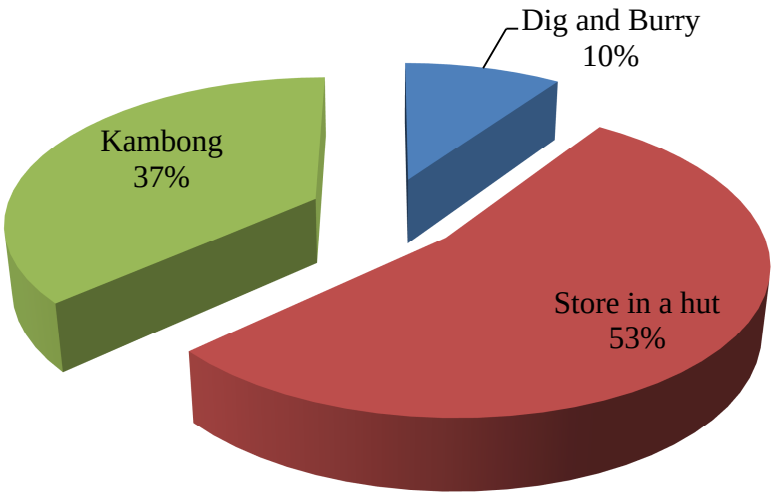


Figure 4.14: Strategies of Storing Yam

Source: Author, 2015

The study further establishes that, 9.6% of the respondents' burry yam in the soil. After harvesting, the yam is buried in the moist soil until it is needed. The proportion of the respondents using this method is small because of the risk it poses to the yam. Recent fluctuations in rainfall as well as high temperature do not favour the use of this method.

Plate 4.4: Dede for Storing Yam in Zosali

4.5 Determinants of choice of Adaptation Strategies in Maize and Yam

This section revealed the determinants of the choice of adaptation strategies. These determinants are discussed in two main categories and these are climatic determinants and non-climatic determinant. These determinants are ranked using the Kendall's coefficient of concordance in order to determine the most pressing determinant.

4.5.1 Climatic Determinants of Adaptation Choice

The study revealed in Table 4.25 that, majority of the respondents representing 37.3% identified drought as the major climatic determinant of their choice of adaptation. This suggests that, the increasing spade of drought is exerting untold pressure on smallholder farmers in the municipality. Among the elements of climate, prolong drought play a key role in the adaptation choice of smallholder farmers in the municipality. The study found also that, rainfall determines 35.5% of the respondents' adaptation response. The erratic nature of the rain influences farmers' adaptation choice as a result of its unpredictable nature. According to the respondents, the rains come very late and only last for a short time thereby causing some plants to either get water in quantities that cannot support it to thrive or gets water at the wrong time. Temperature also account for 19.9% of the respondents. This means that, the reduction in the quantity of rain has resulted into more days of excessive sunshine leading to the production of high temperatures above plant requirement. The study further revealed that, floods which represented 7.2% of the respondents also determines adaptation choice of respondents. This means that, the effect of floods on the municipality is minimal and this has a direct link with the recent reduction of rainfall in the municipality. Some of the areas that experiences floods are low lying marshy areas which usually require early planting. Rainfall has a direct link to all the other climatic factors as the absence or the over presence of it leads to either drought or flood with a concomitant increase in temperature.

Table 4.25: Climatic Determinants of Adaptation

Determinant	Frequency	Percentage
Floods	24	7.2
Droughts	124	37.3
Temperature	66	19.9
Rainfall	118	35.5
Total	**332**	**100.0**

Source: Author, 2015

4.5.2 Non-Climatic Determinants of Adaptation Choice

Aside the climate related factor determinants, other factors also affects the adaptation choice of respondents which is independent of the climate. The outcome of the study as indicated in Table 4.26 revealed that, a lot (146) of the respondents representing 44% say finance play a major role in determining the choice of adaptation strategy. This suggests that, access to finance is a major adaptation barrier of the respondents. The cost of adapting to strategies and the risk involve does not allow smallholder farmers to easily adapt to new and improved strategies. Inadequate finance has worsened the plight of respondents coupled with high cost of borrowing. This will therefore reduce the adaptive capacity of respondents. It agrees also to the findings of Yaro (2013b) that, "poverty is seen as one of the standing blocks to farmers adaptation". This means that, money is needed to buy inputs such as fertilizers and weedicides and the inadequacy is affecting the choice of adaptation.

The study further identifies access to technology representing 31.3% of the respondents as another major determinant of adaptation choice. It is not only getting access to finance but the availability of farm implement for hiring such as tractors are not readily available. The continuous waiting for the implements sometimes leads to late planting as the moisture content in the soil is usually not enough to make ridges. The unavailability of tractors for ploughing at the right time was a major concern to majority of the respondents. Labour also account for about 18.7% of the respondents. The availability of farm hands is necessary to the survival of most smallholder farmers. These days, most of these farms hands who are mostly the children are either in school or even run to southern Ghana to seek greener pastures. Other factors such as education, access to extension services, and access to credit facilities represented 6% of the respondents. Respondents who did not acquire formal education find it difficult adopting strategies requiring some minimal level of education. Extension service is vital to serving some

adaptation needs of smallholder farmers. But their inadequacy in the municipality is affecting most smallholder farmers.

Table 4.26:Non climatic Factors Determining Adaptation Choice

Determinants	Frequency	Percentage
Finance	146	44.0
Labour	62	18.7
Access to Technology	104	31.3
Other	20	6.0
Total	**332**	**100.0**

Source: Author, 2015

4.5.3 Rank of Determinants of Adaptation

The Kendall's Coefficient of Concordance was used to rank the determinants of adaptation. According to Legendre (2005), the Kendall's coefficient of concordance *(W)* is given by the relation

$$w = \frac{12s}{P^2\left(n^3 - n\right)} - p^t \quad \text{.....(1)}$$

Where: *W* denotes the Kendall's coefficient of concordance*; P* denotes number of respondents ranking the challenges, *n* denotes the number of adaptation strategies' denotes correction factor for tied ranks, *S* denotes sum of squares statistics over the row sum of ranks (R_i).

The sum of square statistics (*S)* is given as:

$$S = \sum_{i-1}^{n}\left(R_i - R\right)^2 \text{.....(2)}$$

Where R_i is row sums of rank and *R* is the mean of R_i. The correction factor for tied ranks (T) is also given as:

$$T=\sum_{k-1}^{m}\left(t^{3}-t_{k}\right)\ldots\ldots(3)$$

Where t^3 is the number of ranks in each of m group of ties

The test of significance of the Kendall's coefficient of concordance was done using the chi-square statistics which is computed using the formulae:

$$X^{2}=P(n-1)W\ldots\ldots(4)$$

Where n is the number of constraints, P is the number of respondents and W is Kendall's coefficient of concordance. The null hypothesis for the Kendall's is that, there is no agreement among respondents on the determinants of adaptation while the alternative stood that; there is at least some agreement among respondents. If the calculated chi-square is greater than the critical chi-square, then the null hypothesis is rejected in favour of the alternative hypothesis that there is agreement among the ranking of the constraints by the respondents. The results are presented in Table 4.27.

Table 4.27: Kendall's Coefficient of Concordance

Determinants	Mean Rank	Rank
Rank of Finance	1.30	1st
Rank of Educational background	5.87	7th
Rank of access to credit	4.17	3th
Rank on extension visits	5.74	7th
Rank on technology	4.87	4th
Rank on rainfall Determinant	3.30	2nd
Rank on temperature	5.47	6th
Rank on drought	5.28	5th

N=332, Kendall's W[a] =0.403, Chi-Square=936.424, df=7, Asymp. Sig=0.00

From Table 4.27, finance is considered by the respondents as the most determinant of adaptation with a mean rank of 1.30. This means that, respondents' lack of financial support is a major barrier to respondents' adaptation. Respondents identified rainfall as the next determinant of adaptation. This means that, respondents' farming activities is largely rain-fed and the presence

or lack of rainfall is therefore a major determinant. Access to credit, technology, recurrence of drought are ranked and high temperatures are ranked third, fourth, fifth and sixth with the mean score of 4.17, 4.87, 5.28 and 5.47 respectively. Access to education is ranked very low and is considered to be the least barrier of adaptation. This means that, the most important determinant of crop yield among smallholder farmers are finance and rainfall. This finding partly agrees with the work of Amikuzuno and Donkoh (2012) that "the most important determinant of crop yield among smallholder farmers is rainfall and temperature variability". The Kendall's Coefficient (0.403) shows high agreement in the ranking of the determinants of adaptation. However, it is significant at 99% confidence level as the significant value is 0.00 implying that the model is significant at 1%.

4.6 Challenges of Conventional and Indigenous Strategies of Adaptation

This section examines the challenges of indigenous and conventional strategies of adaptation and how both strategies can complement each other in addressing adverse climatic impacts.

4.6.1 Challenges of Conventional Adaptation Strategies

Respondents indicated whether they face specific challenges in the use of conventional adaptation strategies. As illustrated in Figure 4.15, about 78% of the respondents are challenged in the usage of conventional adaptation strategies. This means that almost all the respondents have problems in adopting conventional adaptation strategies. These challenges range from technology, financial, cultural to education. The adoption of technology for instance is greatly depended on one's educational status and with majority (68.1%) of the respondents not educated, adapting to new technology will be challenged. Inadequate access to extension services also affects the adaptive capacity of respondents. Also 22% of the respondents do not have any problem with the use of conventional adaptation strategies. This is means that the various

challenges associated with technological adoption, finance and cultural barriers do not affect these respondents. This is mainly due to the level of education, or access to good extension services.

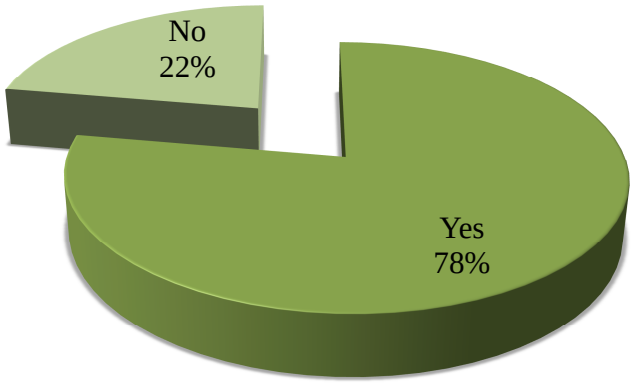


Figure 4.15: Challenges of Conventional Adaptation Strategies

Source: Field Survey, 2015

In order to provide an in-depth understanding on the challenges of respondents, the background characteristics of respondent were measured against the challenges faced by respondents. In Table 4.28, there exist a significant difference between farmers who face challenges in adopting conventional strategies and farmers who do not face challenges in terms of access to extension, educational background and access to credit facilities. About 72 of those who have access to extension services faced challenges in the use of conventional strategies while 182 of those who do not have access also faced challenges. Again, 60 of those who have access to education (comprising primary to tertiary) also have challenges while 182 of the respondents without access to education also have challenges. With access to credit, both of those who have access (72) and those without access to credit (186) face challenges in the adoption of conventional

strategies. In sum, majority of the respondents are challenged in the use of conventional strategies irrespective of their socio characteristics background.

Table 4.28: Challenges of Conventional Adaptation Strategies

		Challenges in Conventional Strategy Adoption			
Variable	**Categories**	**Yes**	**No**	**Chi-Square**	**P-Value**
Sex	Male	220	60	0.764	0.387
	Female	38	14		
Extension Access	Yes	72	12	4.159**	0.04
	No	186	62		
Education	Primary	34	10	10.9**	0.028
	JHS	22	8		
	SHS	20	2		
	Tertiary	4	6		
	None	178	48		
Credit Access	Yes	72	8	9.19***	0.002
	No	186	66		

Where *, **, and * show significance at 10%, 5% and 1% respectively.**

4.6.2 Specific Challenges of Conventional Adaptation Strategies

The study identified technological barriers, cost in adoption, and effects on arable land, as well as the destruction of indigenous varieties and others as the specific challenges of conventional strategies. As shown in Figure 4.16 the study revealed that, 63% of the respondents are challenged in terms of cost of adopting conventional strategies. This means the cost involve in using conventional adaptation strategies such as the use of inorganic fertilizers, weedicides and acquisition of tractors as well as other implements is beyond the reach of respondents. Cost of adoption affects the adaptive capacity of the respondents. The withdrawal of subsides on some agriculture products like fertilizers has even worsen the plight of smallholder farmers. This could reduce the welfare of respondents as a result of increasing cost of agricultural inputs. This agrees with literature on adaptation, climate variability and food crop production. Yaro (2013b)

identified that, “farming is becoming expensive than before leading to fluctuation of welfare and livelihoods of farmers”. The finding also conforms to that of Sammadar et al. (2014) that, financial impediments is a major barrier to the success of adaptation strategies in northern Ghana. With technology, 60.2% of the respondents do not have any challenge in terms of the adoption of conventional adaptation technology. This means that, respondents are better adapted to new and improved technology. In an interview with an extension officer, it was noticed that, some smallholder farmers still have a problem differentiating pre-emergency treatment weedicides from post-emergency treatment weedicides. The most common pre-emergency treatment for maize is the Sarosate, Sanphosate, Glyphadir and Nwurawura. While the common post emergency treatment are the Ervestra, Hervextra and Glycogan. The most common weedicides for yam are the Athrazine and Agrazine. Ones the wrong weedicide is used for a purpose, it result in to some difficulties for either the crop or the land.

About 15.7% of the respondents believe that conventional strategies affect some farm lands. The continuous use of chemical fertilizers results in soil acidity and this increases the pH of the soil. This means that, the quality of natural soil fertility is affected by the use of some weedicides. The study further revealed that, 11.4% of the respondents identified conventional strategies to be destroying indigenous varieties of seeds. The smallholder number of respondents with this view suggests that, the destruction of indigenous seed varieties may not be as a result of conventional strategies but the increasing adverse effects of climate variability. Others consisting of 13.3% of the respondents think the use of conventional strategies are responsible for reducing the length of storage of maize and yam. Certain sicknesses like waist pains, diarrhoea and abdominal pains were also linked to the use of conventional strategies especially fertilizer and weedicides. However, in an interview with an Agricultural Extension Agents, it was revealed that,

respondents do not follow exactly the criteria in application of the inputs. The appropriate dressing for the application of weedicides are not been followed and this could have some repercussions. On the average, 24.2% of the respondents are identified as having challenges with the use of conventional strategies and 53.6% have not experience any challenge. This suggests that, respondents are very pleased with the adoption of conventional adaptation strategies.

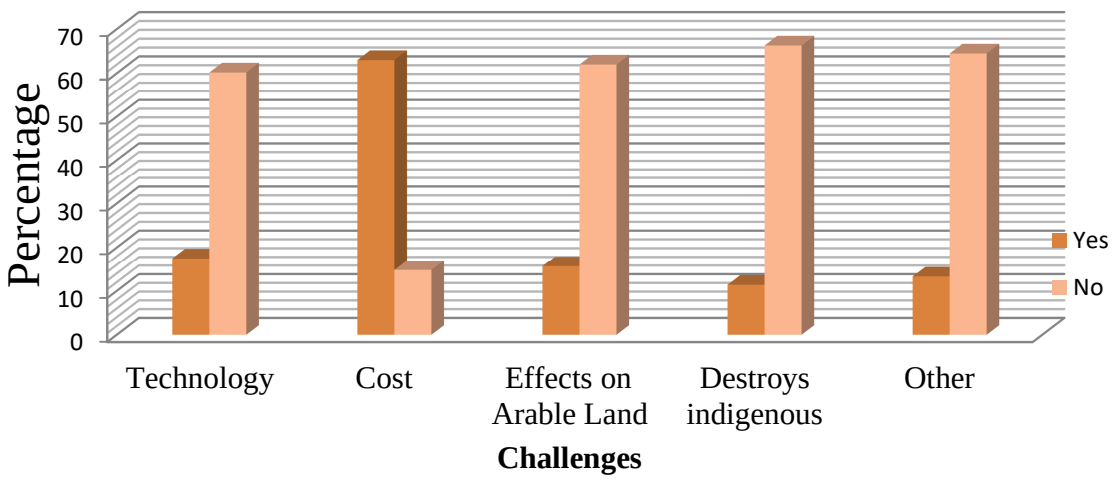


Figure 4.16: Challenges of Conventional Adaptation

Source: Author, 2015

4.6.3. Effects of Conventional Adaptation

In Figure 4.17 respondents perceived effects of conventional adaptation is felt more in maize and yam. About 39.6% of the respondents complain of effects during harvesting and storage. This signifies that, postharvest loses is high among maize and yam. It was contended that respondents, blame the low storage span of maize and yam on the use of agrochemicals. Focus groups argue that, maize and more especially yam easily gets rotten and this is attributed to the use of weedicides. About 25.5% of the respondents are also affected during the use of maize and yam for food. It was argued that, food prepared from maize without the use of fertilizers and other

chemicals last longer and taste better. It was observed that, respondents fail to adequately prepare food very well before usage. Unlike in most urban centre where the milling of maize begins by removing the chaff, respondents do not remove the chaff and this is one of the reasons why food prepared from this is a problem. It was also confirmed by the agricultural extension agents that, pesticides and other chemicals for storing maize and yam, specify the period and length of storage. It is the non-adherence to these expiry dates that poses a problem. About 17.8% and 16.9% of the respondents are affected during planting and the growth stage of maize.

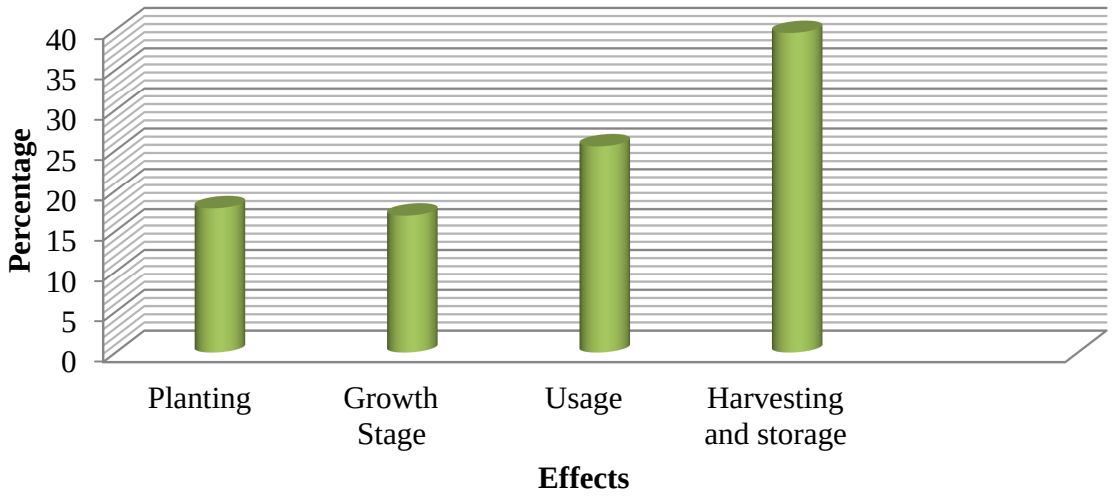


Figure 4.17: Effects of Conventional Adaptation

Source: Author, 2015

4.6.3 Challenges of Indigenous Adaptation Strategies

This section looks at the difficulties that have been with indigenous adaptation strategies. The study results are presented in Table 4.29. About 70.5% of the respondents identify labour intensity as the main challenge of indigenous strategies. This greater percentage suggests that, indigenous strategies involve direct use of human energy in order to realize increase in output. Strategies such as making ridges, mounds and hand weeding depend so much on human labour.

The laborious nature of indigenous strategies will therefore have a direct link with productivity, and this explains why most indigenous farmers are smallholder farmers. As farm households are losing their farm hands to schools and migration down south, the sustenance of the labour needs of the indigenous strategies will be a major problem to contend with.

The study also made it clear that, 71.1% of the respondents think indigenous strategies are not effective in the light of increasing climate variation with about 28.9% not recognizing this as a challenge. This means that, indigenous strategies have failed to match up with the rate of increases in climate variability and hence leading to its ineffectiveness. In the same vein, 64.5% of the respondents attribute low crop yield to indigenous strategies. This means that, the ineffectiveness of indigenous strategies is a direct consequence of the low output experienced by small holder farmers. It is further established from the study that, only 14.5% of the respondents identified inadequate access to improved maize seeds and yam setts as a challenge to indigenous strategies. The study noticed that, smallholder farmers do not easily have access to improve maize seed varieties. The availability of yam mini setts is still a big problem to yam farmers. The cost of generation of yam setts could rise up one-third of the total cost involve. This hinders the adoption of the strategy.

Table 4.29: Challenges of Indigenous Adaptation

Challenge	Yes	No	Total
Labour intensive	70.5	29.5	100
Ineffective	71.1	28.9	100
Low crop output	64.5	35.5	100
Forgetfulness	33.7	66.3	100
Access to seeds/setts	14.5	85.5	100
Average	**42.4**	**57.6**	**100**

Sources: Author, 2015

4.6.4 The Use of Indigenous and Conventional Strategies

As illustrated Table 4.30, majority (92) representing 27.7% of the respondents suggest that, the best way of using both strategies is learn the technology involved in both strategies. This means

that both indigenous and conventional adaptation strategies have specialized technologies underlining its use. These background technologies should be learnt and used as foundation to developing both strategies together. Other respondents representing 21.7% of the respondents think that, only conventional strategies should be used. This means that indigenous strategies have become obsolete and should not be used at all. Again, 15.7% of the respondents are of the conviction that, both strategies should be used for different adaptation demands. They should therefore be used for the appropriate purpose. Approximately 15.7% of the same margin of respondents thinks the use of both strategies will be good for reducing risk associated with climate variability. This means that, when one strategy fails, another might not. About 13.3% of the respondents think the use of both strategies should consist of more conventional and less of the indigenous. In the same vein, only 6% think the usage of both strategies should consist more indigenous and less of conventional strategies. This suggests that, certain strategy requirements favour the use of indigenous strategies and others favour conventional strategies as well. Indigenous strategies cannot therefore be treated differently from conventional strategies and this agrees with Ajani et al. (2013) assertion that "indigenous knowledge cannot be separated from adaptation strategies if only it will be sustainable".

Table 4.30: Effective use of Both Strategies

Response	Frequency	Percentage
Use a strategy for appropriate purpose	52	15.7
Learn technology involved in both strategies	92	27.7
Using both will help reduce risk	52	15.7
Use more of the Conventional	44	13.3
Use more of the Indigenous	20	6.0
Only Conventional Strategies	72	21.7
Total	**332**	**100.0**

Source: Author, 2015

4.6.5 Adoption of Indigenous and Conventional Strategies

The study revealed that, 83% of the respondents agree to the use of both conventional and indigenous strategies. This means that, the use of both strategies could as well serve as a risk reduction strategy. However, respondents agree also that, it is not all the stages of the farming process both strategies could be applied. In the focus group discussions, it was revealed that, one of the reasons why indigenous strategies are failing is mainly as a result of the erratic rainfall. This means that, the success of indigenous strategies hinges on regular rainfall;

"All these are as a result of the rain and its inconsistency. For example, the late Korata Naa used to call on a communal labour anytime it rained first and people with tractors were also cultivating. He usually harvested more maize than those who farmed with tractors during the harvesting season. The reason was that there is usually "Sanzali" in this our town and so to cultivate on ridges (vielim). This made it possible for him (Korata Naa) to still have water in between the ridges enabling the maize to stay strong and even if it rains over, the maize is secured because the maize remains on the ridges without getting soaked in water but those who cultivate their land with tractors, the maize could be soaked in water and hence gets rotten and dies off as a result. But because it does not rain frequently, our town here would be good if one cultivates his/her maize on ridges. It is not that we are lazy here but it is the rain and its unpredictability is our major problem here that is what I have to say". (FGD, Nyolugu)

A female participant in a focus group discussion explained that, one area indigenous strategies have been of great help concerns storage of commodities;

"*For me what I have seen about the indigenous methods is the mode of storage of foodstuffs. That is the benefits of the indigenous methods of farming. The "Kambong", "Chenchenku" and "Pupuri" and the like are all indigenous practices of storing foodstuffs which are helping*

immensely in our farming system. So that is the advantage of the indigenous practices which was left for us by our fathers".(FGD, Fazihini)

Study revealed further that, yam cultivation is still based a lot on indigenous strategies. *The indigenous methods are largely used in this area of the cultivation of yam. Because a tractor cannot cultivate a land into yam mounds, it is only the initial preparation of land that we can use a tractor but when it comes to the making of yam mounds, it is only the indigenous ways that we can use. So the indigenous methods are of immense benefit here. So yam needs only the round mounds. Yam is a very sensitive to cultivate crop.*

On the whole respondents agreed that, it is not in all cases that conventional strategies should be used. In some cases, indigenous strategies are vital in the cultivation of some crops. The recent variability has resulted in over stretching some indigenous systems beyond indigenous strategies.

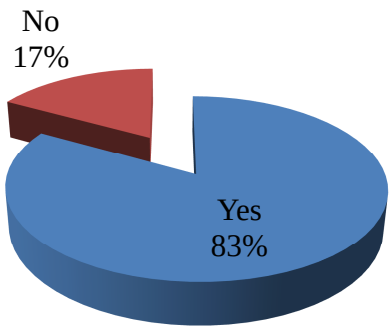


Figure 4.18: Use of Both Strategies of Adaptation

Source: Author, 2015

In order to determine the nature of the recommended use of both strategies, respondents background characteristics were measure against some background characteristics. As illustrated in Table 4.31, about 84% of the male respondents recommended the use of both strategies with 81% of the respondents who are female also recommending the use of both indigenous and

conventional strategies. Of the respondents with access to extension service, 81% and 84% of those with and without access to extension services also recommends for use of both strategies. Also, 88% of the respondents with access with access to credit recommended the use of both strategies with 82% of those without access to credit recommending the same. In all, majority of the respondents recommend the use of both strategies.

Table 4.31: The Use of both Conventional and Indigenous Strategies

		Recommend Use Of Both		
Variable	**Categories**	**YES**	**NO**	**TOTAL**
Sex	Yes	234 (84%)	46 (16%)	280
	NO	42 (81%)	10 (19%)	52
Access to	Yes	68 (81%)	16 (19%)	84
Extension	No	208 (84%)	40 (16%)	248
Education	Primary	40 (91%)	4 (9%)	44
	JHS	30 (100%)	(0%)	30
	SHS	18 (82%)	(18%)	22
	Tertiary	10 (100%)	(0%)	10
	None	178 (79%)	48 (21%)	226
Credit Access	Yes	70 (88%)	10 (12%)	80
	No	206 (82%)	46 (18%)	252

Figures are frequencies whiles those in parentheses are row percentages

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

The study was to assess how indigenous adaptation strategies are complementing conventional adaptation strategies to climate variability in order to increase maize and yam production in the Savelugu-Nanton Municipality. To achieve this, several research questions and objectives were posed. This section presents summary of the major findings of the study, conclusions drawn on the major findings as well as recommendations on the conclusions.

5.2 Summary of Major Findings

5.2.1 Smallholder Farmers' Perception on Climate Variability

i. Smallholder farmers perceived climate in the municipality as changing. These changes are manifested in reducing rainfall amounts, increasing length and frequency of drought as well as erratic rainfall. Erratic rainfalls coupled with prolong droughts and gradual shift in the seasons has made agricultural activities more risky. The combined effect of these changes on agricultural activities creates pressure on the livelihoods of smallholder farmers.

ii. Smallholder farmers attribute the causes of climate variability to the will of God and human activities such as deforestation and bush burning. About 53.6% of the respondents mentioned that, the causes of climate variability have been in existence. Respondents however believe that, the climate will one day come back to normal.

iii. Drought is perceived as either short or long spell. The short spell is found to be desirable because it enhances the growth of maize and yam at certain stages of its growth while long drought spell directly affects crop yields.

iv. Floods are perceived in two main forms. The first form of floods which is less harmful and could be controlled does not necessarily result from excessive down pour but poor farming practices and the use of tractors to plough. The second floods type results from excessive downpour and is mostly dangerous and destructive. The first form is called *Kokpegu* (excess water) and the second is *Kodili* (destruction caused by water)

5.2.2 Adaptation Experiences of Smallholder Farmers

i. Smallholder farmers adopt changing planting times as a major adaptation decision. The timing of planting is key and fundamental to any other form of adaptation. Timing determines whether rainfall, drought occurrence and even application of fertilizers and other chemicals could be successful.

ii. The study revealed that, smallholder farmers use both indigenous and conventional adaptation strategies in the cultivation of maize and yam. The most popular indigenous strategies are crop rotation, indigenous weather prediction, ridging, mixed farming, mulching and organic manure. Conventional strategies that are often used are the application of fertilizers and weedicides, weather forecast information and improved seed varieties.

iii. The study revealed that, indigenous weather forecast is still used among smallholder farmers and it is complemented heavily by conventionally improved weather information. Indigenous weather prediction according the study results can be

categorized in to short and long term. For the short term, movements of black ants and cry of certain birds at certain times and the movement of celestial bodies are used. For the long term, trees such as baobab and *dawadawa* are used to determine seasonal changes in rainfall.

iv. It is revealed further that, the use of ridges and mounds are good strategies in regulating and conserving water for use by plants in terms stress. Smallholder farmers also use it to control of erosion when use as terracing. However, the reduction in the quantity of rainfall is hindering the practice of these strategies.

v. In the post-harvesting of maize and yam, the strategies for storing maize and yam are mostly indigenous. The use of traditional silos (*Buli, Kambong, Kpachagrigu*) for maize storage and *dede* for yam is found to be effective in reducing post-harvest losses.

vi. Smallholder farmers also use land rotation during maize and yam cultivation as it leads to mutual increase productivity for both crops. Aside yield increases in both crops, land rotation is also seen as a means of controlling diseases and pest spread especially in the control of *Striga Hermonthica,*

vii. It was revealed further that, smallholder farmers still prefer indigenous seeds. With the exception of maize where a lot of hybrid seeds are used, respondents acknowledged that, all yam setts are indigenous varieties and thrive very well in appropriate conditions. Also, it was realized that, indigenous seeds are resistant to stress and thrive well is the absence of fertilizers and adequate water compared to hybrid varieties.

5.2.3 Determinants of Adaptation

i. Among the non-climate determinants, finance and access to technology are crucial is the adaptation choice of smallholder farmers.

ii. Access and use of farm tractors was of found to be critical in the choice of adaptation as it influencing the timing of planting in the wake of reducing rainfall amounts.

5.2.4 Challenges of Indigenous and Conventional Adaptation Strategies

i. Both indigenous and conventional strategies are challenge. The most significant of the challenges of the conventional strategies are cost of adoption and availability of technology. Lack of uniformity in the application of strategies and the labour intensive nature are the major challenges.

ii. Specifically on the use of chemical fertilizers and weedicides, the study revealed that respondents attribute the continuous loss of soil fertility, breeding of *Striger Hermonthica* and agricultural land degradation to the use of these chemical fertilizers and weedicides. Some sicknesses like leg and waist pains were attributed to the use of these chemical as well as its effects of the storage span of maize grains and yam tubers. The lack of longevity in the storage of yam is an instance of the use of chemical induced land for its cultivation.

iii. The study revealed that, some indigenous strategies such as mixed cropping, fallowing and the use of some indigenous seeds are becoming obsolete and are therefore not patronized by most of the respondents. Ridges and mounds, crop rotation and the use of indigenous yam seeds are very important to livelihoods of smallholder farmers.

iv. It was also revealed that, even though there are so many improved maize seed varieties, access to these seeds are very difficult. With yam, the availability of mini yam setts is becoming very expensive.

v. The study further found that, both indigenous and conventional strategies of adaptation are used by respondents. However, the conventional strategies are far more becoming

popular than the indigenous strategies due to increasing uncertainty with the weather and climate.

5.3 Conclusion

5.3.1 Smallholder Farmers' Perception on Climate Variability

i. Improved weather forecast is vital for the cultivation of maize and yam but precise weather information technology in still developing and it's still occasioned by some periodic lapses. Indigenous weather predictions are a good source of information necessary to complement and overcome these lapses pose by the conventional improved weather forecast. What is of more essence to the two weather systems is the timing of the information delivery to smallholder farmers.

ii. Although some smallholder farmers attribute the causes of climate variability to increasing social vices, human activities is acknowledged to have contributed more to climate variability among smallholder famers.

iii. In an era of reducing rainfall amounts and increasing frequency and length of drought, conservation of soil moisture is necessary for both maize and yam. The use of indigenous ridges and mounds as well as mulching serve as a good source of moisture conservation, controlling flood, checking erosion and improve the development of the fibrous root of maize and yam tubers.

iv. Incidence of floods are less frequent in the municipality but there are still instance of water invasion of farms and this is attributed to the use of tractor plough and other bad farming practice.

5.3.2 Adaptation Experiences of Smallholder Farmers

i. Timing in the application of adaptation strategies is vital to smallholder farmer adaptation. The onset of rains and the success of adaptation strategies hinge more on timing of application of the strategies.

ii. The use of indigenous and conventional strategies in maize and yam cultivation is evident but however, conventional strategies in maize cultivation are far more advanced than in yam cultivation.

iii. Indigenous weather forecast mechanisms are a good source of weather information that could complement conventional strategies since conventional weather strategies is still developing with periodic lapses.

iv. Some indigenous soil management strategies like ridges and mounds are very good in the conservation of soil moisture.

v. The use of indigenous storage mechanisms has proven to be suitable and more adopted to smallholder farmers than conventional strategies.

vi. The rotation between maize and yam among smallholder farmers is mostly used because of the associated benefits of increasing yield.

vii. Although most indigenous seed varieties are late maturing, some of these indigenous seeds are thrive better than improved seeds in times of water stress, minimal or no fertilizer requirement.

5.3.3 Determinants of Adaptation

i. Access to finance and technology are the most determinants of smallholder farmer adaptation.

ii. The non-availability for hire of farm tractors influences timing of land preparation among smallholder farmers.

5.3.4 Challenges of Indigenous and Conventional Adaptation Strategies

i. Both indigenous and conventional strategies are challenged differently and could benefit from the combination of the two. The most significant challenge of the conventional strategies is the cost of adoption and indigenous strategies are critic on the lack of uniformity and precision of strategies.

ii. The perceived adverse effects of agrochemical among smallholder farmers are fast gaining grounds among smallholder farmers. The use of chemical fertilizers and weedicides are very effective in increasing output of maize and yam. However, its continuous use is detrimental to the soil in the long run. Indigenous soil management practices are however more environmentally friendly than these strategies.

iii. Although the use of some indigenous strategies is becoming obsolete, it is mainly attributed to the reducing rainfall amounts. The increasing popularity and use of conventional strategies among smallholder farmers is growing but this is attributed to the unpredictability of rainfall.

iv. The use of agro-chemicals and the general adoption of conventional strategies is still a major problem among smallholder farmers due to inappropriate usage. The use of pre-emergency and post emergency treatments is a major challenge to smallholder farmers.

v. It was also revealed that, the use of indigenous strategies in the long run could ensure environmental sustainability than conventional strategies.

5.4 Recommendations

5.4.1 Smallholder Farmers' Perception on Climate Variability

i. The study recommends to the Ghana Meteorological and the Ministry of food and Agriculture to assist smallholder farmers with relevant rainfall information. Also relevant aspects of indigenous weather knowledge could be mainstreamed.

ii. The availability of water for farming is also critical. The study recommends to the Savannah Accelerated Development Authority (SADA) help develop irrigation schemes for use by smallholder farmers. This will reduce risk associated with rainfall shortages. Also, the Ministry of Food and Agriculture (MOFA) should effectively identify ways improve on the usage of ridges and mounds. This will enable smallholder farmers' benefit from its associated benefits.

iii. The study recommends also to the Ministry of Food and Agriculture through its extension services, to educate smallholder farmers on the causes and the effects of climate variability. This could address issues of bad farming practices as well as bush burning and woodland degradation.

iv. It is recommended also that Ministry of Food and Agriculture to research into indigenous strategies such as ridges and mounds could modernize through technology in order to harness its associated advantages.

v. The study further recommends to the Ministry of Food and Agriculture to educate smallholder farmers on best land and water management practices to help avoid floods.

5.4.2 Adaptation Experiences of Smallholder Farmers

i. The study recommends to the Ghana Meteorological Agency and the Ministry of Food and Agriculture (MOFA) to make available adequate and timely rainfall information to smallholder farmers. It is also recommended to chief and other opinion leaders in the various communities to revamp the idea of communal farmer in the communities (Kpariba).

ii. The Ministry of Food and Agriculture and the Savannah Agricultural Research Institute (SARI) as well as other research organization including NGOs could research into aspect of indigenous strategies in both maize and yam cultivation. This could reduce cost of adoption since indigenous strategies are relatively cheaper than conventional strategies.

iii. Study recommends also to the Ministry of Food and Agriculture to consider developing relevant aspects of indigenous strategies into the mainstream adaptation process.

iv. Indigenous weather prediction is a good source of weather information to the smallholder farmer. The Ministry of Food and Agriculture should consider aspects of this technology that could effectively complement mainstream climate information.

v. The Ministry of Food and Agriculture should consider developing indigenous strategies of soil management such as ridges, mounds and "*vala nyobu*".

vi. Also, the Ministry of Food and Agriculture and the Savannah Accelerated Development Authority should consider developing further indigenous storage mechanisms in order to reduce post-harvest loses. The technology used in *Buli* is good but only few smallholders can construct it. More smallholders could be trained in order to make the technology more accessible.

vii. The Ministry of Food and Agriculture through it extension agents should encourage smallholder farmers to practice crop rotation especially between crops that could benefit mutually.

viii. The Ministry of Food and Agriculture should make available improve seeds accessible for use by smallholder farmers. Technologies for seed improvement should consider maintaining some relevant indigenous varieties. The Savannah Agricultural Research Institute on the improvement and availability of improved shorter duration yam setts to smallholder farmers. The Ministry of Food and Agriculture could also liaise with organisations such as the Crop Research Institute (CRI) and the Root and Tuber Improvement Marketing Programme on the improvement of yam setts.

5.4.3 Determinants of Adaptation

i. The government and non-governmental organization should consider establishing credit schemes to assist smallholder farmers.

ii. Study recommends also to Ministry of Food and Agriculture to make farm tractors available for hiring by smallholder farmers during time of need. This will help smallholder farmers prepare in advance. Also Farmer Base Organisations (FBOs) should consider reinventing the good old group farming (*Kpariba*). This practice will help reduce the risk associated with the non-availability of tractors.

5.4.4 Challenges of Indigenous and Conventional Adaptation Strategies

i. The study recommends to the Ministry of Food and Agriculture through its extension services to help trained smallholder farmers on the appropriate use of chemical fertilizers

and weedicides including the use of protective clothing, proper use of the labelling as well as disposal of these chemicals after use.

ii. It is recommended also to the government of Ghana through the Ministry of Food and Agriculture and it agencies like the Crop Research Institute (CRI) to make adaptation strategies readily available to smallholder farmers. Training on new and improved technologies should be given prior to its usage. This will enhance the application of the technologies in to the main farming stream.

iii. The Savannah Accelerated Development Authority through it development partners should consider irrigation schemes as a major priority.

iv. I recommend also to Ministry of Food and Agriculture (MOFA) through its extension services to help trained smallholder farmers on the appropriate use of chemicals including the use of protective clothing, proper use of the labelling as well as disposal of these chemicals. Also knowledge on pre emergency and post emergency treatment should be made available to smallholder farmers.

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APPENDICES

APENDIX A: INTERVIEW GUIDE

SECTION A: BASIC CHARACTERISTICS OF RESPONDENTS

1. How old are you A. 18-25 [ ] B. 26-35 [ ] C. 36-45 [ ] D. 46-55 [ ] E. 56+
2. Sex male [ ] female [ ]
3. What is your level of education A. primary [ ] B. JHS [ ] C. SHS [ ] D. tertiary [ ] E. non [ ]
4. What crops do you grow A. maize [ ] B. yam [ ] E. others [ ]
5. Do you have access to any credit facility? Yes [ ] No [ ]
6. If yes, what is the source of the credit? Government [ ] Private [ ] N.G.O [ ]
7. Were you visited by an extension service officer last season? Yes [ ] No [ ]
8. If yes, how many visits? ……..

SECTION B: PERCEPTION OF TRENDS AND FLUCTUATIONS IN THE CLIMATE

1. How can you describe the nature of rainfall in the district?
   A. Stable [ ]
   B. Decreasing [ ]
   C. Erratic [ ]
2. In what way can you say that the rainfall is changing?
   A. Shifting farming season [ ]
   B. Increased temperatures [ ]
   C. Reducing rainfall amounts [ ]
   D. Increasing length and frequency of droughts [ ]
   E. Others……. [ ]

3. When did you start noticing changes in the current rainfall pattern?

   A. Two years ago [ ]

   B. Five years ago [ ]

   C. A decade ago [ ]

   D. Two decades ago [ ]

   E. More than two decades ago [ ]

4. What are the features that show that the climate is changing?

   A. Erratic and reducing rainfall amounts [ ]

   B. High temperatures [ ]

   C. Floods [ ]

   D. Droughts [ ]

   E. Others ……... [ ]

5. What are the specific signs of seasonal changes in the community?

   A. Movements of migratory birds [ ]

   B. Observation of certain trees and plants [ ]

   C. The direction of winds [ ]

   D. Others …….. [ ]

6. For each of the following climate parameters, indicate whether or not, it is less frequent (LF), frequent (FQ) and highly(HF) frequent

Climate Parameter	**LF**	**FQ**	**HF**
Erratic and rainfall			
High temperatures			
Floods			
Droughts			

7. What do you think are the causes of these climate fluctuations?

   A. Bush burning [ ]

   B. Natural phenomena [ ]

   C. Removal of tree cover [ ]

   D. The will of GOD [ ]

   E. Others…… [ ]

8. Do the causes that you have mentioned existed in the past? Yes [ ] No [ ]

9. Do you think the changes in the rainfall and temperature will be normalized very soon?

   Yes [ ] No [ ]

10. What are the main causes of drought in the district?

   A. Poor farming methods [ ]

   B. Bush burning [ ]

   C. Curses [ ]

   D. Application of chemical in farming [ ]

   E. Others……. [ ]

11. How often do you experience droughts in a season?

   A. Once [ ]

   B. Twice [ ]

   C. Thrice [ ]

   D. Others……. [ ]

12. What is the length or duration of the drought you normally experience?

   A. Three weeks [ ]

   B. Six weeks [ ]

   C. Two months [ ]

D. Three months [ ]

E. Others [ ]

13. Which of the following is the main cause of flood in the district?

A. Excessive rainfall [ ]

B. Lack of drainage basins [ ]

C. Low vegetation cover [ ]

D. Others……

14. What are some of the ways of determining the onset of rainfall?

A. Observation of clouds [ ]

B. Direction of winds [ ]

C. Radio announcements/radio forecast [ ]

D. Others **(SPECIFY)** ……..…….. [ ]

SECTION C: SMALLHOLDER FARMERS' ADAPTATION TO CLIMATE VARIABILITY

15. Which of the following ways does the variability in the climate affects you most?

A. Agriculture [ ]

B. Animal rearing [ ]

C. Shortage of water [ ]

D. Others (**SPECIFY**)……. [ ]

16. What measures do you adopt so as to deal with the effects of these climatic changes?

A. Changing planting time [ ]

B. Cultural practices [ ]

C. Effective use of weather prediction methods [ ]

D. Use of chemical fertilizers [ ]

E. Others **(SPECIFY)** …….[ ]

17. In what ways do these changes in the rainfall and temperature affect agriculture?

A. Reducing yields [ ]

B. Increasing yields [ ]

C. Not predictable [ ]

D. Don't know [ ]

E. Others **(SPECIFY)** …….[ ]

18. Which of the following strategies do you adopt in order to reduce the negative impacts of climate variability on agriculture?

A. Chemical fertilizer application [ ]

B. Organic manure [ ]

C. Pesticides/herbicides [ ]

D. Shifting cultivation [ ]

E. Integrated pest and disease management [ ]

F. Mulching [ ]

G. Ridging [ ]

H. Others **(SPECIFY)**……..

19. For each of the following conventional adaptation strategies, indicate whether or not the use of it has been highly satisfactory (HS), satisfactory (SA), indifferent (ID), unsatisfactory (US)

Strategy	**HS**	**SA**	**ID**	**US**
Improved metrological forecast				
Chemical fertilizers				
The use of early maturing crops				

Farm insurance				
Integrated pest and disease management				
Integrated soil fertility management				

20. For each of the following indigenous adaptation strategies, indicate whether or not the use of it has been highly satisfactory (HS), satisfactory (SA), indifferent (ID), unsatisfactory (US)

Strategy	**HS**	**SA**	**ID**	**US**
Crop rotation				
Mixed cropping				
Use of indigenous variety/drought tolerant crops				
Mulching				
Ridging				
fallowing				
Indigenous weather prediction				

21. For each of the following statement, indicate by ticking whether you strongly agree (SA), agree(A), indifferent(ID), disagree(DA) or strongly disagree(SD) with the following statements to adaptation to climate variability

Statement	**SA**	**A**	**ID**	**DA**	**SD**
22. I have decide not farm this year because I don't know exactly when the rain will not come					
23. I prefer indigenous adaptation strategies to conventional strategies					
24. Chemical fertilizers are very expensive but very effective for farming					
25. Climate variability affects maize and yam than other crops					
26. Indigenous strategies are more sustainable than conventional strategies					
27. Conventional strategies are effective than the indigenous strategies					
28. I don't easily understand most of the					

conventional strategies very well					
29. I have been using the conventional strategies alongside the indigenous strategies					
30. I use indigenous strategies only when I cannot afford to use conventional strategies					
31. Conventional strategies is the only answer to the changing climate					
32. I am not educated so I cannot use the conventional strategies very well					

33. How does the current spell of rainfall affect maize and yam

A. Reducing yield [ ]

B. Total crop failure [ ]

C. Affects the storage span of the crop [ ]

D. Increasing yield [ ]

E. Not predictable [ ]

F. Others **(SPECIFY)** ……[ ]

34. What are some of the ways of determining the onset of high temperature in the community?

A. Observation of plants [ ]

B. Drying of water bodies [ ]

C. Observing the texture of soil [ ]

D. Other **(SPECIFY)** …… [ ]

35. How do high temperatures positively affect the production of maize and yam?

A. Helps in the germination [ ]

B. Assist in sprouting of the crops [ ]

C. Helps in enlargement of plant [ ]

D. Other **(SPECIFY)** …….[ ]

36. What are the specific negative effects of high temperatures on maize and yam

A. Affects germination [ ]

B. Leads to poor development of crop [ ]

C. Causes wilting of plants [ ]

D. Others **(SPECIFY)** …… [ ]

37. Do you still use some of the past strategies? Yes [ ] No [ ]

38. For each of the following stages in the cultivation of maize and yam, mention the specific adaptation strategies you adopt in order to cope with the adverse impacts of the climate.

Crop	**Stage of cultivation**	**Strategies**
Maize	Pre-planting	
	Planting	
	Cultural practice	
	Harvesting and storage	
Yam	Pre-planting	
	Planting	
	Cultural practice	
	Harvesting and storage	

SECTION D: CLIMATE VARIABILITY AND THE NUMBER OF ADAPTATION STRATEGIES

39. What is the main climatic factor determining your choice of adopting a strategy?

A. Floods [ ]

B. Droughts [ ]

C. Temperature [ ]

D. Rainfall [ ]

40. What other factor determines your choice of adaptation?

41. For each of the following select the factors that the influences your choice of adapting a strategy from the most to least determinant factors using a scale 1-8 (1= highest and 8= lowest rank)

A. Finance	[ ]	1, 2, 3, 4, 5, 6, 7, 8,
B. Education	[ ]	1, 2, 3, 4, 5, 6, 7, 8,
C. Access to credit	[ ]	1, 2, 3, 4, 5, 6, 7, 8,
D. Extension services	[ ]	1, 2, 3, 4, 5, 6, 7, 8,
E. Technology	[ ]	1, 2, 3, 4, 5, 6, 7, 8,
F. Rainfall	[ ]	1, 2, 3, 4, 5, 6, 7, 8,
G. Temperature	[ ]	1, 2, 3, 4, 5, 6, 7, 8,
H. Drought	[ ]	1, 2, 3, 4, 5, 6, 7, 8,

SECTION E: LIMITATIONS OF ADAPTATION STRATEGIES IN MAIZE AND YAM

42. Do you have any challenge in the use of the conventional adaptation strategies?

Yes [ ] No [ ] **(Skip 45 if the answer is No)**

43. What specific challenges do face in the usage of the conventional adaptation strategies?

A. Difficult to apply technology used [ ]

B. Expensive to adopt [ ]

C. Destroys the land [ ]

D. Destroys indigenous varieties [ ]

E. Other **(SPECIFY)** …… [ ]

44. At which stage of the farming value chain do you think the conventional strategies affects you more?

A. Planting [ ]

B. During the life time of the plant [ ]

C. Maturity [ ]

D. Harvesting and storage [ ]

E. Other **(SPECIFY)** …….. [ ]

45. Rank the following challenges of adaptation in order of the one that affects mostly (AM), affect (AF), least affected (LA), no effect (NE)

Challenge of adaptation	**AM**	**AF**	**LA**	**NE**
Difficulty in understanding technology used				
Costly				
Cultural barriers				
Destroys the soil				
Other				

46. What are the challenges faced by the indigenous strategies?

A. Labour intensive [ ]

B. Not effective in dealing with the effects of climate variability [ ]

C. Low output of crops [ ]

D. Some of the strategies are being forgotten with time [ ]

E. Others……. [ ]

47. What areas of the conventional strategies will you recommend for improvement?

A. Technology used [ ]

B. Chemicals application [ ]

C. Chemical fertilizer [ ]

D. Cost of adoption [ ]

E. Others…….. [ ]

48. What areas of the indigenous strategies will recommend for improvement as well?

A. Technology use [ ]

B. Cultural practices [ ]

C. Crop rotation [ ]

D. Others……. [ ]

49. Which areas of the indigenous strategies will you recommend to be neglected?

A. Mixed cropping [ ]

B. Crop rotation [ ]

C. Ridging [ ]

D. Others…….. [ ]

50. Will you recommend for the adoption of both strategies? Yes [ ] No [ ]

51. What do you think is the best way of using both adaptation strategies?

APENDIX B: KEY INFORMANT/IN-DEPTH INTERVIWS

SMALLHOLDER FARMERS' PERCEPTION OF TRENDS AND FLUCTUATIONS IN THE CLIMATE

1. What is your observation about the nature of rainfall and temperature in the district?

……

2. Do you share the opinion that the rainfall is experiencing some change? Yes [ ] No [ ]

kindly explain if your answer is yes (SKIP TO 4 IF YOU ANSWERED NO)

……

3. How long have been experiencing these changes?

4. On a scale of 1-4 which of these variables of climate is more pronounced in the district?
   A. Erratic and reducing rainfall amounts [ ]
   B. High temperature [ ]
   C. Floods [ ]
   D. Droughts [ ]
5. What do you think are the causes of these fluctuations in rainfall and temperature?

   ……

   ……
6. Which of these causes is more pronounced and how does it affects you?

   ……
7. Do the causes that you have mentioned existed in the past in your own view and what was the nature?

   ……
8. What in your own view is the reason why rainfall and temperature variability is now very rampant?

   ……
9. Do you think the situation will be normalized very soon? Yes [ ] No [ ]
10. What do you think are the causes of drought and why do you think it is becoming frequent?
11. What do you think are the causes of floods?

SECTION B: SMALLHOLDER FARMERS' ADAPTATION TO CLIMATE VARIABILITY

12. How do smallholder farmers respond to these variations in climate?
13. What are the various steps you have been taking do you to avert impacts of these variations in climate on agriculture?
14. What are some of the strategies that were used in the past?
15. How does the strategies do influence the production of maize and yam?
16. Do you think the indigenous strategies can be used effectively today? Yes. [ ] No. [ ] Explain how

SECTION C: DETERMINANTS OF ADOPTION OF ADAPTATION STRATEGIES?

17. Mention some of the strategies you have been using in response to the varying climate?

    ……

18. For each of the following select the influencing factors of your choice of adaptation strategy using a scale 1-5 (1= most influencing factor and 5 = the least influencing factor),

    A. Finance [ ]

    B. Education [ ]

    C. Access to credit [ ]

    D. Extension services [ ]

    E. Technology [ ]

SECTION D: CHALENGES OF ADAPTATION STRATEGIES

19. Do you think the current strategies can be used alongside the strategies you used in the past? Yes [ ] No [ ] Explain you answer
20. What do you think are the weaknesses of the current strategies of adaptation?
21. Do you still use some of the indigenous strategies of adaptation? Yes [ ] No [ ]
22. What do you think is the best way to using both adaptation strategies?

APENDIX C: QUESTIONNAIRE FOR AGRIC EXTENTION AGENTS

1. How old have you been working in this community A. 2-5 [ ] B. 6-10 [ ] C. 10-15 [ ] D. 16-20 [ ] E. 20+
2. Category of organization A. government [ ] B. NGO [ ] C. CBO [ ] D. others…….
3. What is the name of your organization

1. What are the various forms of farmer perceptions on rainfall and temperature variability you have observed in the area?
2. Do you think these perceptions influence their choice of adaptation strategies? Yes [ ] No [ ] explain how

3. What are the various ways in which smallholder farmers usually attribute the causes of fluctuations in the rainfall and temperature to?
4. Do you think such attributions are justified? explain your answer

5. Do you think the perception of the smallholder farmers influences their choice of adaptation strategy? Yes [ ] No [ ] explain your answer
6. What is your assessment of the level of influence of these perceptions on your projects and programs in the community?

7. What are the adaptation strategies you have been implementing in the communities?

8. Indicate by using a scale from 1-7 the most used strategy by smallholder farmers in the communities

   A. Chemical fertilizers [ ]
   B. Organic fertilizers [ ]
   C. Weather/crop insurance [ ]
   D. Mixed cropping/farming [ ]
   E. Crop rotation [ ]
   F. Mixed cropping [ ]
   G. Other……

9. Do you think smallholder farmers are influenced by their past strategies in their choice of current adaptation practices? Yes [ ] No [ ] (skip 10 if your answer is no)

10. Explain why you think smallholder farmers are influenced by their past strategies?

11. What are some of the indigenous adaptation strategies you have observed in the community?

12. Do you think these indigenous strategies impacts positively on food crop production Yes [ ] No [ ] kindly explain your answer

13. What do you think is the major determinant of farmers' choice of adaptation?

14. For each of the following indicators, rank using a scale of 1-5 (1=highest rank and 5=lowest rank) the factors that determine the choice of adaptation of a smallholder farmer

A. Technology [ ]

B. Access to credit [ ]

C. Education [ ]

D. Income [ ]

E. Access to extension service [ ]

15. Does climate variability impacts directly on the choice of adaptation? Yes [ ] No [ ] explain your answer

16. How has been the level of response in general towards the acceptance to new technologies introduce by your outfit by smallholder farmers?

SECTION D: LIMITATION OF ADAPTATION STRATEGIES

17. What do you think are the main limitations of the adaptive choices by smallholder farmers?

18. Do you think indigenous strategies of adaptation are useful today? Explain your answer

19 In what ways do you think indigenous strategies can be made more useful in contemporary agricultural practices?

……

20 What do you think are the weaknesses of the conventional adaptation strategies?

……

21 What do you think can be done in order to merge these two strands of technology?

APENDIX D: FOCUS GROUP DISCUSSION (FGD) INSTRUMENT

(TO BE ADMINISTERED TO GROUPS OF SMALLHOLDER FARMERS)

1. What do you think about the current trends in weather and climate?

2. Can you mention the various forms climate affects agriculture?
3. How do you respond to these effects? (PROBE SPECIFIC STRATEGIES)
4. What make the conventional strategies (a) very easy (b) very difficult
5. What are some of the current strategies you have been adopting to ensure increases in maize and yam production?
6. How do the current strategies differ so much with those employed in the past?
7. What are the specific challenges you faces in the use of the conventional strategies? (PROBE FOR THESE STRATEGIES)
8. What about the indigenous strategies, do you still use them and what are they? (PROBE FOR STRATEGIES)
9. How does climate variability affect the various varieties of maize and yam you cultivate? Are they drought resistant/indigenous
10. Do you think it will be ideal to combine the past strategies with the current strategy?

END TIME ……/…….