UNIVERSITY FOR DEVELOPMENT STUDIES

FARMER ADAPTATION OPTIONS TO CLIMATE CHANGE IMPACTS IN THE KASSENA-NANKANA EAST MUNICIPALITY

MARY ANN ALUA

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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 FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY (MPHIL) IN ENVIRONMENT AND RESOURCE MANAGEMENT

FEBRUARY, 2017

DECLARATION

STUDENT:

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

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

Name: **MARY ANN ALUA**

SUPERVISORS:

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

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ABSTRACT

In a world faced with the problem of climate change, adaptation to climate change indeed helps farmers achieve maximum output while reducing the negative impacts of change. Adaptation therefore is the best choice for reducing vulnerability. The study aimed at assessing farmer adaptation options to climate change impacts in the Kassena-Nankana East Municipality. A mixed method approach was used in the study and data was gathered using interviews, focus group discussions, questionnaires and observation. It was revealed that adaptive measures such as manure application and dry season farming are helping farmers adapt to climate change in the Kassena- Nankana East Municipality and the impact of this adaptation is positive on the lives of farmers due to records of improvement in output. The existence of adaptation has been influenced by farmer initiative and driven by the impact of climate change on farming activities. The Ministry of Food and Agriculture and some Non-Governmental organizations operating in the Municipality also influence adaptation. This is done through farmer education on climate change and by helping farmers improve upon existing adaptive strategies. However, adaptation in the Municipality even though influenced by culture is also challenged greatly by culture. This is because culture has a great influence on farmer perception and willingness to adapt newer strategies that can help reduce negative impacts of climate change. Limited access to capital, failure of some measures and knowledge gap on adaptation are also factors that limit effective adaptation. The study concluded that benefits derived from adaptation are enormous in the Municipality and addressing limitations that make adaptation ineffective will go a long way to improve farmer livelihood.

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I am very grateful to my parents for the financial support. Most especially for funding this entire programme and study.

Many thanks to the chiefs of various communities involved in the study for allowing me carry out my research in their communities. The leaders of various farmer groups cannot be forgotten for their immense contribution in mobilizing farmers for this study.

I am also grateful to farmers for their active participation. To all friends that supported this research in one way or the other, May the Almighty Lord bless us all.

DEDICATION

I dedicate this work to my family especially my parents.

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LIST OF ABBREVIATIONS

ACDEP	Association of Church based Developmental Project
CARE	Co-operative for Assistance and Relief Everywhere
CENSODEV	Centre for Social Mobilization and Sustainable Development
FGD	Focus group Discussion
F.A.O	Food and Agriculture Organization
GDP	Gross Domestic Product
GAWU	General Agricultural Workers Union
GoG	Government of Ghana
GSS	Ghana Statistical Survey
GLCA	Global Leadership for Climate Action
IDS	Institute for Development Studies
IFOAM	International Federation of Organic Agriculture Movements
IPCC	Intergovernmental Panel on Climate Change
KNEMA	Kassena-Nankana East Municipal Assembly
MoFA	Ministry of Food and Agriculture
ORGIIS-	Organization for Indigenous Initiatives and Sustainability
USAID	United States Agency for International Development

UNECA	United Nations Economic Commission for Africa
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER ONE

INTRODUCTION

1.1 Background

Climate change has both negative and positive impacts worldwide. Peoples' understanding with regards to climate change helps them plan as well as adapt to the changing trends of the climate as risks are minimized while societies and individuals benefit from the advantages associated with the change (USAID, 2007). The study adopts the definition of climate change put forward by the United Nations Framework Convention on Climate Change, "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate vulnerability observed over comparable time periods".

Other adopted definitions relate to adaptation which is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates, harms or exploits beneficial opportunities (IPCC, 2001); another, is an adopted definition related to resilience which is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function structure, identity, and feedbacks (Walker, 2004). For the purpose of this study, vulnerability is defined as the "degree to which a unit is susceptible to harm due to exposure to a perturbation or stress, and the ability of the exposure unit to cope, recover or fundamentally adapt" (Selvaraju et al., 2006:6). While "A livelihood comprises

the capabilities, assets (stores, resources, claims and access) and activities required for a means of living" (Chambers and Conway, 1992:7 cited in Antwi-Agyei, 2012:9).

Compared to people living in developed nations, the poor in developing countries are more vulnerable to the impacts of climate change than (USAID, 2007). The hostile effects of climate change are already evident in developing countries. This worsens families' vulnerability to impact given that, most countries are characterised with high population growth, lack of food security, and other socio-economic factors. This situation also gets worse leading to continued encroachment as farm lands are expanded to occupy forest lands (Bishaw et.al, 2013). This therefore, depicts that adaptations to climate change in agriculture is challenging in developing countries, though extremely important (Mertz et al., 2009 cited in Olesen et al., 2013).

The impacts of climate change are particularly severe in Africa most especially in countries where on-going conflicts, poverty, and worsening environmental degradation weakens the strength of communities and institutions to cope with this change. The additional hardships this change brings might lead to the loss of livelihoods which in effect delays economic growth; this worsens conflict drivers, prolongs conflict and obstructs the ability to recover from the effects of conflict. However, if this climate change is addressed as a universal problem which affects the entire globe, perhaps solutions can be identified to cope with

this change within countries, at the regional level and also internationally (Youngblut, 2010).

The ability of the agricultural system to cope with the changes accompanied by climate change is solely based on its adaptive capacity. Indeed, 'adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences' (IPCC, 2001 cited in Gbetibouo, 2009:1). This means, the adaptive capacity of a system or society is determined by the ability of that system to alter its characteristics to suit one that can cope with the changes in external conditions (Gbetibouo, 2009).

Agriculture yield in African countries is threatened due to climate change and variability (Parry et al., 2007 cited in UNECA, 2011); this is the more reason why addressing climate change especially the negative impacts associated with it tends to be urgent in Africa (Boko et al, 2007 cited in Ziervogel et al., 2008). Nyong (2005 cited in Mabe et al., 2012) identified that, the limited capacity to adapt to change tends to be the reason why farmers in Sub-Saharan African countries tend to be highly vulnerable to climate change.

Several studies have been carried out in Africa with respect to farmer's knowledge and understanding of climate change and existing measures and

strategies to cope with this change (Macharia et al., 2012; Mtambanengwe et al., 2012; Henny et al., 2011; Moyo et al., 2012; Ouedraogo et.,al 2010 cited in Sarr et al., 2015), however, these studies have not been extended extensively to suit the conditions in West Africa nor have they been applied yet by extension practitioners (Mertz et al., 2011 cited in Sarr et al., 2015).

In Ghana, climate change tends to pose a danger to agriculture which is the backbone of the economy contributing over 40% of GDP and provides the main source of livelihood for about 60% of the labour force (IFAD, 2006 cited in Penaranda et al., 2012). Agriculture is largely rainfed in Ghana and production tends to be highly sensitive to drought. Recent reduction in yield and poor performance of the sector has been linked to incidence of drought (Ministry of Food and Agriculture, 2007 cited in Antwi-Agyei et al., 2012).

The dangers of climate change affects all regions in Ghana however, some regions are worse hit by the change than others. Due to the physical and economic vulnerability of the northern part of Ghana, households in the various regions may face more devastating effects from the change as will the southern part of the country. The northern part of Ghana is characterized with a longer dry season and a shorter rainy season with average rainfall of about 1,000 mm as it is located within the Savannah region with little lucrative livelihood activities such as petty trading **(**Yaro, 2010 cited in Nkegbe and Kuunibe, 2014).

It is therefore important to note that collaboration amongst stakeholders is needed to help find measures and strategies that will help societies adapt to climate change and also promote food security. The rural people will only cope with the impacts of these changes and the threat it poses to food security if only their resilience to change are strengthened (Yaro, 2013). Strengthening resilience should be enhanced in the Kassena-Nankana East Municipality as 'limits to climate adaptation are endogenous and absolute and therefore unsurpassable' (Hulme et al., 2007; Dow et al., 2013 cited in Antwi-Agyei et al., 2013:10). Even though, Fosu-Mensah et al., (2010) identified crop diversification and changing planting dates for crop plants as the two common adaptation strategies used by farmers, effective implementation of adaptive measures have been hindered by entrenched belief systems (Okonyo et al., 2013).

The perceptions people have on climate change are important for adaptation as these ideas influence decisions involved with agricultural planning and management. It is however worth noting that, these perceptions on climate change are highly influenced by the economic and social impact that these changes have on the lives of individuals (Slegers, 2008 cited in Moyo, 2012). However, there seems to be limited knowledge with respect to the impacts associated with climate change, vulnerability and the various necessary adaptive measures to reduce the level of damage this change brings to bear (UNFCCC, 2007; Seitz and Nyangena, 2009 cited in Bagamba et al., 2012).

Knowledge on farmer perception on climate change and their respective coping strategies to the impacts of these changes are limited. Models cannot be used to project or estimate the ideas of the local population hence the current influence of climate change on the lives of people needs to be recorded and documented periodically (Okanyo et al., 2013). Farmer perception on climate change varies globally as proven by several studies and these varied ideas have influenced the perceptions associated with adaptation to climate change (Mapony and Mpandeli, 2013).

1.2 Problem Statement

This study tends to investigate reasons for limited adaptation to climate change among farmers in the Kassena-Nankana East Municipality. Studies reveal that farmer coping strategies to climate change is ineffective (Apwah, 2014; Atanga, 2014). This creates a lot of hardship for majority of the population who greatest occupation is farming. Also, research has shown that farmers perception and reaction to climate change influence adaptation (Fosu Mensah et al., 2010). Adaptation varies from location to location based on farmer perception; whiles some people associate change in climate to spiritual happenings others associate it to natural phenomenon (Apata et al., 2009; SPORE, 2008; BNRCC 2008 cited in Ayanwuyin et al., 2010). The limited adaptation to climate change in the Kassena-Nankana East Municipality could be as a result of farmers' limited understanding on the concept of climate change or perhaps farmers are unaware that, their perception about climate change influences their activities. This is because despite the existence of some adaptive measures like change in planting date and crop diversification in Ghana as mentioned by Fosu-Mensah et al.(2010) farmer adaptation in the

Kassena-Nankana Municipality is still limited. Long term sustainable agriculture tends to face a major setback in most developing countries such as Ghana due to the knowledge gap associated with climate change and its impact on both agricultural and non-agricultural production (Kotei et al., 2001 cited in Kemausuor, 2011). Adaptation to climate change in the Kassena-Nankana East Municipality is no different as farmer perception play a role in adapting to climate change. The type and success of coping strategies depend on how climate change is perceived by farmers in the Municipality. Hence the study tends to identify how farmers perceive climate change and the impact of this perception on limited adaptation to climate change.

1.3 Research Question

1.3.1 Main Research Question

The main research question is: how are measures employed in response to the negative impacts of climate change in the municipality helping farmers adapt to climate change?

1.3.2 Sub-Research Questions

The above main research question would be answered by finding answers to the following sub-questions;

- How is the concept of climate change understood amongst famers in the Kassena-Nankana East Municipality?
- How does climate change affect the activities of farmers?
- How are existing strategies affecting farmer adaptation?
- How do cultural practices influence adaptation?

1.4 Objectives of the Study

1.4.1 Main Objective

The main objective of the research is to investigate how farmers are adapting to climate change in the Municipality.

1.4.2 Sub - Objectives

This main objective will be achieved by assessing issues related to adaptation through the following sub-objectives:

- Assess farmers understanding on the concept of climate change in the Municipality.
- Examine how climate change affects the activities of farmers.
- Identify the successes of existing strategies on adaptation and their possible impact on policy.
- Examine the extent to which cultural practices influence farmer adaptation.

1.5 Framework for Adaptation

Analysis by Smithers and Smit (1997) revealed that climate change adaptation is made up of interactive facets. Based on a framework designed by Smit (1993), theses facets broadly include: climate disturbance, system characteristics and adaptive responses. Characteristics of the climatic disturbance influence the ability of a system to adapt to climatic disturbances. The amount of a change and the range of the change have implication for adaptation. Characteristics of the climatic disturbance shown in Figure 1.1 interact with the characteristic of a system to determine whether a particular system can adapt to climate change.

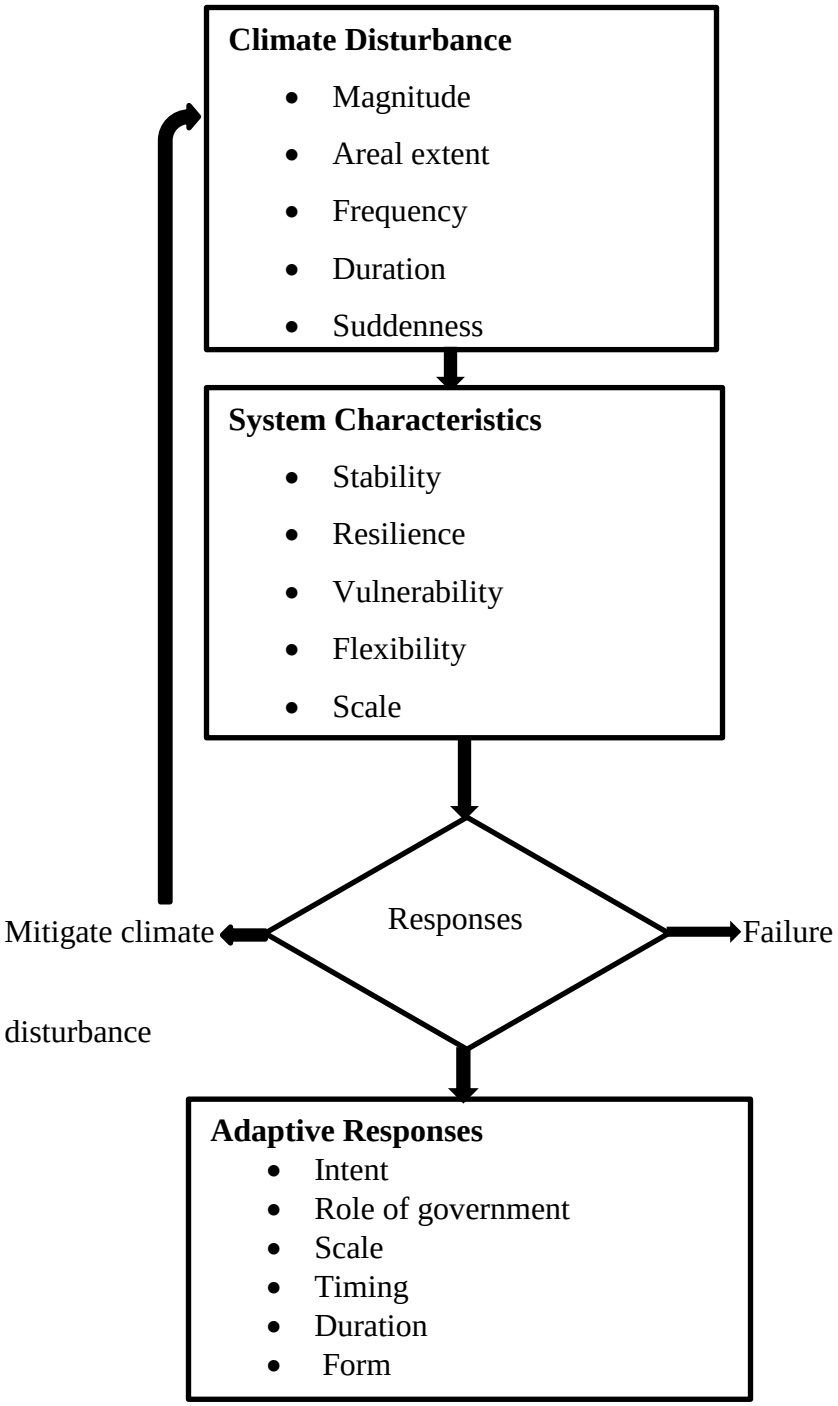

Fig 1.1 Framework for Adaptation

Source: Adopted from Smit (1993) cited in Smithers and Smit (1997)

For instance, a high magnitude of change and the impact it has on a system is endurable when the system is less vulnerable (Smithers and Smit, 1997). Where vulnerability according to Timmerman (1992 cited in Smithers and

Smit, 1997: 138) refers to 'the degree to which a system or "exposure unit" may be adversely affected by a hazardous event.'

The interaction between the characteristics from the first two facts influences the third facet (adaptive responses). That is whether adaptation will be autonomous, planned; at farmer level or government initiated (Smithers and Smit, 1997). Such that, for example, an interaction between a climatic disturbances with a large area extend on a system with weaker resilience influences adaptive response which might include the involvement of government to help build and strengthen resilience to help the system cope with the impact of change. It is worth noting that some responses in the system lead to the collapse or failure of some activities (Smithers and Smit, 1997).

Building on the framework of Smithers and Smit (1997) and other models used to explain adaptation, Tarleton and Ramsey (2008) explains farmer adaptation to climate change using the framework of farm-level adaptation to risk influences. According to the framework shown in Figure 1.2 social-cultural, political-economic, environmental and technological influences have impacts on climate change risks. Socio- cultural influence, for instance, identified include general history, education and demography of a farmer population or community while political-economic influences are manifested in input cost, commodity prices, mortgage and lending rates. Also, environmental influences including crop disease, depletion of soil quality and quantity coupled with climate change affects climate risks.

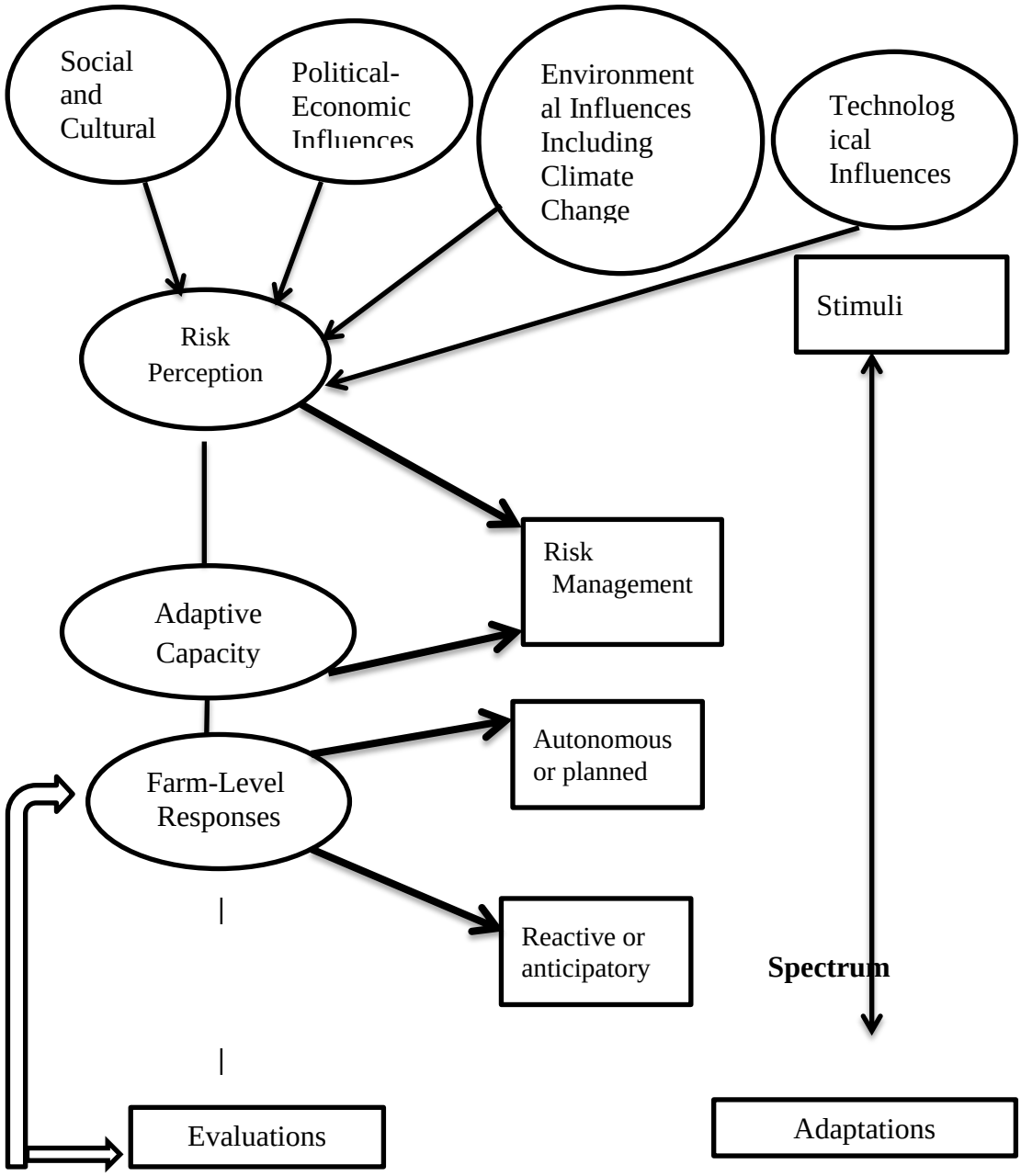

Fig. 1.2 Framework of Farm-level Adaptation to Risk Influences

Source: Adopted and modified from Tarleton and Ramsey (2008)

Technological influence such as availability of crop variety also has implication for climate risk (Tarleton and Ramsey, 2008). The impacts of these factors acting together or individually have implication on one's perception

about risk. Based on this influence, farmers then identify whether a happening is a treat or not. This perceived risk, however, can be managed by farmers dependent on their adaptive capacity as "forces that influence the ability of the system to adapt is the drivers or determinants of adaptive capacity" (Adger, 2003; Turton, 1999; Walker et al., 2002; Wilbanks and Kates, 1999; Blaikie et al., 1994; Kasperson and Kasperson, 2001 cited in Smit and Wandel, 2006:287).

Dependent on the stimuli, farmer identification of the risk (as to whether the stimuli is negative or positive), farmer skills and available resources determine the adaptive response a farmer will choose to address the risk which can be autonomous/planned or anticipatory/reactive. This choice is, however, part of an integrated risk management. Farmers then evaluate the successes of responses based on the influences of factors such as social, environmental, technological and political which initiated the adaptation in the first place (Tarleton and Ramsey, 2008).

Based on the influence of the frameworks in Figure 1 and 2 a framework for farmer adaptation has been designed and presented in Figure 3 for the study. In this framework, climate change and its disturbances, have negative outcomes on farmers and agricultural systems based on the characteristics of the agricultural system. Farmer perception on influences, then leads to farmers' decision to adopt strategies that will result in positive outcomes of reducing the negative impacts of climate change on farming activities. The choice of an adaptive measure however can either be autonomous or planned as well as

reactive or anticipatory. Also, during the process of adaptation, farmer activities such as cutting trees for farm space or emission of methane from manure preparation (rotting of leaves) releases methane into the atmosphere which also contributes to the climate change problem as a result of the interrelated relationship between climate change and agriculture.

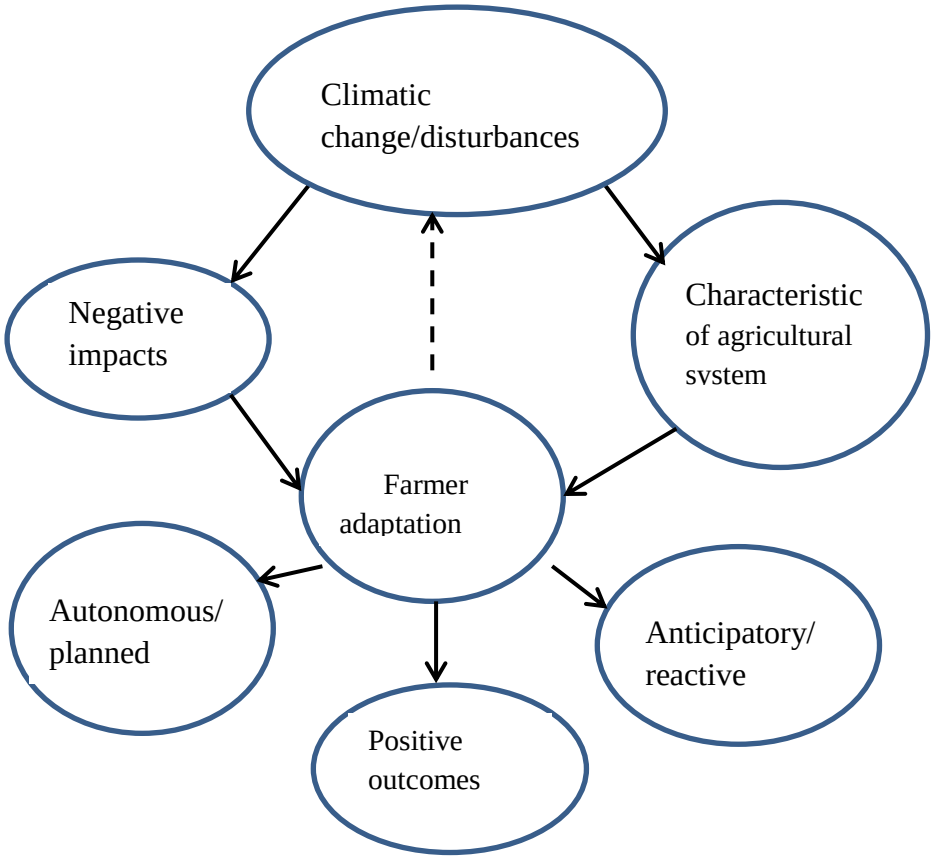

Fig 1.3 Framework for Farmer Adaptation to Climate Change

Source: Adopted and modified from Tarleton and Ramsey (2008); Smit, (1993) cited in Smithers and Smit, (1997)

1.5.1 Relevance of the Framework to the Study

The framework is of relevance to the study because farmers and the agricultural system in the Kassena-Nankana East Municipality is affected by climatic disturbances and the characteristics of the agricultural system of the Municipality ultimately influence the adaptive responses to climate

disturbances. This therefore influences farmer choice of an adaptive strategy that will help reduce the influence of climate change on farming activities. The northern part of Ghana suffers most from the devastating influence of climate change due to high level of vulnerability (Akudugu and Alhassan, 2012**)**.

Kassena-Nankana East Municipal is part of these vulnerable regions and as such farmers, faced with a range of factors (social, environmental, technological and political) influencing farmer activities in the Municipality and farmer risk perception on climatic stimulus. It is therefore important to note that the interaction of these factors on farmer activities will determine whether farmers will identify climate change and its impacts as either negative or positive and as such will also influence their decision to adapt to this change.

The vulnerable state of farmers in the study area, skills of farmers and available resources, influence their adaptive capacity which also has implications on farmer choice of adaptive strategies and measures that best address these negative impacts. This perception will also influence the type of adaptive measure farmers will employ to address climate change issues. This, however, is highly determined on farmer perception about climate change since efforts made either toward change and the impacts of this change on agricultural activities will only happen if farmers even acknowledge the existence of climate change and whether their perception even identifies this change as a threat to their livelihood.

1.6 Ethical Consideration

Before data was collected, community entries in various communities were carried out. Farmer participation in the study was based on their free will. The consent of farmers was also obtained during the focus group discussions before views were recorded. The consent of institutions involved in the study was also obtained before interviews were conducted. Plates obtained from the field and used in the study were also taken with permission from concerned parties. Anonymity and confidentiality of respondents was also held to the highest esteem. Information from secondary sources was also duly acknowledged.

1.7 Scope of the Study

The study identified farmer perception on climate change and the impacts of climate change on farming activities and the lives of farmers in the Kassena-Nankana East Municipality. It further looked at the various coping strategies employed by farmers to cope with the change so as to avoid the harsh impacts that come with climate change, as well as the various limitations that hinder coping strategies. The target group are farmers as well as organizations and institutions such as the Municipal office of the Ministry of Food and Agriculture, the Municipal Meteorological weather station, and some Non-Governmental Organizations in the Municipality who provide support to farmers to help them cope with changes, improve upon existing measures as well as develop indigenous ideas on adaptation.

This study was conducted in four farming communities, one each from the Area Councils. The time frame for this study covers thirty year period, which is, from 1985 to 2015 .This helped acquire data on the variation in climatic

elements as well as ideas from farmers based on their experiences over the years. The state and performance of output over the years was also assessed to establish the state and impact of climate change on the Municipality. Information on climatic elements (rainfall, temperature and sunshine) also helped in understanding the trend of change. This includes records on rainfall pattern and temperature for 32 years on the Municipality. This helped establish the changing trend in climatic elements and the impacts of these changes on the society. The study also tried to identify adaptive measures put in place to cope with these changes over these years till date and the successes of these strategies.

The duration used for the study covered 2 years. Within the two year period, four (4) months was used to collect data that is from 1st October - 10th January, 2015. During this period efforts were made to achieve set objectives with respect to farmer adaptation to climate change in the Kassena-Nankana East Municipality. The breakdown of activities and time frame are represented in the Table 1.1.

Table 1.1 Research Plan

Activities	Duration of the study
Phase: 1 Research Proposal Preliminary Identification of Various Groups and Roles	1st June – 31st July, 2015
Field Phase 2: Preliminary Assessment/Sampling: Sampling Farmers/Respondents Review of Literature Primary and Secondary Data collection	1st August - 30th September, 2015
Phase 3: In-Depth Study Semi-Structured Interview Administer Questionnaire, Focus group discussions	1st October, 2015 – 10th January, 2016
Phase: 4 Field Analysis Data Assessment/ Reviewing and Analysis Presentation of Drafting Thesis	23rd January - 30th February , 2016 4th April, 2016
Phase: 5 Presentation of Final Work to Faculty/Graduate School	30th June, 2016

1.8 Study Area

This focuses on the background information on Kassena-Nankana East Municipal. This includes the physical characteristics (location and size, geology and soils, the relief and drainage and climate and vegetation) of the Municipality. It also talks about the population characteristics, administrative structure, social infrastructure and conditions of the physical environment.

Kassena-Nankana East Municipal was created by legislative instrument 1855 of 2008 and became a Municipal Assembly by Legislative instrument (L.I) 2106 in 2012 with its capital at Navrongo (Ghana Districts, 2015). It is divided into six area councils namely: Navrongo Urban Council, Manyoro, Kologo, Naaga, Pungu and Doba Area. (GSS, 2014).

1.8.1 Physical Characteristics

1.8.1.1 Location and Size

Kassena-Nankana East Municipal lies within the Guinea Savannah woodlands. The Municipal area lies approximately between latitude 11°10’ and 10°3’ North and longitude 10°1’ West. It shares boundaries with Kassena-Nankana West to the north, Bolgatanga Municipal to the east, Builsa and Kassena-Nankana West Districts to the west and to the south, the West Mamprusi District of the Northern region (Ghana Districts, 2015). Figure 1.3 is a map of the Kassena-Nankana East Municipality which shows the location and boundaries of the study area and its surrounding neighbouring districts.

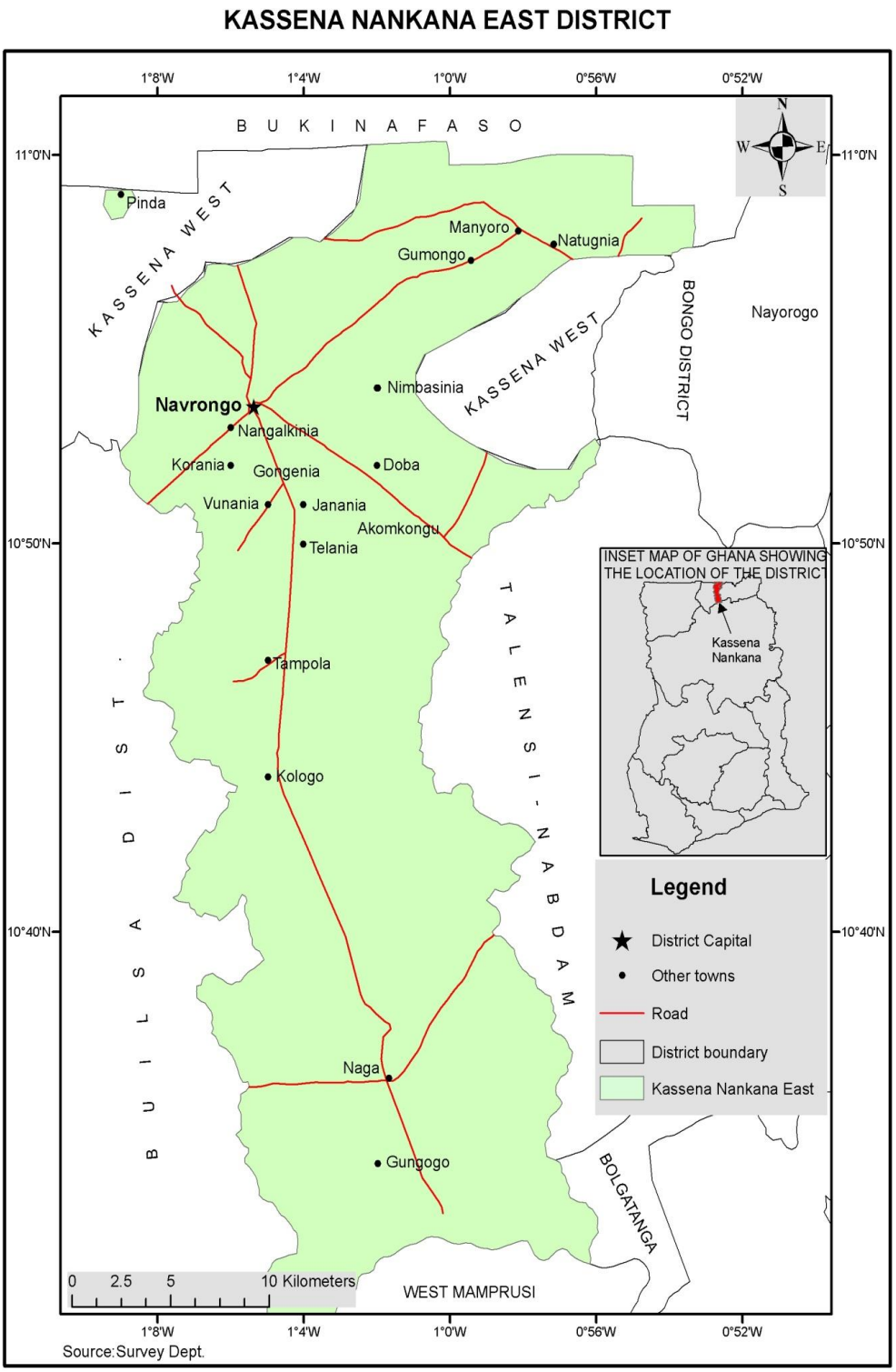

Figure 1.4 Map of Kassena-Nankana East Municipality

Source: Map Library, Department of Geography and Resource Development

1.8.1.2 Geological and Soil

There are two main types of soils present in the Municipality (ochrosols and groundwater laterite). The northern and eastern parts of the Municipality are covered by the savannah ochrosols, with the rest of the Municipality covered by the groundwater laterite. The savannah ochrosols are porous, well drained, loamy, and mildly acidic and interspersed with patches of black or dark-grey clay soils. Due to the rich nature of this soil type, it is suitable for cultivation and hence accounts for the arable land sites. The groundwater laterites are developed mainly over shale and granite. Due to the underlying rock type (granite), the groundwater laterite soil become waterlogged during the rainy season and dry out during the dry season, thus causing cemented layers of iron-stone (hard pan), which makes it hard to work with (MoFA, 2015).

1.8.1.3 Relief and Drainage

The Municipality is generally low-lying. The landscape is generally undulating with isolated hills rising up to about 300 metres above sea level in the western parts of the Municipality. Notably among the hills are Fie (280 metres), Busono (350 metres) and Zambao (360 metres). The drainage system of the Municipality is constituted mainly around the tributaries of the Sissili River – Asibelika, Afumbeli, Bukpegi and Beeyi. A tributary of the Asibelika River (Tono River) has been dammed to provide irrigation facilities (GSS, 2014).

1.8.1.4 Climate and Vegetation

The climatic conditions of the Municipality are characterized by the dry and wet seasons, which are influenced mainly by two (2) air masses – the North-East Trade winds and the South-Westerlies (Tropical Maritime). The Harmattan air mass (North-East Trade Winds) is usually dry and

dusty. During this period, relative humidity, rarely exceeds 20% and vapour pressure is low lesser than 10mb. Day temperatures are high recording 42° Celsius (especially February and March) and night temperatures are as low as 18° Celsius. The bearer of rainfall in the Municipality is the tropical maritime air mass which occurs between May and October. This brings rainfall averaging 950mm per annum.

The vegetation in the Municipality is the Guinea Savannah woodlands type; comprising open savannah with fire-swept grassland and deciduous trees. Densely vegetated parts of the Municipality are found along river basins and forest reserves. Examples are the Sissili and Asibelika basins, Kologo and Naaga forest reserves. The vegetation type is conducive for animal rearing especially small ruminants and poultry. Economic trees found are dawadawa, baobab, sheanut and mangos (GSS, 2014).

1.8.2 Population

The total population of the Municipality is 109,944. A greater percentage of this population is dominated by females while males constitute a lower percentage with records 51.2% (56,268) and 48.8% (53,676) respectively. Between the ages of 0-24 the male population outnumber the females. The males constitute 31% as compared to 29% for females. However, at the adult level, that is, between ages 25-99 females constitute the highest percentage 22% while the male population constitute 16.8%. The sex ratio: 95.4 represent the number of males to 100 females in the Municipality (GSS, 2014).

This indicates that, the Municipality has a young population as the figures from the 2010 population census show higher percentages for the youth as compared to that of adults. The age-dependency ratio (84.0) for the Municipality implies that 'for every 10 persons within the working age bracket 15-64, have about 8 persons within the dependent population, (0-14 and 65 and above) to cater for' (GSS, 2014: 18). This therefore, portrays a low standard of living for the population of the Municipality.

1.8.3 Administrative Structure

Aside the Municipal Chief Executive (MCE) and a Member of Parliament (MP), the Municipality is made up of a Municipal General Assembly which comprises 49 members, 35 elected and 14 appointed. It has a decentralized system of governance as the executive committee operates through sub-committees that are statutory or instituted by the assembly itself. These committees include: the social services, justice and security, finance and administrative, women and children, works, economic and development planning, climate, environment and agriculture, medium and small scale enterprise and public compliant committees.

There are also other departments that help the Municipal Assembly to achieve the overall development in the Municipality. These decentralized departments include: the Central Administration, Works Department, Physical Planning Department, Department of Trade and Industry, Ministry of Food and Agriculture, Social Welfare and Community Development, Finance Department, Department of Education Youth and Sports, Department of

Forestry, Game and Wild Life, Disaster Prevention and Management, Feeder Roads Department, Births and Deaths Registry Department and Information Services Department (GSS, 2014).

1.8.4 Social Infrastructure

The Municipality has a fair share in the distribution of schools in the country to help reduce the state of illiteracy in the country. For the primary level, there are 71 public and 15 private schools, 71 Pre-school and, three private and 48 public Junior High Schools. Also, there are five Senior High Schools, one Vocation Training Institute, a Teacher Training College of Education, a Community Nursing School, and campus of the University for Development Studies, Faculty of Applied Sciences, Navrongo.

Also, with reference to health facilities, there is a Municipal hospital; War Memorial Hospital located in the Municipal capital (Navrongo), two Health Centres, 17 functional Community Health Improvement Services compounds, a Health Research Centre, a Private Clinic and a Health post by the Catholic Mission (KNEMA, 2014). In the context of banking, there is a rural bank (Nara rural Bank), the Ghana Commercial Bank (rebranded GCB limited) and the Agriculture Development Bank.

The water and sanitation progress in the Municipality can be said to have an average record. The total population with access to safe drinking (pipe borne and borehole) water constitute 58%. The supply of water in the municipality is

from Navrongo with water pumping stations located at Navrongo town Centre, Doba and St John Bosco College of Education. There are also, a number of hand dug-out wells, which are not covered and dry up during the long dry season as well as dams (the largest is the Tono Irrigation Dam). The dependence on these water sources by some people due to inadequate water supply causes health issues among the population. However, there are three water system construction works on going in Kologo, Biu and Pungu to help improve the situation. More boreholes are also being drilled by the assembly from government allocated funds (KNEMA, 2013).

There also exist all forms of road networks with a major one linking Navrongo to Paga through to the road leading to Accra. Aside the State Transport Company (STC) and Metro Mass Ghana, there are other private transport companies who provide both long and short distance travel services to the people of the Municipality. An air strip located along Paga and Navrongo also provides space for landing helicopters. A postal office located in Navrongo also makes it possible for people to post letters and parcels. Telephones booths are also made available to serve the public aside the use of mobile phones most especially by the affluent in the Municipality. Also, there is a community radio station (Nabina F.M) and another by the University for Development Studies Navrongo Campus which provides information as well as entertainment to the people of Municipality and its environs (Ghana Districts,2015) .

1.8.5 Conditions of the Physical Environment

The presence of the savannah ochrosols which is fertile provides good grounds for the cultivation of food crops to feed families in the Municipality. Also, these fertile lands are also the grounds upon which the Tono irrigation lands are located which supports both dry and rainy season farming providing all year round availability of crops (rice and vegetables). However the groundwater laterite which covers a larger portion of the Municipality poses problems to agriculture since the population with access to such lands has difficulties tilling these lands and as a result get low yield.

Further, the South-Westerlies (Tropical Maritime) the bearer of rains provides water for cultivation during the rainy season. On the other hand, the North-East Trade winds characterized by dry dusty winds and high temperature poses threats to the population as high temperature associated to these winds affect the health of the population. The vegetation found in the Municipality provides fodder for the rearing of animals which supplement the diet of the population and its environs. Also rivers located in the Municipality are of great importance in making the lives of the population comfortable. An example is the Asibelika River (Tono River) which has been dammed to provide water for both irrigation and fishing. It is however important to establish the fact that both natural and human activities are affecting the state and services of the various components of the physical environment.

1.9 Significance of the Study

The current target of most developmental policies from national to district levels have inclusive measures to address the problems associated with climate change so as to reduce the effects it has on national development. These limitations however, vary from location to location and for that matter, need to be identified and understood so as to help find solutions that will best address them. This enables farmers to reduce risk while exploiting advantages associated with climate change. This research would investigate the factors that limit farmer adaptation to climate change in the Kassena-Nankana East Municipality irrespective of the fact that programs have been put in place to educate and help minimize the negative impacts of climate change. The study also contributes to studies on farmer adaptation carried out in the study area hence a contribution to knowledge.

1.10 Research Challenges/ Mitigated Measures

The challenges to this study basically were related to data collection. Having access to farmer groups with both sexes was the greatest limitation since most farmer groups were single sex. Also, getting access to farmers for questionnaire administration and especially focus group discussions was difficult. This was because some farmers were busy winnowing and bagging their produce while others were also working on their dry season farms and gardens. However series of visits and meetings were organized consistently till goals were achieved.

Also, access to personnel from institutions involved in the study for interviewing was quite difficult. This is due to the busy nature of the work of

most of these personnel. This was however, made possible by consistent schedule of meetings and follow ups till all officials and personnel were interviewed and required information acquired.

1.11 Organization of Thesis

The research is organized in five (5) chapters. Chapter one (1) gives a general introduction to the study, the problem statement, research questions and objectives. It also looks at the conceptual framework of the study, scope of the study, a profile of the area of study, justification of the study, challenges of the research and the organization of the study.

Chapter Two (2) centres on reviewed literature on the subject matter of the study. This includes an overview of climate change, its impact on agriculture and how adaptation creates opportunities for farmers to better survive under climate change. It further looks at various adaptive measures employed by farmers across the world from global to the local length.

Chapter Three (3) deals with the research methodology employed in the study to achieve goals. This centres on the research design chosen for the study, the population and the procedure involved in acquiring the sample size representative of the population. It further looks at the sampling procedure, sources of data and the method of data collections as well as the techniques involved in analysing data.

Chapter four (4) presents details of the research findings and discussions. The findings are discussed to reflect the major issues and outcomes centred on the study. Figures, tables and pictures are used to illustrate and present findings clearly with the use of secondary data to support these outcomes.

Chapter Five (5) presents a summary of the findings, conclusion and recommendations from the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Chapter two focuses on literature reviewed on the impacts of climate change as well as farmer adaptation to these changes. This includes information from books, journals, articles and thesis works that have been conducted on climate change and adaptation. Randolph (2009) identified that this part of a study is very crucial to a student or writer since it helps broaden the students' knowledge on the area of interest as well as exposes the student to varied ideas concerning the topic. This chapter therefore centres on series of studies and findings related to climate change and adaptation.

2.2 Overview of Climate Change

There are varied scholarly views on the definition of climate change however, "Climate change is defined as a significant shift in the average weather condition of an area especially in temperature and precipitation" (MacIver, 1998 cited in Nakuja et al., 2012:298). According to IPCC (2001) the scale of warming (1976 to 1999) has been almost global. Increases in temperature, however, are associated with the mid- and high latitudes of the continents in the Northern Hemisphere. While year-round cooling is evident in the north western North Atlantic and the central North Pacific Oceans, the North Atlantic tends to experience a reversal from its normal cooling state (IPCC, 2001).

The goal of addressing poverty and achieving the Millennium Development Goals (MDGs) as identified by the Institute of Development Studies (2006) tends to be threatened by climate change and the impacts that come with it. Climate change tends to worsen existing stress in the world most especially in poorer nations which are likely to be hardly hit by the impacts even though they contribute least to the problem of climate change.

According to IPCC (2001a cited in Selvaraju et al., 2006) there are projections of an increase in the average surface temperature of the earth of about 1.4-5.8° C. These projections further report an increase in a mean sea level rise of between 9-88 centimetres based on global climate change scenarios between the years 1990 and 2100. Incidence of a continued rise in temperature that is one very likely to be greater than temperature rises observed in the 20th century, events of heavy precipitation, increase heat wave, rising sea level and decrease of rainfall in sub-tropical areas, are the main future projected happenings associated to climate change (IPCC, 2007). According to Raworth (2008 cited in IFAD, 2010) there is the possibility that climate change will affect inequalities between men and women. In the view of IPCC (2007 cited in Etwire et al., 2013:121) "Africa is expected to experience the highest levels of warming with some countries, Ghana inclusive, also experiencing decline in rainfall".

Climate change scenarios have been recorded in Ghana over the years. There has been a 1°C increase in mean temperature experienced annually per decade and a decrease in rainfall of about 2.4 percent since 1960 (GoG, 2011;

McSweeney et al., 2012 cited in De Pinto et al., 2012). Studies show that "in 2006, the mean base year temperature ranged from 26.4°C (Forest) to 28.6°C (Sudan Savannah) with a possible mean temperature change from 0.6°C, 2.0°C and 4.0°C for 2020, 2050 and 2080 respectively. The Environmental Protection Agency had also estimated that the rate of change in total rainfall in the various ecological zones will decrease from 1.1% to 20.5% for 2020 to 2080 and this will reduce agricultural productivity, especially yields in root and tuber crops by about 40% by 2080" (EPA, 2007 cited in Tetteh et al., 2014:80).

2.2.1 Causes of Climate Change

In the view of Crosson (1997 cited in Onyeneke and Madukwe, 2010) existing scientific finding agrees that global climate change in various regions is occurring due to the accumulation of heat trapped by greenhouse gases in the atmosphere. According to the Royal Society and National Academy of science (2014), consistency with scientific findings reveal that, observed warming trends of the tropospheric and stratospheric cooling over the past 30 to 40 years are equated to the activities of man. This is because the activities of man are considered the broad contributor to the emission of carbon dioxide which increases warming of the globe.

It was also released that the percentage of carbon dioxide in the atmosphere increased to a 40% level higher in the year 2012 than the percentage in the nineteenth century which has surpassed the natural amount of carbon dioxide in the atmosphere due to exchanges between the atmosphere, animals and plants. This current problem, however, is associated to the increase in global

consumption of energy. In as much as human activities such as cutting of trees for firewood and charcoal burning and manure preparation contribute the greatest to the problem of climate change; natural happenings also contribute to the problem. Explosive volcanic eruptions are natural contributors to the problem of climate change (IPCC, 2007).

2.2.2 Impacts of Climate Change on Agriculture

Climate change affects agriculture both positively and negatively. However, the negative impacts tend to cause more harm to agriculture over a period of time. This in effect will create shortage of food if the problem of climate change is not addressed (Zhu, 2005 cited in Farauta et al., 2011). "Studies show that without adaptation, climate change is generally problematic for agricultural production and for agricultural economies and communities; but with adaptation, vulnerability can be reduced and there are numerous opportunities to be realized" (Nordhaus 1991; Easterling et al. 1993; Rosenzwieg and Parry 1994; Fankhauser 1996; Smith 1996; Mendelsohn 1998; Wheaton and McIver 1999 cited in Smith and Skinner, 2001:86).

Mendelsohn et al. (2010) based on the use of the Global Impact Model (GIM) in assessing the impact of climate change on Africa agriculture, record that there is a potential loose of about $25 billion to $194 billion per year dependent on the climate sensitivity used. These findings further suggest that though Africa as a continent will suffer most due to the impact of climate change there will be regional variations as some regions within the continent will be worse hit than others with the Saharan region suffering the greatest percentage losses. Further findings of the impacts on individual countries

identified Zambia, Niger, Chad, Burkina Faso, Togo, Botswana, Guinea Bissau, and Gambia to be worse hit with the first three countries practically losing their entire farming sector.

According to Burton and Lim (2005 cited in Phuong, 2011) climate change plays an important role in agriculture as it is one of the factors that have significant impact on agriculture in these present days as well as the future. Climate change affects agriculture globally. Developing countries tend to be more vulnerable to these changes since agriculture in these countries depends solely on the climate with limited technologies to help cope with these changes. However, as much as climate change influence agriculture, agricultural practices and by products also contribute to the problem of climate change (Lybbert and Sumner, 2010**)**. It has been noted that the problem of climate change has been affected by the continual emission of greenhouse gases from agricultural practices (Edwards- Jones et al., 2009; Byravan & Chella, 2009 cited in Apata, 2011).

Also, there are dangers associated with increases in hunger as countries with rainfed agricultural will record 50% decrease in yields by 2020 coupled with the fact that, scientific evidence show that due to warming crop yield will fall between 10 to 20% by the year 2050 (Jones and Thornton, 2003; 2006 cited in Tachie-Obeng et al., 2010). According to the World Development Report (2010) of the World Bank (2009), projections made based on analysis of the Intergovernmental Panel on Climate Change (IPCC, 2007) indicate that

agriculture contributes 14% emissions of greenhouse gases directly and 17% indirectly.

Distribution of agro-ecological zones, habitats, distribution patterns of plant diseases and pests change over the years just as climate pattern do. This tends to have significant impacts on agriculture and food production (FAO, 2007, Jianchu et.al, 2007 cited in Bhusal, 2009). The Food and Agriculture Organization (2005) predicted that "in developing countries, 11 percent of arable land would be affected by climate change, including a reduction of cereal production in up to 65 countries, about 16 percent of agricultural Gross Domestic Product (GDP)" (Bhusal, 2009: 1).

The most vulnerable continent with the highest exposure to the negative impacts of climate change is Africa. Due to the existence of extreme poverty, poor infrastructure, insufficient safety nets and heavy dependence on rain-fed agriculture in the region, the capacity of adapting to climate change tends to be low (Boko et al., 2007 cited in Antwi-Agyei, 2012). This however will affect the livelihood of the people living on this continent since according to Mendelsohn et al. (2000a cited in Mendelsohn et al., 2010) the agriculture sector contributes a greater percentage of the economy of most African countries with an average of 21% and a range from 10% to 70% of the Gross Domestic Product. According to Boko et al. (2007) climate models suggest that "SSA will experience a temperature rise of 2–4°C by 2100, which represents an increase of about 1.5 times higher than the projected mean global temperature increase" (Antwi-Agyei, 2012:1).

Easterling et al. (2007) identified that increasing incidence of recurrent floods and drought across Sub- Saharan African has negative effects on the agricultural sectors of countries located within this region most especially on small scale agriculture which tends to be the dominant type of farming system in the region. It has been identified that, even though most agricultural systems have a natural capacity to adopt to change, IPCC, (2007) encourages deliberate policies to help the agricultural sector adjust to the changing nature of the climate due to the risks of secondary changes undermining the ability to cope (Ziervogel et al., 2008).

"Climatic changes have always had, and continue to have, a large impact on local agricultural production: from the 1960s to the 1990s West Africa encountered a particularly dry period, with terrible droughts in the Sahel and the semi-arid Guinea-Savannah, particularly in the late 1970s and early 1980s, although rainfall averages have since recovered" (Hulme, 2001 cited in Luabe et al., 2011:754).

There are serious expectations on the influence of climate change on environmental, economic and social aspects of Ghana. Farmers, most especially those in rural areas tend to solely depend on rainfed agriculture for their survival and are particularly more vulnerable to the impacts associated with climate change. This is important to Ghana since the backbone of her economy is the agricultural sector contributing about 35% of Gross Domestic Product, generates about 30-40% of the foreign exchange earnings, and

employs about 55% of the population (Ghana fact sheet, 2010 cited in Fosu-Mensah, 2010).

Total precipitation in the south of Ghana has been projected to increase based on 21 climate model used by the Intergovernmental Panel on Climate Change (IPCC, 2007). These projections also identify that lands in the northern part of the country will become drier (Christensen et al., 2007 cited in Antwi Agyei, 2012). Cereal crops tend to have higher risks of being affected by climate change as there has been projections that increases of about 1-2° C for small local temperature will cause reduction in outputs in lower latitudes where Ghana is located (0-15° N) (Antwi Agyei, 2012). "Projections for the future indicate that, for the three regions of the North, temperature is projected to increase by 2.1–2.4°C and total annual rainfall is projected to decline by 1.1% and 20.5% in 2020 and 2080, respectively" (The World Bank Group, 2011: cited in Atanga, 2014:1).

2.3 Adaptation to Climate Change

"Adaptation has the potential to significantly contribute to reductions in negative impacts from changes in climatic conditions as well as other changing socioeconomic conditions, such as volatile short-term changes in local and international markets" (Kandlinkar and Risbey, 2000 cited in Nchemachena and Hassan 2007: 84). Acquah and Onumah (2011) recognize that adaptation is an important component in climate change policy making. This is because adaptation helps limit the adverse negative effects of climate change on livelihood while taking advantage of the opportunities accompanying this change as vulnerability is reduced and resilience built.

Adaptation has long been recorded as a practice in societies in response to changes related to climate and weather. Additional adaptive measures need to be enhanced to help reduce the negative impacts of these changes while complementing efforts to help reduce the contribution of humans to the problem of climate change. There are barriers to climate change adaptation as adaptation is influenced by a society's productive base (IPCC, 2007). The problem of climate change combined with the presence of multiple stresses in Africa makes adaptation to climate change a necessity not an option (Thornton et al., 2006 cited in IPCC, 2007).

According to Global Leadership for Climate Action (2009) adaptation to climate change goes beyond designing projects in the national policy targeted at reducing the negative impacts associated with change but should also include a protective response in the countries framework for economic growth and poverty alleviation most especially in developing country. Building the resilience of vulnerable people to climate change can be strengthened when policies and programs are initiated to address specifically climate change as it will help people manage risks associated with it while taking advantage of the opportunities that comes with these changes. This however, can be achieved when these governments perform their required duties and responsibilities to their people. The necessary requirement for effective adaptation requires a participatory approach that takes into consideration the views of the affected people as well as makes sure that people have access to right information (GLCA, 2009).

Climate change adaptation tends to address issues of justice, which is both moral and economic responsibility. Morally industrialized nations who contribute highest to the problem of climate change can help manage climate change by cutting down emission. On the other hand they fulfil their economic responsibilities by providing technical and financial assistance to less industrialized countries which are more vulnerable to climate change to cope with the difficulties associated with climate change (IDS, 2006). Climate-related risks in human-managed systems are reduced by adaptation from regional to local scales; however, this is usually over short lead time. Scopes of specific systems are generally limited in their various environments (Fussel and Klein, 2004 cited in Legesse et al., 2013).

According to Carter et al. (1994 cited in Skambraks, 2014) adaptation tends to address the impacts of climate change rather than the causes of climate change. It is however not to say that the influence of adaptation on climate change doesn't matter but rather is one that is considered a secondary issue rather than a primary issue. "Adaptation does not occur without influence from other factors such as socio-economic, cultural, political, geographical, ecological and institutional that shapes the human-environment interactions" (Eriksen et al., 2011 cited in Kalinda, 2011:74).

Long-term initiatives taken by individuals which influence changes in production and managerial decisions to help households adjust and limit the negative impacts associated with climate change are known as adaptation

strategies (Smith et al., 2000; Kelly and Adger, 2000 cited in Antwi Agyei, 2012).“Adaptive strategies can take the form of processes, actions or outcomes in order to better adjust to, cope with and manage changing conditions” (Smit and Wandel 2006 cited in Kam et al., 2012: 5). Adaptation is highly influenced by perception as it informs agricultural decision and management planning (Bryant et al. 2008 cited in Moyo, 2012).

According to Leautier (2004 cited in IPCC, 2007) over the years indigenous knowledge has influenced farmer and community adaptation to climate change in Africa, however, full participation by local communities can be achieved when these indigenous ideas are enhanced. It has been reported that agricultural insurance is one of the approaches that will help farmers adapt to climate change. This helps shift the risks involved with climate change away from the vulnerable through pay-outs which they can use to recover from shocks. Farmers can acquire loans which they can invest in their productions thereby equipping themselves for protection against climate change (Nnadi et al., 2013).

Adaptation according to Ziervogel et al. (2008) is limited by lack of access to climate data. They further identified three casual factors that make the accessibility of climate data difficult. Lack of spatial climate data they reported limits farmers ability to observe their climate and adjust to changes. Also, the time frame for which data are gathered and the limited number of scientist for climate data interpretation to agricultural information limits adaptation in the African continent.

In the view of the Food and Agricultural Organization (2007 cited in Juana et al., 2013) adaptation to the harsh impacts of climate change has two distinctive perspectives. One is the perception people have on climate change and its negative impact on their livelihood as well as the capacity to adapt to these changes. While the other involves careful planning and implementation of adaptive strategies to ensure that adaption yields the necessary results.

According to Brooks and Adger (2005 cited in Lasco et al., 2011) the main goals of climate change adaptation are to reduce vulnerability and build resilience to the negative impacts associated with climate change. "Vulnerability can be defined as the level of human exposure .to extreme weather activities like earthquakes, floods, and drought, which threatens their very existence, and means of livelihood through food production" (Adger, 1999 cited in Yaro, 2013:5).

Barriers affect farmer efforts to adapt to climate change. However, these obstacles can be overcome with "concerted effort, creative management, change of thinking, prioritization and related shifts in resources, land uses, and institutions" (Adger et al., 2007 cited in Acquah, 2011:4). According to Mertz et al., (2009 cited in Ogalleh et al., 2012) farmer adaptive capacity can be enhanced if already existing adaptive measures employed by farmers in response to impacts of climate change are supported by national policies. Farmer adaptation approaches in response to climate change aimed at improving the livelihoods of people can undermine other approaches. It is

therefore important to consider the cost and trade-offs involved in taking decisions related to farmer adaptation (Bishaw et al., 2013).

2.3.1 Types of Adaptation

According to Martin et al. (2012 cited in Klein, 2013) distinctions can be made between the types of adaptation that is exploitative innovations which is identified as a type of adaptation designed to achieve newer goals that will make existing farming systems more adjustable as well as help the systems cope with the changes in the world and exploratory innovations which on the other hand he identified purposely targets the farming systems to create new production output.

Easterling (1996 cited in F.A.O. 2007) identified that there are two types (autonomous and planned) of adaptation. Autonomous adaptation to climate change is one's reaction to adjust to the harsh impacts of climate change. On the other hand, planned adaptation refers to a conscious effort made in providing strategies to improve upon adaptation to climate change. Fankhauser et al. (1999 cited in Phuong, 2011) identified that adaptation can be reactive or anticipatory. Reactive adaptation refers to the actions living organisms implement after the facts happen while anticipatory adaptation tend to be future preparations to help organisms cope with the impacts of climate changes before facts occur.

According to Smit and Skinner (2002) adaptation choices can be grouped into four categories to include; technological developments, government programs and insurance, farm production practices, and farm financial management.

These categories they added are associated with various stakeholder participation and contribution with the first two (technological developments, government programs and insurance) categories identified as the responsibilities of governments and public agencies. Farm production practices and farm financial management on the other hand are solely farmer initiated decisions, activities and measures for adaptation.

2.4 Mitigation

Though efforts are being put in place to help reduce farmer risks to climate change; there are also concerns about reducing the contributions of human activities to the problem of climate change. The attempt to address the problem of climate change is by reducing carbon emissions including emissions contributed by the quest to achieve economic growth through industrialization (Twomlow et al., 2015). Mitigation can be said to be the actions taken to reduce or limit the emission of greenhouse gases in the atmosphere. Solving the problem of climate change can also be achieved by increasing carbon stored in vegetation and soil (USAID, 2011). In the views of Bishaw et al (2013) mitigation and adaptation complement each other. This is because in as much as mitigation options provide benefits for adaptation, adaptive strategies also benefit mitigation by lowering the quantity of greenhouse gases in the atmosphere.

2.5 Farmer Adaptation to Climate Change

The availability of markets for farmers to have access to inputs such as irrigation technologies, fertilizer and seed varieties helps farmers easily adapt to climate change. Also, the availability of markets to absorb farm products encourage farmers to increase their output most especially cash crops which

intend increases their resource base there by limiting their vulnerability to climate change (Mano et al., 2003 cited in Hassan and Nhemachena, 2008). A study by Lapar & Pandely (1999) in the Philippines identified that farmer use and increase in conservation technologies was influenced significantly by farmer access to markets (Hassan and Nhemachena, 2008).

According to the findings of a study carried out in Vietnam by Yu et al. (2010) rice production tends to be threatened by the incidence of climate change as findings projected that under the influence of these changes, rice yield will reduced by 2.7 million tons by the year 2050. Therefore, identifying the need to limit farmer risks through adaptation which they identified will best be achieved by integrating climate change into long term strategic planning which will consider the workability of strategies to fit local conditions. They further added that introducing modern technology will help adaptation but will be effective when spatial variations are considered in climate change decision making. Rural roads should also be developed as many studies in other developing countries have noticed that this yields higher returns.

Lasco et al. (2011) work on climate change adaptation for smallholder farmers in southeast Asia identified that various strategies are been employed by farmers to cope with the negative impacts of climate change. Changes in cropping patterns and cropping calendar, improved farm management, and use of climate-resilient crop varieties are some of the strategies employed by farmers to cope with changes. Integrated Climate Risk Assessment Framework for Small Farmers (ICRAF) was identified as a potential strategy to help small

scale farmers adapt to changes. This is an appraisal tool which is made of interdisciplinary and inter-sectorial researchers, development workers and farmers who through participation, interactive and bottom up approach involving farmers helps them improve upon their adaptive capacity.

A study in Vietnam identified rationing; borrowing money or rice from relatives or wealthier households in the community; selling livestock (cattle, pigs and chickens to access funds to buy rice) and increased extraction of forest products as strategies adopted by farmers to cope with the problem of climate change. It was also revealed that male migration to find paid work is another coping strategy employed to reduce vulnerability. This however affects the family negatively in times that families are faced with hazardous circumstances because reconstruction and recovery from such shocks needs hard physical labour which women mostly cannot offer (Care, 2011).

Farmer adaptation to climate change can be enhanced if only the concept of climate change is understood. It is only when climate change is noticed that measures will be employed to adjust to it (Madison, 2007 cited in Nchemachena et al., 2014). Nchemachena et al. (2014) asserted that this was the case in the southern part of Africa as a study in the region identified that the farmer population that adopted various strategies to help them cope with climate change were those with the knowledge of the climate change problem as compared with those with little knowledge on climate change.

Using a multinomial logic model in 11 African countries to identify the determinates of choosing adaptation strategies in coping with climate change it was revealed that, increase warming in all seasons has seen a shift from mono cropping to irrigation, multiple cropping and mixed crop-livestock systems. This warming tends to have powerful influence on adaptive systems than the influence of changes in rainfall (Hassan and Nhemachena, 2008).

The choice to adapt to climate change tends to be influenced by lots of factors which in turn inform the choice of a strategy that best suits coping with change.

A study by Tazeze et al. (2012) in Ethiopia on adaptive strategies employed by smallholder farmers to cope with climate change identified that the sex of a family head influences adaptation. This is because families with male house heads tend to be more likely to adapt to coping measures and newer technologies than families with female households which they attributed to the flexible nature of man giving him an edge in farming experiences and adaptive measures. This they associate to the fact that most farming activities are done by males while women are more into processing. Also, one's level of education and age was identified to have an influence on adaptation. Farmer's experiences to varied coping strategies, access to climate information accumulated over years of their lives as well as literate farmers tend to increase their probability to adapt. They further identified that access to climate information and extension officers service help improve adaptation to climate change.

Adaptation to climate change is more effective according to Ozor et al. (2010) when extrinsic and intrinsic factors are integrated. Extrinsic factors identified include efforts made by governmental, nongovernmental and donor institutions to support local farmers increase their coping strategies in responds to the negative impacts of climate change. Intrinsic factors on the other hand are self-initiated adaptive measures by farmers themselves through collaboration in groups such as rural youth associations and community groups. Their study in Southern Nigeria identified that due to the poor state of most rural farmers intrinsic factors are weak therefore limits farmer's ability to adapt to climate change hence the need for external support. Land constraints, poor climate change information and agricultural extension service delivery, high cost of farm inputs and processing facilities, high cost of irrigation facilities and government irresponsiveness to climate change risk management, credit constraints, labour constraints, and income constraints were some of the barriers that hindered climate change adaptation in the region.

A study on the role of extension services in climate change adaptation in South Africa by Maponya and Mpandeli (2010) identified that farmers will best adapt to climate change when extension services are available to them. These extension officers however should be well trained and periodically undergo training to help them understand issues related to climate change as well as have access to newer technologies and skills which they will pass on to farmers to help them adjust to changes since "low levels of education of some extension officers adversely affect the quality of extension services" (Mmbengwa, 2009 cited in Maponya and Mpandeli, 2010:140). This was the

case in Limpopo Province as Maponya and Mpandeli (2010) noticed from their study that farmers with access to extension service were more vulnerable and highly affected by climate change than those without access to extension services. This was attributed to the fact that extension officers did not have the relevant qualifications to provide farmers with valuable information.

Okonya et al. (2013) identified that rural communities in Uganda have over the years been coping with the impacts of climate change. They however, suggest that in addition to coping, it is time for farmers to also adapt to these changes. This can be made possible when forecast information are provided and explained to the understanding of farmers to exploit the rainfall distribution.

Bagamba et al. (2012) using the Trade-off Analysis Model for Multi-Dimensional impact assessment (TOAMD) in three regions of Uganda realised that encroachment of swamps and crop livestock integration were the traditional adaptive strategies used by farmers to cope with the harsh impacts of climate change. They further identified that encroachment of swamps was not yielding economic benefits hence the need to opt for a strategy that will be more effective. One can therefore say effective adaptation to climate change requires productive strategies.

Gbetibouo (2009) based on a study in the Limpopo Province, South Africa identified that farmer choice of an adaptive strategy was largely influenced by

perception. However she further realised that, perception on climate change does not ultimately mean adaptation as some farmers with the knowledge of climate change did not adapt to changes as a result of their lands being fertile. Adaptation by farmers from the study was highly influenced by the economic benefit derived from adaptive strategies and also the wealth of farmers as it was revealed that wealthier farmers adapted the most in the Province.

Yesuf et al.(2008) in a study realised that, adaptation practiced by Farmers in Ethiopia included; changing crop variety, soil and water conservation, water harvesting and changing planting and harvesting periods. The decision to adapt to climate change is influenced by access to future climate information as well as access to formal and informal institution. Their study in the Nile Basin, Ethiopia also revealed that farmers who chose various adaptive measures recorded high yields in food crops than farmers who did not.

Evidence from a study by Barbier et al. (2009) in Burkina Faso revealed that households resort to selling smaller animals (example, chicken), migration as well as reducing the number of meals per day as an adaptive measure to cope with the negative impacts of climate change on agriculture. Noted also was that the explanation of adaptive strategies employed by farmers was difficult on the part of the farmers as they believed that there was less they could do to reduce the risks they encounter. However, there was evidence of new adaption techniques (small-scale irrigation, soil and water conservation) employed

which they noticed will help reduce the risk of climate change when guided by policies.

According to Akponikpe et al. (2011) based on findings from a study in five Sub Saharan West Africa countries scientist timeline (40 years) reported for change in climate tends to be higher than the timeline perceived by farmers (between 20- 30 years) who also perceive reductions in rainfall and increases in temperature. Adaptive strategies employed by farmers in these countries included: crop management strategies (change in sowing date and crop cultivar), soil fertility and soil water management practices. However, socio-economic constrains created room for less adoption of some of these strategies with the exception of crop management strategies.

Juana et al. (2013) assessing empirical data on farmer perception on climate change, adaptive measures employed by farmers to cope with the changes and barriers to climate change adaptation in Sub Saharan Africa found out that, perceptions on climate change are well establish as farmers establish an observed changes in rainfall patterns and temperature. The review further found out that as farmers in East Africa report records of dry lands and increase in droughts, farmers in West Africa experienced wetter but shorter rainy season. Lack of access to information about climate change and adaptation technologies, and access to affordable credit are identified factors that limit farmer adaptation in the region. Further, findings had implications on both private and public policies. Publicly, Sub Saharan governments should

include adaptation in their policy agenda while privately it involves farm level decisions taken by farmers to help in adapting to changes as well as support from Non-Governmental Organizations to improve farmer resilience.

Accessing Indigenous peoples' perception on climate change and adaptation strategies in Nigeria, Ishaya and Abaje (2008) found out that, the threat of climate change is more on health, food supply, biodiversity quality and availability of fuel wood rather than on businesses, instigating of disaster. They further realised that, locals take the problem of climate change seriously but however, have a weak approach of dealing with these negative impacts. This weakness they found out is as a resultant of poverty and high levels of ignorance. They added that the role of implementation by public administration in the area when shifted to specific climate conservation and adaptive programmes with guidance and promoting local participation will help locals apply more sustainable practices.

A study by Bessie et al. (2013) in Zimbabwe noticed that, the most vulnerable to the problem of climate change are smaller farming communities. This, they further identified is the case in other developing nations due to communities' limited access to necessary conditions for adaptation. This is because such communities normally lack the means and conditions to adapt to the impacts of these changes. Findings also indicated that there was a need for collective collaboration amongst all sectors (government political will, academia, non-governmental organizations and researchers) to help develop strategies,

educate communities on the applications of these strategies to help reduce the vulnerability of these farmers.

According to Hassan (2010), findings from most studies in Africa on vulnerability, floods and droughts and hydrological consequences for water resources' stresses portray evidence of the impacts of climate change on agriculture. These studies are however limited on the magnitude of economic damage climate change creates. Results from the analysis on the implication of climate change on African agriculture revealed that the sensitivity to both temperature and precipitation informs farmer's decision to adapt to climate change. Livestock species and mix farming are some important adaptation measures farmers employ. There where records of a switch from specialised large-scale beef and dairy cattle to local breeds (goats and sheep) that are more adaptive to warmer African climate.

Amdu et al.(2013) in a study in the Variability in the Upper Catchment of Blue Nile, Ethiopia revealed that though farmers were adapting to climate change through strategies that included shortening cropping calendar and adjusting livestock management most of the adaptive strategies were reactive measures which were self-initiated by farmers themselves out of necessity. The study further revealed that farmers actual adaptation measures varied from those adaptive strategies they perceived. Farmer perception about having fertile soil discourages the use of enhancing livelihood productivity while increased market distance decreases the use of different agricultural inputs.

Evidence from a study by Ogalleh et al. (2012) reveal that local knowledge tends to help farmers adapt very well to the changing trend of the climate and for that matter should be integrated into policy making. The study further identified that due to the heterogeneous nature of the world, integrating local knowledge in policy making will go a long way to help improve agricultural practices and measures farmers adapt in response to climate change impacts rather than prescribing solutions for farmers that might be difficult to implement.

According to the Ghana national climate change policy document, (2013) impacts of climate change on the national economy are very much visible due to the influence climate change has on the coastal zone, agriculture and water resources, health and livelihoods, most especially for women, which the policy document also identified is increasing levels of poverty. This tends to have a negative toll on achieving developmental objectives as such, the vision to 'ensure a climate-resilient and climate-compatible economy while achieving sustainable development through equitable low-carbon economic growth for Ghana" through the achievement of effective adaptation, social development and mitigation. Adaptive measures such as modernising agriculture, as a way to increase yields, which requires a transformation of current agricultural practices to include new crop varieties that are better suited to the changing climate conditions; higher energy and water inputs to support large-scale irrigation; and mechanization were included to measures that will help make the agricultural sector resilient to climate change.

The influence of climate change on rainfall intensity will ultimately affect agriculture in Ghana. The three northern regions (Upper East, Upper West and Northern) are identified as the regions which will be worse hit by these changes as a result of the dry nature of their lands (Dasgupta et al., 2012; Stanturf et al., 2011 cited in Pinto et al., 2012). Pinto et al. (2012) added based on findings of International Food Policy Research Institute that adaptation is very important as it will help stop a decrease in the yield of some major crops which include rice, groundnut and maize. Mitigation strategies which will help reduce the level of greenhouse gases should also be those that will help adaptation achieve its objectives.

Evidence from a study by Antwi Agyei (2012) in Ghana identified that strategies adopted by households which helps cope with the impacts of climate change are associated with livelihood diversification. This he identified to include both on-farm and off-farm strategies. He further identified that the country just like other Sub Saharan African countries is influenced by multiple climatic and non-climatic factors and the best way of improving household's adaptive capacity to climate change is by considering both when it comes to climate change policies.

Studies carried out in the coastal and northern savannah regions by USAID (2011) revealed that these regions are currently facing negative impacts from climate change. The northern savannah region however tends to suffer most in the country with projections depicting future stresses on the region due to growing population. As a way of coping with these harsh impacts fishermen

tend to spend more time at sea to enable them get good catch to support their families. For the northern Savannah region, planting early-maturing and higher yielding crop varieties, increasing crop density in fields, weeding more often and diversification of women economic activities such as engaging in petty trade are some adaptive measures practiced. Identified coping strategies in the northern savannah region depict opportunities for farmer adaptation to the harsh conditions of climate change. These opportunities, however, are limited and threatened by certain factors such lack of access to credit to diversify farmers' livelihood activity outside agriculture and improving water infrastructure (USAID, 2011).

Kemausuor et al. (2011) revealed from a study in Ejura-Sekyedumase district of Ghana that a greater percentage of the farmer population in the district agreed to the changing nature of the climate. Despite this knowledge they added, that there was room to intensify adaptation in the district due to limited adaptive strategies. They however concluded that farmers be educated on soil moisture conservation through mulching as well as encouraging them to stop the practice of burning fields before planting season because soils are left to the mercy of the sun which affects the soil.

A study by Klutse et al. (2013) revealed that due to the high dependence of maize on rainfall, the negative impact of climate change has affected maize cultivation in a selected agro ecological zone in Ghana and as a result farmers tend to adapt to these changes by resorting to cultivating other crops instead of

the usual maize. It will therefore take effective and efficient measures to help farmers build up their resilience to these changes as well as improve upon yield. Antwi-Agyei et al. (2012) based on a study in two selected regions in Ghana revealed that the negative impacts of climate change affects individuals and various households differently. The rural population they noticed are worse hit by these changes and vulnerability can be reduced with household's access to capital. Hence the need to formulate specific policies targeted at helping vulnerable households.

Acquah and Onumah (2011) analysed farmers perception and adaptation to climate change as well as the willingness of farmers to pay for mitigation policies and identified that changing planting dates, usage of different crop varieties, tree planting, irrigation practices, soil conservation, water harvesting and prayers were the main adaptive practices in Ghana. They also realised that the willingness to pay for mitigation policy was high. This however based on the probit regression estimation results indicate that one's age, years of education and farm land ownership influence the e nthusiasm to pay. They therefore noticed that adaptation can be made productive through governments' initiated programmes to educate the people.

Evidence from a study by Tetteh et al. (2014) revealed that most policy makers understood the changing trend of the climate and its impact on agriculture especially small scale farming. Even though Ghana's economic growth rely greatly on the agricultural sector, policy makers had little knowledge on Ghana's climate change policy document. This they identified affects Ghana's

ability to cope with the problem of climate change as knowledge about the "dos" and "don'ts" will help educate farmers on effective adaptive strategies that will help reduce vulnerability to the harsh impacts of climate change.

Perception plays a vital role in helping farmers adapt to climate change. Varied studies carried out in Ghana show that people are aware of the changing trend of the climate however it is worth noting that perception about the causes of the problem of climate change vary across the country. A study by Codjoe et al. (2013) revealed that majority of cocoa farmers interviewed associate the cause of climate change to the will of God. They think these changes are God's plan to signifying the end time. Despite varied perceptions about causes of climate change farmers however are coping with these changes as shade management strategy, soil fertility strategy, land preparation strategy, farm size strategy (diversification of crop) and lining and pegging strategy where some adaptive practices employed by farmers.

Acqua (2011) in a study in Beposo revealed that in as much as majority of farmers interviewed found measures to adapt to climate change, adaptation is limited by lack of information about climate change, adaptation measures, lack of knowledge about adaptation options and access to credit as well as no access to water and insufficient access to inputs.

A study by Nukuja et al. (2012) in the Upper East Region of Ghana using the Ordered Logit Model revealed that water harvesting plays a vital role in helping farmers adapt to climate change. This is because findings from their

study show that people with access to dugouts in the region had higher adaptive capacities to climate change than those without access to these resources which increase farm vegetable income. The study further revealed that men's adaptive capacity was higher than that of women but reduces as they age amongst low adapters. Increase in the number of years one goes through formal education they added improves adaptive capacity.

Using the Agricultural Production Systems Simulator (APSIM) crop model and nine (9) General Circulation Models (GCMs) to assess farmers' adaptation measures in maize production in semi-arid zones (Wa district), Tachie-Obeng et al. (2010) identified that, late planting dates led to increased maize yields in the near and far future. Projections further showed that the rainfall pattern will change with expected increase during the onset of the rainy season (April and May) and the dry season (November-March). The study therefore identified that research into climate change tolerant crops and the promotion of late-maturing/heat-tolerant cultivars will help increase the yield of maize cultivation in semi-arid zones.

A study by Amikuzuno (2013) in the White Volta Basin of the Upper East Region of Ghana revealed that irrigated farms had higher advantage of adapting to climate change than farms that were rainfed. He further added that, access to irrigation impacts positively on rain-fed agriculture due to the supplementary role of making water available for cultivation during events of drought. Also, he concluded that due to incidence of lack of surface water everywhere for irrigation in the study area policies to help farmers adapt to

climate change should include an intensive and expanded technological approach to make adaptation in the Basin productive.

Atanga (2014) study in Kassena-Nankana West District on mainstreaming climate change adaptation into development planning for sustainable development revealed that the agricultural sector of the district was highly sensitive to the influence of climate change due to changes in rainfall. Based on his findings, he further concluded that the adaptive capacity of the district is low as the district lacks the needed resources to adapt to the problem of climate change. Integrated Water Resources Management through the buffer zone system which involves creating barrier between a water body (river or dug-out) and farms, education and awareness creation, Integrated Soil and Land Management, and Integrated Soil and Land Management were some identified adaptive initiative measures. It was however realised that climate change adaptation wasn't captured in the plans and budgets of the District Assembly as no direct climate change programmes were carried out. Limited information about the levels of vulnerability to climate change impacts, lack of early warning system and disaster risk management schemes, lack of institutional structures at the district and sub-district level to deal with climate change and neglect of local/indigenous knowledge on climate change adaptation where some identified limitations to adaptation.

Eguavoen (2013) revealed from a study in the northern part of Ghana that in order to understand the perception of people most especially the locals and the measures they employ in coping with climate change, then one must

understand that ideas which hold that cultural models and Western models are not in accordance need to be reviewed. Though the level of formal education tends to be low in the northern region it does not necessarily mean that the perceptions of the locals are wrong. This is because one's perception about phenomena tends to be one's vision of the real world. It will therefore count to consider the ideas of these locals when trying to find measures that will help farmers adapt to climate change.

A study by Etwire et al. (2013) in the three northern regions of Ghana revealed that a greater percentage of the population owned radios which ultimately signified access to information concerning the state of the weather which however is not necessarily so. It was however realised that farmer access to extension service was limited. Soil and plant health strategies are the adaptive measures employed by majority of the farmers which was highly influenced by agro ecology and noticing of unpredictable temperatures.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

Chapter three focuses on the method used in getting a representative number of the population for the study. It further includes the various methods used in gathering, analysing and presenting data on farmer knowledge and adaptation to climate change.

3.2 Research Design

The study employed a mixed method approach, thus the use of both qualitative and quantitative methods in acquiring and analysing data. This is also reflected in the presentation of findings on the changes in climatic elements and the impacts of these changes on the livelihood of farmers. This methodology is also used in identifying adaptive measures put in place to cope with these changes. The choice of a mixed method is to help counter the limitations of both the quantitative and qualitative methods as well as provide an expanded understanding of the research problem.

3.3 Sampling Procedure

The study was carried out in four selected farming communities to cover all the six area councils in the Kassena-Nankana East Municipality. Within these communities, farmer groups were involved in the study. The study included 235 farmers which is a total of the four farmer groups involved in the study. A formula by Taro Yamane (1967) $n = \frac{N}{1+N*(e)^2}$ was used to select a sample size

of 148 farmers for questionnaire administration. Where n is the sample size, N the population and e the acceptable sampling error. Also, 1is a Constance, with a 95% confidence level and p= 0.05 assumed. The calculation of the sample size is as follows $n = \frac{235}{1+235*(0.05)^2} = \frac{235}{1+235*(0.0025)} = \frac{235}{1+0.5875} = \frac{235}{1.5875}$=148.0. Farmer groups were selected to reflect the target age from the communities. This enabled the researcher to achieve results since these farmer groups included the target population who fell within the age groups of interest which is between 30 to 70 years and above. Series of meetings were organized till the target sample size was obtained for questionnaire administration.

3.3.1 Purposive Sampling Method

The communities (Manyoro, Doba, Biu, and Bonia) were selected purposively because though all communities in the Municipality are involved in some level of farming, these chosen communities' engage extensively in farming activities and had organized farmer groups. The purposive selection of these communities was obtained using the division of communities in the Municipality by the Ministry of Food and Agriculture into four zones to include east, west, north and south. The communities were then chosen with Manyoro representing the north, Biu representing the south, Doba representing the east and Bonia representing the west. This technique is used based on the objectives of the study to find respondents who will give useful information for the study (Twumasi, 2001). Institutions working in the Municipality which are of relevance to the study were also purposively selected and interviews conducted on farmers understanding and acceptance of climate smart methods. Also people with specialised insights on the effects of indigenous knowledge

systems on adaptation to climate variability such as the aged and chiefs were also purposively consulted.

3.4 Source of Data

Both primary and secondary sources were used in gathering data. Primary data was assembled mainly through interviews, questionnaire administration as well as through focus group discussions to ascertain farmer's perception on changes in climatic elements. It was also to identify some of the perceived impacts of these changes on agriculture as well as on farm outputs over the years. Officials from the Municipal office of the Ministry of Food and Agriculture were interviewed to gather information on available sensitization progammes and adaptive measures being carried out in the Municipality by the institution that help farmers cope with the changing trend of the climate.

Also personnel from Non-Governmental organizations (Tread Aid Integrated, United States Agency for International Development: Agricultural Development and Value Change, Association of Church based Developmental Project, Organization for Indigenous Initiatives and Sustainability, Centre for Social Mobilization and Sustainable Development) and General Agricultural Workers Union a development partner were interviewed in relation to their activities in the Municipality and the influence of these activities on climate change adaptation. The secondary sources included data on crop yield for 22 years as well as data for area of land cultivated for 14 years. This data was acquired from the Municipal office of the Ministry of Food and Agriculture in order to study the trend of output and the impact of change on farmland cultivated respectively.

More so, data on rainfall and temperature for 32 years were obtained from the Navrongo Meteorological weather station to establish the changing trend in climate. This enquiry also helped identify various sensitization progammes institutions put in place to keep farmers informed about the state of change in the climate as well as identify the impact of these changes on water sources.

3.5 Data Gathering Methods

3.5.1 Interviews

Structured interview guides were used to collect information from the Ministry of Food and Agriculture, (Tread Aid Integrated, United States Agency for International Development: Agricultural Development and Value Change, Association of Church based Developmental Project, Organization for Indigenous Initiatives and Sustainability, Centre for Social Mobilization and Sustainable Development) and General Agricultural Workers Union.

This method helped collect information from these institutions in the Municipality through an institutional survey that helped get the required information needed for the study. The use of this method involved seeking the opinions of project officers of various institutions operating within the Municipality on the subject matter and views of interviewees recorded. These institutions in addition also, had officers who were climate change ambassadors who provided information on farmer knowledge on climate change and what their institutions are doing to help farmers adapt better to the change.

3.5.2 Questionnaires

Questionnaires were administered to 148 farmers to solicit their understanding on climate change as well as factors that foster adaptation or otherwise. This method was largely appropriate since the study deals with farmers, most of who are illiterates. It also allows for probes to bring out details. The questionnaire administration was largely done by the researcher with the help of two research assistance. Questions were asked in the local dialect and responses were ticked against questions where it applied. Views expressed for open ended questions were written in spaces provided.

3.5.3 Focus Group Discussion

Meetings were organised for members of farmer groups to brainstorm on climate smart approaches to the problem. The number of people that constitute the focus group varied for all communities. However, effort was made to ensure that the groups were sizeable enough to be controlled and generate diverse ideas in a convenient atmosphere. Eight (8) focus group discussions were organized two each for the four communities involved in the study. For each community there was a division for the focus group discussions between males and females. Meetings for various male and female groups were however, organized through schedules. Questions on the focus group guide were asked sequentially in the local dialect and response recorded.

The discussions were organized in a way that views were not supressed as everyone was inclusive in the discussions. Contributions were made by drawing the attention of the researcher by simply raising ones' hand when one wanted to contribute. This was agreed on by participants themselves upon the

suggestion of the researcher since farmers testified that it worked for them during meetings.

3.5.4 Observation

The research covers farming, various farming practices that are of importance to the study were observed during the farm visits using a checklist of practices. Photographs were also taken to compliment narrations in order to portray the effect of climate change and adaptation in the Municipality to outsiders.

3.6. Techniques for Data Analysis and Presentation

This covers data evaluation, description statistics and transcription of response. Different methods and procedures were used to analyse both qualitative and quantitative set of data. For the quantitative set of data, questionnaires were analysed using the descriptive statistical tool of the Statistical package for Social Sciences (SPSS) version 20. The process involved assigning values to each possible answer during the coding process using the SPSS software. This however was done for close questions while for the open ended questions, the views and ideas of the respondents where fused and presented in the discussion. SPSS outputs were then exported and converted to bar and pie charts using Microsoft Excel for the presentation of findings. Tables were also used to present these findings. Data on rainfall and temperature, crop yield performance and total area cultivated from the Municipal office of the Ministry of Food and Agriculture and Meteorological weather station were also analysed using Microsoft Excel.

With the qualitative data set, analysis presentation is in the form of narrative and descriptive. Data sets were all in recording and as such, focus group discussions and interviews with personnel's from institutions and organizations involved in the study were transcribed. The recordings for the focus group discussions were in the local dialect and as such transcribed to English. The views and contributions from these recording were discussed in the work alongside with finding from the qualitative data set. Pictures were also taken and used to present some observed measures farmers employ to help them cope with the impact of change on their farming activities. These also, however are presented alongside the discussions.

CHAPTER FOUR

ANALYSIS, PRENSENTATION AND DISCUSSION

4.1 Introduction

Chapter four focuses on data analysis and presentation on farmer adaptation to climate change in the Kassena-Nankana East Municipality. This includes analysis on farmer perception on climate change, the effect of climate change on farming activities, how farmers are coping with this change and some limiting factors to adaptation. It also presents analysis of data on rainfall and temperature recorded over years as well as information on the performance of different crops cultivated in the Municipality and area cultivated.

4.2 Socio- Demographics of Respondents

This highlights the socioeconomic characteristics of respondents such as sex, age among others.

4.2.1 Sex of Respondents

A total of 148 farmers were interviewed with questionnaire during the period. Out of this, 88 representing 59.5% were female and 60 representing 40.5% were males. From the study it was revealed that women are more involved in group activity and meetings than men. This is the more reason why women outnumber the men in the study and not because women were given priority in the study. One of the chiefs who is also the leader of a farmer group in his community highlighted on this issue as he acknowledged that, women are more active in group meetings and as such are always first to receive aid as well as information. He added that this advantage even creates problems for

his leadership since the men accuse him of favouring the women when aid arrives but rather neglecting the fact that, it is because of their absenteeism that makes opportunities pass them by. This therefore revealed that women in the Municipality have access to agricultural information as such, can also easily get information on issues related to climate change and adaptation.

4.2.2 Age of Respondents

The age distributions of respondents in the survey ranged from 30 years to over 60 years and were classified as follows: 30-50, 51-70, and above 70. This target ages were selected to reflect and capture respondents who have lived for 30 years and above and have seen the changes that occur with the weather over the period of their existence. A greater percentage (54.1) of the respondents fell within 51-70, 37.2% for 51-70 with a lower percentage (8.8) of respondents falling within farmers above 70 years as shown in Figure 4.1. The same age distribution was used for the farmers who participated in the focus group discussions.

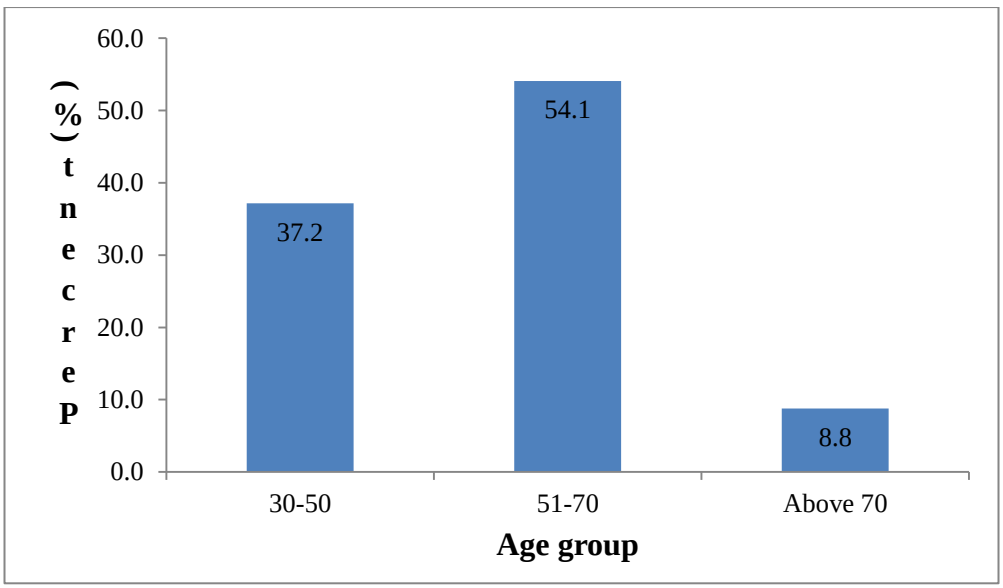

Figure 4.1 Age of Respondents

Source: Field Survey, 2015

4.2.3 Level of Education

The level of education of the respondents varied from elementary school to those who do not have any form of formal education. From the response, majority representing 52.7% of the respondents have never had any formal education. About 31.8% have had elementary education while 10.8% said they have had junior high school education. A few of the respondents representing 2.0% and 2.7% said they have had secondary and tertiary education respectively. The results show that farming in the study is predominantly done by farmers with no formal education. The study also revealed that, farmers that had formal education up to the secondary and tertiary level understood clearly matters and issues surrounding climate change and the impacts it had on their farming activities and lives as a whole.

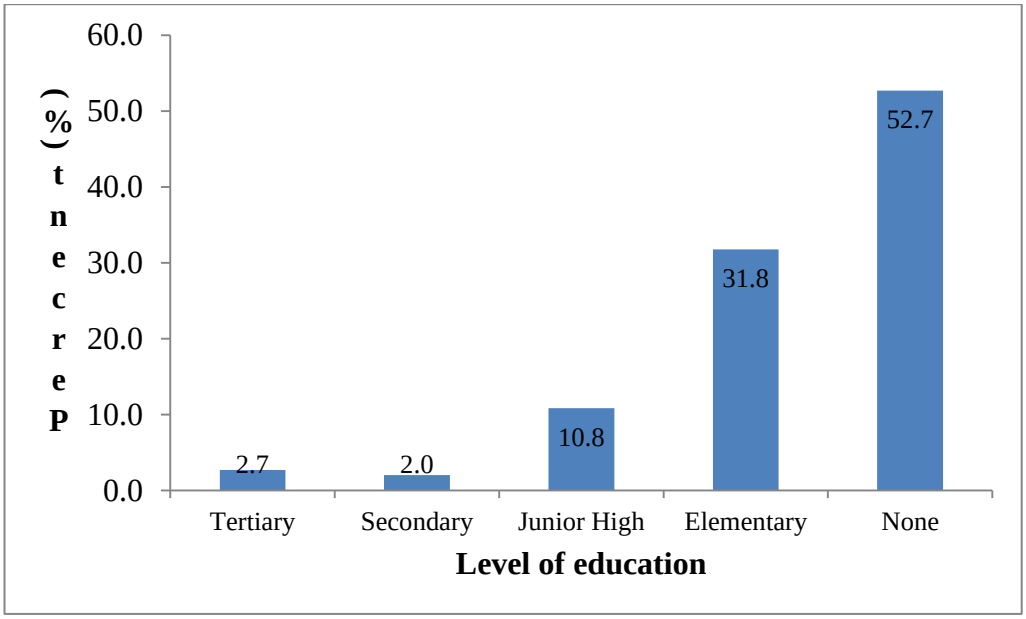

Figure 4.2 Level of Education

Source: Field Survey, 2015

4.3 Perception and Understanding of Climate Change

All respondents asserted to having heard about climate change and had an idea on what climate change was about. A total of 51.4% of the respondents said they understand climate change to be change in rainfall, 17.6% understood climate change to mean a change in the elements of the weather, 6.8% understood climate change to be a shift in planting season. Yet 24.3% said they understood climate change to mean the world was coming to an end. This was also made clear in the discussion as one farmer said:

"*We have heard, seen and also experienced the presence of changes in the climate. The rains do not set in the time it is supposed to and when it does it suddenly stops when crops are yielding leaving the crops to wither and others even drying up therefore destroying the crops rendering all our hard work and efforts useless*"(FGD, Bonia, 25/11/2015).

The responses given also mean that, there are varied views and understanding on the concept of climate change amongst farmers within the study area. This is clearly evident in the response in Figure 4.3. It can however be said that, majority of the farmers from focus group discussions have an idea about climate change. This finding agrees with the study by Ayanwuyi et al. (2010) which indicated clearly that farmers were aware of climate change and its impacts on food crop production. From the focus group discussion surrounding the causes of climate change, it was clear from the responses that, humans are perceived as the sole cause of climate change. Despite this view, there are varied understanding as to the exact activities of humans that contribute to the problem of climate change.

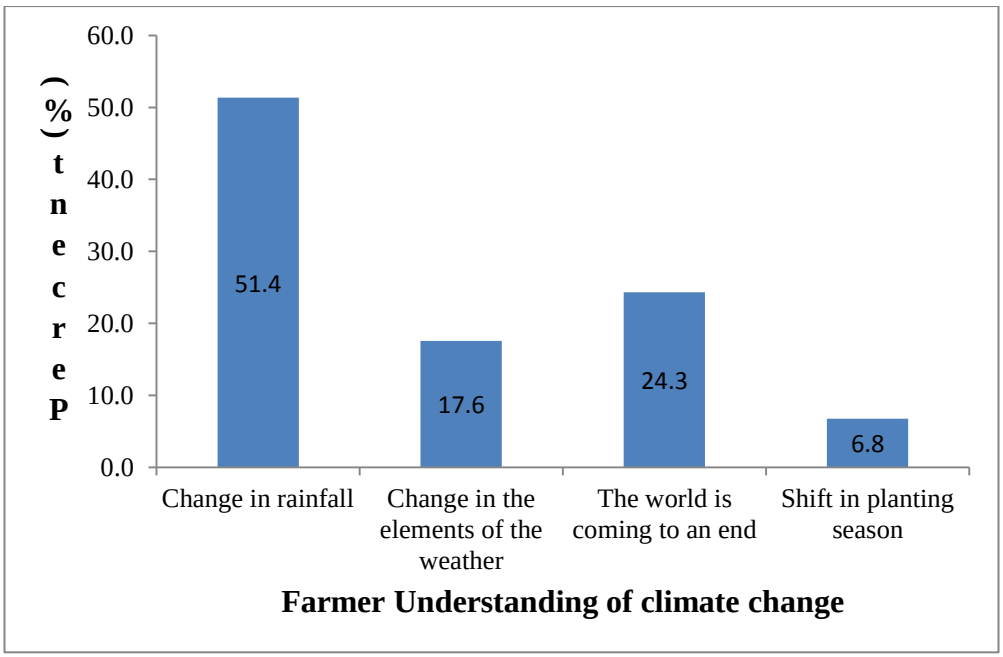

Fig 4.3 Farmer Understanding of the Concept of Climate Change

Source: Field Survey, 2015

From the discussion the greatest view was that, the inability of humans to pay respect to the gods of the land is the cause of the changes in the weather. Others hold different views based on the stories from their fathers such as the prohibition of certain acts. For instance, it was established that trees in their days were not felled carelessly especially trees that were fruiting but in our days all we see is how humans carelessly cut trees without planting more. According to an elder:

"*In the days of our fathers, children respected their parents and there was a form of discipline in society and the way things were done. Look at our generation for instance growing up, we respected our elders and in the days of our youth, society had its "dos" and "don'ts" that made living easy. Children of today do the opposite. They take alcohol and insult us as well as slap their elders ignoring the words of wisdom passed down onto them. Children therefore go about defying all the rules of the land and the result is the*

problem of climate change and the negative effects that are associated with the change" (FGD, Doba, 01/12/2015).

This portrays that in as much as the knowledge of the existence of change is established in the minds of farmers and locals; the understanding of the causes and activities by humans that contributes to the problem of climate change has not yet been established. This agrees with the conclusion made by Baul et al. (2013) on the fact that farmers may not understand the reason for the changes they are experiencing even though they have identified changes in the weather.

A cross tabulation of the age of respondents against farmer understanding of the concept climate change in Table 4.1 revealed that, varied views of how the concept climate change is understood is highest for respondents within the ages 51- 70 years with the greatest understanding of climate change being change in rainfall. This indicates that, majority of the respondents lie within 51 – 70 years and the lowest number of respondents lie within 70 years and above.

Table 4.1 Ages of Respondents and Understanding of the Concept of Climate Change

Understanding	**Age**			**Total**
	30-50	51-70	70+	
Change in rainfall	31	40	5	76
Change in the elements of the weather	8	14	4	26
The world is coming to an end	13	20	3	36
Shift in planting season	3	6	1	10
Total	55	80	13	148

Source: Field Survey, 2015

4.3.1 Signs Associated with Climate Change

The impact of climate change on the weather for decades has been negative. This study showed that there has been visible changes in the weather conditions in the study area and consequently on farming activities. This is visible as respondents from the survey alluded to this. As shown in Figure 4.4, 32.4% of the farmers interviewed said the impact of climate change in the area was visible as a result of the low rainfall they received year on.

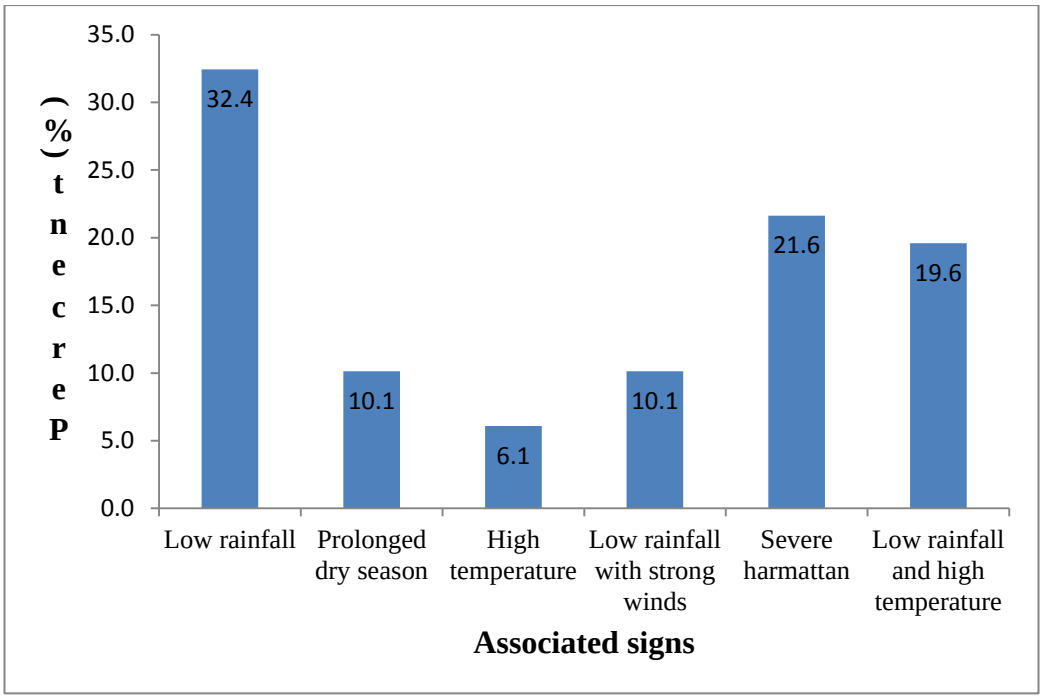

Figure 4.4 Signs Associated with Climate Change

Source: Field Survey, 2015

]In an interview with a coordinator of one Non-Governmental Organization which works with farmers in the Municipality, it was highlighted that, there is a distinction between the understanding of climate change within academia and that of the locals whose understanding of climate change is changes in rainfall. This is due to the fact that, the rains are what farmers work with and for that matter, take notice of that than any other change in the elements of the weather

(Interview, ORGIIS, 07/01/2016). This confirms the conclusion drawn by Shashidahra and Reddy (2012) from their study in UKP area of Karnataka which revealed that, farmer understanding of climate change was based on the study of rainfall and conclusions made on these changes. The severity of the harmattan was another sign identified to be occurring due to change with 21.6% of the respondents attesting to that. From the discussions when asked about signs associated with climate change a farmer had to say:

"*There have been signs of changes over the past 30 years and beyond to include severe dryness especially during the dry season, low rains and severe harmattan that sets in earlier than it used to. As you can see and feel the winds, aren't they strong, cold and dry? This wasn't the case growing up during those days; the winds were severe in January and February. However, this has changed. Imagine we are in November and the winds are stronger than we can ever imagine experiencing.* (FGD, Biu, 27/11/2015).

Other signs identified by 19.6% respondents are low rainfall with high temperature. The low rainfall is associated with the rainy seasons while high temperatures according to the respondents are experienced during the dry seasons. The dry seasons are not only isolated with high temperatures but also 10.1% of the respondents noticed that, dry seasons are prolonged. It was further revealed that, the rains used to set in right after the celebration of Easter (April) and when these rains started one could see farmers sowing everywhere but now, the month has shifted to June and even in 2015 July. Also, 10.1% of the response identified rains accompanied with strong winds as a sign associated with climate change as it was clearly explained in their views that:

"*The rainfall has its own way of disturbing farming activities in our community. The time that we need the rains for crops to grow; all we get are showers that do not have significant influence on plant growth. Then when the crops do their best with the little water and do not need water in large quantity it pours beyond the quantity the plans need"*(FGD, Bonia, 25/11/2015).

A percentage of (10.1) of the respondents also identified only high temperature as a sign that has been noticed in connection with climate change with the idea being influenced by the experience of the scorching sun.

From Table 4.2, males dominate the choice of low rainfall as a sign in the change of weather and as such identify low rainfall as the greatest sign of the existence of change. For severe harmattan, though males and females identified it as a sign, the females think it is also a great indicator with a record of 20 responses.

Table 4.2 Sex of Respondents and Signs of Climate Change

Sign	**Sex**		**Total**
	Male	Female	
Low rainfall	26	22	48
Prolonged dry season	3	12	15
High temperature	4	5	9
Low rainfall with strong winds	4	11	15
Severe harmattan	12	20	32
Low rainfall and high temperature	11	18	29
Total	60	88	148

Source: Field Survey, 2015

This can also be said for low rainfall and high temperature which recorded the third highest sign indicating a change. For low rainfall and high temperature 18 of the respondents were females while 11 were males. This can be said to be true for the remaining indicators which all record higher responses amongst females but a minimal difference between male and female responses for high temperature. A total number of responses 4 and 5 were recorded for males and females respectively.

4.3.2 Factors that Influence Knowledge on Climate Change

The knowledge of the existence of climate change is influenced by various factors. An investigation into the factors that influence farmer knowledge on climate change revealed that farmers' experiences over time played a key role. This is because from Figure 4.5, 45.9% of the farmers said their knowledge was informed by experience. This is followed by sensitization from MoFA with a percentage of 29.7 respondents agreeing to that. A total of 18.2% of the respondents said their knowledge was informed by their experience and sensitization from MoFA while a few representing 1.4%, 2.7 % and, 2.0% said their knowledge was influenced by experience and NGOs sensitization, sensitization from MoFA and NGOs and sensitization from NGOs respectively. The result shows that farmers pay attention to what is happening within the environment in which they live. This is due to the fact that, there was awareness that there is a change in the weather before sensitizations from institutions. One of the farmer's remarked:

"*this knowledge of change has been influenced by experience during childhood when rains use to set in early and our fathers sowed on time giving us a good*

*harvest however, growing up we have noticed changes with records of delay and low rainfall"(*FGD, Biu, 27/11/2015).

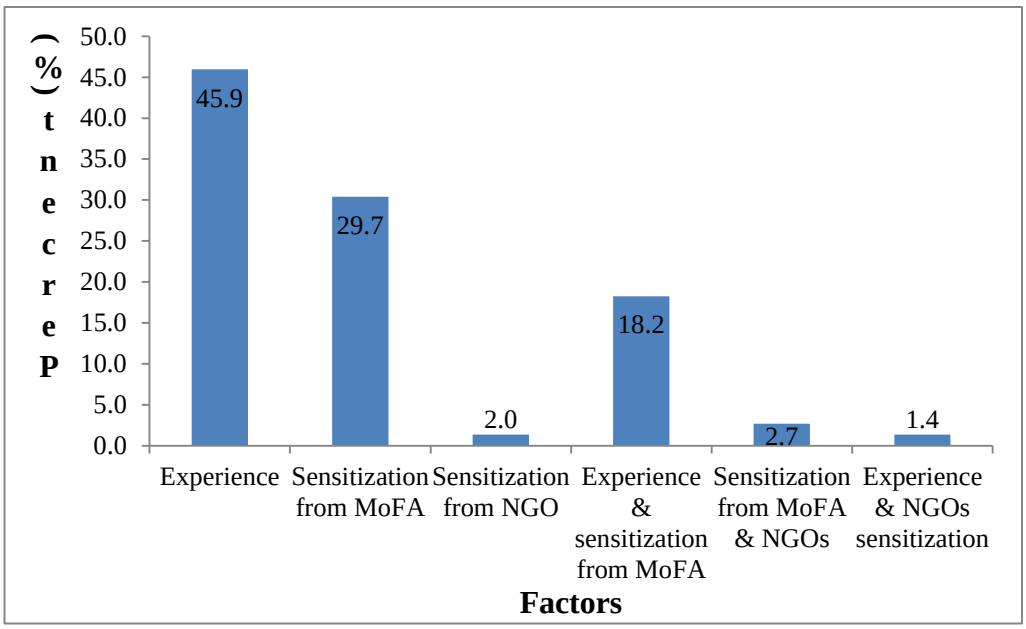

Figure 4.5 Factors that Influence Knowledge on Climate Change

Source: Field Survey, 2015

A cross tabulation presenting factors that influenced farmer knowledge on climate change and age of farmers revealed that, respondents between ages 51-70 were greatly informed about the existence of climate change through experience. For knowledge about climate change through sensitization from MoFA, farmers within the ages 30-50 years were greatly informed through the activities of MoFA. Also, knowledge on climate change influenced by the combination of experience and sensitization from MoFA was greatest for farmer within ages 30-50. While the influence of knowledge of climate change through sensitization from NGOs, a combination of sensitization from MoFA and NGOs, a combination of experience and NGOs sensitization recorded a minimal influence on farmer awareness of the existence of climate change.

Table 4.3 Factors that Influence Knowledge on Climate Change and Age of Respondents

Factor	Age			Total
	30-50	51-70	70+	
Experience	15	48	5	68
Sensitization from MoFA	25	19	1	45
Sensitization from NGOs	0	1	1	2
Experience and sensitization from MoFA	12	10	5	27
Sensitization from MoFA and NGOs	2	1	1	4
experience and NGOs sensitization	1	1	0	2
Total	55	80	13	148

Source: Field Survey, 2015

Also it was revealed from the study that farmers have their own methods of telling when the seasons were changing. For instance, it was made clear that the migration of birds at particular times and month informed the knowledge of farmers as to when rains will set in and when the rainy season is ending. However, this has changed due to the fact that everything has been influenced by the change in the weather. An interview with the coordinator of ORGIIS a Non-Governmental Organization operating in the Municipality added that, there was knowledge of the change already upon their visit to various villages and communities because farmers could tell that the weather they were experiencing isn't the same weather once experienced (Interview,07/01/2016).

This is the more reason why awareness on climate change was based on experience for majority of the respondents. This knowledge through experience is informed by the comparison respondents make of the nature of

the weather and its influence on their livelihood from the days of their childhood through to that of their youth to that of present day.

Aside from the direct experience famers have gone through and comparison farmers make, history also contributed to their knowledge of changes in the weather. This history the study further revealed has been informed from the stories told by their parents about their day and the nature of the weather during the days of their aging. This indirectly contributed to their direct experiences to inform their knowledge on the problem of climate change. The general idea therefore is that, in this present day all they experience is hardship due to the reduction of output which they associate to the difference in the weather they experience. Farmers' knowledge on climate change from the study is greatly influenced by culture. This is because experience and history has influenced farmer knowledge on climate change. It is to this reason that, though majority of the farming population have no form of formal education, they understand that there are changes in the weather. Efforts of officials in increasing the awareness of the presence of change in the climate has been appreciated as farmers acknowledged that efforts have been made by officials from both governmental and non-governmental organizations to educate them on climate change.

4.3.3 Climatic Events Recorded for the Past 30-60 Years

The study also revealed that for the past 30 years dating back to 60 years and beyond, various communities identified floods, drought, wind storms, rainstorms, drought accompanied wind storms and rainstorms accompanied by

wind storms as the climate change event predominant in their communities. In Figure 4.6 drought was identified as one of the event that has been occurring and has been experienced the most in communities with 50.0% of the respondents agreeing to this fact. The occurrence of drought from discussions affects the farming activities of farmers most especially their farm sizes which reduces due to limited access to water thereby resulting in low output.

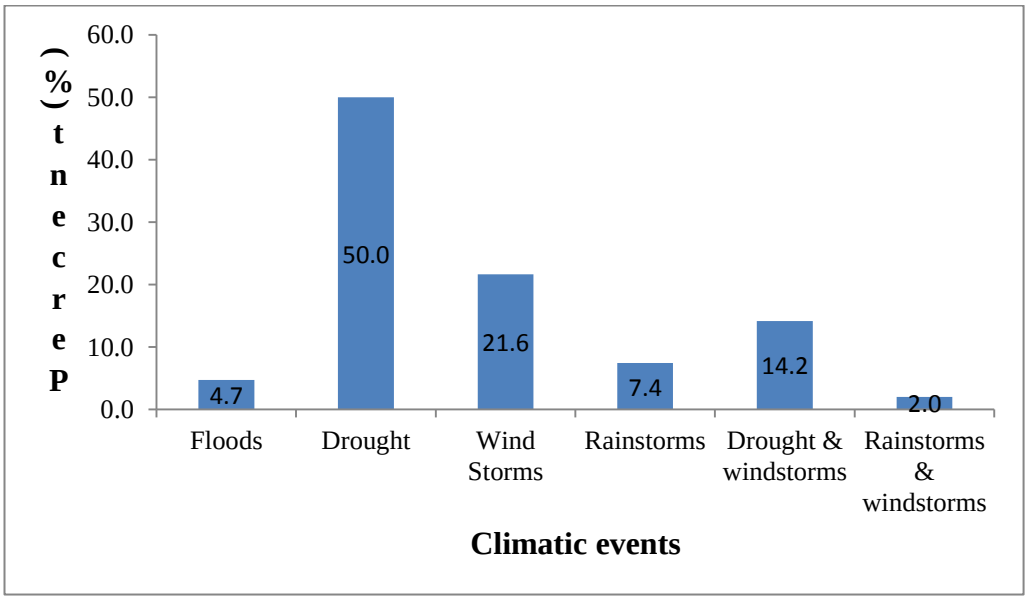

Figure 4.6 Climatic Events Recorded Over the Past 30 - 60 Years

Source: Field Survey, 2015

Also, 21.6% of the respondents identified wind storms as an event due to claims made on the fact that clouds do form and when they are hopeful that it will rain, strong winds rather are experienced destroying not only crops but also their homes. A percentage of (14.2) also identified a combination of drought and windstorms as climatic events experience in their community with the combination of these two as stated by respondents affecting their lives negatively. Farmers added from the discussions that even though all the events identified pose a lot of dangers to their livelihood, drought is the "devil" itself.

They lamented about the nature of this draught as very severe and dry destroying every agricultural move they make. Some farmers said that this nature has cause them to sometimes buy water to their farms to sprinkle on the farm for it to get soaked before they can harvest groundnut and bambara beans. Others added that, under the influence of drought they cannot afford to get water for their fields and so go with hard sticks which they use to beat on the earth till it loosens up for them to access their groundnut.

Lower percentages (7.4, 4.7 and 2.0) of response also identified rainstorm, floods, and a combination of floods and rainstorm respectively as events that occur in their communities. These events and their impacts do not only affect humans but also every other living thing. It is based on this that farmers complained that farm animals are also suffering due to limited water for drinking and grass for grazing which has resulted into the miserable and lean state of these animals. An interview with personnel's from the Ministry of Food and Agriculture also agreed to this as in their view drought has been the climatic event that has hit the Municipality over the years negatively and is evident in the dry nature of the land and the plight of farmers (Interview, 15/12/2015). All these events were found to be on the increase with a percentage of (68.2) responses supporting this claim as represented in Figure 4.7.

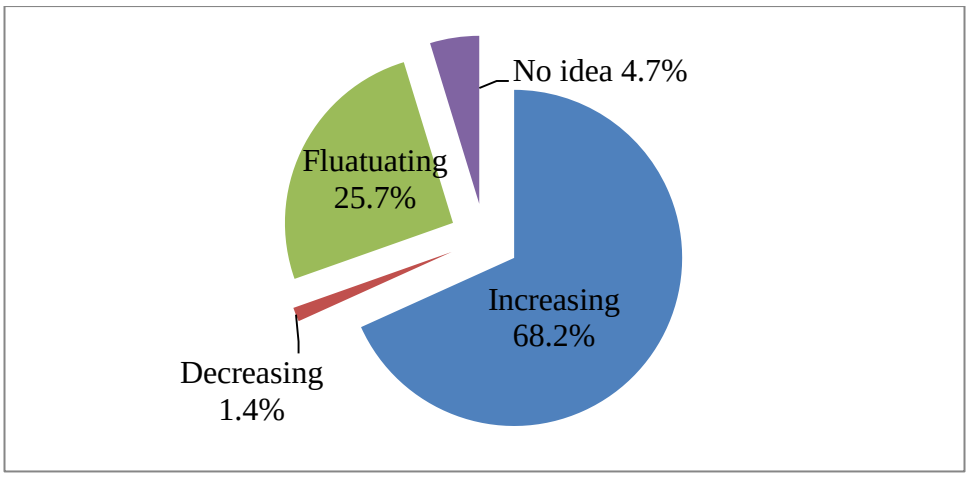

Figure 4.7 Trend of Climatic Events

Source: Field Survey, 2015

4.3. 4 Duration, Intensity and Pattern of Rainfall

Climate change has been known to result in unpredictable weather patterns. This is seen in the response to questions on duration of rainfall, intensity of rainfall and pattern of rainfall over the years. The results show variation in response from the duration of the rainy season and intensity of the rains. In Figure 4.8 while 79.1% of respondents said they experienced 4months of rainfall, 16. 9% said rains lasts for five months while 4.1% of the response said the rainy season lasts for three months.

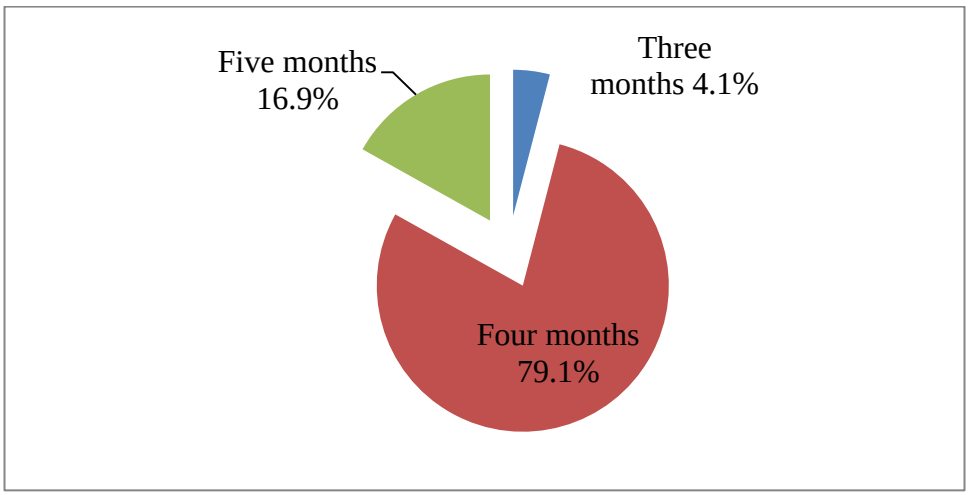

Fig 4.8 Duration of Rainfall

Source : Field Survey, 2015

In relation to the intensity of rainfall, 54.1% said they experience low rainfall, 38.5% said the intensity is moderate while 7.4% say the rains are high as presented in Figure 4.9. It was also clear from the discussions that despite the fact that the rains are low and late when they indeed set in and farmer are trying to manage with the rains to enable them get a little yield, the rains overdo it destroying the crops on their farmlands and consequently affecting their yield.

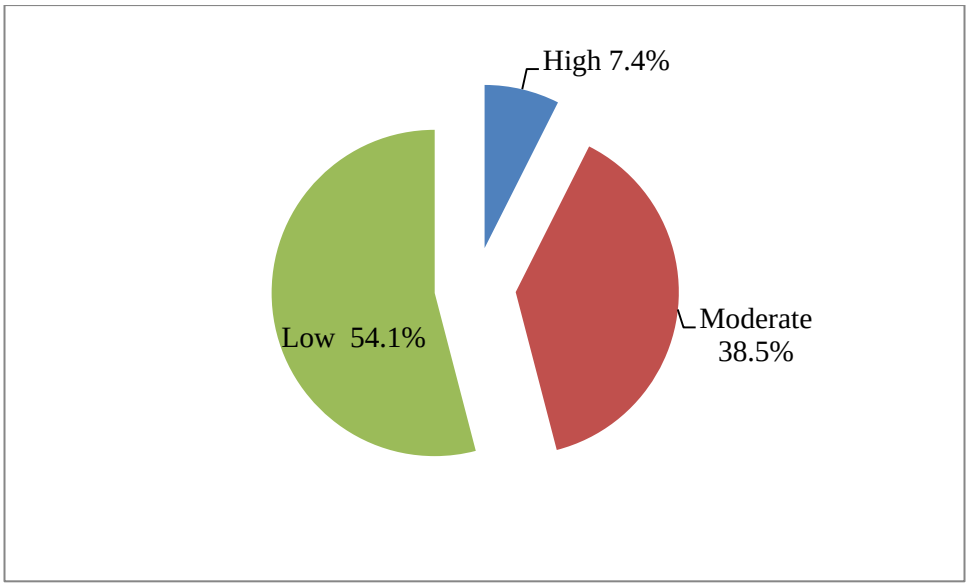

Fig 4.9 Intensity of Rainfall

Source : Field Survey, 2015

The month of August was identified by all involved in the study as the month associated with this unstoppable downpour which is largely referred to as "du liew"(torrential rain). This is because of the nature of the rains which is characterized with low downpour but drizzles that last the whole day. This nature of the rains soaks the earth making available too much water with little to no sun shine for crops. Crops then get rotten in the water thereby affecting

yield. Also it was further revealed that in some circumstance the down pour is great such that farmlands and homes are destroyed as one interviewee stated:

"The greatest impact of changes in the weather is the records of low rainfall over the years; however floods also occurring in some parts of the Municipality destroy farms, homes and even lead to the outbreak of diseases such as cholera"(Interview, USAID: ADVANCE, 08/01/16).

Further, the severity and nature of the harmattan which according to farmers and all interviewed personnel asserted, also set in earlier than the time it used to and is also as a result of low rains.

Analysis of rainfall data showed in Figure 4.10 from the Municipal Meteorological weather station shows that there has been variation in rainfall. The year 2014 from Figure 4.10 recorded the lowest total annual rainfall. This reduction caused severe hardship for farmers and other people of the Municipality as dugouts dried up and the water in the irrigation dam reduced so much that there was no dry season farming since farmers were told by the authorities at the irrigation scheme not to cultivate due the unavailability of enough water for the cropping season. Even wells according to farmers were also empty which led to incidence of hunger as a result of limited access to food due to no harvests during the dry season and the high cost of available food staff from the rainy season which many could not afford.

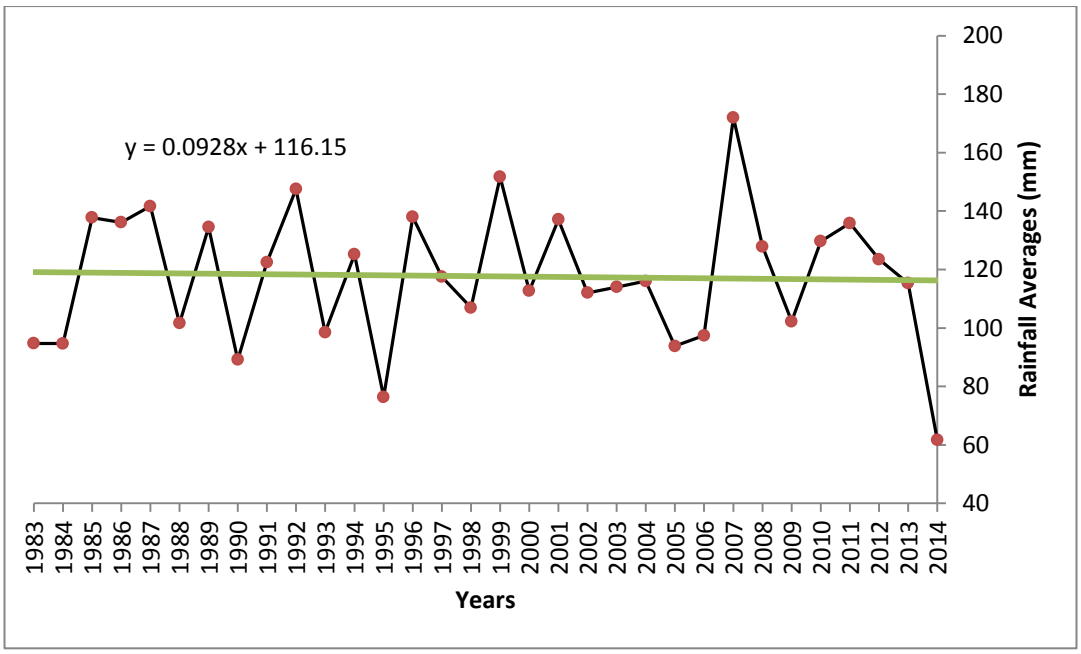

Figure 4.10 Rainfall Pattern Over the Past 32 Years

Source: Ghana Meteorological Agency-Navrongo, 2015

The equation in the Figure 4.10 indicates an average increase in rainfall from the year 1983 to 2014 however yearly variations have different implications. Yearly increase or decrease in rainfall affects varieties of crops differently. An experience of high rainfall will favour water loving crops while crops that require less water suffer. The impact of rainfall however is also influenced by the time the rainy season starts and the duration. From the focus group discussions, farmers indicated that there is a shift in the time for the onset of rains and the duration of the rainy season in the study area. The focus group discussions also identified that the time rains set in and the planting season have shifted backward which was associated with the changes in the climate. A farmer indicated that, the shift is visible in the month rains set in and the month crops are sown as follows:

"*Our father used to sow around March harvest early millet and sow late millet and groundnut before the rainy and planting seasons were over. This,*

however, cannot be said to be the case in our day. In our days, we do not only sow late but also once and as to whether the crops we sow will do well is another problem that we pray to God not to fail us " (FGD, Manyoro, 29/12/2015).

Interviews with officials from the Ministry of Food and Agriculture and other personnel's from the NGOs involved in the study also threw more light to the effect that there is evidence to show that this change has not only changed planting dates but has also distorted the farming pattern and calendar in the Municipality.

4.3. 5 Nature of the Dry Season

With respect to the dry season, 85.8% responses said they experience 5-9 months of dry season, 8.1% said they experience the dry season for 9 months and above while 6.1% said they experience the dry season between 1-4 months. The intensity of the dry season as alluded before has been on the increase. However, 95.3% of the nature of the dry season in their communities is often characterized by very high temperatures with dryness as shown in Figure 4.11. The nature of the dry season also affects available water. Low rains as identified by farmers provides little water for farming and the dry nature of the long dry season also results in massive evaporation causing further reduction in the quantity of water available for dry season farming.

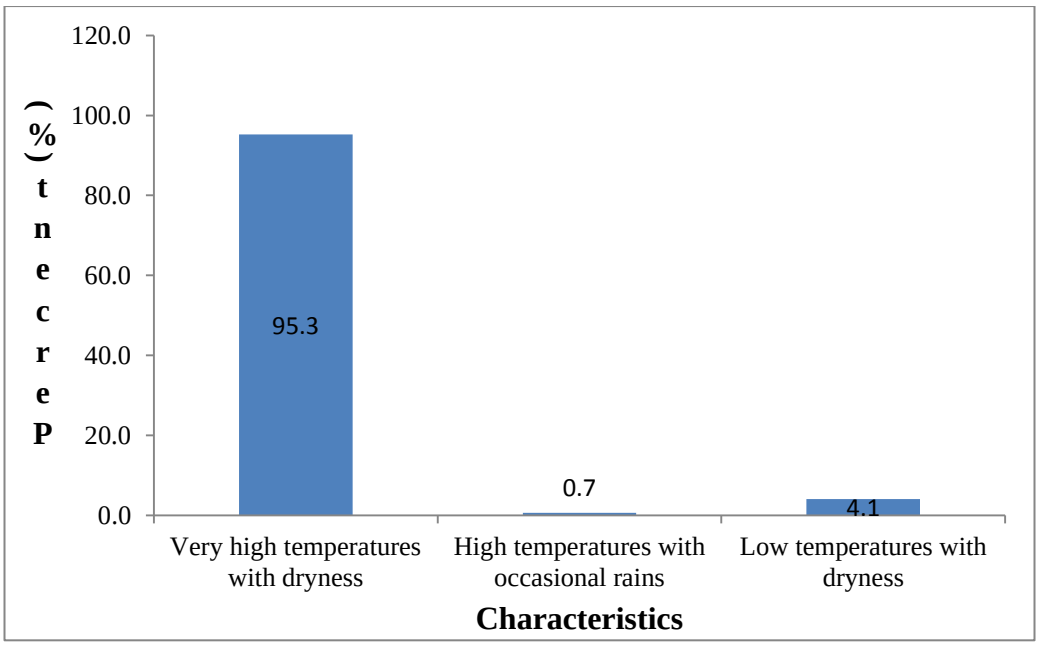

Figure 4.11 Characteristics of the Dry Season

Source: Field Survey, 2015

During the discussions, the nature of the dry season and its impact on the lives of farmer was stressed as farmers expressed the severity of the dry season over the years and the fact that it has negative impacts on their livelihood. A participant during the focus group discussion stated:

"*Growing up, signs of changes in the climate have been noticed for the past 30 years and beyond to include severe dryness especially during the dry season, this results in crops drying up leading to the reduction in crop yield. As at March due to low rains in 2014 and high sunshine, our dugout dried up and our animals suffered the most because that is their source of drinking water during the dry season"(*FGD, Doba, 01/01/2016).

Data from the Municipal Meteorological weather station on temperature further verifies the claims farmers made about the high nature of temperature

experienced over years and the consequent effect this has on their farming activities. This is visible as presented in Figure 4.12 which shows that though there are yearly variations in temperature, it signifies an increasing trend in maximum temperature from the year 1983 to 2014.

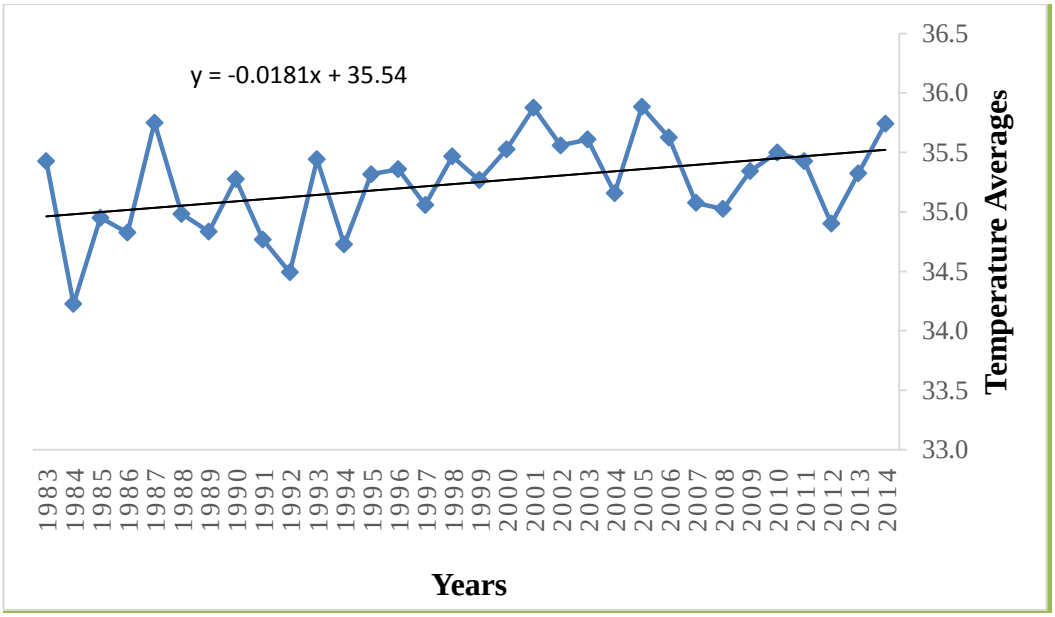

Fig 4.12 Maximum Temperature from 1983 to 2014

Source: Ghana Meteorological Agency-Navrongo, 2015

The equation in Figure 4.12 indicates an average increase in temperature from the year 1983 to 2014. This implies that increase in evaporations and dryness and consequently affects availability of water all year and crop output.

4.4 Impact of Climate Change on the Activities of Farmers

All the farmers interviewed said these changes have had negative impacts on their farming activities. It is to this reason that most farmers that is 50.0% presented in Figure. 4.13 said water availability for cropping was the area that was most affected by the impact of climate change with 55% of the respondents asserting that this has an extremely negative impact on their farming activities. With respect to the direct effect these changes have on crops

and output it was revealed by a greater percentage (35.1) that records of low crop yield is the greatest impact of climate change on their farming activities.

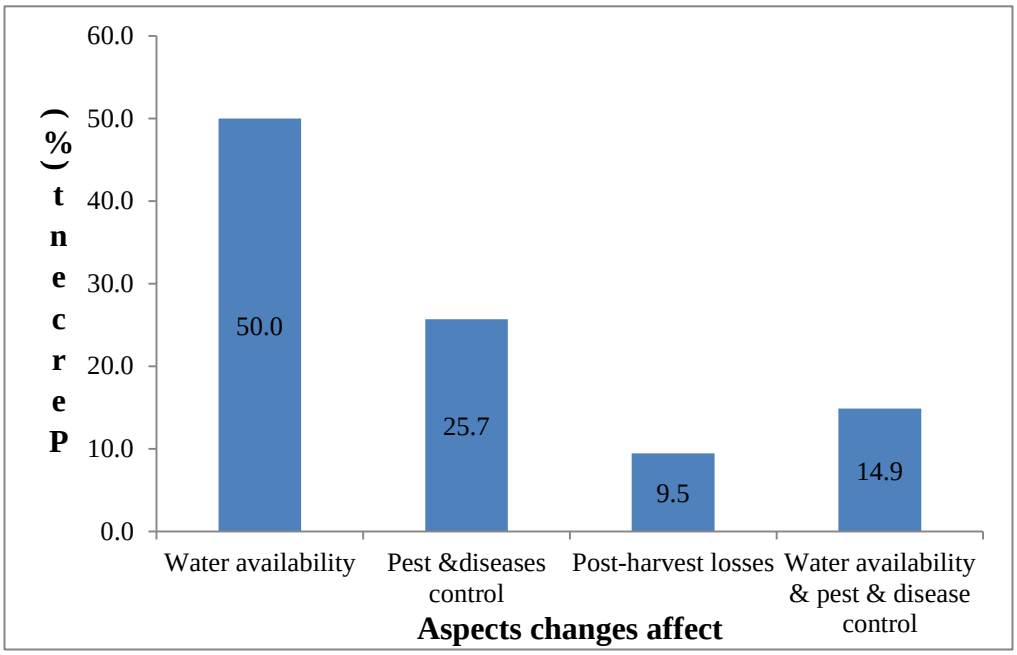

Figure 4.13 Aspect of Farming Affected by Climate Change

Source: Field Survey, 2015

It was further revealed from all the discussion that this change has brought a lot of pain and disturbance into the lives of farmers as farmers lamented that not only do they not get food to feed their families but also do not have enough to sell for funds to pay their children's school fees and also purchase clothes, books and pens for their children since money is used for everything. These monies are earned mainly from their farms, the major contributor to their income hence any limitation on it affects their every activity. This therefore highlights the importance of agriculture in the Municipality and the severity of the limiting impact of climate change on agriculture and the lives of the people of the Municipality since everyone located in the Municipality engage in some level of farming. Further, this impact of change on agriculture according to

farmers has left farm outputs in a sorry state compared to what their fathers use to earn. It is to this that one farmer stated that:

*"These changes have brought a lot of hardship upon our lives. Our parents used to cultivate on smaller parcels of land as compared to the acres and hectares of land we farm on yet upon all this their harvest was far greater than ours. Upon all this we are burdened with responsibilities such as paying school fees, feeding children and buying other necessities to make learning easy. So you can imagine the struggles we are going through and wonder what your generation will go through" (*FGD, Bonia, 25/11/2015).

More so, analysis of crop yield data from the Municipal office of the Ministry of Food and Agriculture show a variation in output for maize, millet, sorghum, groundnut and rice. There has been a general increase in average crop yield for rice, maize and sorghum from 1991 to 2014 with rice recording the highest increase in yield and sorghum recording minimal increase in yield for the years 2001 to 2009. However, for millet and groundnut there has been an average decrease in output. Though there were incidences of increase between the years 2001-2009 most especially for groundnut, the year's 2011 to 2014 saw a fall in output for both crops as shown in Figure 4.14. This reduction from the data therefore supports farmer's lamentation on the loss of the local breed of millet known as "chara" as presented in the words of a farmer:

'*There is a variety of millet called 'chara' (early millet) which is usually grown three to four months after Christmas. This millet matures and is harvested before the late millet and groundnut. However, this has changed due*

*to the fact that when we grow "chara" of late we end up cutting and burning the crops to make way for others because it doesn't yield. This is saddening because I invest money and get no returns' (*FGD, Manyoro, 29/12/2015).

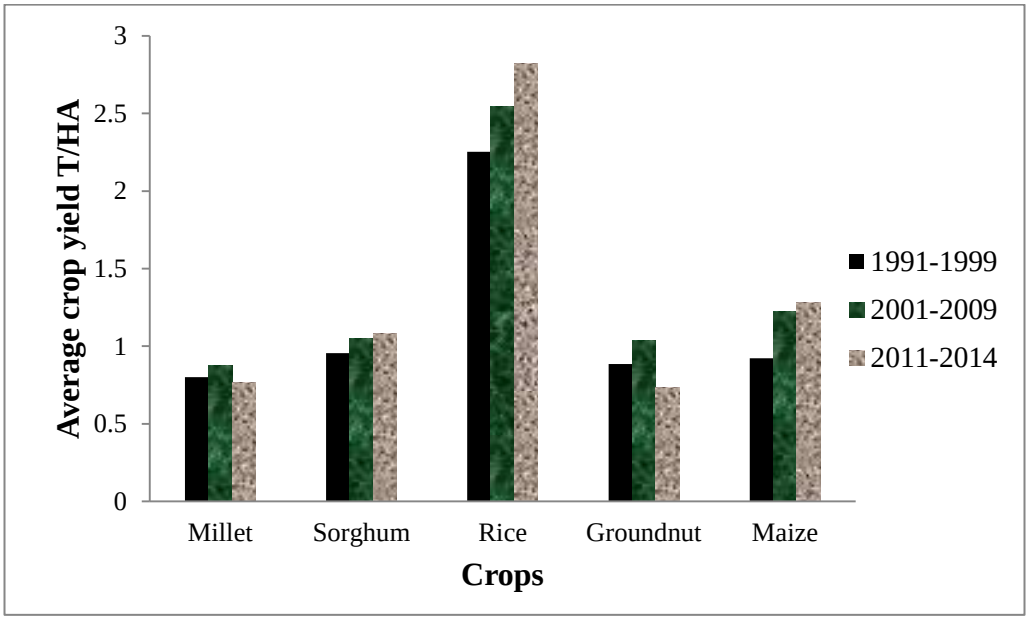

Figure 4.14 Crop Yield from the Year 1991to 2014

Source: MoFA-Navrongo, 2015

The increase in output in maize, rice and sorghum is due to interventions like the introduction of improved seeds, access to water, introduction of good farm practices, application of farmers coping strategies and the use of manure and fertilizer.

However, there are also variations in the total area of land farmers cultivate. As stated in the words of a farmer earlier; though farmers in their day cultivate hectors and acres of land larger than what their fathers use to work with, yields are low and are further threated as presented in Figure 4.15. Information from the figure indicates that there have been significant variations in area cultivated

from 2001 to 2014. This is due to the impact of climate change on farming activities. As variations in rainfall affect the parcels of land cultivated.

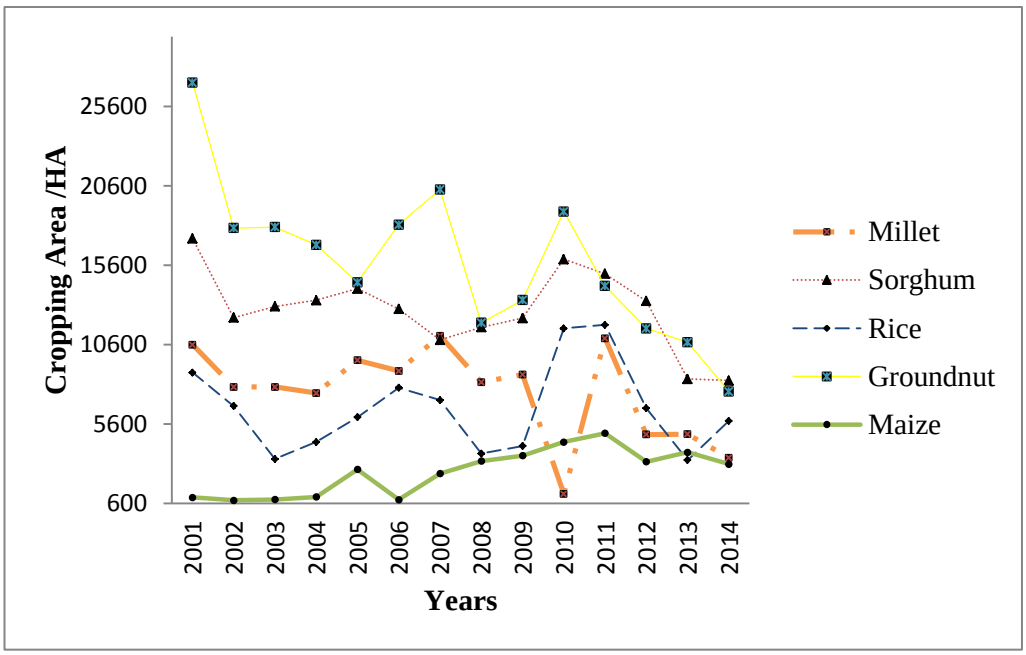

Fig 4.15 Total Area Cultivated from the Year 2001 to 2014

Source: MoFA-Navrongo, 2015

Another impact of climate change on the lives of farmers is the introduction of diseases that affect plants and animals as well as pest that destroy crops on the field and after harvest. An interview, of an officer from centre for social mobilization and sustainable development, an organization that works with farmers in the Municipality revealed that, certain new species of insect have emerged as a result of the change which destroys plants. He further added that growing up, farmers used to spray little quantities of chemicals and others none at all to get rid of these insects but these days it is just too much spray and persistent insects that destroy crops (Interview, CENSODEV, 05/01/2016).

Farmers also complained about how their animals are attacked by -diseases resulting in the death of many of these animals while those that survive look miserable. The emergence of diseases do not only affect animals and plants but also humans as farmers made it clear that there are sicknesses that befall them that they never saw or heard of when they were growing up. A farmer stated:

"These changes have brought a lot of diseases especially the sun and hunger to our land. There are strange sickness accompanying these changes and coupled with hunger you can imagine the pain we are going through. It has not been easy on us at all (FGD, Bonia, 25/11/2015)."

The impact of these diseases on farmers as added from the study affects the active nature of farmers as farmers are weakened and cannot work long hours on their farms therefore resulting in lower output. Others who also gain income from the sale of farm animals, complained about great losses due to sicknesses/diseases.

4.5 Farmer Adaptation to Climate Change

4.5.1 Coping Strategies

The study revealed that farmers are coping with the change. Farmers however, say that, despite the effects of change on output, God, their maker provides them with their daily bread. Farmers also added that at their end, they do their best to manage with what they have been given because they have no other option but to survive with the change since the change has occurred and cannot be manipulated to suit the desires of humans with a snap of a finger. From the study, credit was given to women by the men for their ability to manage the yields they get from their farmlands till the next harvesting season. Farmers

further added that, when the food shorts, their wives go out into the world and do their best so as to raise money or food to feed the family. Also, aside the yields from their farmlands, farmers also engage in supplementary livelihood activities to help them earn money to complement the output they get to enable them carter for the needs of their families.

The supplementary livelihood activity that contributes to the income of farmers aside the sale of crops was the sale of farm animals. This, according to farmers is very lucrative since prices for these animals are very good. Other farmers though a few of the men are skilled and offer carpentering services to people in need for a fee which earns them extra money when they are not busy on their farms. Petty trading and the brewing and sale of pito were also supplementary income activities dominant among the women. Most of the farmers asserted that the cutting and sale of fire wood from the forest was also a lucrative means of earning money but lamented on how it has been limited these days because there are no trees like there was growing up. Offering ones labour for a fee was another source of income as most farmers said they provide their services at construction sites and on the farms of others to earn money and termed it as "by day". This according to farmers is mostly at the irrigation sites and neighbouring towns where services are either offered to transplant crops or harvest. According to one famer:

"Others also travel as far as Tumu to offer their services in picking cotton as well as harvesting maize. The truck just arriving with the women getting off it

are from Tumu after a week's stay. These are some of the things we do to help survive with these changes" (FGD, Manyoro, 29/12/2015*).*

From the discussions, it was also made known that belonging to farmer groups as well as savings and loans groups helps farmers cope with the change as farmers support each other in kind and cash. In the words of one farmer:

"Joining this farmer group has helped a lot most especially for members that are old and not strong enough to travel to the irrigation site to offer services for a fee. This is because collectively working with others on our group gardens helps us earn money from the sale of vegetables." (FGD, Doba, 01/12/2015).

Table 4.4 present a summary of how farmers have decided to cope with climate change and reasons for the decision.

Table 4.4 Coping Strategies and Justification for the Choice

S/N	Coping strategy(form of adaptation)	Justification for the coping strategy
1	Manage with the harvest God provides	To survive till the next harvesting season
2	Survive with the harvest and money from labour services offered	Money earned is used to buy foodstuffs to supplement yield from harvest
3	On the harvest and money from petty trading	Earn extra money to contribute to the upkeep of families
4	On the harvest and money from carpentering services	Survive on money made from carpentry jobs too
5	On the harvest and sale of farm animals	Money earned from sale supplements farm harvest

Source: Field Survey, 2015

4.5.2 Adaptive Measures Employed

It was revealed that with respect to general measures put in place by farmers to cope with climate change, dry season farming has been the most practiced measure. Interviews with personnel from all seven institutions and organizations commended that farmers themselves have been doing their best to cope with this change. This they say is evident from the rate at which there is an increase in the number of farmers involved in dry season farming over the years. It was also brought to notice by farmers that they do their best to survive and try to work with the rains given. It was observed that this dry season farming mostly is in the form of gardens as presented in Plate 4.1 with only those with their farms at the irrigation site cultivating large parcels of land.

Plate 4.1 Farmer in his Garden

Source: Field Survey, 23/12/2015

Further, it was revealed that the sources of water for these gardens and farms varied with the location of the communities. The communities that are closer to the Tono irrigation site mostly have their farms closer to the site hence use water from the dam for cultivation. Information gathered from other communities indicate that , communities further away from the irrigation dam with access to dugouts also make use of water from this water source for their farming activities while communities without any access to open water sources dig wells manually as presented in Plate 4.2 to water their crops. Wells have always been with the people as a source of water for domestic use but now also a mode of adaptation; farmers move to valley areas within their communities and use these dugouts to water their crops. These wells however are not improved wells.

Plate 4.2 Handdug well

Source: Field Survey, 23/12/ 2015

The crops that farmers cultivate during the dry season also varied across communities based on their location and source of water. For the communities that farm closer to the irrigation site, rice was the major crop cultivated as presented in Plate 4.3 though others varieties of crops were cultivated. However, it was noticed that communities that use water from dugouts and hand dug wells largely cultivated vegetables. Some of these crops include; tomato, pepper, cabbage, carrot and green pepper, with a few farmers cultivating maize occasionally.

Plate 4.3 Rice Farm

Source: Field Survey, 20/12/ 2015

Farmers with their farms along the Tono irrigation site aside from rice, also cultivate varieties of crops mainly grains which include maize. While others, cultivate vegetables as presented in Plate 4.4. Tomatoes and pepper are also cultivated largely. This gives farmers along the irrigation site an advantage over farmers in communities that rely on water from dugouts and wells.

However, all these water sources are influenced by the intensity of rainfall. This is similar to the findings by Luabe et al., (2011) from a study in Atankwidi and Anayere catchments of the Upper East Region which revealed that shallow groundwater irrigation has helped small scale farmers adapt to the changes in the climate that affects their immediate environment. The water supply is usually from wells and dugouts which farmers use buckets to carry to water plants. The study further realize that even though the Tono and Vea irrigation dams were constructed by government in the 1990s to help support farmers in the long dry season, lack of rain has reduced farming around these irrigation dams with much of the farmers resorting to shallow groundwater irrigation.

Plate 4.4 Vegetable Farm

Source: Field Survey, 20/12/ 2015

Also, another identified measure employed by farmers to help improve upon their ability to cope with climate change is planting trees at the edges of their farms. It was observed that farmers were indeed planting trees as presented in Plate 4.5 to help shield crops from the rainstorms and windstorms that destroy crops. Most of these trees were however economical trees such as mango trees which earn farmers money from the sale of fruits. According to farmers this decision largely has been influences by the sensitization that Ministry of Food and Agriculture and other Non-Governmental Organizations provide.

Plate 4.5 Farmland Showing Tress at its Edges

Source: Field Survey, 27/11/ 2015

The responses from the interviews with personnel's also stated clearly that institutions are doing their best to educate farmers on climate change as well as help them improve upon their adaptive skills and measures through radio

programs, forums, meetings and demonstrations. These efforts they added are to help increase farmer awareness on climate smart measures that will help them cope better than they are doing currently under the influence of the negative impact of climate change. As stated by an interviewee:

"Our institution has tried to educate farmers on climate change and also promote some climate smart measures to help farmers in the region through the use of demonstration. We also try to encourage farmers to grow cover crops as well as practice mulching to protect their soil and also help retain water on their farmlands for long. It is also important to add that, these measures are yielding positive results as some farmers have been seen employing some of these measures upon visits back to communities and the grater hope is that upon seeing the benefits of these measures on farmers other farmers will also emulate"(Interview, USAID: ADVANCE, 08/01/2016).

In addition, the application of manure and chemical fertilizer has also been measures farmers employ to cope with the change. This is to help improve the fertility of the soil so that, even when rains are low due to the fertile nature of their farmlands, their yields will be good. Besides enriching the soil, it also retains moisture. Even though most farmers assert they prefer the application of manure due to the trust they have in it, majority however, apply a combination of both chemical fertilizer and manure to complement each other since they indicated that, there is limited access to manure. The manure is usually prepared by feeding farm animals with groundnut leaves after harvest. Animal dropping during the course of feeding, mix with the leaves to form

manure which is collected and applied on farmlands as presented in Plate 4.6. Manure is also prepared by burying groundnut leaves. The groundnut leaves are usually collected and stored as presented in Plate 4.7 and used for the manure preparation and mulching.

According to farmers, during the rainy season they do their best to practice multiple cropping so that if some of the crops fail, those that are apply to survive under the conditions of change will provide food for their consumption. Also, the act of expanding farmlands is another adaptive measure employed by farmers as majority of the women stated that they help their husbands expand their farmland so that their yields will also increase. The act of raising bunds on farmland to retain water was another measure identified as a measure farmers employ to cope with the change. An interview with a personnel from the Municipal office of the Ministry of Food and Agriculture even revealed the same as it was brought to notice that, this method of harvesting water was been practiced. He raised the point that, water harvesting method also known as “tying the ridge” upon their sensitization have recorded a higher percentage of farmers practicing the method. It involves the practice of farmers creating bunds on their ridges to trap water for longer periods on farmlands for plants to absorb the water periodically for growth.

Plate 4.6 Applied Manure on Farmland

Source: Field Survey, 25/11/ 2015

Plate 4.7 Stored Hay for Animal Feed and Mulching

Source: Field Survey, 27/11/ 2015

The study further revealed that change in planting date; crop diversification and soil fertility conservation are some farming strategies adapted by farmers. As presented in Figure 4.16 change in planting date was the highest strategy adapted with a greater percentage (41.2) of respondents attesting to this fact. The discussion revealed that this change in planting date is an initiative by the farmers themselves as farmers said they had to take this measure because the rains have changed and as such are directed by the rains on the time to sow hence their decision to sow immediately after the rains set in. All institutions involved in the study revealed that upon their visits to communities it came to their realization that immediately it starts to rain farmer's sow.

A percentage of *(*25.0) responses adopt soil conservation while 23% adopt crop diversification. The choice of soil conservation and crop diversification helps make sufficient nutrients available for crops and increase yield as new varieties withstand change respectively, A smaller number of the respondents from the study practice a combination of these strategies. Early maturing and drought resistant seeds made available by the Ministry of Food and Agriculture is also helping improve farmer adaptation in various communities.

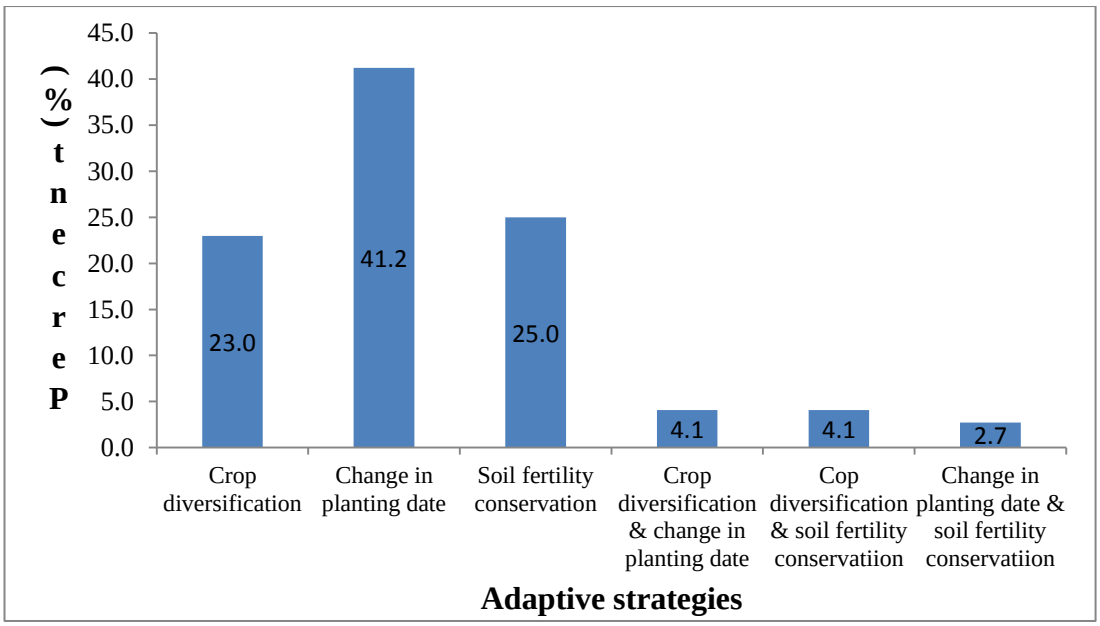

Figure 4.16 Farming Strategies Adopted

Source: Field Survey, 2015

Table 4.5 presents a summary of adaptive measures farmers have adopted and reasons why farmers opted for such measures to help reduce the negative impact of climate change on their farming activities.

Table 4.5 Farmer Adaptive Measures

S/N	Adaptive measure	Justification for use as adaptation measure
1	Dry season farming	Availability of food all year round
2	Tree planting	Protect crops from rainstorms and windstorms
3	Manure and chemical fertilizer application	Improve soil fertility
4	Multiple cropping	yield security
5	Raising bunds on farmland	Traps water for long on farmlands
6	Expanding farmlands	Increase in output
7	Change in planting date	Access to water for crops
8	Soil conservation	Makes nutrients available for crop growth
9	Crop diversification	Old varieties cannot withstand change

Source: Field Survey, 2015

The decision however to employ these measures to survive as identified by farmers is driven by the impact of climate change which farmers refer to as the "hunger" that they are experiencing. In their view, when one is hungry he or she applies the brains given to find solutions to feed oneself. It is for this reason therefore that they adapt these strategies to avoid their families from starving to death. This can be likened to the result from a study by Uddin et al. (2014) who concluded that, farmers' decision to adapt is based on their actionable steps to address issues related to change. Most institutions testified that most of the adaptive measures these farmers are employing are from indigenous knowledge and their influence largely is to build on these existing strategies enhancing them for the benefits of all.

However, the role of extension officers from the Ministry of Food and Agriculture and other Non-Governmental Organisations according to farmers cannot be undermined. Farmers added that, the knowledge these institutions have shared with them most especially on how to apply fertilizer, grow cover crops to protect the soil, practice minimum and low tillage, promotion of the use of bullocks to plug instead of the use of tractors to protect soil structure and other farming practices helps a lot in their farming activities and adaptation. It was however brought to notice by institutions involved in the study that, though the number of farmers involved in climate change adaptation measures are greater than the number that use to practice these measures, the increase is considerably low.

4.5.3 Impact of Existing Measures on Farmer Adaptation

From the study, it was revealed that farmers' decision to employ some farming measures and strategies to help minimize the negative impact of climate change on their lives has influenced adaptation positively. A greater number of farmers involved in the study said upon their decision to employ these measures there have been an improvement in their yield and a reduction in their level of vulnerability to climate change. A percentage of (56.8) of the respondents said the improvement in their yield is minimal, 25.7% said the improvement is moderate while 17.6% assert that the improvement is significant. Contributions from the discussions with farmers also revealed the same. Also, information from interviews further added that, there is indeed an improvement in yield as farmers gradually employ these measures though the impact was minimal. One interviewee stated:

"To an extend the strategies farmers have adopted has reduced their vulnerability to climate change as shifting to early maturing seeds and a shift from millet to maize has increased farmer yield. This however is minimal as change is quite difficult for farmers to abandon the traditional ways of doing things completely" (Interview, ACDEP, 08/01/2016).

This finding further confirms the finding of Adebayo et al. (2012) from a study in Adamawa State, Nigeria which also revealed that adaptation measures embarked upon by respondents has contributed to the minimization of the effect of climate change on the activities of farmers. Table 4.6 presents a summary of the influence of adaptive measures on farm produce as well as the livelihood of farmers.

Table 4.6 Adaptive Measures and their Influence on the Lives of Farmers

S/N	Climate change adaptations	Positive influence on produce	Positive influence on farmer livelihood
1	Dry season farming	Availability of water	Availability of food year round
2	Tree planting	Protects produce from strong winds and rains	Secured yield
3	Manure and chemical fertilizer application	Availability of nutrients for produce	Increase in yield
4	Multiple cropping	Produce benefit from each other	Increase in yield
5	Raising bunds on farmlands	Produce have access to water	Increase in yield
6	Change in planting date	Produce have access to water	Increase in yield
7	Soil conservation	Sufficient nutrients for produce	Increase in yield
8	Crop diversification	Good yield due to resistance	Increase in output

Source: Field Survey, 2015

4.6 Culture and Adaptation

4.6.1 Cultural Practices that Influence Agriculture

According to farmers their forefathers left behind a range of practices that influence agriculture. The greatest is the consultation of the gods for direction and guidance especially with respect to rains. The gods will then listen to their request and communicate to them as to when rains will set in as well as the time these rains will stop hence influencing their decisions to sow. However, they also added that this current generation has abandoned this practice passed down by our forefathers . In the words of one farmer:

*"In the days of our fathers the "Tindana' (land custodian) and the chief were united and consulted the gods of our land for advice on when to sow crops and when not to, after a down pour. The message was then relayed to the people of the land which was relied on and also worked for them. However, these days we do not consult the gods of the land for direction and actions to take but just do as we please and now suffering the consequences of our action (*FGD, Manyoro, 29/12/2015).

Further, the preparation and application of manure was another practice identified by farmers as a cultural practice that has been passed down that influences agriculture. According to farmers, the practice by their fathers that they observed growing up has always been that, after every harvest farmers gathered the straws of maize, millet as well as leaves of other crops such as groundnut, beans and pumpkin. These straws and leaves are then taken to the portion of the house known as "naboo" (kraal) for animals to feed on. While animals feed on these leaves and straws, they left their droppings which mixed up with the hay forming manure which farmers then collect and applied on their farmlands.

This practice of manure preparation was also observed though it was revealed that the method used in the preparation of manure has changed for some farmers. As presented in Plate 4.8 after every harvest some farmers rather leave the straw on their farmlands for animals to eat while leaving their dropping. The preference of leaving the straws and leaves on farmlands

according to farmers is due to the fact that, they do not have animals to feed at home while others said it was tiring to carry hay inside and latter collect it to apply on their farmlands.

Plate 4.8 Farmland Showing Straws After Harvest

Source: Field Survey, 25/11/ 2015

It was further revealed that, land preparation was another practice that has been handed down from generation to generation in the view of farmers. This is done before the rainy season begins. The process involves farmers clearing their farmlands while turning the soil in the process to evenly mix the nutrients. This, farmers claimed used to be done by their fathers after they celebrated Easter in the month of April but has changed over time because now they usually do that when there is a continuous pattern of rainfall for say a week and are convinced the rainy season will set in fully. Another is the knowledge and skill needed in the selection and storage of seed for the next planting season.

It was further added that the practice of turning cattle dropping to food for fowls to feed on is another practices that influenced agriculture. The process included these droppings being collected and placed at an area where termites are dominate for days in some cases three days to attract these termites which are then collected and fed to fowls.

4.6.2 Influence of Cultural Practices on Adaptation

The study revealed that cultural practices influence adaptation to climate change in the Municipality. From the study, the perception majority of the farmers hold is that culture has only a positive influence on agriculture. This is evident as 50.0% of the respondents said culture had no negative impact on agriculture and adaptation. This is because of the benefits farmers derive from some farming practices passed down to them. Manure preparation and application, land preparation and seed storage are some practices that still hold grounds as they help increase fertility of the land, make the land conducive for cultivation and makes available healthy seed respectively. However it is worth noting that, of all these practices manure was hailed the most.

A case study by Edwards in Ethiopia captured in IFOAM (2009) policy document on the use of organic manure as an adaptive measure to climate change yielded good results as results proved that, the application of organic manure is a very effective and important tool in adaptation to climate change. This is because the use of organic manure by farmers helped farmers use water more efficiently and also lead to the increase of yield which helped improve upon food security.

The study further revealed that indeed some practices have influenced adaptation positively as an interview with the director of Centre for Social Mobilization and Sustainable Development, who brought to light that, culture, has always influences agriculture positively for generations. This is through taboos such as apportioning days that prohibited farmers from going to the farm and taboos that govern the felling of tress in certain communities. In his view, the protection of sacred groves and the celebration of the "Fao" festival also influenced adaptation till this day. "Fao" festival for instance is celebrated to give gratitude to the gods of the land for a good harvest but also present an avenue for farmers to meet and share ideas as well as a ground for information from institutions and organizations to reach farmers including information on climate change and adaptation. For example at the festival grounds if you are a farmer who has noticed that your yields are lower than others, you will surely ask others to know what you are doing wrong so that you can improve upon the strategies you practice(Interview, 05/01/2016). According to a personnel from the Ministry of Food and Agriculture, ploughing across slopes which reduces water runoffs is another practice that one can say has been passed down from generation to generation because upon their visits to communities, this practice was in existence (Interview, 15/12/2015).

Though culture has a positive influence on agriculture and adaptation there are also some limitation that culture poses to effective adaptation. This is because farmer's ability to adapt newer measures and strategies which will help reduce vulnerability tends to be limited by culture and its influence on perception.

This is because change from the old ways of doing things tends to difficult. As one interviewee stated:

"One of the factors that influence climate change is the belief system concerning what climate change really is. Majority see the changes in the elements of the weather as a punishment from God and not what it really is which is that their own activities contribute to the problem of climate change. The only way we can achieve reducing farmer vulnerability to the impacts of climate change is to first of all make sure that farmers understand what they are experiencing"(Interview, CENSODEV, 05/01/2016).

A summary of cultural practices and their influence on adaptation is presented in Table 4.7.

Table 4.7 Summary of the Influence of Cultural Practices on Climate Change Adaptation

S/N	Cultural practices	Positive influence on climate change adaptation	Negative influence on climate change adaptation
1	Consultation of the gods		Limits farmer decision to adapt newer strategies
2	Manure preparation and application	Increases soil fertility on farmlands	
3	Land preparation	Turning the soil in the process helps distribute nutrients	
4	Seed selection and storage	Maintains quality of seeds	
5	Celebrating Fao Festival	A platform for climate change information to reach farmers	
6	Ploughing across slopes	Reduces runoffs hence protects crops from damage	
7	Turning cow dung to feed	Provide feed for farm birds	

Source: Field Survey, 2015

4.7 Limitations to Adaptation

From the study the greatest limitation to adaptation as identified by farmers is availability of water for farming especially for dry season farming. This as explained earlier affects crop output. During one focus group discussion presented in Plate 4.7, a farmer states:

"The dry season gardening you are seeing is another way we support our families in this community however, just a few are lucky to farm around the project area. The land is available but due to limited access to water just those with farmlands close to the dugout partake in this dry season farming" (FGD, Doba, 01/12/2015).

Plate 4.9 Focus Group Discussion at Doba

Source: Field Survey, 23/12/ 2015

Further, access to capital is another limiting factor that affects adaptation. This was reflected in the responses as 67.6% of the responses assert to this fact

while 32.4% said it is due to knowledge gap on adaptation. According to farmers, capital is very important when it comes to agriculture this is because at every stage it is needed. That is from the purchase of tools, new varieties of seeds and fertilizer to the bagging of produce. Farmers further added that even water for dry season farming comes at a fee. Farmers that cultivate along the irrigation site using water from the dam said they pay water levy which is charged according to the number of acres one cultivates. The amount paid they added is 30 Ghana cedi per acre. Farmers that use dugouts and hand dug wells also added that, though dugouts are community property and wells are self-constructed, the cost of buying tools to dig wells and machines to pump the water to farmlands is quite expensive and require huge sums of money.

Farmers also said, dry season farms which are in the form of gardens use wire mesh to fence their farms protecting them from wondering animals. This wire mesh they added also comes at a cost. One will think that from the sale of produce farmers will earn money which they can invest back onto their farms. This however isn't the case as farmers complained that they send their produce most especially rice to the market and carry them back home due to lack of market for their produce. This also affects available capital for further farming activities. In the words of a farmer:

*"We sent rice to the market yesterday and had to carry it back due to poor patronage. This is saddening because one will invest all that he or she has and get negative feedback when without the sale of these produce I have no money to farm again"(*FGD, Bonia, 25/11/2015)

Luabe et al. (2011) in their study also revealed such findings pertaining to farmer sale of produce which they identified is subjected to the influence of market failures and identified as a threat to farmer's adaptation to environmental changes as well as overcoming poverty.

More so, it was revealed that the Municipality is characterized by an open system of grazing where animals roam about on fields feeding with most of these animals destroying farmlands and gardens in their quest for food. A personnel from one organization asserted that the Fulani heads men and the cattle under their care pose serious challenge to farmer's ability to adapt effectively due to the destruction these animals cause to crops. He further added that, the incidence of bush fires also limits farmer's ability to adapt effectively. (Interview, GAWU, 22/11/2015).). Farmers also complained about how most of their farms are being destroyed by animals and bush fires. The inferior nature of the wire mesh from donors and on the market makes their gardens more vulnerable to animal destruction. Farmers further added that education on the prohibition of the burning of the bush has been well received but others still burn the bush. In the words of one farmer:

"*Yesterday for instance we heard an announcement that rice farms in one community near a dam called Gungolo were on fire. We can only imagine the pain these farmers are going through. After all the energy and capital they have invested onto these farms" (*FGD, Doba, 01/12/2015).

Availability of labour also poses limitations for adaptation. Farmers complained that limited number of hands to work with on farmlands has also affected agriculture and adaptation most especially during the dry season. This is because when there is little to do on farmlands with much to do at the irrigation site where services can be offered for a fee, strong energetic men and women are unavailable to offer their services for a fee. The blame however, farmers largely put on the introduction of formal education by the white man that has caused the absorption of all the able and strong men who they added are strong enough to work. Farmers, however, stressed that this is not to say they condemn formal education but just that with the presence of change and the impacts it brings, they need all the labour that is available.

Farmers further lamented about the unavailability of the early maturing and drought resistant seeds. Some farmers said upon the hearing of the introduction of early maturing and drought resistant varieties of maize which farmers in other communities were sowing, they tried their best to acquire seeds but these seeds as usual were not made available to their community. Others also lamented about the disappointing nature of some of these seeds as majority said they had to cut the cowpea variety they sowed during the 2015 rainy season for animals to feed on since all it produced was leaves with no single seed. Also, limited number of agriculture extension agents hinders the ability of information on adaptation to reach communities. According to one personnel from the Ministry of Food and Agriculture, the Municipality has only eight (8) extension officers working in all the communities within the

entire Municipality which makes accessing all these communities difficult (Interview, 15/12/2015). The influence of limiting factors to adaptation is summarized in Table 4.8

Table 4.8 Influence of Limiting Factors to Climate Change Adaptation

S/N	Limiting factors of climate change adaptation	Negative influence on climate change adaptation
1	Lack of water	Limited access for farming
2	Limited capital	Limits farmers ability to purchase farm inputs as well as pay water levy
3	Limited market for farm produce	No returns to invest in adaptive measure
4	Open system of grazing	Farmlands and gardens are destroyed
5	Bush burning	Farmlands and gardens are destroyed
6	Lack of labour	Affects farmers ability to increase farmlands and farming activities
7	Limited access to of improved seeds	Affects crop output since old varieties cannot withstand the change
8	Limited number of extension officers	Limits farmer access to information on climate change and adaptation

Source: Field Survey, 2015

4.8 Measures to Help Reduce Limitation to Adaptation

From the study, it was brought to light that 33.1% of the respondents said increase and improve access to capital will make farmer adaption to climate change more effective especially when loans that attract lower interest rates are made available to them. Farmers, who constitute 30.4% of the responds, said improving exiting adaptive measures to climate change will help adaptation while 23.4% said sensitization on adaptation will help reduce the limiting factors that hinder effective adaptation. A fewer population of the

responses however think a combination of all these measures will help promote effective adaptation hence reducing vulnerability.

The discussion further added that farmer's opinion on improving adaptation is to embrace their culture and follow in the steps of their forefathers so as to enjoy the favours that they enjoyed. As one farmer stated:

"The suffering we are experiencing is due to the disrespect the youth now portray towards our forefathers and their parents. When we try to explain to them that neglecting the ways of our fathers is disturbing us they tell us what we are saying, is of the days of the past "kolo." Christianity has come to change everything and we do not have that contact with the gods to ask for such favours. We rather acknowledge Christianity and regard our ways as the ways of the devil" (FGD, Doba, 01/12/2015).

Women from the discussion identified themselves as the sole cause of the neglect of the ways of their forefathers. In the view of women ,they first accepted Christianity and started going to church and due to the love some of their husbands have for them and the desire for peace, the men also joined in neglecting the believes inherited from their fathers.

The study again showed that, access to technology will help improve upon water harvesting and land preparation which will add up to solutions that will help reduce the influence of limiting factors on farmer adaptation to climate change. In the view of one interviewee, agriculture is the means through which

Africa and our communities can grow and it would mean we all playing a role in helping farmers adapt to the change. It would therefore help a lot if all this knowledge is made available to farmers to help promote agriculture and provide food for as all.

Table 4.9 Measure to Help Reduce Limitations to Adaptation

Actions to be taken	Frequency	Percent
Improve access to capital	49	33.1
Sensitization on adaptation	35	23.6
Improving existing adaptive measures	45	30.4
Improve access to capital and sensitization on adaptation	10	6.8
Improve access to capital and existing adaptive measures	6	4.1
Sensitization on adaptation and improve existing adaptive measures	3	2.0
Total	148	100

Source: Field Survey, 2015

Farmers added that most supports provided to them with the purpose of helping them improve upon their farming activities are usually handed into the hands of selected representatives outside their communities who really do not know what they are going through in their communities. As such these aids rarely reach them and in some cases when they do arrive late. An example of such happenings farmers added was the delay in making available early maturing maize seed for the 2015 planting season. Even though they heard these seeds were given months before they started sowing, these seeds arrived in their communities after they had sowed and crops were three weeks old.

4.9 Applying Framework for Farmer Adaptation to Climate Change to Findings

Adaptation in the Municipality from the influence of climatic disturbances indeed influences farmer risk perception and farmer responses. This is because from the study it was realized that the impact of climatic disturbance informed farmer knowledge on the existence of climate change and within their capacity, employ measures to help them limit the impact of change on their lives. This decision to cope with the change has also informed the types of adaptation farmers in the Municipality employ which are autonomous and reactive. Autonomous because adaptation by farmers has been self-initiated and driven by the suffering farmers say they feel. It is also reactive because measures adapted are to help farmers survive after the fact of climate change has occurred.

4.10 Conclusion

The study aimed at looking at farmer adaptation to climate change in the Kassena- Nankana East Municipality. The findings show that farmers, the Ministry of Food and Agriculture and all seven concerned Non- Governmental Organizations involved in the study are doing their part to help promote farmer adaptation in the Municipality. This collective effort as revealed in the study, however, is not yielding effective adaptation due to limitations.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Major Findings

Chapter five focuses on the concluding phase of the study. It includes a summary of the major findings from the study, conclusions drawn from these findings and recommendations from the study that can be acted upon to influence policy for the good of farmers and society at large.

5.1.1 Major Findings on Objective One: Farmer Adaptation to Climate Change in Kassena-Nankana East Municipality

Findings show that, farmers are adapting to climate change in the Municipality. This adaptation is influenced by the negative impact climate change has on farmer activity most especially output thereby informing farmer decision to adapt. This is visible in some of the strategies and measures farmers have adopted to lessen the impact of change on their farming activities. Farmer decision to employ existing adaptive strategies and measure as findings show helps reduce farmer vulnerability to the harsh impacts of climate change. Some of these strategies and measures however have been self-initiated. The major influence institutions and organizations have on farmer adaptation to climate change in the Municipality is their efforts toward improving existing strategies while also introducing newer ones. Adaptation is however limited by factors such as limited access to improved varieties, open system of grazing, culture and knowledge gap on adaptation.

5.1.2 Major Findings on Objective Two: Farmers Understanding on the Concept of Climate Change

The study revealed that farmer perception and understanding of the concept of climate change has greater bearing on the knowledge of the harm climate change brings to the lives of farmers and farmer willingness to adapt to this change. Analysis on rainfall and temperature data for the past 32 years portrayed that, indeed there is a change in the climate and this is explained by a study on yearly variations of rainfall and temperature grouped for a decade compared with other two decades. The study further revealed that, farmers in the Municipality have informed knowledge of the existence of climate change. This knowledge from the study is largely influenced by experience and history. Farmers' understanding on the causes of climate change however is that, all the suffering befalling them is due to the neglect of the beliefs and practices of their forefathers. As such, what they are experiencing is as a result of the anger of the gods.

5.1.3 Major Findings on Objective Three: Influence of Climate Change on Activities of Farmers

Climate change, from the study affects farming activities in the Municipality negatively. This is greatly due to variations in rainfall and a shift in the rainy season. Rains do not set in when needed and when crops don't need too much water torrential rains destroys these crops. The increase in temperature and its impact on water evaporation also affects farming activities. These variations in rainfall and temperature, based on data from the Municipal office of the Ghana Meteorological Agency affect crop yield and also area of land cultivated.

5.1.4 Major Findings on Objective Four: Successes of Existing Strategies on Adaptation

The study further shows that, dry season farming is the greatest measure farmers have put in place to help cope with change. This dry season farming is influenced by availability of harvested water sources. These water sources however have made some communities better off than others. Communities that are closer to the irrigation dam are better off than communities dependent on dugouts. More so, communities with dugouts are also more advantaged than communities dependent on hand dug wells. Soil fertility conservation, change in planting date, mixed farming practices and planting of tress at the edges of farmlands are some other strategies farmers have adopted. These strategies are helping reduce farmer's vulnerability to climate change; they are however, limited by factors such as limited capital and lack of market.

5.1.5 Major Findings on Objective Five: Influence of Cultural Practices on Farmer Adaptation

Culture from the study greatly influences agriculture and adaptation positively. This is due to the benefits farmers derive from employing practices that have been passed down for generations. Direct and indirect experiences have influenced farmer knowledge on climate change. Also, practices such as digging wells for domestic use which has been exiting for years have also influenced adaptation as farmers have extended the use of these wells to include farming. However, despite this influence, culture also poses danger to effective adaptation. This is due to the fact that, it has influenced the way things are done which has made letting go off some practices, activities and perceptions passed down for generations quite impossible. Though it is

established that farmers are adapting to climate change in the Municipality, adaptation generally is not effective due to some factors that limit farmer ability to adapt fully with culture identified as one.

5.2 Conclusions

5.2.1 Conclusions on Objective One

Adaptation to climate change informed from the study indeed creates opportunities for farmers. The impact of climate change on the lives of people can be reduced when efforts are made to promote effective adaptation. Farmer adaptation to climate change is more advantageous to a country like Ghana whose economy's strong hold is the agricultural sector. In a Municipality like Kassena-Nankana East where every home practically cultivates food crops to feed their family, it is very necessary for farmer adaptation to climate change to be enhanced since livelihoods especially output as well as income earned from the sale of outputs depend on agriculture. This can be achieved by addressing limiting factors to adaptation.

5.2.2 Conclusions on Objective Two

Farmers understand that there is a change in the climate and this is evident from the study. This knowledge is credited to the fact that, farmers pay attention to their environment. However, farmer education on the existence of change is limited most especially with regards to the causes of climate change and as such; still do not know the activities by human which contributes greatly to the problem of climate change.

5.2.3 Conclusions on Objective Three

Climate change impacts negatively on farming activities in the Municipality. This causes problems for people in the Municipality since majority are into farming as well as for Ghana whose economy depends greatly on the agricultural industry. It will therefore, help if these negative impacts of change are acted upon to help minimize if not eliminate them.

5.2.4 Conclusions on Objective Four

This study sought to find out the level of farmer adaptation to climate change in the Kassena-Nankana East Municipality. The study therefore, aimed at looking at the influence of climate change on agriculture and how farmers are adapting to climate change. This involves assessing measures and strategies employed to help reduce farmer vulnerability. The study revealed that, indigenous knowledge has not only influenced farmer awareness of the existence of climate change but also choice of adaptive strategies to help reduce the negative impact of this change. It further revealed that, adopted strategies impacts positively on agriculture and the lives of farmers at large. These strategies however, are ineffective and would yield greater results when improved upon. Hence there is a need to intensify measures to help achieve goals of effective adaptation.

5.2.5 Conclusions on Objective Five

Culture from the study affects every aspect of climate change from the knowledge of the existence of climate change to strategies to help minimize the negative impact of climate change on farming activities in the Kassena-Nankana East Municipality. Culture just like every other thing in society has its shortcomings and also, limits farmer ability to let go of some ideas, believes

and practices that limits effective adaptation. Limiting the negative influence of culture while embracing its positive impact on adaptation will help improve farmer adaptation.

5.3 Recommendations

Enhancing adaptation in the Municipality will mean helping farmers improve upon their resistance to the negative impact of climate change while making good use of the opportunities it brings, it will therefore require that concerned parties improve upon their activities and contributions to this course to help achieve desired goals. This includes farmers, government and philanthropic organizations operating in the municipality playing their roles effectively. For adaptation to be effective the study recommends the following;

5.3.1 Recommendations on Objective One

The government of Ghana and the Ministry of Food and Agriculture should make sure that, available improved varieties of seeds that are introduced into the system to help farmers adapt to changes should be tested and proven to be viable before they are introduced onto the market. They should also be supplied on time in quantities that will be available for all to patronize. A reward program when established by these organizations will also help improve farmer's adaptation. This can be done by assigning rewards to some strategies which will motivate farmers to adapt measures for rewards

5.3.2 Recommendations on Objective Two

Though the Ministry of Food and Agriculture and Non-Governmental agricultural base Organizations have been sensitizing farmers on the existence

and reality of climate change, more education should be given to help improve farmer understanding on issues surrounding the causes of climate change most especially the exact activities of humans that contributes to the problem of climate change. This will also help reduce the negative factors that affect adaptation while increasing farmer decision to adapt newer strategies. Government should also increase the number of extension officers as it is required to help increase awareness. Periodic trainings for these officers to help keep them current on issues related to climate change are also important so that information will trickle down to farmers.

5.3.3 Recommendations on Objective Three

The influence of the negative impacts of climate change on farming activities can be minimized by donor intervention through the provision of funds to help farmers overcome limiting factors to adaptation due to lack of capital. Water harvesting is essential for dry season farming. It is therefore important for the Ministry of Food and Agriculture and Ghana Irrigation Authority to help improve dugouts into dams in communities that have them and also construct dams in communities that do not have such to collect water irrespective of the intensity of rains which will be used during the dry season. Wells can also be improved to help farmers get access to water for farming.

5.3.4 Recommendations on Objective Four

Existing adaptive measures and strategies should be enhanced by officials from the Ministry of Food and Agriculture and other agriculture based organizations operating in the Municipality. These institutions also through the use of

intensified behaviour change communication techniques can enable farmers embrace climate smart practices.

5.3.5 Recommendations on Objective Five

Non-Governmental Organizations and other donor organizations when drafting programmes on climate change should do well to consider the role culture plays in the lives of people. By doing this, positive influences of culture on climate change adaptation can be improved for the benefit of farmers' while addressing the limitations it poses to adaptation. Regular sensitizations through the community radio and forums on some limiting factors influence by culture by the Municipal Assembly will also help influence perception such that, limitations that culture poses will be reduced.

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APPENDIX A: QUESTIONNAIRE

UNIVERSITY FOR DEVELOPMENT STUDIES

DEPARTMENT OF ENVIRONMENT AND RESOURCE MANAGEMENT

TOPIC: FARMER ADAPTATION TO CLIMATE CHANGE IN THE KASSENA-NANKANA EAST MUNICIPALITY.

Questionnaire for farmers

Name of community……..……

Questionnaire number ……. [00][ ]

A. Personal Information

1. Sex A. Male [ ] B. Female [ ]

2. Age A. 30-50[ ] B. 51- 70 [ ] C. above 70[ ]

3. Level of education A. Tertiary [ ] B. Secondary [ ] C. Junior high [ ] D. elementary [ ] E. none of the above [ ]

4. Religion A. Christianity [ ] B. Traditional Religion [ ] C. Islam [ ] D. Others [ ] (specify)……

5. Occupation A. Farmer [ ] B. Trader [ ] C. Civil servant [ ]

D. Others [ ] (specify) ……

B. Farmer perception on climate change

1. Have you heard of the term climate change? A. Yes [ ] B. No [ ] C. No idea [ ]

2. What do you understand about the concept climate change?

A. Low rainfall B. Prolonged dry season C. High temperature D. Low rainfall with strong winds E. Severe harmattan F. Low rainfall and high temperature

3. Have you noticed any changes in the weather over the past 30 to 60 years?

A. Signs of changes [ ] B. No changes [ ] C. The weather is the same [ ] D. No idea [ ]

4. What are some of the signs that you associate with climate change?

A. Low rainfall [ ] B. Prolonged dry season [ ] C. High temperature [ ] D. Low rain with winds [ ] E. Severe harmattan [ ]

5. What informed your knowledge about climate change? A. Experience [ ] B. Sensitization from MoFA [ ] C. Sensitization from NGOs [ ] D. Others

……

……

6. What are some of the climatic events recorded over the past 30 to 60 years in your community? A. Floods [ ] B. Drought [ ] C. Wind storms D. Rainstorms E. Others (specify)

……

7. What has been the trend of these climatic events over the years? A. Increasing [ ] B. Decreasing [ ] C Fluctuating [ ] D. No idea [ ]

8. For how many months do you experience rainfall in your community? A. Three [ ] B. four [ ] C. Five [ ] D. More than five [ ]

9. What is the intensity of rainfall in your community? A. Very high [ ] B. High [ ] C. Moderate [ ] D. low [ ]

10. How long do you experience the dry season? A. 1-4 months [ ] B. 5-9months [ ] C. 9 and above [ ]

11. What is the nature of the dry season in your community? A. Very high temperatures with dryness [ ] B. High temperatures with occasional rains [ ] C. Moderate with cool temperatures [ ] D. low temperatures with dryness [ ]

B. Effects of climate change on farming activities

1. How have these changes affected your farming activities over the past 30 years? A. Negatively [ ] B. Positively [ ] C. No impact at all [ ]

2. Which aspect of farming do these changes affect the most? A. Water availability [ ] B. Pest and diseases control [ ] C. Post-harvest losses [ ] D. others (specify)

……

……

……

3. How do these changes affect crops? A. Crops dry up [ ] B. High crop yield [ ] C. Low crop yield [ ] D. others(specify)

……

……

…….....

4. What is the rate of the impact of these changes on the types of crops you grow?

A. extremely severe [ ] B. very severe [ ] C. moderately severe [ ] D. not severe **[ ]**

C. Effects of existing adaptation measures to climate change

1. How are you coping with these changes?

……

……...……

……

……..

2. What general measures have you put in place to help you cope with these changes?

……

……

……

……..

3. What are some of the farming strategies you employ to cope with these changes? A. Crop diversification [ ] B. Changing plant date [ ] C. Soil fertility conservation [ ] D. Other

(specify)……

……

……..

4. What influenced the choice of this adaptive strategy? A. Self-initiative [ ] B. Extension officers from MoFA [ ] C. NGOs [ ] D. Others (specify)

……

……

5. Are these strategies helping in reducing the negative impacts of climate change on your farming activities? A. Yes [ ] B. No [ ]

6. If yes in question 5 in which way? A. Minimal increase in yield [ ] B. Moderate increase in yield [ ] C. Significant increase in yield [ ]

D. Adaptive challenges to climate change

1. What are some of the factors that limit the application of these strategies? A. Access to capital [ ] B. Knowledge gap [ ] C. Others (specify)

……

……

…….....

2. What are some cultural practices that influence agriculture in your locality?

……

……

……

3. Do you think some cultural practices limit your ability to adapt to climate change? A. Yes [ ] B. No [ ] C. Have no idea [ ]

4. What do you think can be done to help reduce the influence of limiting factors on your ability to adapt to climate change? A. Improve access to capital [ ] B. Sensitizations on adaptation [ ] C. Improve existing adaptive measures [ ] D. Others (specify)

……

……

…….

5. Is there anything you would like to add?

……

……

……

……....

THANK YOU FOR YOUR COOPERATION

APPENDIX B: FOCUS GROUP DISCUSSION GUIDE

1. Have you heard of the term climate change and what does it mean to you?
2. Have you noticed any changes with the weather over the past 30 to 60 years?
3. What do you think is responsible for such changes?
4. What are some climatic events that have been experienced in your community over the past 30 years?
5. What are some of the effects of these climatic events on livelihood activities especially agricultural activities in your community?
6. How do these climatic elements affect agricultural activities in your community?

(i) Rainfall……

……

(ii) Sunshine

……

7. How are you coping with the incidence of climate change?
8. What are some of the adaptive strategies you employ to minimize the effects of climate change on your lives?
9. What influenced the choice of some of these adaptive strategies?
10. What are some of the cultural practices in your community that influence adaptation to climate change in your community?
11. What are some of the factors that affect adaptation strategies in your communities?

12. What do you think can be done to help prevent or limit the influence of these negative factors on adaptation?
13. What contribution do you think you can make to help make adaptation effective?

APPENDIX C: INTERVIEW GUIDE FOR INSTITUTIONS AND ORGANIZATIONS

UNIVERSITY FOR DEVELOPMENT STUDIES

DEPARTMENT OF ENVIRONMENT AND RESOURCE MANAGEMENT

MPHIL: ENVIRONMENT AND RESOURCE MANAGEMENT

TOPIC: FARMER ADAPTATION TO CLIMATE CHANGE IN THE KASSENA-NANKANA EAST MUNICIPALITY.

1. Name of your organization/institution?
2. Have you heard of climate change?
3. What do you understand by climate change?
4. How does climate change in your view affect the activities of farmers in the Kassena- Nankana East Municipality?
5. What measures have you employed to help educate farmers on the issue of climate change?
6. What adaptive measures do you think farmers employ to cope with climate change?
7. What are some of the measures put in place by this institution that has influenced farmer adaption to climate change?
8. How are these adaptive measures helping to reduce farmer vulnerability to climate change?
9. Are you aware of any cultural practices in various communities influence farmer adaptation to climate change?

10. Identify some factors that limit farmer adaptation to climate change in the Kassena- Nankana East Municipality?

11. In which way (s) do these factors affect the farming activities and the lives of farmers?

12. What do you think can be done to limit the influence of these factors on agriculture?