UNIVERSITY OF CAPE COAST

CLIMATE VARIABILITY AND ITS EFFECTS ON RURAL LIVELIHOODS IN THE KASSENA-NANKANA MUNICIPALITY, GHANA

APWAH FREDERICK

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BY

APWAH FREDERICK

Thesis submitted to the Institute for Development Studies of the Faculty of Social Sciences, University of Cape Coast in partial fulfilment of the requirements for award of Master of Philosophy degree in Development Studies.

NOVEMBER, 2014

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Name: **Apwah Frederick**

Signature:…….. Date:……...

Supervisors' Declaration

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

Principal Supervisor's Name: **Prof. S. B. Kendie**

Signature:…… Date:…….....

Co-Supervisor's Name: **Dr. J. B. Agyenim**

Signature:……..... Date:…….....

ABSTRACT

The effects of seasonal changes in weather patterns have been recognised as long-standing environmental issue and development concern. The study thus, sought to examine the nature, extent, and effects of seasonal changes in weather patterns on rural livelihoods on one hand and the response strategies on the other hand in the Kassena-Nankana Municipality of the Upper East Region of Ghana.

In doing so, the study adopted the mixed method research approach.. Data for the study were derived from 240 rural small holder farmers through a multi-stage sampling procedure. Key informants from the Meteorological Station, Municipal Agricultural Directorate and NADMO were also purposively sampled. Data generated from the field were analysed using descriptive statistics and narratives.

It was revealed that there are considerable variations in the weather patterns. Thus, rainfall amounts are generally decreasing with late on-sets, as well as considerable temperature variations. Seasonal variations and manifestations (such as floods, droughts, and windstorms) have been found to have substantial effects on livelihoods especially in the areas of cropping, livestock keeping, water sources and housing/dwellings. The study further found out that a wide range of strategies in the areas of both diversification of farm and non-farm activity have been adopted in response to these variations.

The study therefore recommended effective collaborative work among major stake holders to create and increase awareness and support to effectively manage the effects of climate variability to lessen its burden in the study area.

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DEDICATION

To my dear mother, Madam Ann Balunu Doris Apwah.

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LIST OF ACRONYMS

AGW	-	Anthropogenic Global Warming
AMCEN	-	African Ministerial Conference on Environment
CARE	-	Cooperative for Assistance and Relief Everywhere
DFID	-	Department for International Development
EPA	-	Environmental Protection Agency
FAO	-	Food and Agriculture Organisation
GDP	-	Gross Domestic Product
GLSS	-	Ghana Living Standards Survey
GPRS	-	Growth and Poverty Reduction Strategy
GSGDA	-	Ghana Shared Growth and Development Agenda
GSS	-	Ghana Statistical Service
IFAD	-	International Fund for Agricultural Development
IISD	-	International Institute for Sustainable Development
IPCC	-	Inter-governmental Panel on Climate Change
MA	-	Millennium Ecosystem Assessment
MEST	-	Ministry Environment, Science and Technology
MIIAG	-	Mo Ibrahim Index of African Governance
MMDAs	-	Metropolitan, Municipal, and District Assemblies
NADMO	-	National Disaster Management Organization
NDPC	-	National Development Planning Commission
NREG	-	Natural Resources and Environment Governance
SLA	-	Sustainable Livelihood Approach
SPSS	-	Statistical Product and Service Solutions
SRM	-	Social Risk Management

UNDP	-	United Nations Development Programme
UNFCCC	-	United Nations Framework Convention on Climate Change
USCCSP	-	United States Climate Change Science Program.
USGCRP	-	United States Global Change Research Program
WMO	-	World Meteorological Organisation
WRI	-	World Resources Institute

CHAPTER ONE

INTRODUCTION

Background to the study

The effects of climate variability have become critical global environmental issue and a development concern (Dazé et al., 2009; Parry et al, 2007). Climate variability is a very old phenomenon, however, current projections indicate that, it is increasing and becoming more pronounced in its effects on socio-economic structures, ecosystems and livelihoods, with the rural poor being the hardest hit. Seasonal variations exert a significant control on the day-to-day development of economies by threatening agricultural activity and rural livelihoods through higher and more variable temperatures, changing precipitation patterns and increased occurrence of extreme events like droughts and floods (Boko et al., 2007; Christensen et al., 2007).

According to Parry et al. (2007), there is already evidence that Africa is warming faster than the global average, and this is likely to continue. This warming, it has been noted occurs all year-round. Further, it is projected that, by 2100, temperature changes will fall into ranges of about 1.4 to almost 5.8°C increase in mean surface temperature (Parry et al., 2007).

Ghana's climate is tropical and influenced by two air masses-namely, North-East Trade Winds and the South-West Monsoons. The major rainfall and temperature patterns form the basis of the agro-climatic zones. Observations are that, rainfall and temperature variations in Ghana are greatest in the northern savannah belt, with exposure and vulnerability associated with

natural hazards such as; floods, landslides, drought, bushfires and disease and pests infestations (World Bank, 2011). The nexus between the fate of Ghana's economy and the factual presence and worrying trends in climate change and variability has been established, and captured in a number of national policy papers (GSS, 2008; NDPC, 2005; NDPC, 2010).

Basically, two broad theoretical perspectives have been employed to explain the phenomena of climate change and vulnerability. While natural developments have been noted as long-standing drivers of climate change and variability, proponents of the Anthropogenic Global Warming (AGW) Theory contend that human actions are primarily responsible for the worrying trends in climate change and variability. The emission of greenhouse gases in the industrial west is one critical component of the human dimension of the climate phenomenon.

While the debate on the drivers of climate change and variability rages on, what is less in contention is the fact that seasonal changes in weather patterns are becoming more varying and less predictable, with devastating consequences on humanity (McCarthy et al., 2001). Thus, impacts associated with extreme variations in temperature and precipitation result in possible increase in the frequency of extreme events such as droughts, floods and windstorms that could negatively affect productivity and worsen poverty levels.

Essentially, the human environment hypothesis posits that there is a clear coincidental correlation between environmental conditions and poverty dimensions, as supported by trends in the South. For instance, the Millennium Ecosystem Assessment, (2005) findings indicate that 60 percent of critical

ecosystem services upon which humans depend for their well-being were being degraded or used unsustainably with negative consequences on livelihoods.

The fate, especially, of the third world economies and the sustenance and community livelihoods of their people is fundamentally and to a significant extent dependent on natural resource base, which has a strong anchorage on climate variability. It is a truism that in sub-Saharan Africa, the agricultural sector is a critical mainstay of local livelihoods and national GDP (Ringler et al., 2009; Mendelsohn, et al., 2000).

Agriculture is of enduring relevance to the achievement of the United Nations Millennium Development Goals. Thus, agriculture relates to nearly all these goals, and is central to at least three of them—reducing poverty and hunger, fostering gender equality, and sustainable management of the environment. The crucial role that agriculture plays in development has long been recognized. It is therefore argued that, "it is in the agricultural sector that the battle for long-term economic development will be won or lost" Myrdal (as cited in Todaro & Smith, 2009, p. 431). Pondering on the potential and constraints to agriculture, Brooks (as cited in Meijerink, & Roza, 2007, p. 1) puts it more succinctly: "if agriculture can do such great things, why have they not yet happened?"

As is well known, one of the main challenges to agricultural activity is climate variability as it impacts negatively on the livelihoods of many communities. From a decline in precipitation to floods, extreme weather events impose a limitation on the ability of agricultural dependent economies to unleash their full production potential. From this view point, Yaro and

Hesselberg (2010) state that, the dependent nature of rural people on environmental resources makes them vulnerable even to minor climate changes. Thus, considering that nearly 75 percent of the world's poor live in rural areas, the majority of whom depend primarily on agriculture and related activities for their livelihoods as noted by Rao (2006), the threats posed by climate variability and extreme weather changes cannot be over emphasised.

These adverse effects of climate extremes, combined with poverty, poor policy and institutional frameworks, make Africa one of the most vulnerable continents to climate change and climate variability (AMCEN, 2011). Apparently, responding to the livelihood and other basic needs of vulnerable communities has been a major concern and challenge worldwide, especially after decades of limited success in eliminating rural poverty (Rao, 2006). In this direction, more refined conceptual approaches such as the Sustainable Livelihood Approach (SLA) and the Social Risk Management (SRM) risk- vulnerability chain have been propounded, adapted and used widely to help explain social vulnerabilities, especially in relation to climate related stresses on livelihoods and poverty in poor vulnerable areas in developing countries.

The Ghanaian economy depends heavily on the agriculture, forestry, and fishery sectors, all of which are highly sensitive to projected climatic fluctuations. It has been noted, that the adverse impacts associated with climate change and variability will most likely hit poor rural communities the hardest; the very communities engaged in agricultural production, for their livelihoods (Agyeman-Bonsu et al., 2009; Government of Ghana, 2010). Evidence indicates that: "...climate change is manifesting in increasing levels

of desertification in the northern savannah zone. This undermines the agricultural potential and the economic viability of the northern ecological zone and its capacity to contribute to national development" (Government of Ghana, 2010, p. 33) thus, further exacerbating the already precarious poverty condition in rural communities.

Thus, with increasing evidence on the ground pointing to the seriousness of the challenges of climate change and variability on ecosystems and livelihoods, concerted efforts are being put in place to put climate related concerns into perspective and to address them. Pursuant to Article 4, paragraph 1, and Article 12, paragraph 1 of the United Nations Framework Convention (to which Ghana is a signatory), Ghana's initial national communication was submitted to the conference of parties to the UNFCCC in December 2000. In the same vein, the second national communication document was submitted in September 2011. These National Communications generally highlight efforts in areas of mitigating climate change and adaptation to impacts thereof (Environmental Protection Agency [EPA], 2011).

Attention on climate change concerns in Ghana continues to gain recognition and momentum both at the highest political level and across sectors. Climate change has also been mainstreamed into the national development framework, particularly in Ghana's Shared Growth and Development Agenda (GSGDA). Additionally, climate change is among various thematic areas receiving support under the "Natural Resources and Environment Governance" initiative (NREG) among key development partners and the World Bank. The Environmental Protection Agency (EPA) under the Ministry Environment, Science and Technology (MEST) is the lead

institution for Climate Change and UNFCCC activities in the country. The EPA is the UNFCCC Focal Point, whilst MEST host the National Climate Change Committee.

In spite of the above efforts and arrangements, there are certain critical disparities and imbalances that make the climate variability scenario of particularly concern. Poverty trends differ among the various economic sectors, with the informal sector and agriculture being the worst affected. Farming households are noted to be the poorest among all other economic segments (UNDP, 2010). Increased environmental variability resulting from climate change brings additional challenges to poverty reduction in northern Ghana. A north-south poverty divide is exacerbated by climatic stress in the northern regions where temperatures are already relatively high. Lower agricultural productivity is only increasing the pressure to migrate to the South (Ministry of Environment Science and Technology [MEST], 2010).

The study area ─ Kassena-Nankana East Municipality has always had its fair share of these climate related hazards. The effects of climate variability cut across all the communities in the area. For instance, in 2007, floods caused wide range destruction to community livelihoods in the district. In September 2010, heavy rains affected unprecedented number of persons, causing a lot of devastation leading to loss of lives and property. Communities that have always suffered severe climatic consequences include Naaga, Kologo and Biu, which recorded flood victims of 1,268; 4,910 and 756 respectively in 2010 (National Disaster Management Organisation [NADMO], 2012).

In April 2012, rains that had set in stopped abruptly for nearly two months, leading to the withering of crops that had already been planted.

According to NADMO (2012), about 3,000 farmers did not have good farming season due to the drought situation. Moreover, rain/windstorms are another phenomenon that the municipality has always had to deal with. They recur yearly, at the beginning of every planting season, but with varying intensity. In April 2012, rains/windstorms affected almost half of the communities in the municipality.

From the foregoing, it has become apparent that climate variability even though a universal phenomenon manifests itself in various forms and is not proportionate in its effects across the globe and on national and local ecosystems and livelihoods. It is a "discriminatory phenomenon" ―affecting different geographical regions, localities and communities differently, given their vulnerability context and their ability to cope and adapt. Consequently, individuals and communities in particular environmental situations as well as the development community have devised various strategies and responses towards achieving sustainable livelihood.

Problem statement

Ghana is exposed to floods, droughts and storms, particularly in the agricultural areas of the Northern Savannah belt. It has been reported that: "In the north of the country, the 2007 floods demonstrated how extreme weather events undermines development investments, with 317,000 people affected, 1,000 km of roads destroyed, 210 schools and 45 health facilities damaged, and 630 drinking water facilities damaged or contaminated. Direct emergency funding cost around $25 million" (MEST, 2010 p.10). The 2007 floods followed immediately after a period of drought that damaged the initial maize

harvest, and were indicative of the high variability in climate and hydrological flows in northern Ghana (Amoako & Ampofo, 2009). Thus, the impacts of localized disasters (droughts, local floods, windstorms, epidemics and wildfires) are likely to have accumulated impacts on rural livelihoods over time as a consequence of climate change and variability, in particular on communities in northern Ghana.

The main climate related conditions in the Kassena-Nankana Municipality include floods, drought, wind/rainstorms, bushfires, epidemics (e.g. anthrax, meningitis, cholera and malaria) and insect infestation (NADMO, 2012; & UNDP, 2010). These affect livelihoods in wide-ranging areas, notably agriculture-based livelihoods, health, education, shelter, unemployment and underemployment.

It has also been acknowledged that windstorms which occur at the onset of every season mostly bring in their wake massive destruction. For instance, 2012 recorded what has been described as the worst windstorm incidence in history of the district, affecting about 1,433 households, translating into 1,946 rooms being ripped-off (NADMO, 2012).

Moreover, there have also been reports of sporadic incidences of disease and insect infestation (e.g. anthrax and army worms). Malaria, Meningitis and cholera epidemics are also major seasonal health concerns in the district (NADMO, 2012). These have both direct and indirect consequences for livelihoods in the municipality.

It is also important to point out that food insecurity is a major challenge in the municipality which is to a significant extent attributed to

climate related conditions such as pests, diseases floods and drought. The food situation raises issues of vulnerability for about 75.1 percent of households who suffer severe food shortages every year (UNDP, 2010).

While several research works have been done covering climate change, environmental degradation and impacts on ecosystems around the study area (Ofori-Sarpong, 2001; Yaro, 2004; Gyasi, Karikari, Kranjac-Berisavljevic & Vordzogbe 2006; Stanturf et al., 2011), these studies have largely been broad, and less specific on the nature and extent of climate variability, local perceptions, livelihood experiences and responses in the face of the fact that these may vary and change with time. This calls for further studies to help follow and understand unfolding trends with respect to climate variability and livelihoods.

According to Ofori-Sarpong (2001), rainfall figures as recorded in Navrongo (the capital of the Kassena-Nankana district) have decreased tremendously in the last 30-40 years, or so while annual mean and monthly temperature figures show an increase. This makes the region a very risky and harsh environment for their livelihoods (especially for farmers and pastoralists). In the same vein, Yaro (2004) hints that, social structures and ecosystems in the Kassena-Nankana District are generally undergoing changes, one of the main influences being climatic changes and that, enhancing the livelihoods and food security of households and individuals in villages should therefore be targeted.

It is against this background that the study seeks to examine the effects of seasonal variations and changing weather patterns on rural livelihoods in the Kassena-Nankana Municipality. Further, rural communities elsewhere, and

in Ghana may have analogous characteristics but surely they are not homogenous in terms of their perceptions, vulnerability and responsiveness to climate variability. Hence, putting the local context into perspective would be useful in assessing the effects of peculiar climatic challenges on rural livelihoods in the study area.

Objectives of the study

The general objective of the study is to examine the effects of seasonal changes in weather patterns on livelihoods in the Kassena-Nankana Municipality.

The specific objectives are to:

1. describe the nature and extent of climate variability in the study area,
2. examine the effects of seasonal variability on livelihoods,
3. analyse the livelihood responses to seasonal variability,
4. make recommendations on the measures of reducing the effects of climate variability on livelihoods.

Research questions

1. What is the nature and extent of climate variability in the study area?
2. How are livelihoods affected by seasonal variability?
3. How have livelihood responses to seasonal variations been in the study area?
4. What should the way forward be?

Significance of the study

Increasing environmental pressures and vulnerability to weather patterns are profoundly reconfiguring sub-Saharan Africa's development options, as sustainability to livelihoods and food systems are being threatened (UNDP, 2012). One group of indicators of the Mo Ibrahim Index of African Governance (MIIAG) covers rural and environmental issues.

Vulnerability to climate extremes and weather patterns assume an intra-sectoral dimension and are affecting livelihoods involving for instance, agriculture and food security, human settlement and infrastructure, health etc, with most affected areas being rural communities (EPA, 2007). Health, water and sanitation, agriculture productivity, migration, seasonality of unemployment and underemployment in a predominantly rural Kassena-Nankana District all have a link with the local climate context of the area (UNDP, 2010).

Thus, with seasonal variation in weather patterns becoming increasingly severe, with rural communities having to face the full reality of this phenomenon, greater attention in this direction is required. Providing a lens for the assessment of the role of changing weather patterns on rural livelihoods in the study area can be considered a decent way forward in contributing to literature that seeks to aid in the understanding of the nature and extent of climate variability on livelihoods in peculiar environmental contexts, crucial for planning and taking the necessary measures to stem the effects of the phenomenon.

Scope of the study

The study covers the selected communities within the Kassena-Nankana municipality geographically. Smallholder farmers and officers from the Municipal Meteorological, Agriculture and NADMO offices were selected for the study. Contextually, the study spans issues bordering on climate variability and livelihood experiences. Adaptation and responsiveness to the seasonal variations in weather pattern to secure more sustainable wellbeing have also been the focus of the study. With respect to time, meteorological data from the synoptic weather station was gathered for a 23 year period (1999-2012).

Organisation of the study

The study contains five chapters which constitute the major thematic and organisational structure of the research. Chapter one is devoted to the introduction of the study. Specifically, the background, problem statement, objectives, research questions, significance and scope of the study have been addressed. Chapter two sets out to review related literature. Issues in climate variability, vulnerability and livelihood discourses are discussed. Relevant theories, empirical studies and a conceptual framework has also been presented.

Presented in Chapter three is the research methodology. The study design, the study area and the target population have been provided. Also presented are the sample and sampling procedures and the data sources, collection and analysis processes and techniques. Chapter four deals with the analysis and discussion of the data obtained from the deployment of the

research instruments developed based on the research objectives and questions set out in chapter one. Finally, the summary of findings, conclusions and recommendations are presented in Chapter five.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This chapter reviews relevant issues (conceptual issues, theoretical approaches and empirical works) bordering on climate variability and extremes, vulnerabilities to these shocks as well as adaptations to these trends. Specifically, the review is done along these thematic areas: conceptual definitions and measurement approaches to climate variability and extremes; livelihoods in the climate change and variability context; poverty and vulnerability to risks associated with climate variability and adaptation and responsiveness to climate variability and extremes. Further explored are: theoretical approaches; a conceptual framework and empirical studies.

Conceptual definitions and measurement approaches to climate variability and extremes

Under this section, key concepts underlying the study have been defined and their distinctions and relationships established. These include: weather and climate, and climate change and variability. The section went on to explore how these are observed and measured.

Weather and climate

Drawing a distinction between weather and climate comes in as a good starting point in considering climatic change and variability issues. Attempting to make the distinction between these two concepts clearer, Burroughs (2001,

p. 2) states that "at the simplest level the weather is what is happening to the atmosphere at any given time, while climate is what would be expected to occur at any given time of the year based on statistics built up over many years". In the same vein, Ramamasy and Baas (2007) consider weather as the atmospheric condition in a given place and it is short term (from hours to few weeks), whereas climate is "average" weather for a given place or region based on long term averages. Thus, climate refers to the average weather conditions over an extended period of time – usually 30 years. It constitutes the sum of all statistical weather information that helps describe a place or a region.

Even though separate concepts, weather and climate are interrelated and share common grounds. They both take similar elements into account, the most important of these are: air temperature, type and amount of cloudiness and precipitation, air pressure, and wind speed and direction. Likewise, because climate variability and climate change are inextricably linked concepts they may be used interchangeably in discussions and arguments in the course of the work.

Defining climate change

The concept of climate change has been variously defined. According to Berger (1980), climate change refers to a secular trend that produces a change in average climate. In a similar discussion, Burroughs (2001) states that, changes in climate constitute shifts in meteorological conditions lasting a few years or longer. Burroughs (2001) then argues that, these changes may involve a single parameter such as temperature or rainfall, but usually

accompany more general shifts in weather patterns which might result in a shift to, say, colder, wetter, drier and hotter conditions.

The Parry et al. (2007) in a similar manner defines climate change as any change in climate over time, whether due to natural variability or as a result of human activity. The Framework Convention on Climate Change (UNFCCC, Article 1) defines "climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". In these latter definitions, much emphasis is placed on the key drivers of climate change.

Drawing on the above perspectives on the concept of climate change, it has become apparent that in whatever form that climate change is defined, it essentially include the critical issue of the considerable longer time dimension, and the involvement of one or a combination of climatic parameters. Further, it has been made clear that, climate change is attributed to both natural conditions and human activities or anthropogenic forces. Yet, climate changes are usually subtle, imperceptible and not readily detectable but profound in accumulated effects.

Climate variability

Like climate change, the concept of climate variability has also been looked at variously. It refers to variations in the climate on all temporal and spatial scales beyond that of individual weather events (Christensen et al., 2007). Following Gibbs, Maher and Coughlan (1975) variability is an inherent characteristic of climate and closely related to the concept of climate change.

According to Ramamasy and Baas (2007), climate variability refers to the climate parameter(s) varying from its/their long–term mean. Hence, for every year in a specific time period, the climate of a location is different. For instance some years have below average rainfall/temperatures, and some having average or above average rainfall/temperatures.

Drawing from the above definitions of the concept of climate variability, it basically has to do with the shorter term (daily, seasonal, annual, inter-annual, several years) variations in weather parameters such as temperature and rainfall patterns within and between regions, countries or localities. It is the accumulation of these internal variations that give rise to climate change.

Even though the comprehensive analysis of climate variability may require that all climatic parameters be considered, this study would focus on the most critical ones -temperature and rainfall which are easily and relatively noticeable and observable, as emphasised by the Parry et al. (2007). It must also be emphasised that all the climatic parameters interact in unison, are interrelated and affect each other. Hence the close measurement and assessment of any one or more of the parameter could effectively give an indication of climate variability. Therefore, concentrating on temperature and rainfall, would effectively serve the purpose of the study.

Observing and measuring climate variability and extremes

Usually, it is the extreme events which affects livelihoods disproportionately, that provide the key massages when it comes to the exploration of vulnerability to climate variability (World Meteorological

Organisation [WMO], 2013). An extreme event can be described as one that occurs and stands out distinctively from the normal range of occurrences. While at times some may be easily perceptible, at other times it might take a more determined and conscious effort for any meaningful observations of some climatic conditions to be made. Given this background, it is instructive again to note that, taking notice of climatic conditions is nothing new. Around the world and in various localities, people have observed and measured climatic conditions for a very long time.

At any given time, or in a period or season, it is very possible for the estimation to be made about an observation for a particular locality to determine whether it is part of the normal expectations for that particular locality or it represents a marked shift from the normal range of events (an extreme). This brings in a very illustrative definition of variability as: *"the extent to which data in a series or statistical distribution diverge from the average value"* (FAO, 2012, p. 361). Fundamentally, these observations have been done more accurately by meteorological instruments. Example being the minimum and maximum thermometers for temperature measured in Degrees Celsius (^{O}C) and the rainfall gauge-measuring rainfall in millimeters (mm) and fairly well too by local observations and perceptions.

According to the WMO (2013), a critical assessment of the basic properties of any climatic data series such as temperature and rainfall can be determined usually in terms of the mean over time and the amount of variance about the mean. There is always a reference period which is typically the climatological baseline interval for the assessment of observed changes with other periods in the past or future. As shown by literature, for climate change,

reference periods are usually three decades (30-35 year period) and a much lesser time for climate variability.

In the consideration of temperature and rainfall as critical climatic parameters, there are also differences in their observations and measurement. For instance, while temperature is often a year-long running phenomenon, in all parts of the world, that of rainfall is episodic in many parts of the world and limited mostly to particular months (rainy season) of the year.

In whatever way one is considering the assessment of climate variability, critical dimensions of data—the climatic event/parameter in questions, the measurement value, the date and location are essentially required. This would form the basis for any meaningful analysis of climate variability situation in a given locality.

The combined effects of climate variability usually lead to extremes such as floods, drought/dry spells, windstorms and extreme temperatures. Floods are weather events that can occur, usually after rains. Mostly, after relatively longer periods of drought/dry spells, heavy and torrential rains often cannot penetrate very dry and hard grounds, thereby resulting in floods (flash floods). At times, floods can involve sheets of water covering large areas of land and unable to readily drain through their natural course, causing usually massive destruction to live and property (WMO, 2013).

In addition to floods, droughts/dry spells are other common and readily observable weather extremes. Droughts/dry spells are basically caused by lack of rainfall. Droughts develop very slowly, sometimes over years and can be very destructive. However, with a dry spell, the period involved is relatively

short as compared to a drought. Laux (2009) considers a dry spell as a period of more than six consecutive days (7 days and above) of no rainfall or a threshold of 1mm for a rainy day during a rainy season. These types of conditions are common in the study area as demonstrated in this study. Winds/rainstorms and extreme temperatures too are associated with both direct and indirect consequences on life and property.

These drought conditions as is well known are usually characterized by wide-ranging livelihood stresses such as; drying up of water supplies, the failure of crops to grow, the death of animals and general and widespread hunger, malnutrition and ill health (Aragón, Barreto & Epstein, 1998; WMO, 2013). Such turn of events would naturally affect rural communities more because of the heavy dependence on the weather and the relatively higher poverty levels.

Livelihoods in the climate change and variability context

An extensive body of literature points to the recognition that livelihoods could be severely hampered by the effects of climate variability. According to Rakodi and Lloyd-Jones (2002), the increased attention paid to livelihoods in both research and policy follows from a wide recognition that the majority of especially poor rural households in middle and low-income countries rely on interrelated set of natural resource based activities to support themselves. Livelihoods perspectives have been central to rural development thinking and practice for quite a long time. They start with how different people in different places live (Scoones, 2009).

Therefore, a variety of definitions are offered in the literature addressing livelihoods. A livelihood comprises assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and systems) that together determine the living gained by the individual or household (Ellis, 2000). The construction of a livelihood therefore has to be seen as an ongoing process, in which it cannot be assumed that the elements remain the same from one season, or from one year to the next. Assets can be built up, eroded, or instantaneously destroyed (as, for example, in a flood). Access to resources and opportunities may change for individual households due to shifting events and fluctuating activities seasonally and across years, in relation to the environmental context surrounding their livelihoods.

A livelihood is the material means whereby one lives. It involves the bundle or round of activities that people undertake to provide for their basic needs. Livelihood as a concept for research and development thus, includes what people do (given their resources and assets) and what they achieve by doing it (Niehof & Price, 2001). From this view point, a distinction is made between the dimensions of the processes, activities, assets and resources, and outcomes and how these are related and variously or collectively affected by individual or combined effects of climate changes.

Ranging from the everyday noticeable changes in the weather in specific locations to the more subtle but large scale changes in rising sea levels and melting glaciers, a wide range of challenges to human well-being, the economy and the natural ecosystems are presented across the world. Thus, livelihood parameters such as agriculture, ecosystems, forestry and

biodiversity, human health, water resources, infrastructure and human settlement have been seriously affected by climate change and variability aspects such as temperatures, precipitations, floods and drought.

Aspects of agriculture such as crops, livestock and fisheries are highly dependent on specific climatic conditions and are affected in a variety of ways. Changes in temperature and the frequency and intensity of extreme weather could have significant impacts on crop yields. Warmer temperatures may make many crops grow more quickly, but warmer temperatures could also reduce yields. Crops tend to grow faster in warmer conditions. However, for some crops (such as grains), faster growth reduces the amount of time that seeds have to grow and mature (United States Global Change Research Program [USGCRP], 2009). This can result in the reduction of yields (i.e. is the amount of crop produced from a given amount of land).

Projections are that yields in Sub-Saharan African countries could be reduced as much as 50 percent by 2020, and crop net revenues could fall by as much as 90 percent by 2100, with small-scale farmers being the most affected (Boko et al., 2007). Low-income rural populations that depend on traditional agricultural systems or on marginal lands are particularly vulnerable, with profound consequences for their livelihood security. Countries with lower initial temperatures can better withstand temperature rises— whereas in climate-sensitive tropical areas a small rise in temperature can severely disrupt natural conditions, with adverse repercussions for water availability and crop productivity (Cooper, 2008).

Livestock is also another component of agriculture that sustains the livelihoods of many in the developing world. Changes in climate could have

adverse effects on animals both directly and indirectly. Overtime, heat stress can increase vulnerability to disease, reduce fertility, and reduce milk production. Drought may threaten pasture and feed supplies, as it reduces the amount and quality of forage available to grazing livestock. Variations and changes in climate may also increase the prevalence of parasites and diseases that affect livestock. Thus, with earlier onset of increased rainfall, moisture–reliant pathogens could thrive (USCCSP, 2008).

According to USGCRP (2009), Coastal and inland water fisheries also support substantial livelihoods in many societies. However, many fisheries already face multiple stresses, including overfishing and water pollution. Seasonal weather changes may worsen these stresses. Changes in temperatures and seasons could affect the timing of reproduction and migration as well as the prevalence of diseases that affect aquatic life.

The high risk traditionally associated with the agriculture sector does not make it attractive for private equity investments. The unpredictability in food supply and prices due to climate variability and other natural occurrences negatively impact on food security all-year-round, especially in tropical savannah (Government of Ghana, 2010).

Forestry and biodiversity provide many benefits and services to society. These include recreation, wildlife habitat, fuel and a variety of non-wood products. However, changing climate may worsen many of the threats to forests such as pest outbreaks, fires and drought.

Climate changes and variations also affect infrastructure and human settlement in a variety of ways. Heavy rains result in floods that wash away

road infrastructure and collapse rural dwellings especially. Rain/windstorms rip off roofing of buildings and pull down electricity mains.

Water resources constitute a critical livelihoods source for both society and ecosystems. Water supports livelihoods in a number of ways. These include water for drinking, agriculture and other range of domestic and industrial activities. Many of these uses put pressure on water resources, stresses that are likely to be exacerbated by changes in climatic conditions. In especially the tropical world, climate changes are likely to increase water demand while shrinking supplies thereby putting people's livelihoods in even more precarious situation. Warmer temperatures increase the rate of evaporation of water into the atmosphere. As temperatures rise, people and animals need more water to maintain their health.

Weather and climate play a significant role in people's health. Warmer average temperatures will likely lead to hotter days. This could increase the number of heat-related illnesses and deaths. Increase in the frequency or severity of extreme weather events such as storms could increase the risk of dangerous flooding, high and destructive winds, and other direct threats to live and property. Meade and Emch (2010) note that, changes in temperature precipitation patterns, and extreme events could enhance the spread of some diseases (such as, cholera, malaria, meningitis and anthrax). The impacts and extent of these weather related health concerns in a given locality will depend on many interrelated factors. These factors include the habitat, population, and the behaviour of the people.

In a similar vein, the IPCC (1997) reports that, as extreme weather events increase, poverty will be exacerbated, community welfare affected, and

consequently ill-health is likely to increase. Extreme events such as storms, floods and droughts also impact human health through increasing pathology rates. This is either directly through injuries, or indirectly through infectious diseases caused by community dislocation, lack of water and other stresses.

Poverty and vulnerability to risks associated with climate change and variability

Molua (2002) opines that variability in agriculture and related activities results from variability in rainfall and temperature in many parts of Africa and elsewhere. Natural disasters caused by climate extremes repeatedly wipe out gains from development, destroying lives and livelihoods. According to Sen (1981), famines are manmade disasters that result from climatic risks and human failure to respond to the resulting declines in food production. Thus, climate events can result in irreversible losses of human and physical capital and may cause poverty traps.

Vulnerability to climate change has been defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (Sen, 1981). Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (McCarthy et al., 2001). According to Chambers (1989), vulnerability refers to exposure to contingencies and stress, and difficulty in coping with them. Kasperson, Kasperson and Turner (1995), defined vulnerability as the propensity of social and ecological systems to suffer harm from external stressors and perturbations. In other words, it means the insecurity of

individuals or communities in the face of changing ecological, economic and political environments in the form of shocks, long term trends or seasonal cycles (Yaro, 2004).

According to Watson et al. (1996) vulnerability defines the extent to which climate change may damage or harm a system; it depends not only on a system's sensitivity but also on its ability to adapt to new climatic conditions. Sensitivity in this context is the degree to which a system will respond to a change in climatic conditions. From this perspective, the definition of vulnerability must be contingent on estimates of the potential climate change and adaptive responses.

Rural people tend to be the most vulnerable to climate change (Sen, 1999; World Resources Institute [WRI], 1996). Sen (1999) further advanced three reasons to explain this. First, rural people live in areas that are more susceptible to the climate extremes. Besides, they do not have the resources to cope with these events and lastly, the poor in developing countries cannot depend on social opportunities like safety nets to cushion the impacts of extreme events.

The conditions as noted above may surely not be the same in individual rural communities or produce the same combined effects. However, as noted by Dercon (2004), improved management of climatic variability becomes all the more important as climate changes lower the returns to assets and livelihoods and increases volatility.

Adaptation and responsiveness to climate change and variability

Adaptation to climate changes is nothing new. Human societies throughout history have repeatedly demonstrated a strong capacity for adapting to different climate and environmental changes-whether by migration to new areas, changing the crops cultivated, or putting up different types of shelter (Adger, 2007). However, the frightening rapidity and frequency, and gravity and intensity of these changes and the ability to adapt are of concern (USGCRP, 2009). According to Parry et al. (2008), and Schellnhuber (2008), the rate and magnitude of climate and weather extremes have enormous influence on livelihoods, and adaptation and mitigation are seen as necessary responses.

Adaptation refers to adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects. Adaptation can include actions by individuals and communities. Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer-term climate change. Adaptations vary not only with respect to their climatic stimuli but also with respect to other, non-climate conditions, sometimes called intervening conditions, (example; differing economic socio-economic and institutional arrangement) which serve to influence the sensitivity of systems and the nature of their adjustments, and may well result in quite different impacts on farmers and hence in quite different adaptive responses, both in the short and long terms (Smit et al., 2000). Parry et al. (2007) defines adaptation as: Adjustment in natural or human systems in response to actual or

expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

According to Challinor and Wheeler (2007), adaptation to climate variability and change occurs (or not) at multiple levels, from the smallholder to the national and even global level. Farmers are vulnerable to shocks (unexpected events such as flooding from extreme weather), seasonal variation, particularly in timing and amount of rainfall, and long-term trends (such as increased mean temperature).

The urgency for adaptation is highlighted by projections from the three reports produced by the IPCC. The predictions are that greenhouse gas emissions could rise by 25 – 90 percent by 2030 relative to 2000 and the Earth could warm by 3°C this century. These could lead to wide-ranging effects on especially agriculture-dependent livelihoods. The predictions are also that by 2020, 250 million people in Africa could face serious climate change and variability related stresses (Parry et al., 2007).

Adaptation can be spontaneous or planned, passive or reactive, or anticipatory and can be carried out in response to or in anticipation of change in conditions. As a result, understanding how particular societies adapt, and how successful these adaptations can be enhanced, are critical for sustainable and equitable policy, practice and livelihood security (Smit et al., 2000; Watson et al., 1996).

Two valuable perspectives are critical to the promotion of climate change and variability adaptation: First, the biophysical effects of climate change and variability and their trend in specific places must be understood.

Secondly, the context of variability in terms of social and environmental vulnerability in a given place must also be understood. With this background, adaptation strategies would be more effective, if they are developed using a community-based approach that takes into account the local circumstances of specific communities (Stanturf et al., 2011).

Wide range and varying adaptation, mitigating, coping and response mechanisms and strategies have been devised to meet the threats and challenges of climate change and variability in differentiated localities given the peculiarity and gravity of the threat and the nature of livelihood component under stress, and the institutional capacity to deal with the threat. Ferris and Petz (as cited in the UNDP, 2012, p. 40) notes that, "although, the destructive power of some natural disasters can overwhelm even well-prepared communities, hazards need not turn into full-fledge disasters if a community is prepared to cope with them". Development is therefore seen to be closely linked to better response and coping strategies and social protection (UNDP, 2012).

Theoretical approaches

With the established and long standing correlation between the broad area of environmental degradation, livelihood stresses and rising poverty, a multitude of theories have been put forward to explain these relationships. More specific theoretical perspectives bordering on seasonal shocks (including climate variability and change), livelihoods and vulnerability have emerged. The approaches germane to this study and which have been reviewed are: the

Sustainable Livelihoods Approach (SLA), and the Social Risk Management (SRM) risk-vulnerability chain.

The Sustainable Livelihood Approach (SLA)

The sustainable livelihoods concept was formally introduced by Robert Chambers and Gordon Conway (1991) to help improve understanding of the livelihoods of poor people. The first elaborated definition of the concept of sustainable livelihoods reads:

> A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term (Chambers & Conway, 1991, p. 6).

The sustainable livelihoods approach (SLA) is broad and encompassing (Rao, 2006). The SLA seeks to facilitate understanding of the context of the livelihoods of poor people. It draws on the main factors that affect poor people's livelihoods and the typical relationships between these factors. It can be used in planning new development activities and in assessing the contribution that existing activities have made to sustaining livelihoods.

In essence, SLA places people, particularly rural poor people, at the centre of a web of inter-related influences that affect how these people create a livelihood for themselves. Closest to the people at the centre of the framework

are the resources and *livelihood assets* that they have access to and use. These can include natural resources, technologies, their skills, knowledge and capacity. Access and control over these assets is significantly influenced by their vulnerability context, which takes into account seasonal variations and shocks pertaining to climate variability.

The SLA also offers a fresh vision of a holistic and/or integrative approach with the capacity to analyse and understand the complexity of rural development (Chambers & Conway, 1991; Solesbury, 2003; UNDP, 1999). It also helps to describe and analyse the driving forces, pressures, and the impacts of all types of activities related to local livelihood situation.

Only five years after its introduction, important research and donor institutions such as CARE, Oxfam and the United Nations' Development Programme (UNDP), the International Institute for Sustainable Development (IISD) and the UK Department for International Development (DFID) had adopted the SLA as the basis for their development programmes and practices (Knutsson, 2006). These institutions have explored the SLA's and have developed their own perspective and methodologies.

The DFID sees the SLA as a more realistic understanding of poor people's livelihoods and the factors that shape them. These factors include support for development that builds on the strengths of poor people to provide them with opportunities to improve their livelihoods. The SLA is seen by DFID as a way of thinking about the objectives, scope and priorities for development, in order to enhance progress in poverty elimination. SL aims to help poor people achieve lasting improvements against the indicators of poverty that they define. The premise is that the effectiveness of development

activity can be improved through: systematic – but manageable – analysis of poverty and its causes; taking a wider and better informed view of the opportunities for development activity, their likely impact and 'fit' with livelihood priorities; and placing people and the priorities they define firmly at the centre of analysis and objective-setting (Ashley & Carney, 1999)

As an analytical framework, some of the core principles of the SLA as espoused by DFID include:

1) People centred: Sustainable poverty elimination will be achieved and livelihoods improved only if external support focuses on what matters to people, understands the differences between groups of people and works with them in a way that is congruent with their livelihood strategies, environment and the ability to adapt.
2) Responsive and participatory: Poor people themselves must be key actors in identifying and addressing livelihood priorities.
3) Sustainable: There are four key dimensions to sustainability-economic, institutional, social and environmental sustainability. All are important – a balance must be found, and
4) Dynamic: External support must recognise the dynamic nature of livelihood strategies - reflecting how the complex livelihood portfolios change in response to the threats and opportunities the poor face and thereby responding flexibly to these changes in people's situations, and develop longer-term commitment.

Sustainable livelihoods have proved versatile in their relevance and application (Ashley & Carney, 1999). They have provided organising concepts in relation to a range of subjects and different contexts. The most

common have been natural resources and agriculture, for example household food security and environmental sustainability in farming systems research - paying attention to marked seasonality of livelihood activities.

The vulnerability context of the SL framework covers the trends, shocks, culture and stresses that may characterise the environment. On the capital or livelihood assets component of the Sustainable Livelihood framework, human capital refers to the skills, knowledge, ability to labour and good health important to the ability to pursue different livelihood strategies. Physical capital covers the basic infrastructure (transport, shelter, water, energy and communications) and the production equipment and means that enable people to pursue livelihoods. Social capital refers to the social resources (networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of livelihoods. The financial capital includes the financial resources which are available to people (whether savings, supplies of credit or regular remittances or pensions) and which provide them with different livelihood options. Natural capital covers the natural resource stocks from which resource flows useful for livelihoods are derived (e.g. land, water, wildlife, biodiversity, environmental resources).

The transforming structures and processes refer to the governmental and private sector structures and institutions and the laws, policies and culture that exist and operate to generate and aid in the livelihood strategies in the face of the impact of the shocks and trends on the livelihood assets. The livelihood strategies cover activities employed to cope with stresses and shocks and to generate and sustain meaningful livelihoods. The last component of the SL

framework- the livelihood outcomes deals with the more sustainable environment resources, wellbeing , reduced vulnerability, improved food security, security of health, water, shelter, education and personal safety.

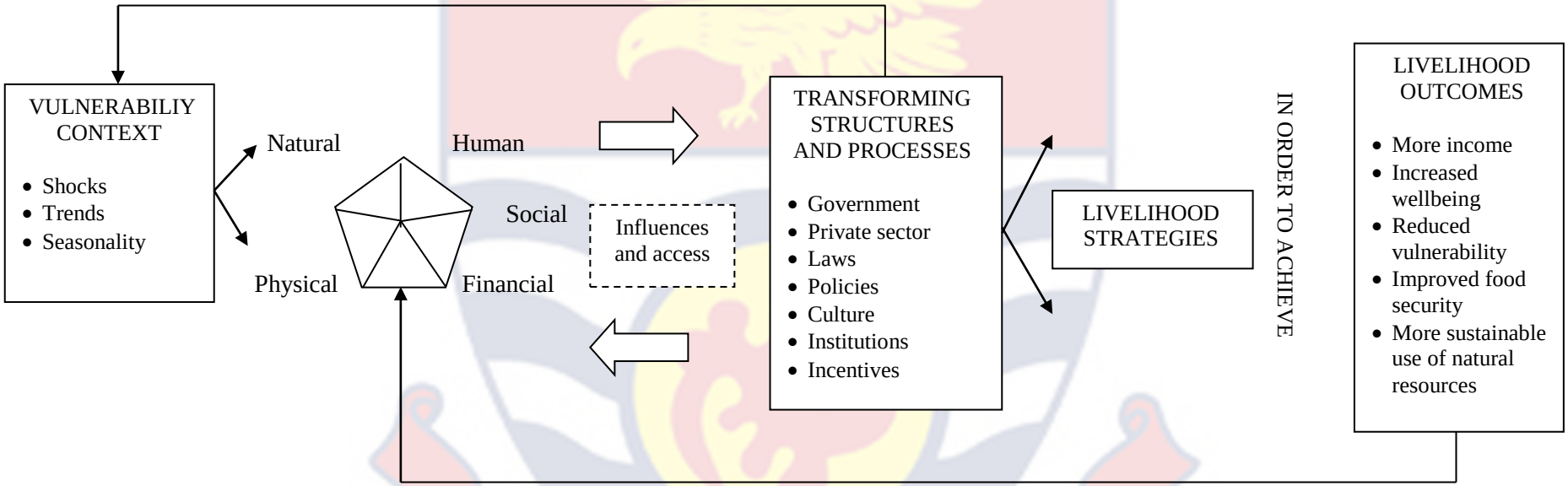

Figure 1: The DFID Sustainable Livelihood Framework

Source: Carney, (1998).

The SLA also offers neutral ground on which all can meet- on the basis of the identified capitals (natural, physical, human, financial and social). It is inclusive and flexible as it meets the needs of diverse sectors and contextual situations.

The SLAs have a lot to offer, but they have been debated and criticised on many fronts. First, it is contended that some of its less tangible aspects such as livelihood security which is in large part about perceptions but which drive behaviour and practice are difficult to measure (Swift & Kate, 2001). Besides, "Sustainable livelihoods" are two words put together initially without an explicit meaning. The criteria that will be used to assess sustainability and period of time in question are critical concerns (Murray, 2000). This creates the avenue that they could be appropriated and given meanings by different actors to suit their conditions and purposes. The disadvantage that goes with this is that meanings or implications which are complicating, inconvenient or threatening can be ignored.

The SLA is also criticised as having little to say about distributional issues, despite implicit concern for the poorest it falls short of advocating issues of equity, but rather promotes the removal of constraints and increasing of opportunities for the poor (Swift & Kate, 2001). In practice, the household has usually been taken as the unit of analysis, which tends to overlook gender issues including intra-house distribution and dynamics. Also, inequalities of power and conflicts of interest are not sufficiently acknowledged (Carney et al., 1999).

Against this backdrop of poverty and inequality, Ashley and Carney (1999) argue that the livelihoods framework implicitly accepts the status quo of poverty and inequality. They further argue that it focuses only on encouraging the poor to use what they have in a better way: At times, the sustainable livelihoods framework conveys a sense of accommodating the way the world works. Even if it is used in an explicitly pro-poor fashion, some have found it scandalous to develop an analysis of poverty that enumerates the 'resources' that characterise that context, labels them 'capital', and proposes – indeed insists – that these constitute the building blocks to overcome that poverty. Such an interpretation would be in grave danger of cordoning off poverty as if it, and its solution, is somehow separate from life and development of the broader community (Butler & Greenstein, 1999).

The social risk management (SRM) risk-vulnerability chain

The social risk management (SRM) risk-vulnerability chain conceptualises the relationship between management arrangements, and household vulnerability. Major proponents of this approach include: Alwang et al. (2001); Heitzmann et al. (2002); and Siegel et al. (2003). According to this approach, the risks and the exposure and sensitivity to risk together determine expected losses from the risks. Therefore, households use risk management strategies that are either ex-ante (risk prevention, reduction, and mitigation) or ex-post (coping) actions. Vulnerability – the probability of well-being below a benchmark such as the poverty line – depends on the risks, exposure and sensitivity, expected impacts and losses, and risk management Adger (as cited in Heltberg, Siegel, & Jorgensen, 2009). The model makes

reference to risk, which is explained as the chance of danger, damage, loss, injury, or any other undesirable consequences for an individual, household or community. Risks interact. Many climatic risks and climate variables are correlated and have inter-related impacts (Heltberg et al., 2009).

The approach also captures as one of its critical components, exposure and sensitivity. Households' risk exposure and sensitivity depend on their asset portfolio, asset allocation, and livelihood strategies (e.g., crop and livestock mix and varieties, diversification of farm and off-farm or non-farm activities). The risk exposure and sensitivity of households is shaped by the policy, institutional, and structural context outside the control of households.

Further, the expected losses from any risk have also been noted to depend on the probability of a risky event occurring and the exposure. Expected losses denote the severity of potential negative impacts from risks before any ex-ante or ex-post risk management.

Moreover, the imperative need for risk management strategies has also been addressed. Here, the point is made that, households and societies manage risks through multiple complementary strategies. These strategies all have real and opportunity costs and can be separated into ex-ante (before a shock occurs) and ex-post strategies (after a shock has occurred). Risk management, if successful, results in resilience: ability to avoid the negative impacts of risky events and recover from them.

The ex-ante risk management component basically encompasses critical issues. These are the prevention of risk reduction—which essentially deals with actions taken to reduce the probability of risky or hazardous events

(e.g. emissions reduction and savings insurance); the risk exposure and sensitivity reduction—involving basically household exposure to given risks; and finally the last issue which is risk compensation or mitigation, which represents the ex-ante actions to provide compensation in case of risk-generated loss (e.g., formal insurance, holding of savings, social networks).

Ex-post risk management includes, risk coping—actions taken to make up for losses after realization of a risky event. This is often an ad hoc risk management strategy with negligible upfront costs, but with potentially serious costs. Coping costs are rarely shared equally within households but borne according to age, gender, and status (for example, poor households forced to reduce food consumption of some members).

Household vulnerability is the expectation of falling below benchmark levels of well-being should a risky event occur. Given measurement difficulties, well-being proxies such as poverty lines and health and nutritional status are often used. Thus, an individual or household is vulnerable to risks associated with climate change if these risks will result in a loss that pushes the household below the well-being benchmark (say, the poverty line). Vulnerability depends on the characteristics of the risks; exposure and sensitivity to the risks; expected impacts and losses; and risk management capacity (See Figure 2).

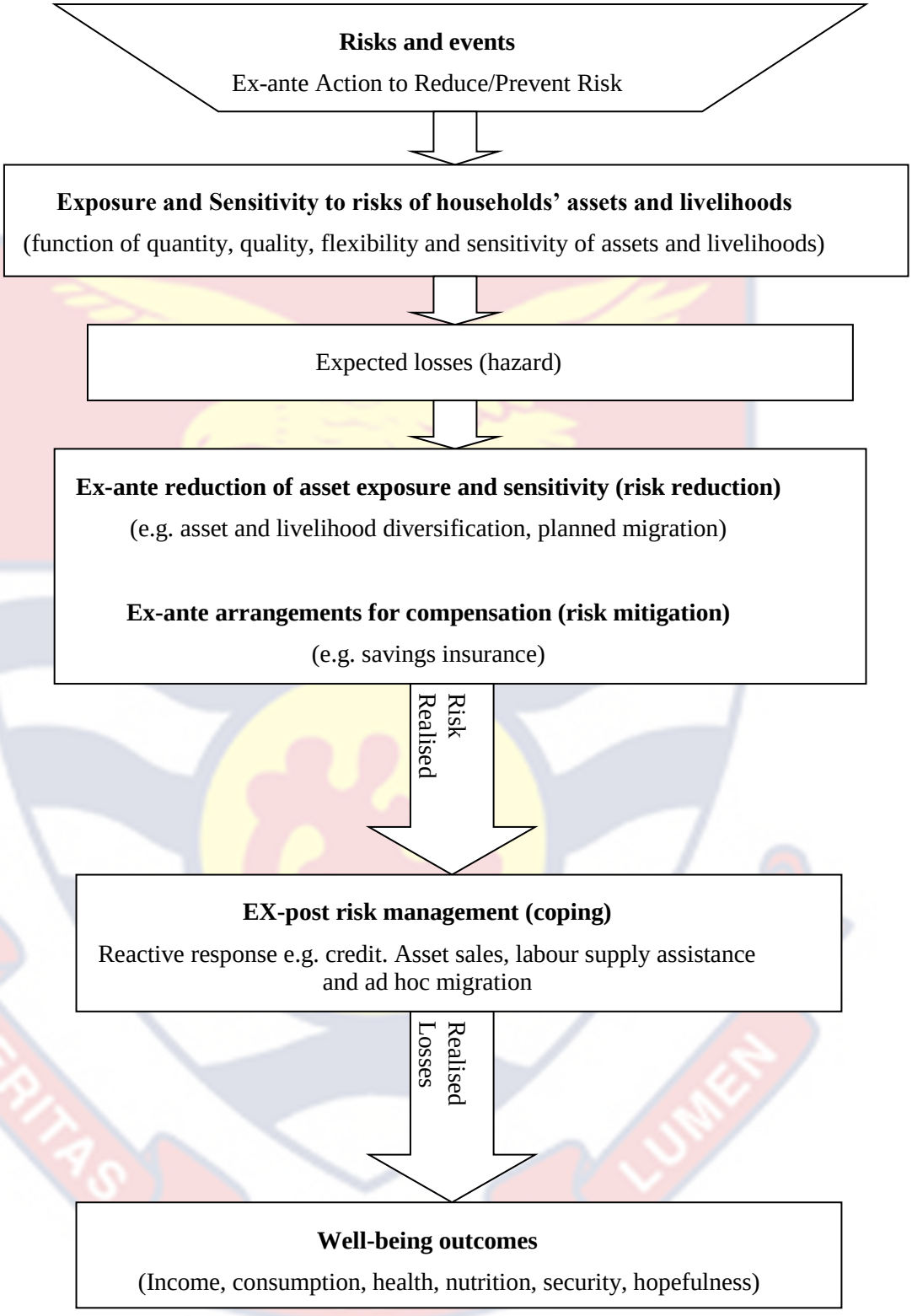

Figure 2: SRM risk- vulnerability chain

Source: Heltberg et al. (2009).

Empirical studies

The majority of people in developing countries live in rural areas, and most of them depend directly or indirectly on agriculture for their livelihoods (IFAD, 2001; Agrawala et al., 2003; World Bank, 2008; World Bank, FAO, & IFAD, 2009). The consequences of rising temperatures and changing precipitation patterns will alter and transform social-ecosystems (Steffen et al., 2004; Millennium Ecosystem Assessment [MA], 2005). A number of research works (Ofori-Sarpong, 2001; Yaro, 2004; Mary & Majule, 2009; Lyimo, & Kangalawe, 2010; Codjoe & Owusu, 2011; Idowu, Ayoola, Opele & Ikenweiwe, 2011) have been conducted in this direction– seeking to understand the uniqueness of the climate change/variability, agriculture and livelihoods nexus as they pertain to differentiated communities.

In examining the impact of climate change on agriculture and farming coping strategies in the Upper East Region of Ghana (Ofori-Sarpong, 2001), issues such as; climate change, climate variability were examined. The study narrowed down to critical climatic variables/parameters (temperatures, precipitation, soil moisture and evapotranspiration), which are considered critical for agriculture productivity.

The findings and conclusions were that, the Upper East Region is a very harsh environment for farmers and peasants due to high rainfall variability and its erratic nature. The study further reveals that, annual and monthly rainfall figures have been decreasing in the last 30-40 years or so. Also, increases in annual and monthly temperatures were observed. In order that, the challenges of drought and desertification in the region are confronted

and their livelihoods secured, the population adopted and developed coping strategies. Some of these strategies include using drought resistant crops and early maturing varieties, shifting the planting season, relying on more legumes than cereals, and selling their labour for cash and food.

Yaro (2004) in a study in the Kassena-Nankana adapted the Sustainable Livelihoods Approach. Attention was particularly given to the natural capital component which forms the context under which people strive to meet their food needs and to sustain their livelihoods.

Some of the findings and conclusions were that, about 85 percent of the population in the three villages (Korani, Chiana and Kajelo), depend on agriculture as primary source of livelihood. Farm and off-farm livelihood systems are constrained by weather-based shocks. Farm practices such as the use of the hand hoe delays farm work resulting in low output since the rainy season is short.

Social structures in the villages are undergoing change under the influence of climatic, edaphic, demographics, micro-economic policy changes, and the effects of globalisation. Enhancing the livelihood and food security of households and individuals in the villages should therefore be targeted.

In another research in Tanzania, Mary and Majule (2009) sought to understand local community perception on climate and variability issues and to establish its impacts and adaptation strategies with the agricultural sector. The study concluded that, participatory knowledge is of essence. Thus, the wealth of knowledge on coping and adaptation that farmers have built should

form a foundation for designing agriculture innovation systems to deal with impacts of climate change and variability.

In assessing community vulnerability and existing adaptive strategies (Lyimo & kangalawe, 2010) in their study in Tanzania, climate change and variability provided the guiding conceptual perspectives. The study noted that poor groups with limited livelihood assets were particularly vulnerable to the impacts of climate change due to their low adaptive capacity. The conclusion of the study was that, livelihood diversification strategies, including diversification of on-farm and non-farm activities are crucial to enhance adaptive capacity and ensure rural livelihood in changing climate.

Somorin (2010) in reviewing climate impacts on forest-dependent rural livelihoods and adaptation strategies in Africa posited that, rising surface temperatures and precipitation variations are very likely to have been caused by human activities. The Anthropogenic Global Warming Theory and the SLA were adopted to guide the study.

The review synthesized information of climate impacts and vulnerabilities on forest ecosystems and forest-related sectors. The Gambia, Botswana, Republic of Congo, Ethiopia, Malawi and Uganda were selected country cases from the United Nations Framework Convention on Climate Change (UNFCCC), whose national climate communications submissions were reviewed.

The review stressed that; the impacts of climate change will vary in degree and magnitude across ecosystems in Africa. These variations would

disproportionately affect long-established relationships between people and ecosystems and their services, with the poor carrying the heaviest burden.

The cross-county review further sharpened the focus on the fact that, adaptation is Africa's best bet in the face of the risks and multiple stresses associated with climate change and variability. Urgently required in this direction, are commitments from local, national and international levels.

Codjoe and Owusu (2011) in their study in the Afram Plains in Ghana, concepts on climate change; food systems and their relationships to food security were reviewed. Thus, food security and livelihoods framework was used to analyse the research.

The findings were that, climate extremes were having their toll on livelihood systems in the study area. The study also came out with the view that, even though, climatic changes are largely assumed to impact on agriculture and other livelihood activities in Ghana, empirical research studies are limited. Consequently, local specific research work would offer the opportunity for assessing the effects of climate changes on food security in a specific locality and the adaptation capacities of communities.

Valuable theoretical and conceptual insights and methods which are derived from the empirical works reviewed and which have proved useful in building the conceptual framework include; Climate change and variability theories, rural livelihood strategies, the vulnerability context and adaptation assessments. Participatory and non-participatory rural appraisal techniques, purposive sampling methods and descriptive and inferential analytical techniques would also prove useful considerations.

The findings and conclusions, place the spotlight on climate change and variability as critical development concerns, with wide-ranging impacts on differentiated communities. Consensus seems to be reached on the urgency for adaptation as the most viable option and further attention in this direction encouraged.

Idowu et al. (2011) paid attention to the reality and extent of climate change and the resultant threats to farming communities in Nigeria. Thus a wide range of extreme weather events were looked at in relation to their resultant impacts on communities.

The study came out with far-reaching findings and recommendations. The study reveals that, extreme weather events (drought, floods, high temperatures, storm surges and so on) are indeed featured prominently especially north wards of the country. These extreme weather events affect the structure stability and general livelihoods base, to wit, population displacement, communal crises, forced migration (promoting ecological refugees), and so on of most communities whose sustenance hinges on farm activities crop and livestock production and fishing).

They therefore recommended among other things, the imperative need for a strong and effective collaboration between government and other relevant partners in consultation with farming communities to keep promises and management options developed on policy and agricultural project strategies for assessing cost-effective adaptation by stake holders given the devastating impact of climate change on communities.

Against the premise that in sub-Saharan Africa, drought and floods are the two main extreme climatic events that negatively affect the agricultural sector and to a significant extent households (Gichere et al., 2013) investigated the effects of drought and floods on crop and animal production and losses among households in Kenya.

The findings and conclusions were generally that, even though both crop production and livestock rearing are adversely affected by extreme climatic events such as floods and drought, the former (crop farming) is relatively risky and has more climate related losses as compared to livestock rearing. The study further reveals that, irrespective of this risk, most households in the study area still rely more heavily on the cultivation of crops. The indication is that, people are either not aware of this fact or are simply unwilling to embrace change through diversification to other potentially beneficial sources of livelihoods.

The study thus recommends the adoption of cheaper and affordable alternatives to crops cultivation such as small holder dairy goats ranching and poultry farming among households. This it is hoped would substantially reduce the toll of extreme weather events on the sustenance base of households' livelihoods.

Conceptual framework for climate variability, livelihood effects and response

A number of conceptual issues have been reviewed in an effort to arrive at a suitable framework to guide the study. These concepts include:

climate change and climate variability, vulnerability context, livelihoods, adaptation and responses to climate variability.

The conceptual framework starts on the premise that, there are wide range variations in seasonal and weather patterns in the study area. Livelihoods assets are greatly influenced by these seasonal conditions and changes in weather patterns. It is also considered that, as active agents in the environment, people resort to varying response, and adaptive strategies to secure their livelihoods. The sustainability of the outcomes as people strive to achieve in these vulnerable conditions are assessed.

Climate variability (rainfall and temperatures)

The climate variability component on the conceptual framework represents the state of climate variability in the study area, thus the, nature, extent and historical dimensions of seasonal weather changes by way of especially assessing variations in precipitation and temperature, the two most critical meteorological elements that affect livelihoods in the study area.

Vulnerability context (i.e. livelihood experiences, nature and scope of shocks and trends)

Next on the framework, is presented the vulnerability context. As climate elements translate into shocks and trends in the form of drought, floods etc. with attendant effects on livelihoods. It is acknowledged that, where people live and work and other aspects of their local context influence the scale and nature of deprivation. It is further recognised that, there are

typical rural characteristics that cause or influence peoples livelihoods, although care is required in generalization because of great diversities between different rural locations.

Responses and adaptive strategies

There is a continuous interaction between specific livelihoods experiences under climate stress and adaptation and responses in search of suitable livelihood outcomes. People are not passive but active agents in their environment. Hence, in the face of these challenges, diverse strategies are developed in response to the changing peculiarities of the trends, though with varying degrees of success.

Desired/sustainable livelihood status/outcomes

Assesses what kinds of outcome emerge as the struggle for more secured livelihoods goes on. Also considers the resilience of livelihoods as these outcomes iteratively reconstitutes livelihoods assets which in turn are under the influence of climate variability.

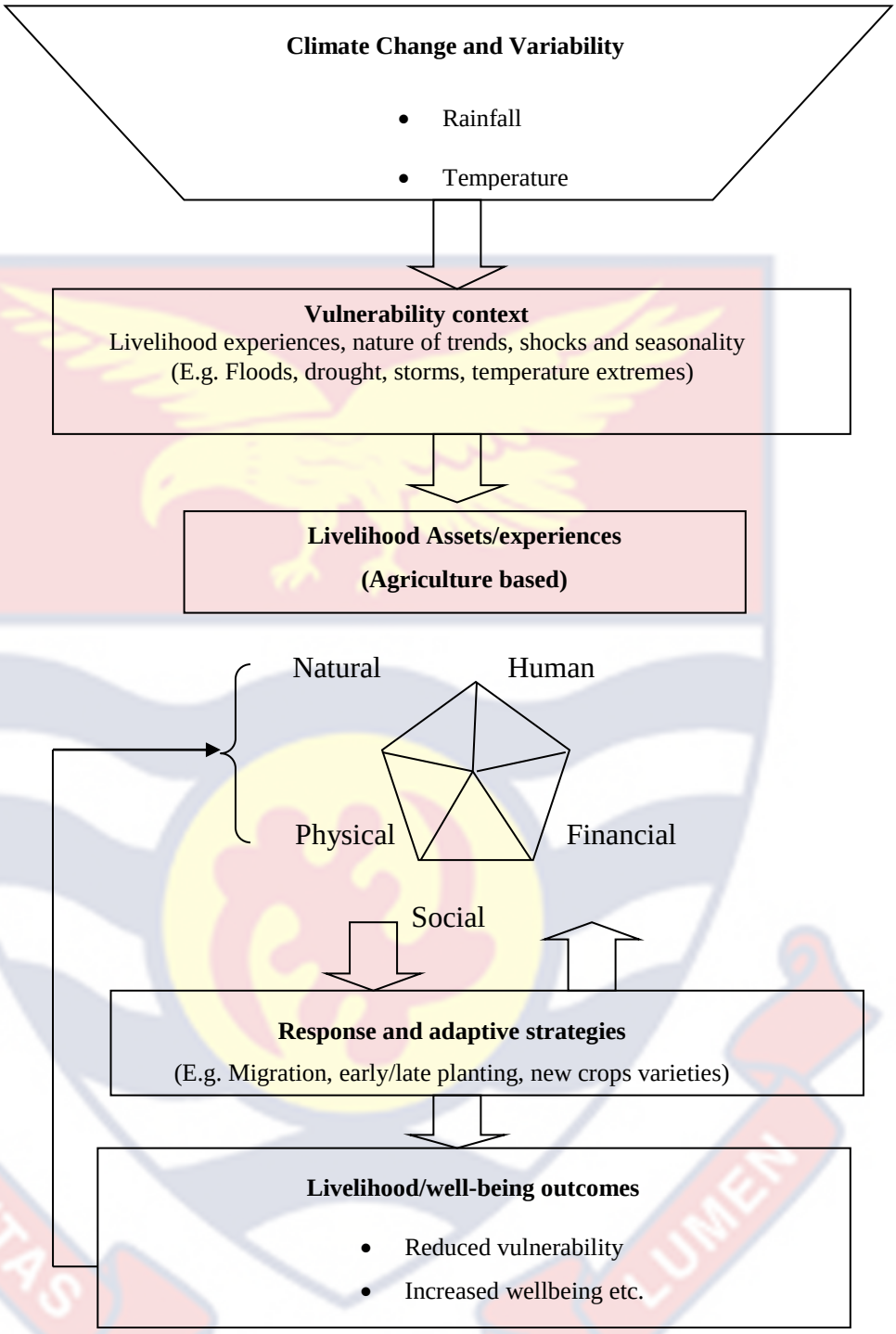

Figure 3: Climate variability, livelihoods effects and response framework

Source: Adaptation of the SL Framework, Carney (1998); The SRM risk-vulnerability chain, Heltberg et al. (2009).

CHAPTER THREE

METHODOLOGY

Introduction

This chapter covers the research methodology for the study. It looks specifically at the research design, the study area, the population of the study and the procedures for sampling and the sample size. Data types and sources, as well as the techniques and procedures for the data collection and analysis for the study have also been clearly specified.

Study design

The research approach was the mixed method – employing both quantitative and qualitative approaches. "Mixed methods research is an approach to inquiry that combines or associates both qualitative and quantitative forms. It involves philosophical assumptions, the use of qualitative and quantitative approaches, and the mixing of both approaches in a study" (Creswell, 2009, p.4). The mixed method research approach was preferred because the study in one breadth sought to describe the nature of climate variability in the study area by analysing quantitative data from the synoptic weather station and in another breadth by assessing respondents perceptions on its development and effects on their livelihoods.

The study area

The Kassena-Nankana East District, with its capital at Navrongo, was carved out from the Kassena-Nankana District in 2008, by Legislative Instrument (L.I) 1855 of 2008. It became a Municipality— created by Legislative Instrument (L.I) 2106 of 2012. The Municipality lies within the guinea savannah woodlands and falls approximately between latitudes 10°30' and 11°00' North and longitudes 0°55' and 1º30' West. The Municipality shares boundaries to the North with the newly carved out Kassena-Nankana West District, to the East with the Bolgatanga Municipal, to the West with the Builsa and Kassena-Nankana West Districts and to the South with the West Mamprusi District of the Northern Region (Kassena-Nankana East District Assembly, 2012). According to the GSS, (2012), the population of the district was put at 109,944 as at 2010. Thus, the district constitutes slightly over a tenth (10.5%) of the total regional population (Upper East) of 1,046,545 as at 2010.

The municipality is covered mainly by the Sahel and Sudan-Savannah types of vegetations; comprising open savannah with fire-swept grassland and deciduous trees. According to the classification by Dickson and Benneh (as cited in Yaro, 2004), the area falls within the Tropical Continental climatic zone. The area is characterised by two distinct wet and dry seasons. The North-East trade winds which blow across the area from the Sahara desert reach their maximum southwards in January ─ bringing dry conditions to the area. On the other hand, the South-West monsoon winds blow across the Atlantic Ocean─ bringing wet humid conditions and setting in the wet

season– reaching its maximum northern extent in August. The unimodal rainfall regime is concentrated into about four to six months of the year, with the remaining period being dry. Periods of excessive and highly erosive rainfall occurring just after the prolonged dry periods, predispose most areas to land degradation, particularly in the form of erosion.

Temperature in the area are considerably higher and variable than the rest of the country, with mean monthly temperatures ranging between 18ºC and 38ºC (Dickson and Benneh as cited in Yaro, 2004). Bush fires are common phenomena, due to the dryness of the atmosphere (i.e. low humidity, high evapotranspiration) and the availability of combustible materials (EPA, 2003; UNEP, 1997).

The sustenance of the district's economy rests mainly on agricultural activity like many other areas in northern Ghana. Livestock keeping is common in this part of the country. "Livestock, involving cows, sheep, goats, pigs and fowls thrive well in the region" (Gyasi et al., 2006). A small percentage of the population is engaged in white-collar jobs and other activities such as artefacts making, wood cutting, quarrying, traditional medicine and others, practised alongside agriculture. Artefact making involves leatherworks, weaving, pottery and blacksmithing. Yet, other activities that sustain women in particular include *sheabutter* processing, *dawadawa* processing, *pito* brewing and trading in food staffs (Yaro, 2004).

In terms of its contribution towards the Gross Domestic Product and labour employment, the primary sector activities which are dominated by agricultural practices contribute about 68.6 percent. The secondary sector's

performance, dominated by small-scale enterprise activities contribute about 3 percent to the Gross Domestic Product and about 2 percent exclusively to labour employment, thus excluding those who are engaged in direct primary agricultural activities. The tertiary sector whose contribution comes mainly from informal private individual economic activities, records about 11 percent to the district's local economy in terms of her Gross Domestic Product (GDP) and also accounts for about 30 percent to the labour employment figure.

The Kassena-Nankana Municipality has a dispersed population density of 92 people per square kilometres, with majority of the communities being rural- at least three out of every four people in the district live in a rural area. The settlement patterns are mostly dispersed-regarding the location of housing structures. Such structures are thus interspersed with household farmlands, other livelihood enhancing facilities including schools, governmental and other organisational agencies and water sources (UNDP, 2010). The municipality has an average household size of 5.7, much smaller than the regional average of 6.3 and slightly higher than the national average of 5.1. Heads of households constitute 14.8 percent of the membership of households in the region.

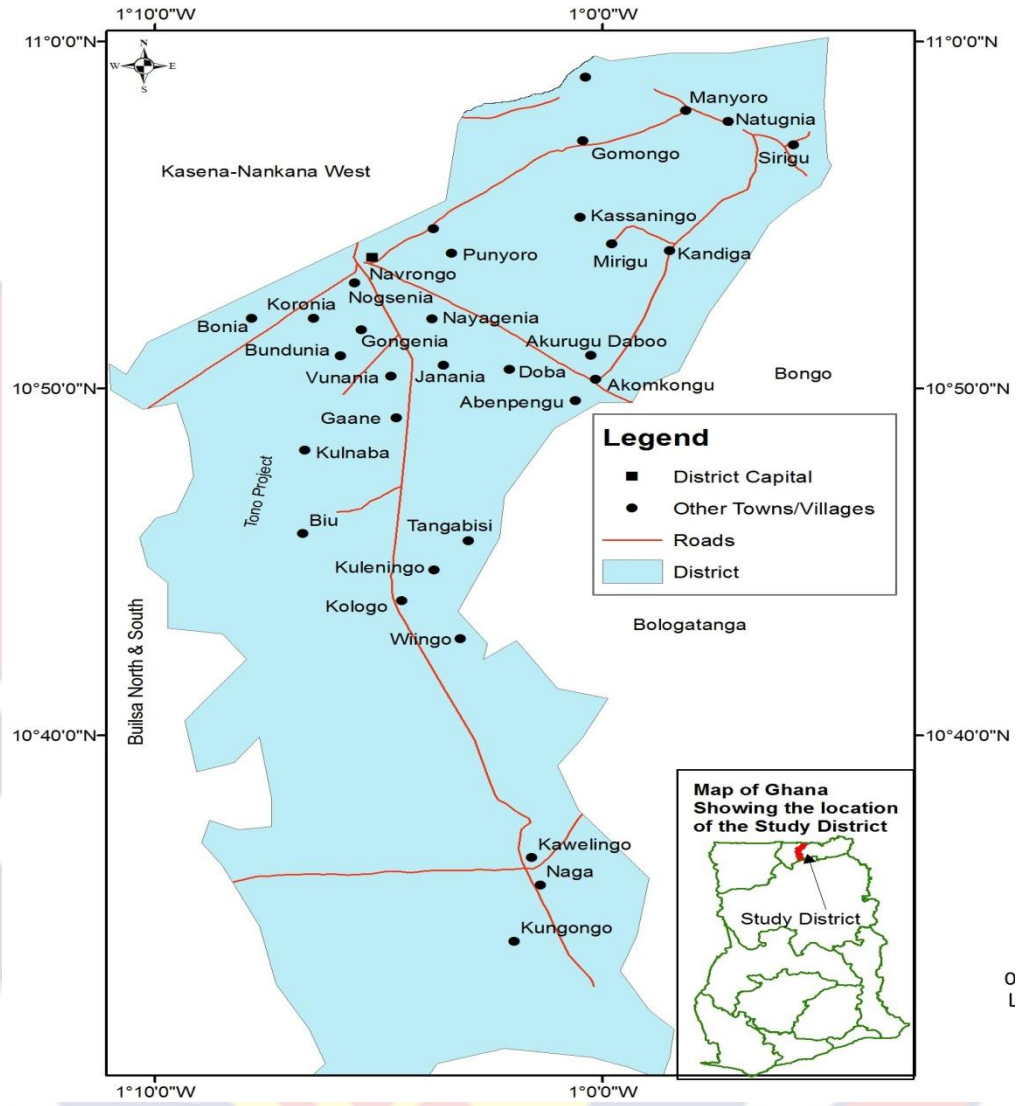

Figure 4: Map of the study Municipality

Source: Department of Geography and Resource Development, Legon (2013)

Target population

Rural household farmers and relevant agencies and bodies such as the Meteorological Agency, the Municipal Agriculture office and NADMO constituted the target population. The rural individual household farmers were chosen because by virtue of their occupation they would to an appreciable level represent a collective voice for the other members of the family when it comes to issues relating to climate variability and agriculture based

livelihoods. The Municipal Meteorological, Agriculture and NADMO officers were also considered as appropriate because they possess appreciable level of insight and in-depth knowledge of the seasonal trends and weather patterns and their effects on livelihoods in the area.

Sample and sampling procedures

The study employed both multi-stage sampling and purposive sampling procedures to sample the respondents. Whereas multi-stage sampling procedure was used to select the rural farm household respondents, purposive sampling was used to select the key informants ─ the Municipal Meteorological, Agriculture and NADMO officers.

First, communities in the Municipality were grouped under the four zones─ South, East, Central East and Central West─ that NADMO uses for its monitoring and operational activities. The South zone has 44 communities, the East 14, Central-West 32 and the Central-East 14 giving a total of 104 communities. Second, within the four zones and with the total number of communities being 104, 20 percent of the communities were selected for the study. This was because the communities within each zone had similar characteristics. According to Sarantakos (2005), one of the cardinal principles of sample size determination is the homogeneity of the target population. Thus, the more homogenous the target population the smaller the sample size could be and vice versa. It was hoped that this percentage would ensure a proportional representation of the communities within each zone. So this gave a total of 21 communities comprising 9 communities from the south zone, 3

from the East zone, 6 communities from the Central-west and 3 communities for the Central-east. Table 1, shows the community selection procedure.

Table 1: Sampled communities

Zones	Total number of communities	Sampled communities
South	44	9
East	14	3
Central-west	32	6
Central-east	14	3
Total	104	21

Source: Field survey, 2013.

Third, a sample size determination formula below: was employed to get the required number of respondents (See Appendix F).

$$n = \frac{N}{1 + N(\alpha)^2}$$

The sample size formula generated a sample size of 343. However, the issue of manageability was not only considered as necessary but also vital to this study. Hence, specifically, because of time factor and resource constraints the researcher was able to measure only 70 percent of the 343 or a household sample size of 240 for the study. This was then distributed proportionally

among the 21 communities within the four zones. Table 2 shows the communities and sampled households.

Table 2: Sampling procedure for smallholder rural farmers

Names of zones	Sampled communities	Total number of Households (HHs)	Sampled small holder farmers per community
South	Naga-Nayire	124	12
	Chaaba	124	12
	Biu-Sensa	80	8
	Anamolgabisi	123	12
	Digoogo	128	13
	Tampola	85	8
	Kolgo-Nayire	103	10
	Tou	111	11
	Zou	95	9
East	Wanjagnia	110	11
	Sabisi	110	11
	Saforo	96	10
Central-west	Namolo	133	13
	Telania	140	14
	Pun-Yoro	120	12
	Yangua	122	12
	Bawiabia	127	13
	Balobia	147	15
Central-east	Doba –Nayire	103	10
	Kansaa	128	13
	Gingabnia	110	11
Total	21	2,419	240

Source: Field survey, 2013.

Fourth, simple random sampling technique was used to select the study units (household respondents) from each of the communities selected. Here, individual farmers were thus picked randomly from the selected households till the required number of each community was obtained. Also, 15 respondents each (giving a total of 60) from the four zones were selected based on their willingness to participate in four separate Focus Group Discussions. This was to help unearth more in-depth information that would further enhance understanding of the issues under consideration.

The Meteorological, Agricultural and NADMO officers were respondents purposively sampled—one from each office. This ensured an in-depth comparative assessment of their perspective of seasonal variations in the weather and related incidences over time and in relation to their effects on rural livelihoods.

Types and sources of data

Data for the study was obtained from two main sources—primary and secondary sources. The primary data sources included the individual smallholder farmers, and Key informants (Meteorological, Agriculture and NADMO officers). For the secondary data, sources included meteorological or climatological data from the synoptic weather station in Navrongo. Information from this source helped to give an overview and to describe and analyse the nature and trends of climate variability in the study area. Besides, secondary data in the form of information relating to climate related hazards and stresses were also obtained from the Municipality's NADMO reports and Agricultural records. These sources were considered because they are the

institutions that deal more directly with climate and livelihoods related issues. Finally, additional data sources relied on were published secondary sources including journals and books.

Data collection techniques

Different data collection instruments and techniques were used for both the primary and secondary data. Three main instruments types were designed for the primary data. The interview schedule and Focus Group guide were used for the household respondents whereas key informant interview guides were used for the key informants (Agricultural, Meteorological and NADMO Offices). The research instruments basically covered background characteristics of respondents, and three key areas; perception on climate change and variability, effects of climate variability on livelihoods and adaptation and responsiveness to weather changes and seasonal variations—based on the study objectives and research questions set out in chapter one.

Secondary data in the form of meteorological information (rainfall and temperature figures) were collected from the synoptic weather station records in Navrongo. The data of the various climatoligical parameters such as temperature, humidity, wind direction and speed have been recorded daily and further put into weekly, monthly and annual averages. Also, recorded information pertaining to climate variability effects on the Municipality and various communities as gathered overtime by the Municipality's NADMO and Agriculture offices was accessed.

On the critical issues of validity and reliability, a number of measures were employed to ensure that these were adequately catered for. First, for validity, greater attention was paid to the clear and unambiguous definition of the key concepts and variables in the study. For reliability, the instruments employed were also chosen and designed to adequately and comprehensively address the needs of the study. For the households interviews, the same set and order of questions were adopted. Field assistants were trained and the questionnaire pre-tested to streamline it. A recorder was also used in addition to the note taking from the in-depth interviews schedules. This it was hoped would help capture relevant data for processing and analysis.

Data processing and analysis

Data generated from the field was analysed using both quantitative and qualitative methods. Quantitative meteorological parameters such as rainfall and temperature trends and variations were presented using charts and graphs. Field data from the interviews of the farmers were edited and manually entered into a computer, using the Statistical Product and Service Solutions (SPSS) software, version 16. Specifically, Descriptive statistics such as frequency tables, bar and line graphs were employed to analyse and present the results of the study. Qualitative description of perceptions on the nature and extent of climate variability and livelihood experiences also came in to complement the quantitative analysis of the views of the farmers. The views of the Key informants (Meteorological, Agricultural and NADMO Officers) were also presented qualitatively. Specifically, the Descriptive statistics were

complemented by direct quotations and narrative reporting of the respondents views to give more meaning to the figures.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter aims primarily at addressing the objectives and the research questions set out in chapter one. This has been done in three parts: First, the nature and extent of climate variability in the study area has been graphically described and discussed; secondly, the specific livelihood experiences in relation to climate variability have been lucidly reported, and; finally, information on livelihood responses to seasonal variability has also been clearly presented.

Nature and extent of climate variability

This section of the study presents information sought on the nature and extent of climate variability to better appreciate the climate variability situation, as captured by the first objective and the first part of the conceptual framework. Thus, quantitative data was gathered and analysed on two critical climatic parameters—rainfall and temperature, obtained from the synoptic weather station in Navrongo in the Upper East Region. The data covered a twenty-three year period (1990-2012). The intention was to cover for at least thirty years (a base period for climate change) but patchy data before 1990 did not allow for this.

Besides, for the purposes of comparison with the synoptic weather data, information on the observations and perceptions on rainfall and temperature variability by farm households respondents and key informants (Municipal Agricultural and NADMO officers) have also been utilised. Most often, such weather variations result in seasonal shocks such as floods, drought, windstorms, climate related epidemics, insect infestations among others, with attendant consequences on communities.

Observed rainfall trends and variations for the study area

Rainfall trends and patterns have been considered as one of the main climatic parameters that can amply demonstrate variations in the climate of a locality or a region. The analysis of the data gathered on rainfall includes the annuals, mean monthly distribution and annual divergence. Figure 5 shows the annual rainfall totals in the Kassena-Nankana Municipality from 1990-2012.

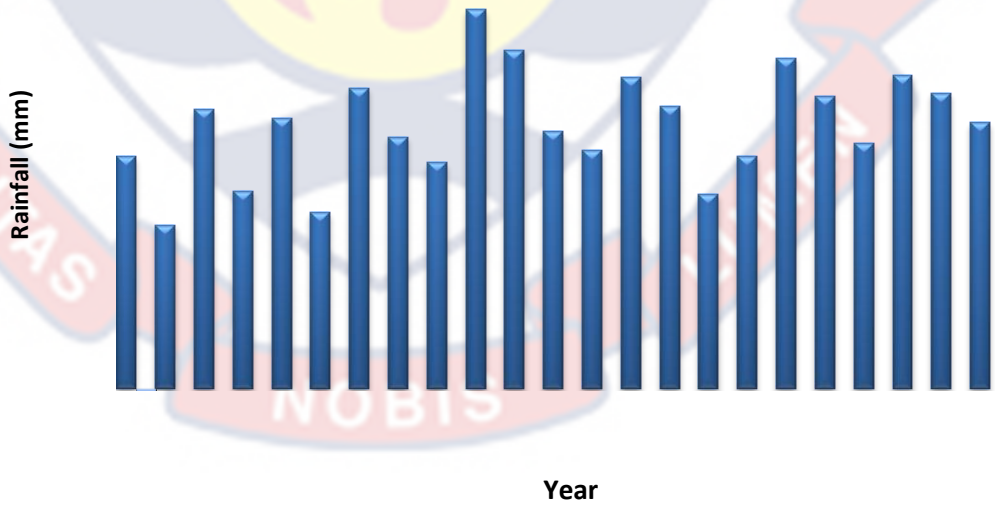

Figure 5: Annual rainfall from 1990-2012

Source: Fieldwork, 2013.

The climate in the study area is characterized by a single rainfall regime—marked by distinct dry and wet seasons. The period between 1990 and 2012 recorded a mean annual rainfall of 979.8mm with conspicuously higher variability. For instance, the year 1991 recorded annual minimum of 646.2mm compared to a maximum of 1,365.3mm in 1999 representing over 719.1mm difference of rainfall amount between these years. It is also significant to note that there were relatively lower amounts of rainfall in the following years: 1991, 646.2mm; 1993, 760.4mm; 1998, 687.6mm; and 2005, 750.3mm as compared to years of higher amounts such as: 1104mm in 1996; 1365.3mm in 1999; 1230.5mm in 2000; 1140mm in 2003; 1203.8mm in 2007; 1147mm in 2010; and 1086.9mm in 2011.

It is apparently clear from this information that overall remarkably high and low alternating periods (variations) of rainfall have been experienced. These findings corroborate assertions that the northern part of Ghana is experiencing erratic and highly variable patterns of rainfall (Ofori-Sarpong, 2001; Amoako & Ampofo, 2009). This has implications for an area where rural poverty levels are relatively high with agricultural enterprise being heavily dependent on the rains.

Also, to further show the variations of seasonal shifts of rainfall, data on mean monthly distribution is presented in Figure 6.

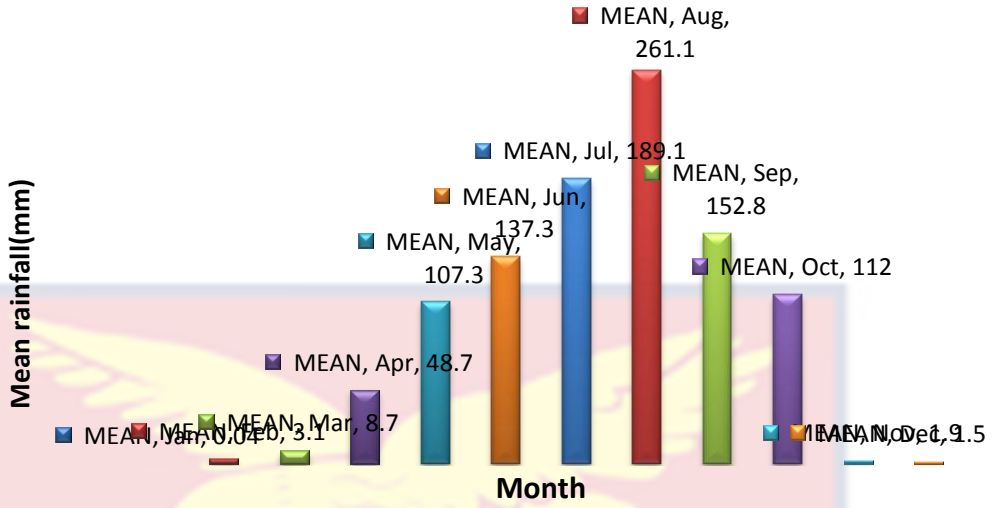

Figure 6: Mean distribution of monthly rainfall (1990-2012)

Source: Fieldwork, 2013.

The information presented in Figure 6 shows that monthly rainfall amounts increase steadily and peaks up in the month of July and August, from which period it decreases sharply through the months of September and October, to insignificant amounts in the last two months of the year. During the high rainfall months of June, July, August and September, the intensity of rainfall could be accompanied by shocks such as floods and windstorms (squalls).

Sivakumar (as cited in Laux, 2009) opines that droughts and dry spells have been noted to be a major manifestation of climate variability which could result in both direct and indirect consequences on agriculture dependent livelihoods. With respect to this an attempt was made to determine the number of rainfall days and dry spells during the wet/planting season between the months of April and October for the complete year of 2012 (Figure 7).

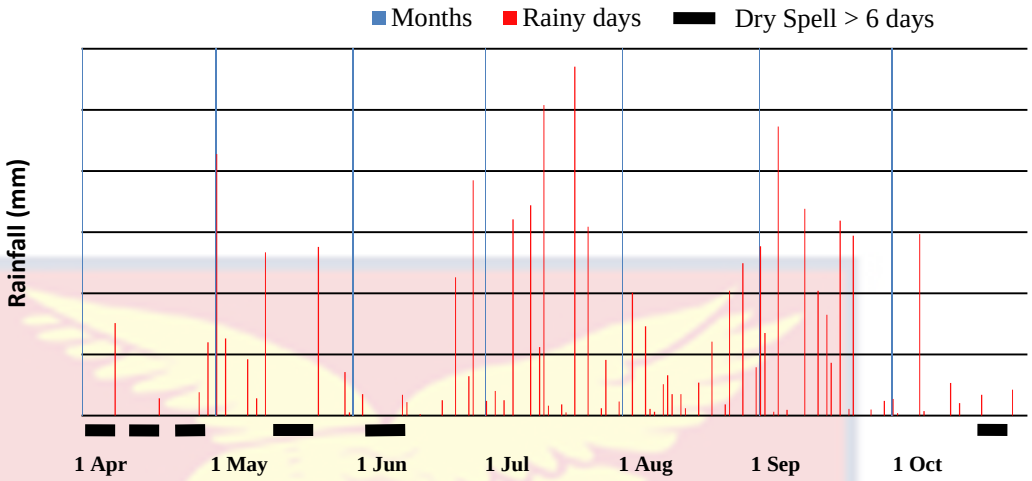

Figure 7: Monthly distribution of rainfall in the wet/planting season (April-October) for 2012

Source: Fieldwork, 2013.

The information shows that the entire wet/planting season recorded six dry spells. As noted by Laux (2009) a dry spell is characterized by more than six (6) consecutive days without rain with a threshold of 1mm for a rainy day. The month of April recorded only four rainy days and reveals three dry spells— between the periods 1st-8th, 8th-18th, and 18th-27th. Other dry spells were recorded in May (12th-24th), June (3rd-12th) and October (20th-27th).

In the context of an environment where rain water harvesting is poor this dry spell phenomenon could result into serious livelihood stresses where farming households may have to look elsewhere in order to meet their livelihood needs. The foregoing findings confirm (Gichere et al., 2013; Idowu et al., 2011) assertions that droughts are increasingly representing a critical challenge faced by most farming households in sub-Saharan Africa.

To further describe the nature and extent of climate variability, data on the annual rainfall divergence for a 23 year period (1990-2012) has been presented (Figure 8).

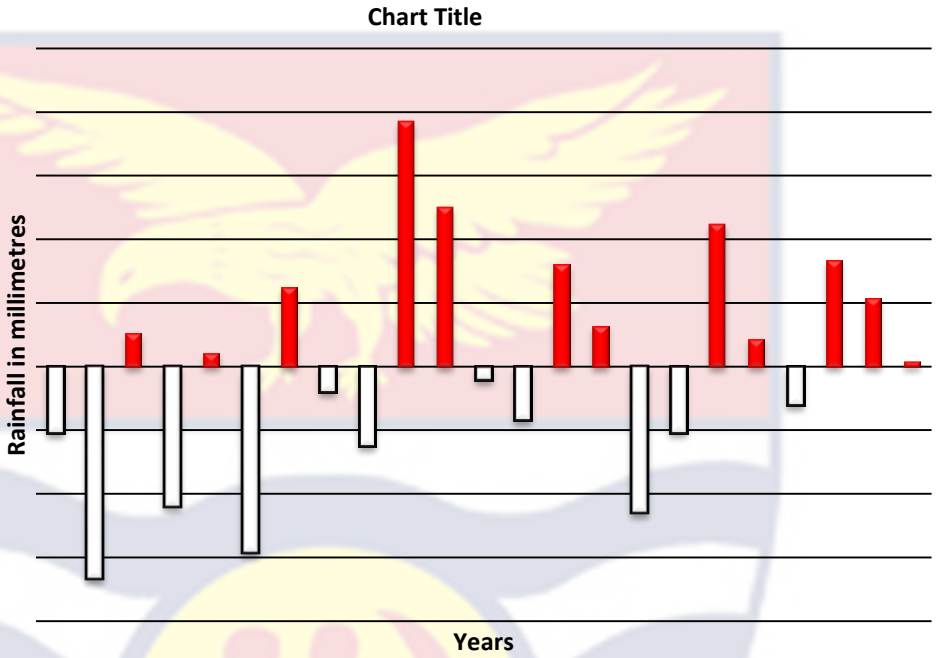

Figure 8: Divergence of annual rainfall (mean values) 1990-2012
Source: Fieldwork, 2013.

The data shows the difference of each year's (annual) rainfall, compared to the mean annual rainfall for the entire period. Thus, in relation to the annual mean of 979.8 (index of 0) the upwards projecting bars show positive deviations whereas those facing downwards indicate negative deviations to each of the corresponding years. It is further illustrated from the data that some of the years (e.g. 1999, 2000, 2003, 2007, & 2011) show a relatively high mean variation of over 150 mm of rainfall. Conversely, a

marked negative divergence of more than -200 mm is recorded in some years (1991, 1993, 1995, & 2005) from the mean.

According to the Municipal disaster data collected by NADMO, 1999, 2000, 2003, 2007, 2010, 2011 and 2012 were years of severe floods. These years correspond to years of heavy rainfall as indicated by the meteorological data above. The following years; 2003, 2004, 2007 and 2012 have also been cited as years of severe windstorms. From this data it can also be said that severe windstorms come with heavy rains/floods. In contrast, 1998, 2002, 2005 and 2012 were cited as years of severe droughts. The meteorological data shows that the years 1998 and 2002, and 2005 were years of low rainfall with negative deviations.

In all of the above, the observed variations in terms of the distribution and divergence of rainfall point to the fact that indeed climate variability is an issue of concern. As noted by the WMO (2013), such observed variations disproportionately affect communities given their vulnerability context. The implication of this is that given the setting where poverty levels are relatively high with agriculture constituting the main livelihood base, a wide range of activates: from the determination of the planting period through to the harvest season would be difficult to predict and work within. This could naturally affect household agricultural productivity resulting in food insecurity and related stresses.

Observed temperature trends and variations for the study area

The study further sought to ascertain the nature and extent of climate variability by gathering information on temperature. In respect of this, attention was paid to the monthly and annual means for the period 1990-2012. Figure 9 shows the monthly mean of temperature which gives a clearer picture of the temperature situation. The information shows that the hottest months of the year for the period are February, March, April and May with mean average temperatures of more than 30°C, most of the months registered temperatures below 27°C.

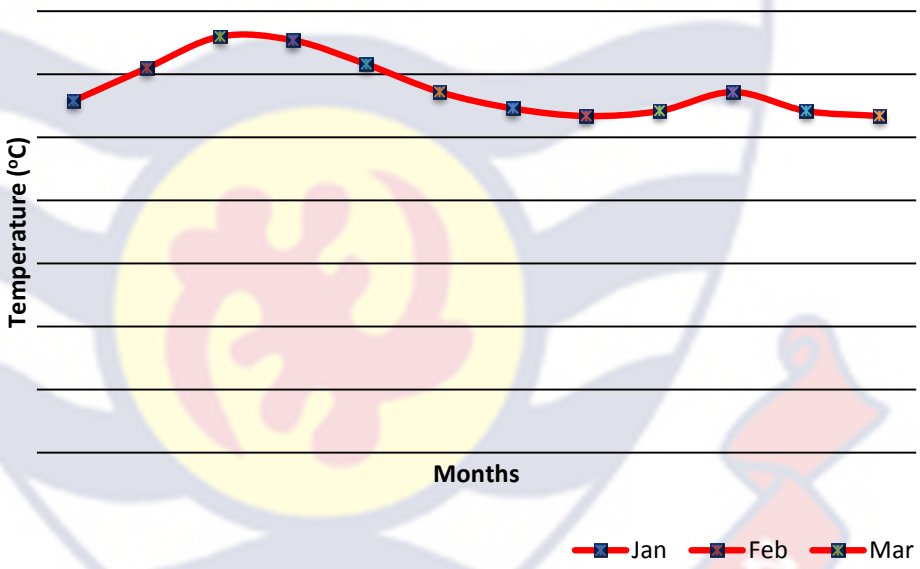

Figure 9: Mean monthly rainfall and temperature for the study area

Source: Fieldwork, 2013.

Further evidence of the climate variability pattern is indicated by the annual mean temperature trends (Figure 10). The data indicates that for the 23 year period under consideration (1990-2012) the annual mean temperature is 29.2°C (index of 0). The highest annual mean temperature was recorded in

2005 with a figure of 29.8°C as compared to a figure of 28.5°C in 1992 with a marked difference of 1.3°C. It is also to be noted that 1992 and 1994 recorded relatively lower temperatures as compared to 1995, 2005 and 2006. It can further be noted from the temperature data that, years of high temperature deviations also correspond with NADMO municipal disaster data that recorded 1998, 2002, 2005, and 2010 as years of severe droughts.

Over all, while the data show an alternating and irregular pattern, the trend line (linear mean) shows that the annual mean temperature rose from 29°C in 1990 to about 29.4°C in 2012—representing a trend of 0.4°C. This means that the inter-annual temperatures can be described as relatively variable, with the area being approximately 0.4°C warmer than it was 23 years ago.

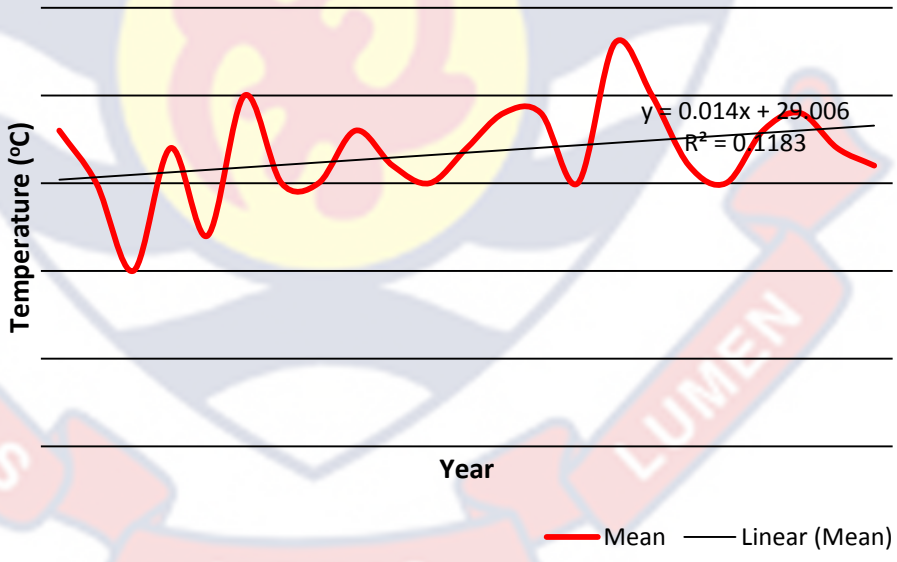

Figure 10: Annual mean temperature and linear trend from 1990-2012
Source: Fieldwork, 2013.

The information confirms findings (Carney, 1998; Cooper, 2008; Laux, 2009; Ofori-Sarpong, 2001; & Yaro, 2004) that in climate sensitive tropical regions, such variations and even a small rise in temperature could have both direct and indirect bearing on natural resource based dependent livelihood experiences and activities. This implies that in a region where crop production is the main agricultural activity with considerable water availability strains, livelihoods would apparently be severely affected.

Respondents' perceptions on the nature and extent of climate variability

This section pays attention to respondents' perception on the nature and extent of variations of local climatic conditions —rainfall and temperature— which as emphasised by the Parry et al. (2007), are relatively easier to notice and observe. The section also looks at manifestations in respect of floods, wind storms, recurrence of drought, intensity of drought, and extreme temperature) in the last 10 years or so. The literature revealed that local observations and perception on the climate situation are critical in informing decisions and actions concerning agricultural activity. Information was thus sought from the smallholder rural household farmers, a meteorological officer and municipal agricultural and NADMO officers—to allow for some comparison with the data from the synoptic weather station.

An attempt to examine perceptions on the amount and frequency of rainfall indicates that most of the respondents were of the view that the rainfall pattern has decreased (Figure 11). For instance, 64.2 percent of the respondents were of the view that rainfall has decreased. In contrast, 28.3

percent said that the rainfall has rather been increasing. Eighteen of them (7.5%) indicated that they have not noticed any changes. The majority of the respondents who reported that rainfall patterns are generally decreasing suggests that awareness on the variation of rainfall is high among small holder rural farmers. The finding corroborates with the assertion of Ofori-Sarpong (2001) that the rainfall pattern in the area have been decreasing for the past couple of decades.

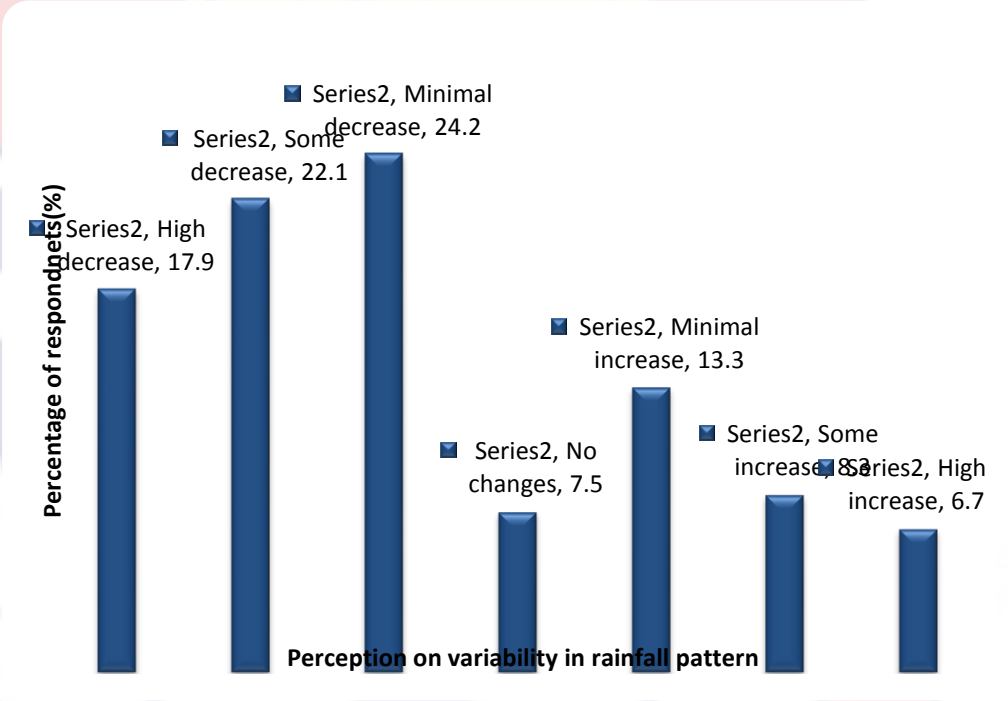

Figure 11: Perception on variability in rainfall patterns in the last 10 years Note: (Each response category of rainfall perception is expressed as a percentage of n = 240).

Source: Field survey, 2013.

In terms of the timings in rainfall, as shown in Table 3 a greater number of the respondents (85%) indicated that the rains are late, 7.9 claimed

that the rains show alternating seasons of early and late patterns and 5 percent reported that the rains have rather been early. With respect to shifts in the planting season (Table 3) 76.3 percent said that these have become shorter, 8 of them (3.3 %) said that they have become longer, 14.9 percent reported of alternating and irregular shorter and longer seasons and 14 of them (5.8 percent) indicated that there are no changes.

Table 3: Perceptions on variations in rainfall timings and planting season

Timings in rainfall				Planting season			
Early rains	Late rains	Alternating periods of early and late rains	Don't know	No changes	Shorter seasons	Longer seasons	Alternating longer and shorter seasons
N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)
12(5)	204(85)	19(7.9)	5(2.1)	14(5.8)	183(76.3)	8(3.3)	35(14.9)

Source: Field survey, 2013.

Thus, the rainfall patterns appear to show signs of considerable variation from the perspective of majority of the respondents. One respondent commented in a FGD thus:

> Current trends in rainfall have shown some shifts from what we know. The rains have become highly unpredictable. The planting season has also become shorter. These trends are making agricultural activity more risky and less rewarding. This leaves some of us wondering what the years ahead would have to offer (A 56 year old respondent from Naga).

Concerning the rainfall pattern, this was what a meteorological officer (who has been working at the Navrongo weather station for 14 years) said:

> In terms of individual rainfalls, the amounts are generally falling. For instance, we use to record rainfalls of up to 60mm, but with current trends, hardly do we make readings above 40mm. Besides, the rains set in late and rather stop early. We use to record some rains in November, but now most of the rains end in October. The other dimension of the individual rainfall pattern is that, they have become intermittent as compared to the more continuous pattern that we know.

The Municipal Agriculture crop officer also reported: *"Our experience with the farming community is that the rainfall pattern has changed markedly. The planting season has become shorter because the rains start late and end early."*

This means that aside respondents' perception that the rainfall amounts are generally decreasing, they also appear to be keenly aware of the timings of the rains with apparent reflection on the planting period. This further confirms findings (Ofori-Sarpong, 2001; Yaro, 2004) that the rainfall pattern around the area are becoming less predictable with adverse effects on agricultural activity.

With respect to variations in temperature as shown in Figure 12, it was found that 57.5 percent of the respondents reported that temperatures are generally getting warmer, 32 said that they are exhibiting alternating warmer and cooler trends and only 5 percent were of the view they are generally getting cooler. The views of majority of the farmers about the temperature

situation are captured by a 51 year old man from Pungu as follows: *"Within the past decade or so, temperatures have relatively become warmer than what has been the trend".*

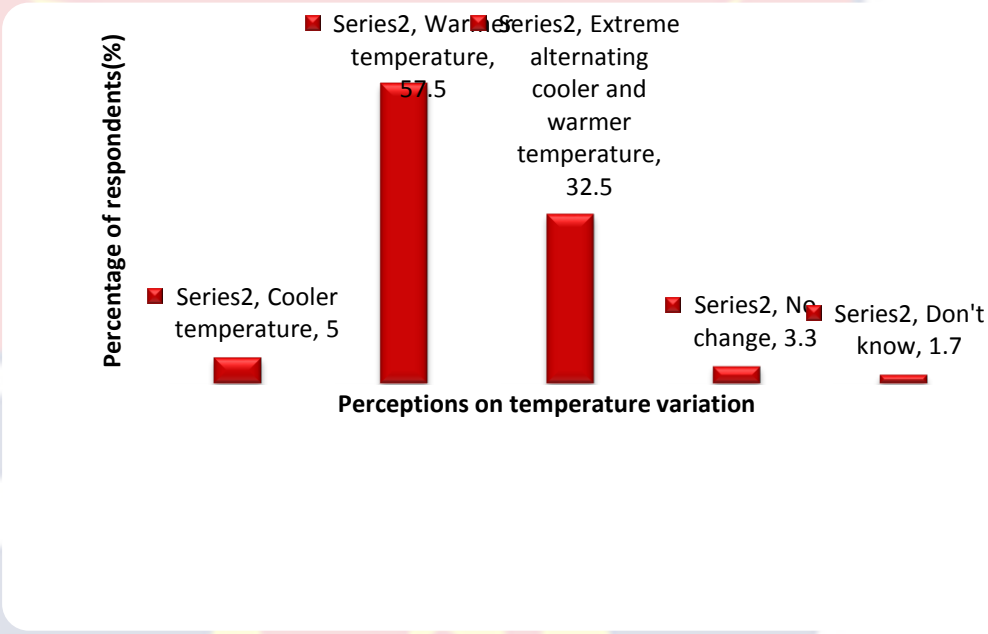

Figure 12: Perception on changes in temperature for the last 10 years
Note: (Each response category of temperature changes perception is expressed as a percentage of n = 240).
Source: Field survey, 2013.

In the same vein, the Meteorological officer remarked:

The temperatures for the area are rising abnormally. We use to have a lot of maximum temperature readings within the range of 35°C to 39°C, but the maximum temperatures are now going way beyond 40°C. Also, if you look at the earth thermometer (that reads the temperature at the soil level), there have been some abnormal recordings. For

instance, earth (soil) temperatures have been rising above 40^{o}C which is the maximum calibrated mark on the earth thermometer.

The significant percentages of respondents who reported that temperatures are either generally getting warmer or swinging between cooler and warmer extremes seems to reflect the temperature data from the weather station from Navrongo which showed relative variation about the mean but with a marginal rise of 0.4 percent over the study period. Besides, the views of the meteorological officer point to the fact that there are some marked variations in the temperature. The finding further confirms assertions by Ofori-Sarpong (2001) that annual and monthly temperatures show considerable variable patterns and rising steadily around the area. Such trends could have serious implication on agricultural activity.

According to Molua (2002) and WMO (2013), variability in climatic parameters such as rainfall and temperature usually lead to extremes such as floods, drought/ dry spells, windstorms and extreme temperatures, which result in variability in agriculture and related activities. Consequently, having assessed the perceptions of households respondents on the extent of variation of the climatic situation with particular reference to rainfall and temperature, further information was sought on the respondents' perception on the degree of seriousness of the resultant climate related conditions (floods, wind storm, drought, extreme temperature) (Table 4).

As Table 4 shows, 52.5 percent of the respondents were of the opinion that floods were either very serious or extremely serious. Besides, majority of the respondents (60.5%) were of the view that windstorms are either very or

extremely serious. Also, on the degree of seriousness of drought a significant number (54.6%) had taken the position that droughts are either very serious or extremely serious. Finally, on the item of extreme temperature, another significant number (52.1%) was also of the opinion that extreme temperatures have become either very serious or extremely serious. This was what a 48 year old male farmer from Doba said in a focus group discussion:

> Now, floods have become more serious. I recall major ones being in 2007, 2011 and 2012 which destroyed most of our farms. Most of the rains too come with heavy winds which reap-off buildings, pull down trees and destroy crops. Just at the beginning of the planting period of last year my roof got blown off by these winds. Also, we use to harvest our groundnuts in October but for most of the seasons now, we hardly get enough rains to do this, making the whole harvesting process tedious.

Table 4: Respondents' opinion on the seriousness of climate related incidences in the area

Climatic related incidence	Not at all serious N (%)	Minimally Serious N (%)	Somewhat serious N (%)	Very Serious N (%)	Extremely Serious N (%)	DK N (%)
Flood	14(5.8)	50 (20.8)	50(20.8)	72 (30)	54 (22.5)	-
Windstorm	12 (5)	20 (8.3)	63(26.3)	88(36.7)	57 (23.8)	-
Drought	12 (5)	54 (22.5)	41(17.1)	79(32.9)	52 (21.7)	2(0.8)
Extreme temperature	17(7.1)	47(19.6)	43(17.9)	61(25.4)	64 (26.7)	8 (3.3)

Source: Field survey, 2013. Note: (Each response category is expressed as a percentage of n=240).

Concerning the seriousness of the climate related incidences, an officer at the Meteorological Station confirmed the views of majority of the farmers when he reported:

> Even though individual rainfall amounts have been observed to be reducing, they mostly come in torrents and could lead to floods. Also of late, the phenomenon of squalls (sudden and very strong winds that accompany rains) is becoming quite common. These strong winds can scatter the clouds and cause uneven or reduced rains fall amount. They can be very destructive. This is what we are experiencing here.

Flowing from above, it is apparent that generally, the view of the respondents is that floods, windstorms, drought and temperature extremes can be said to be serious. The general observable trend of the degree of seriousness of the aforementioned climate related incidences is that they indeed represent a serious source of concern for weather dependant livelihood activities of households and communities. The finding corroborates the observation of Ayoola, Opele and Ikenweiwe (2011) that farming communities in the north wards parts of Nigeria are being affected by these weather extreme events leading to structural changes in livelihood base such as forced migration.

Livelihood experiences in relation to climate variability

Presented in this section is information on how exposure to climate variability risk and shocks such as floods, droughts, wind storms, and extreme temperature experienced in the area affect the livelihoods of people such as agricultural activity, dwellings, and health and how their inability to deal

effectively with them could contribute to poverty and prevent people from seizing opportunities to overcome them and to achieve more sustainable livelihoods in the current environmental context.

Effects of rains/floods on livelihoods

Floods are one of the main weather related threats that affect livelihoods. An attempt to examine respondents' perceptions on the effects of floods on various commonly identified aspects of livelihoods revealed that most of the respondents were of the view that floods are considered a serious issue (Table 5).

Table 5: Findings on the effects of excessive rains/floods on livelihoods

Livelihoods; aspects	SD N(%)	D N(%)	NS N(%)	A N(%)	SA N(%)
Crop	13 (5.4)	50 (20.8)	48 (20)	72 (30)	57 (23.8)
Livestock/poultry keeping	12 (5)	20 (8.3)	60 (25)	93 (38.8)	55 (22.9)
Housing/dwelling	38 (15.8)	56 (23.3)	54 (22.5)	65 (27.1)	27 (11.2)
Health	36 (15)	63 (26.3)	48 (20)	34 (14.2)	59 (24.6)
Water sources	48 (20)	59 (24.6)	51 (21.3)	55 (22.9)	29 (11.2)

Key: SD – Strongly Disagree, D – Disagree, NS – Not sure, A – Agree, SA – Strongly Agree. Note: (Each response category is expressed as a percentage of n=240).

Source: Field survey, 2013.

For instance, on crop production, 53.8 percent of the respondents either agreed or strongly agreed that floods are a worrying issue. On the contrary, 26.2 percent of the respondents either seriously disagreed or disagreed that

floods affect food crop production. The significant number (53.8%) that was of the opinion that floods represent a serious challenge views can be summarised by what a 61 year old farmer from Naga remarked in a focus group discussion:

> Floods can be considered quite serious in this area, as they directly affect farming activity in many ways. Floods normally cause soil erosion, inundate farms and affect crop productivity. The years 2007 and 2011 were particular years when the floods were so devastating.

This finding is in direct consonance with findings (Gichere et al., 2012) that floods are one of the main climatic extreme that negatively affect the agricultural sector (especially crop activity) of most rural farm households in Kenya. By this it is implied that most rural farm households would have to be supported to come up with more innovative ways of copying and adapting to these developments.

The effects of floods on livestock which constitute an integral part of the agricultural base of most rural households have also been looked at. The respondents who spoke to this issue gave a diverse range of responses (Table 5). The majority of them (61.7%) either agreed or strongly agreed that floods affect livestock keeping while 13.3 percent of them either disagreed or strongly disagreed. It is also noted from the data that, 25 percent of them were not sure the extent to which this livelihood aspect (livestock keeping) is being affected by floods. The views of the majority of respondents who reported that floods affects livestock keeping reflected in a focus group discussion as below:

During heavy rains and floods, grazing fields may not be accessible and at times our animals are carried away. In 2011, we had the bitter experience of some animals being washed away. Kraals too were inundated causing discomfort and even disease outbreak in animals (A 65 year old farmer from Telania)

By these findings, it has become evident as confirmed by USCCSP, (2008) that livestock keeping which has been an age old practice by most rural households in sub-Saharan Africa is being adversely affected by pronounced changes in weather pattern, leaving poor household with little means of proper husbandry practices challenged. The implication is that in rural set ups where livestock keeping supplement cropping, households could face serious challenges that could further worsen the incidence of poverty among rural folks.

Effects of droughts on livelihoods

Aside rains/floods, the study sought to ascertain the effects of drought on livelihoods (crops, livestock and water sources). The question thus put to the respondents on the extent to which they agree or disagree to the effects of droughts on various livelihood aspects. The information in Table 6 gives a wide range of responses in respect of each livelihood category.

Table 6: Survey data on the effects of drought on livelihoods

Livelihood aspects	SD N(%)	D N(%)	NS N(%)	A N(%)	SA N(%)
Crops	16 (6.7)	20 (8.3)	41 (17.1)	65 (27.1)	100 (41.7)
Livestock	13 (5.4)	15 (6.3)	18 (7.5)	89 (37)	105 (43.8)
Water sources	3 (1.3)	7 (2.9)	5 (2.1)	111(46.3)	114(47.5)

Key: SD – Strongly Disagree, D – Disagree, NS – Not sure, A – Agree, SA – Strongly Agree. Note: (Each response category is expressed as a percentage of n=240).

Source: Field survey, 2013.

From Table 6, a significant number of the respondents (68.8%) submitted that they either agreed or strongly agreed that crop production has been substantially affected by the occurrences of droughts/dry spells while 15 percent took the position that they either strongly disagreed or disagreed. Also, majority of the respondents (80.8%) either agreed or strongly agreed that droughts have substantial and material effects on livestock rearing/poultry keeping. Contrasting this, 11 percent of the respondents either disagreed or strongly disagreed that drought significantly affects livestock/poultry rearing, while 7.5 percent of the respondents remained ambivalent. An overwhelming majority (93.8%) of the respondents either agreed or strongly agreed that droughts have a telling effect on water sources/supply. In contrast, an insignificant percentage of 4.2 percent of the respondents were of the view that drought were not much of an issue affecting water sources/water supply.

The views of the majority of the respondents who reported that droughts have far-reaching effects of livelihoods have also been captured by what one farmer from Kologo reported in a focus group discussion:

> The incidence of drought is becoming serious. We have had numerous seasons of poor harvest due to droughts. Besides, foddering is inhibited and some water sources from which animals drink dry up.

The above finding is a clear indication that farmers are aware of the seriousness of the phenomenon of droughts/dry spells as having adverse effects on the livelihoods. Be that as it may, the high percent of respondents who in this study reported that droughts/dry spell have substantial effect on crop productivity are not alone in this thinking as other studies (Offri-Sarpong, 2001; Yaro, 2004; Idowu et al, 2011; Gichere et al., 2013) have pointed to this. It also bears stating that the high percentage of respondents who reported that indeed droughts are adversely affecting livestock and poultry keeping reflects similar studies (Gichere, 2013; WMO, 2013) that livestock keeping especially in sub-Sahara Africa is being threatened by drought which adversely affect households.

Effects of wind storms on livelihoods

The literature has shown that, in the sub-Saharan Africa region, wind storms constitute another disturbing outcome of the climate variability phenomenon, with varying degree of impacts on communities. Regarding this, the question was put to respondents to assess the extent to which they agree or

do not agree in their estimation, the effects of wind storms on their livelihoods. The livelihood aspects/issues considered here were crop production, livestock rearing, housing/dwelling, which are presented in Table 7.

Table 7: Responses on the effects of windstorms on their livelihoods

Livelihood aspects	SD N(%)	D N(%)	NS N(%)	A N(%)	SA N(%)
Crop production	14(5.8)	7(2.9)	13 (5.4)	107(44.6)	99(41.3)
Livestock rearing	17 (7.1)	47 (19.6)	41 (17.1)	64 (26.7)	71 (29.6)
Housing/dwelling	12(5)	21(8.8)	23(9.6)	90(37.5)	94(39.2)

Key: SD – Strongly Disagree, D – Disagree, NS – Not sure, A – Agree, SA – Strongly Agree. Note: (Each response category is expressed as a percentage of n=240).

Source: Field survey, 2013.

As can be seen from Table 7, as high as 85.9 percent of the respondents agreed or strongly agreed that windstorms are a problem insofar as their cropping culture is concerned. On the contrary, 21 of the respondents (8.7%) strongly disagreed or disagreed that windstorms affects their crop productivity. Similarly, while 56.3 percent of the respondents either agreed or strongly agreed that windstorms are having serious effects on livestock keeping, 26.7 percent either strongly disagreed or disagreed. Also, a significant number of the respondents (76.9%) were of the position that wind storms have marked effects on the housing/dwelling structures. In contrast, a

little over a tenth of them (13.8%) either disagreed or strongly disagreed that, windstorms did not have any negative effect on the housing/dwelling units.

The views of the respondents were captured perfectly in a statement by one farmer in a focus group discussion as follows:

> In most years, especially during the beginning of the rainy season, strong winds are normally experienced. But in recent times these winds are becoming more serious; as they leave in their wake massive destruction to live and property". For instance, during the beginning of the rainy season last year, rainstorms caused considerable damage to my roofs. Also, strong winds affected my maize farm towards the later parts of the rainy season (A 39 old farmer from Wanjagnia).

Corroborating the findings above, the Kassena-Nankana municipal NADMO records also indicates that, since 1998, the total number of victims as a result of Windstorms stands at 2,513, with the number of public property destroyed being 110. The records further indicate that the number of houses affected stood at 338 with five deaths.

With the above findings, while it can be considered that wind storms are a serious weather threat to grapple with, it cannot be said of this threat as being peculiar to the study area as other studies have shown that most communities in the sub-Saharan African region have this weather issue (wind storms) to deal with (Idowu, et al., 2011). The bottom line of this assessment is that, the destructive nature of the windstorm aspect of the generality of the climate variability phenomenon is a well known fact across different

communities. It can therefore be validly asserted that, past experiences with this extreme weather event as shown by the literature could form part of the overall assessment and response strategies to mitigate its effects as would be explored further in the subsequent section of this study.

Effects of temperature on livelihoods

It also came out clearly from the literature review that extreme temperature variations is one of the manifestations of climate variability that presents serious challenges to livelihood based resources and activities. Consequently, data was gathered in this respect from the respondents and the Municipal Agriculture and NADMO outfits. The information thus, gathered from the households respondents are captured in Table 8.

Table 8: Survey findings on the effects of extreme temperature

Livelihood aspects	SD N(%)	D N(%)	NS N(%)	A N(%)	SA N(%)
Crops	14 (5.8)	8 (3.3)	27 (11.3)	92 (38.3)	99 (41.3)
Livestock	17 (7.1)	11(4.6)	16 (6.7)	98 (40.8)	98 (40.8)
Housing/dwelling	14 (5.8)	50 (20.8)	52 (21.7)	69 (28.8)	55 (22.9)
Health	14 (5.8)	55 (22.9)	43 (17.9)	73 (31.5)	53 (22.1)
Water source	14 (5,8)	21 (8.8)	62 (25.8)	88 (36.7)	55 (22.9)

Key: SD – Strongly Disagree, D – Disagree, NS – Not sure, A – Agree, SA – Strongly Agree. Note: (Each response category is expressed as a percentage of n=240).

Source: Field survey, 2013.

It emerges from Table 8 that a good number of the respondents (79.6%) reported that temperature extremes affects crop productivity while 9.1 percent of them either agreed or disagreed. It could also be seen that a whopping proportion (81%) said livestock are affected by extreme temperature while 11.7 percent either strongly disagreed or disagreed. Besides, 53.6 percent indicated that extreme temperatures could have implications on their health whereas 28.7 percent did not agree to this.

The views of the respondents can be captured more aptly, for example by what one of them remarked in a focus group discussion:

> Extreme temperature makes life very uncomfortable here. Ranging from working in the farm under the scorching sun to high night time temperatures life can be very uncomfortable. Crops and livestock's are affected as well. We are also aware that during periods of extremely high temperature: thus mostly around the month of March, CSM could break out (A farmer from Chaaba).

It is manifestly clear from the above that the position of the majority of the respondents indicates that in the face of the effects of climate variability on livelihoods, extreme temperatures and their variability cannot be counted out. The finding is in line with Somorin's (2010) claim that such variations could disrupt the relationships between people and ecosystems with the poor in rural communities carrying the heaviest burden. This implies that high temperatures and their variability too contribute to people's vulnerability context, as these cause disruptions in their livelihoods base.

Following from the foregoing analysis of the effects of extreme weather events on livelihoods, it comes out quite clearly that by and large they indeed posed enormous challenges and constraints on rural communities. These findings clearly corroborates assertions by McCarthy et al. (2001) that associated influences and impacts of altered precipitation and temperature patterns with corresponding increase in the frequency of extreme events such as drought and floods and windstorms would definitely work to increase risks associated with productivity with the resultant decrease in yields. These have wide ranging implications for especially rural areas in developing countries and could further widen the gap between the rich and the poor.

Adaptation and mitigation strategies/responses to the effects of seasonal variability on their livelihoods

The preceding section examined the effects of extreme weather events on livelihoods. Presented in this section is information on the response strategies and coping mechanisms that rural farm households undertake to meet the identified threats and challenges posed by climate variability in order to ultimately attain and secure more sustainable livelihood outcomes (i.e. reduced vulnerability, increased wellbeing etc).

Farm households responses and coping strategies to seasonal changes in weather patterns

First, on farm households' response strategies and coping mechanisms to seasonal weather changes and the resultant extreme events, a wide response

range was provided. As Adger (2007) notes, human societies throughout history have always shown a remarkable capacity for adapting to climate and environmental changes through various means. Considering the nature of rural households, basically, these strategies are actions to reduce/prevent risk and ex-post risk management, involving essentially both diversification of farm and the adaptation of nonfarm activities.

Respondents' views were then sought on how they are coping with this climate variability situation. As it is evident from Table 9, 47.1 percent of the respondents admitted that diversification of the farm crops was a viable response strategy. In contrast, 47.1 percent of them did not agree. A little over five percent (5.8%) were not sure (unable to answer).

The equal percentages for either side of those who agreed and those who did not, coupled with the rest of the respondents (5.8%) who were not sure, reveals something interesting— while people may feel the need to be responsive, some may hold on to their age-old ways of doing things. These findings correspond to similar results reached by Gichere et al. (2013) in their study in Kenya, that people may not easily budge either because of ignorance or simply being unwilling to embrace change.

Aside crop diversification, diversification of livestock featured next in the livelihoods response options. A noteworthy number of respondents (42.6%) did not agree. A small number of the respondents (3.3%) were not sure (unable to answer) while 42.8 percent of them agreed. This response pattern in a sense could be linked to the explanation given in relation to peoples' attitude towards crop diversification—as some may diversify, others

simply do not find it easy to break away from their old and usual ways of doing things.

Table 9: Range of responses by households to climate variability and trends

Livelihood responses	SD N(%)	D N(%)	NS N(%)	A N(%)	SA N(%)
Diversification of farm activity					
Diversification of crops	48(20)	65(27.1)	14(5.8)	76(31.7)	37(15.4)
Diversification of livestock	50(20.8)	80(33.3)	8(3.3)	45(18.8)	57(23.8)
Integration of crops and livestock	18 (7.5)	47(19.6)	45(18.5)	60 (25)	70(29.2)
Irrigation	105(43.8)	89(37.1)	3(1.3)	26(10.8)	17(7.1)
Early cropping	78 (32.5)	62(25.8)	12 (5)	48(20)	40(16.7)
Late cropping	43(17.9)	37(15.4)	14(5.8)	80 (33.3)	66(27.5)
Using drought tolerant crops and early maturing varieties	63(26.3)	48(20)	19(7.9)	61(25.4)	49(20.4)
Sale of labour for cash and food	55(23)	45(19)	5(2)	72(30)	63(26)
Sale of livestock to buy food	63(26)	59(25)	-	43(18)	75(31)
Borrowing food	96(40)	79(33)	7(3)	34(14)	24(10)
Adaptation of non- farm activity					
Trading	63(26.3)	43(17.9)	-	69(28.8|)	65(27.1)
Out-migration	36 (15)	60 (25)	52(21.7)	35(14.6)	57(23.8)

Key: SD – Strongly Disagree, D – Disagree, NS – Not sure (Unable to answer), A – Agree, SA – Strongly Agree.

Source: Field survey, 2013.

Droughts have been noted as one of the major climate extremes in the study area, with devastating effects on especially crop production. The survey data in Table 9 indicates that irrigation has been one of the response options. Thus, the data illustrates that only less than a fifth (17.9%) of the respondents agreed that irrigation was part of their response strategies while a whopping 80 percent strongly disagreed or disagreed that irrigation was an option they resort to in response to climate challenges. To that huge number who did not use irrigation, it was apparently because they were not close to dependable water sources from which to irrigate their farms.

This finding thus, confirms early findings by Ofori-Sarpong, (2000) that even though farmers are aware of the importance of irrigation in drought periods, they do not have water bodies. Perhaps this situation may call for mini water resource conservation-based technologies such as *in situ* moisture conservation, rainwater harvesting and recycling, dug-outs (wells and mini earth dams) as highlighted by Venkateswarlu and Shanker (2009) in their study of climate change agriculture and adaptation strategies in India.

Aside crop and livestock diversification and irrigation being some of the response options as discussed above, the study also found out as illustrated in Table 9 that households tend to shift planting seasons, that is, by either early or late cropping. On early cropping, nearly three-fifths (58.3%) of the survey respondents disagreed that this was their response option, a fifth (5%) was not sure (unable to answer) and 36.7 percent of them agreed that this was their household response options. While on late cropping, a third (33.3%) disagreed that this was an option, a little over a fifth (5.8%) were unable to answer and

60.8 percent agreed that this was their household response option to climate variability.

The above early and late cropping data were not merely to determine the shift in the planting season as a response to climate variability, but to go further to determine which direction this shift goes. Thus, the information shows that majority of the survey respondents do not consider early cropping an effective option, implying that they favour late cropping.

Besides the information on shifting the planting season, the study sought information on the usage of drought tolerant crops and the early maturing varieties. The data is thus, displayed in Table 9. It is shown that, 46.3 percent of the survey respondents did not agree that their household use draught tolerant crops and early maturing varieties, less than a tenth (7.9%) were not sure (unable to answer), and 45.8 percent of them agreed.

From the above, the majority of respondents either did not agree or could not answer for sure that they use drought tolerant and early maturing varieties. This may suggest that, they either have little or no information and/or access to these varieties or they simply do not want to venture into new varieties they may have little knowledge on. This information seems to confirm the findings from the municipal agricultural directorate that some are embracing this, but more still needs to be done.

Considering the fact that formal employment is significantly low among rural households in the area, the study attempted to gather information on some of the non-farm activity that households resort to in the face of climatic stresses aside the farm diversifications options discussed earlier.

Under the adaptation of non-farm activity category, the study captured data on two basic and critical areas—petty trading and out-migration. From Table 9, the data indicates that 55.9 percent of the survey respondents agreed that trading (in its varied form) has to be taken to since agricultural activity has become less predictable. The rest of the respondents (44.2%) disagreed that trading and related activities have been resorted to, given the effects of extreme weather events on agricultural-based livelihoods. This perhaps implies that they have other sources of livelihoods aside agriculture activity and trading.

Similarly, on migration, information from Table 9 reveals that 40 percent of the survey respondents did not agree that migrations constitute their household response options to climate stresses, about a fifth (21.7%) could not answer for sure whether migration was as a result of climate stresses and the remaining 38.4 percent agreed that migration was part of their households response towards the adverse effects of the weather as it impacts negatively on agriculture-based livelihoods. Thus, even though the majority of the respondents did not consider migration as an option, a considerable number of them (38.4%) were of the position that, migration constituted part of their response options to climatic stresses.

The views of the majority of the respondents on the coping and adaptation strategies are reflected in what one farmer from Tampola reported in a focus group discussion:

> With current variations in the weather pattern, we are facing serious challenges. For instance, we are experiencing food deficits —a

situation which pushes some of us to borrow food and even to the extent that we have to sell our livestock on regular basis to buy food and other household expenses something which was not very common in the past. Others simply migrate or take to other non-farm activities such as trading.

The information from non-farm activities (trading and migration) as discussed above corresponds to findings similar to Ofori-Sarpong (2001) which suggests that given low formal employment opportunities, climate stressed communities may naturally combine both non-farm activities with farm-diversification options in their quest to achieve sustainable livelihoods.

Municipal Agriculture officer's view on farm households livelihoods and climate extremities

On the specific question of how they assists farm households to cope with and adapt to the effects of the climatic hazards on livelihoods, the municipal agricultural crop officer gave a variety of responses and coping strategies considering the particular livelihood activity involved. He was emphatic on especially food crop production strategies which most farm households are buying into. As he puts it:

We encourage the use of early maturing (short duration), high yielding and drought tolerant food varieties. This is because, the varieties mature before floods set in and the drought resistant varieties surviving, thereby significantly reducing the amount of loss. For instance, for maize we have *Doke* (an early maturing variety that takes

two and an half months to mature), *golden crystal* (an early maturing 90 days variety); and *Obatampa (*which is a drought resistant variety). We also have an early maturing rice variety known as *Jasmine* that takes 85-90 days to mature; an early maturing sorghum variety known as *Naga red* and the *early millet* that takes 57 days to mature.

Information was further sought on whether the strategies/responses put forward have proved effective and what their directorate is doing to further enhance the capacities of rural households especially to effectively deal with these climate effects. The response was that:

> Some of the strategies and responses we have been advocating have proved very useful. What we normally do is that, we organise training on the use of these new technologies to the farmers. However, we have sustainability problems. Our experience has been that, when we withdraw, some of the farmers tend to revert to their old and familiar ways of doing things. This is perhaps because these innovations require a lot of inputs and some of the farmers lack the resources and capacity to adapt. However, we try to embark on sustained and continuous education and training on the need for the adaptation of appropriate coping and response strategies in the face of the changing climatic conditions.

The assertion by the municipal crop officer corroborates the mixed views of some of the farmers and their incapacity to adapt. The findings fall in line with assertions by Sen (1999) that rural people tend to be most vulnerable to climate variability because not only do they not have the resources and

capacity to cope with these but also they cannot depend on safety nets to cushion the impacts of these climatic extremes. But as noted by Smit et al., (2000); and Watson et al., (1996), understanding the dynamics behind a particular society's adaptation and how positive such adaptations can be enhanced are crucial for sustainable practice and livelihood security.

The above findings from the municipal agricultural directorate indicates that even though efforts such as sustained education on the viability and the provision of such new varieties, as part of the overall adaptation and mitigation strategies, there are significant challenges that must be addressed to make these efforts more effective.

Municipal NADMO outfits perspectives on the response and coping strategies to extremities of climatic variations

The research further elicited information from NADMO on their assistance to rural households coping and response efforts regarding the effects of the climatic extremes (especially, floods, drought, wind/rainstorms and extreme temperatures) on livelihoods. On this question, the municipal NADMO officer provided elaborate and incisive information per each of the above stated climatic hazards as follows:

> In terms of floods, some of the coping mechanisms put in place include: Provision of shelter for displaced victims through mounting of tents and the use of public facilities like schools, community clinics and churches to accommodate victims temporarily while permanent options are being evaluated; the supply of relief items, after an

assessment of the situation is completed to ascertain the definite number of person affected by the disaster in order to alleviate their hardships; and environmental cleaning after a disaster to forestall the outbreak and spread of any health related hazard like cholera, diarrhoea and malaria.

On drought, the Municipal NADMO officer further states that:

In terms of droughts which obviously have the general tendency of causing food shortage among other things, a variety of strategies are put in place both in anticipation and in the event of drought. For instance, public sensitisation is done on regular basis to emphasise the need to plant more trees in the environment in order to reduce the effects of drought in the area. Also, advocacy continues on a sustained basis on the imperative need to take irrigation farming seriously as well as the diversification of their conventional livelihood activities in order to insulate against and mitigate the impacts of droughts.

With regard to wind/rainstorms, the Municipal NADMO officer's response reads:

As a precautionary measure, advocacy is done on the possibilities of windstorms occurrences which are mostly common at the beginning of the rainy season. However, in the event of a wind/rainstorm, the coping mechanisms are similar to that of the flood mentioned earlier on, thus: evacuating the displaced victims, and the use of facilities such as schools and churches to accommodate the displaced as a temporary measure. Relief items such as food, roofing sheets and nails, blankets

and bed sheets, pillows, mattresses, clothing and so on are provided upon a close assessment of the situation. The environment is also cleared of filth in order to avoid environmental health hazards like cholera, diarrhoea and so on.

Finally, in respect of the NADMO outfit assisting in dealing with the threat of extreme temperatures, and the upshot on livelihoods, the official states as follows:

> We embark on education and sensitisation programmes to create and increase awareness on the need to desist from environmentally unhealthy practices such as cutting down lush vegetation for charcoal burning, and indiscriminate chainsaw activities. We also advocate strongly, the need to strictly enforce bye laws in this regard. Further, we seek to promote tree planting through the provision of plant seedlings at the community level to improve the environment and the local ambient temperature. Thus, mindful of the saying that: *When the last tree dies, the last man dies".*

The above responses from the municipal NADMO indicate the reality of the climate variability issue as revealed by the farmers and municipal agricultural directorate, which require appropriate responses. As noted by Parry et al. (2008); and Schellnhuber (2008) such weather extremes pose enormous influence on livelihoods and adaptation and mitigation are considered very crucial.

Further information was sought in respect of the foregoing efforts by NADMO as to whether these coping strategies/responses are working out to

their expectation. On this question the answer from the NADMO officer was very emphatic thus:

> To a large extent, most of our strategies and efforts have paid off. However, I must admit that, we are faced with major challenges which essentially border on finance and logistics.

The study also sought to gather information (from the NADMO outfit) on whether or not their response strategies have changed based on changing seasonal events or in the light of new developments. In the words of the NADMO officer:

> There have been some changes in our approach since the organisation has instituted new modalities and reforms in our programmes and projects which are aimed at effective Disaster Risk Reduction (DRR) in the face of the fact that, these weather related disasters in the area have remained intense as before if not worse. For instance, we have the Community Based Disaster Risk Reduction (CBDRR) programme being introduced. The idea behind the CBDRR is to promote a community based disaster management and organisation such that the people will feel a sense of belongingness and engaged to work hard and coordinate better to ensure that disasters if not curtailed are reduced to the barest minimum.

The above measures adopted by NADMO to actively incorporate the local communities in their management and organisational efforts fall in line with findings by Mary and Majule (2009) and Stanturf et al. (2011) that participatory knowledge and community-based approaches are of essence for

designing innovative systems to deal effectively with effects of climate variability. With such collaborative work, the influence of the effects of weather variations could be reduced and make life bearable for especially poor rural communities.

Finally, information was sought from the Municipal NADMO officer on what the organisation is doing specifically to contribute to appropriate response needs of the people. On this question, he notes:

> The organisation is holistically looking at adequately resourcing all its outfits to enable them work effectively. Currently, the organisation is going through a process of being changed into a service, so that it can be budgeted for during the reading of the national budget. This will enhance the outfit's response time to incidence of disasters and avoid the delays associated with raising money to fund items our current state as a subvented organisation.

In view of the above findings, it stands out quite clearly that, like the agricultural outfit in the municipality, NADMO, having recognised the increasing seriousness of the nature of climate variability and the effects it exerts on livelihoods have come out more forcefully to help meet some of the challenges it poses. However, the concern is that they are seriously under resourced to deal effectively with the enormity of the situation as it manifests itself variously year in and year out.

Chapter summary

The chapter reveals that extreme changes and variations in weather patterns are real, and are presenting real challenges to especially agriculture-dependent livelihoods among most rural households. Given this, a wide range of both ex ante and ex post actions have been taken to meet these challenges by households and relevant outfits such as the Municipal agriculture and NADMO offices to secure more sustainable livelihoods. However, major areas of concerns still exist which need to be addressed in order to adequately meet the challenges posed by the weather extremes in the area. The next chapter presents a summary of the conclusion of the study findings as well as offering constructive recommendations for possible future action.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This is the last chapter of the study. Essentially, the chapter sets out to round off the study with a summary of the findings, conclusions reached, and recommendations made for further attention and action in the area of reducing the effects of climate variability on livelihoods in the study area and elsewhere.

Summary of findings

The research provided the opportunity to explore the main subject of concern which essentially was, on one hand to describe the nature and extent of climate variability and on the other hand to examine the effects of the seasonal changes in weather patterns on rural livelihoods and the response strategies thereof in the Kassena-Nankana Municipality. The study employed the cross sectional descriptive survey design in carrying out the research based on the stated objectives.

Quantitative meteorological data was obtained from the synoptic weather station for the climate variability analysis. Multi-stage sampling technique was used to select 240 household respondents from 21 selected rural communities. Focus group discussions were also conducted with farm the household respondents. Besides, a respondent each from the District

agricultural and NADMO offices were purposively sampled to further assess the extent and nature of climate variability, its manifestations and effects on livelihoods as well as response strategies adapted. In all, thus, a total of 242 respondents were involved in the study. Taking the nature of the data gathered into consideration, both quantitative descriptive and qualitative procedures and techniques were used for the analysis. Specifically, simple descriptive statistics such as graphs, percentages and frequencies were used. Also, employed were simple descriptive narratives of responses given. Relevant records and documents also proved useful.

The main findings of the study were as follows:

1. The study clearly reveals, regarding the observed trends and patterns of climate parameters (especially rainfall and temperatures) from the synoptic weather station that, the nature and extent of climate variability is quite significant. This has been shown by substantial variations and divergence of annual and monthly mean distributions of climatic data for a twenty three year period (1990-2012). For instance, rainfall amounts have been found to be generally variable and decreasing with late on-sets. The temperatures too have also shown considerable variations but with marginal increases. Also, findings on the perceptions of the survey respondents showed a close affinity to the data from the synoptic weather station on the nature and extent of climate variability.

2. The research has shown that, climate variability manifests itself in weather shocks and extremes such as excessive rainfalls/floods, droughts,

windstorms and extreme temperatures. These weather extremes have been found to have substantial effects on ecosystem-dependent livelihoods of households in the area.

3. A wide range of adaptation and mitigation strategies have been used by farming households in response to the climatic variability shocks and extremes on their livelihoods. These are basically diversification of farm activities and the adaptation of non-farm activities. The diversification of farm activities include crop and livestock diversification, crop and livestock integration, irrigation, sale of livestock, early cropping, and late cropping. With the adaptation of non-farm activities, responses include shift to trading and out-migration.

4. Findings from the Municipal Agricultural Directorate indicate that, they encourage the use of early maturing and drought tolerant food varieties, as well as continuous education and training on the courses of extreme weather changes as well as coping and response strategies thereof. It was also found out that the municipal NADMO embark on periodic early warning and public sensitisation as well as providing relief assistance to forestall and mitigate the effects of the weather extremes on livelihoods in the area.

Conclusions

Based on the objectives, analysis, and key findings, the conclusion of the study is drawn along the following: context (the nature and extent of the climate variability); consequence (the effects of seasonal variations and

weather extremes on livelihoods); and response (coping options and strategies).

Contextually, the considerable variations in the climatic parameters as showed by the climatic parameters and confirmed by the survey responses are ample manifestation of the unpredictability of the weather and resultant stresses. This confirms current and emerging concerns about the phenomenon of climate variability and change and the potential strains and challenges that could be posed on especially agriculture dependent rural livelihoods.

Consequentially, it has indeed been shown that these observed climatic extremes are having a critical toll on the activities and livelihoods of the rural farmers. With most rural livelihood being largely dependent on agricultural activity, coupled with the fact that they are relatively poor, this trend in seasonal variability means that these areas are being substantially challenged. The implication being that, this serves to frustrate efforts and erode any gains made towards agricultural development and rural livelihood improvement.

In the face of these observed weather variations and extremes, the people have naturally, resorted to both age-old and more refined and innovative combination of farm diversification and non-farm methods/activities to secure more sustainable livelihoods. However, concerns such as the sheer dimensions of the weather extremes coupled with unwillingness of some of the farmers to break from tradition and embrace more innovative farming practices constitute real challenges.

Recommendations

Based on the findings and conclusions of the study, the following recommendations were made on the measures to reduce the effects of climate variability on livelihoods in the study area:

1. The climatic data analysis, survey respondents' perceptions and records of the municipal agricultural directorate as well as NADMO confirm a considerable climate variability trend in the study area. This underscores the need for greater attention and priority to be given by government in the area of supporting and resourcing relevant agencies such as the meteorological, agriculture and NADMO offices and other related bodies, whose mandate border on climate related issues to be able to keep more accurate data and provide timely reliable and useful information on unfolding climate variability and livelihood related trends that would help take informed decision and actions.

2. There is also the imperative need for close collaboration between key stake holders such as the meteorological agency, agricultural directorate, local media, traditional authorities, the municipal assembly, farmer-based organisations and faith-based organisations in the areas of creating and increasing awareness on the nature and extent of climate variability and its effects on livelihoods and the way forward.

3. On the effects of climate variability on households' livelihoods, it is valuable for the scaling up of pro-poor and pro-rural assistance programmes by government and other stakeholders regarding the provision of small scale water harvesting and conservation methods, the provision of credit facilities and the most viable options in the range of both farm activity and non-farm diversification and adaptation responses resorted to by farm households.

Suggested areas for further research

Further research is recommended in the area of effective collaborative work between MMDAs, traditional authorities and other relevant stakeholders in working towards adequate and effective adaptation and mitigation strategies and mechanisms to reduce the effects of climate variability on livelihoods as well as the effective management of livelihood-based resources at local levels.

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APPENDICES

Appendix A: Interview schedule for rural farmers

Section A: Background Information

1. Name of Village/Community: .....
2. Sex: M [ ] F [ ]
3. Age……
4. Level of education……
5. a) Primary (Major) occupation…….
6. b) Subsidiary occupation(s)
   i. ……..
   ii. ……..
7. Household size (Number of persons)…….....

Section B: Perceptions on the nature and extent of climate variability

8. How would you describe the amount and frequency and of rainfall in the areas for the past 10 years? *(Choose an answer from below, by marking in the appropriate box.)*

(a)

High decrease	Some decrease	Minimum decrease	No decrease	Minimal increase	Some decrease	High decrease

(b)

Timings in rainfall				Planting season			
Early rains	Late rains	Alternating periods of early and late rains	Don't know	No changes	Shorter seasons	Longer seasons	Alternating longer and shorter seasons

Further explanation……...

9. What is your perception on changes in temperature for the past 10 years? *(Choose an answer from below, by marking in the appropriate box.)*

Cooler temperature	Warmer temperature	Extreme alternating cooler and warmer temperature	No changes	Don't know

Further explanation……...

10. How would you describe the seriousness of the climate related incidences in the area for the last 10 years or so?

*(Choose an answer from (1) to (6) by marking in the appropriate box. Choose **DK** if you don't know).*

Climatic related incidence	Not at all serious	Minimally Serious	Somewhat serious	Very Serious	Extremely Serious	DK
Flood						
Windstorm						
Drought						
Extreme temperature						

Further explanation……...

Section C: Effects of seasonal variability on livelihoods

11. To what extent to you agreed with the effects of these weather events on various aspects of your livelihoods?

(I)Rains/floods

Livelihoods; aspects	SD N(%)	D N(%)	NS N(%)	A N(%)	SA N(%)
Crops					
Livestock/poultry keeping					
Housing/dwelling					
Water Sources					

Further explanation……..

(II). Drought

Livelihood aspects	SD N(%)	D N(%)	NS N(%)	A N(%)	SA N(%)
Crop-agric					
Livestock					
Water Source					

Further explanation……

(III). Wind/Rainstorm

Livelihood aspects	SD N(%)	D N(%)	NS N(%)	A N(%)	SA N(%)
Crop production					
Livestock rearing					
Housing/dwelling					
Water Source					

Further explanation……

(IV). Extreme temperatures

Livelihood aspects	SD N(%)	D N(%)	NS N(%)	A N(%)	SA N(%)
Crops					
Livestock					
Housing/dwelling					
Water Source					

Further explanation……

Section D: Livelihood responses to seasonal variability

12. To what extent would you agree or disagree that the options provided below apply as possible to responses by farm households to climate variations and trends? *(Mark the appropriate box)*

Livelihood responses	SD N(%)	D N(%)	NS N(%)	A N(%)	SA N(%)
Diversification of farm activity					
Diversification of crops					
Diversification of livestock					
Integration crop and livestock					
Irrigation					
Early cropping					
Late cropping					
Using drought tolerant crops and early maturing varieties					
Sale of labour for cash and food					
Borrowing food					
Adaptation of non- farm activity.					
Trading					
Out-migration					

Further explanation……...

Appendix B: Focus Group Discussion guide for rural farmers

- Place and date of discussion: ……
- Number of People participating: ……

Section A: The nature and extent of climate variability

1. Can you give a general over view of the climate trend experienced here?
2. How would you describe the weather pattern (e.g. rainfall pattern and temperature trends) in recent times?
3. Can you mention specific climate induced events common in this area?
4. Are there any differences as compared to 10/20/30 years ago?
5. Can you predict any trends in these weather events?

Section B: Effects of seasonal variability on livelihoods

6. How would you explain the effects of these extreme weather events (hazards) on your livelihoods? (Especially, floods, drought, wind/rainstorms and extreme temperatures)

Section C: Livelihood responses to seasonal variability

7. How do you cope with the effects of the climatic hazards on your livelihoods? (Especially, floods, drought, wind/rainstorms and extreme temperatures)
8. Are these strategies/responses working?

9. Have these livelihood strategies/responses changed, based on changing seasonal events? (e.g. over the past 10-20 years).
10. How could these livelihood response strategies be enhanced?

Appendix C: Key informant interview guide for Meteorological Officer

- Date of interview.....
- Specific position.....

How would you describe the climate situation in the area in terms of changing patterns in respect of the following for the past 10 years or so?

1. Rainfall patterns (amounts, set-in and end periods, intensity etc)
2. Temperature
3. Windstorms etc

Appendix D: Key informant interview guide for Agricultural Officer

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Section A: Background information

- Date of Interview.....
- Specific Position.....

Section B: The nature and extent of climate variability

1. Can you give a general over view of the climate trend experienced here?
2. How would you describe the weather pattern (e.g. rainfall pattern and temperature trends) in recent times?
3. Can you mention specific climate induced events common in this area?
4. Can you predict any trends in these weather events?

Section C: Effects of seasonal variability on livelihoods

5. What livelihood assets are most vulnerable to these weather events? (Especially, floods, drought, wind/rainstorms and extreme temperatures)

Section D: Livelihood responses to seasonal variability

6. How do farm households cope with the effects of the climatic hazards on livelihoods? (Especially, floods, drought, wind/rainstorms and extreme temperatures)
7. Are these strategies/responses working?
8. Have these livelihood strategies/responses changed, based on changing seasonal events?
9. What is your outfit doing to enhance the capacities of rural households to effectively deal with these climate effects?
10. What do you consider could be done to enhance these livelihood response strategies to the seasonal variations?

Appendix E: Key informant interview guide for NADMO Officer

Section A: Background Information

- Date of Interview.....
- Specific Position.....

Section B: The nature and extent of climate variability

1. What type of extreme weather events are experienced here?
2. How would you describe the weather trend (e.g. rainfall pattern and temperature trends) in recent times?
3. Are there any differences as compared to 10/20/30 years ago?
4. Can you predict trends of the changes?

Section C: Effects of seasonal variability on livelihoods

5. What livelihood assets are most vulnerable to these weather events? (Especially, floods, drought, wind/rainstorms and extreme temperatures)

Section D: Livelihood responses to seasonal variability

6. How do farm households cope with the effects of the climatic hazards on livelihoods? (Especially, floods, drought, wind/rainstorms and extreme temperatures)
7. Are these strategies/responses working?
8. Have these livelihood strategies/responses changed, based on changing seasonal events?

9. What specifically is your outfit doing to contribute to appropriate response needs of the people?

Appendix F: Sample size determination formula

The following formula was used to determine the size of the farmers for the interview:

$$\mathbf{n} = \frac{\mathbf{N}}{\mathbf{1 + N (\alpha)^2}}$$

Where: **n** = Sample size

N = Total population, and

α = Error margin

Thus, with a total household population of **2,419,** with an error margin of 5%

$$n = \frac{2419}{1 + 2419 (0.05)^2}$$

$$= \frac{2419}{1 + 2419 (.0025)}$$

$$= \frac{2419}{1+ 6.0475}$$

= **343**