**UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE**

# FARMER PERCEPTION AND ADAPTATION TO CLIMATE VARIABILITY AND CHANGE: A STUDY OF SMALLHOLDER YAM FAMERS IN THE YENDI MUNICIPALITY AND THE NANUMBA SOUTH DISTRICT OF THE NORTHERN REGION

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**2023**

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THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL INNOVTION COMMUNICATION, FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIALFULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A DOCTOR OF PHILOSOPHY DEGREE (PhD) IN INNOVATION COMMUNICATION

APRIL, 2023

## DECLARATION

I hereby declare that, except for references to other people's work, which have been duly acknowledged, this thesis is the result of my own independent work carried out in the Department of Agricultural Innovation Communication under the supervision of Prof. Francis Kwabena Obeng and Dr. Hamza Adam. I hereby declare that this thesis has never been presented either in whole or in part for the award of any degree in this University or elsewhere.

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## ABSTRACT

The study examined smallholder yam farmer's perception and response to climate variability and change. A multistage sampling technique was used to select the study districts, study communities and the sample size of four hundred respondents. Questionnaires, key informant interviews and focus group discussions were conducted to elicit relevant information from the respondents. Data were analysed using descriptive statistics, qualitative narratives, community resource maps, seasonal calendars and a multivariate econometric model. The findings indicate that temperature levels in the study area are on the rise, whilst rainfall figures show a declining trend. The increased dryness is causing yam setts, both planted and in storage, to rot. Mounding, land clearance, planting and overall quality of tubers have been affected as well. Farmers have responded by planting early maturing varieties, moving closer to valleys, using tractors to plough before mounding and engaging in off-farm activities, as adaptive measures. Farmers' choice of adaptation strategies was influenced by age, educational level, marital status, years of awareness of climate change, access to market and farm distance. The study recommends that the Ministry of Food and Agriculture in collaboration with research institutions identifies heat and rodent proof storage facilities to reduce storage losses. The ministry, together with the Savannah Agricultural Research Institute should also identify early maturing, drought and heat tolerant yam varieties and make

them available to farmers. Farmers must also use corn husks, rice and soya bean straw as alternative mulching materials.

## ACKNOWLEDGEMENT

This thesis will not have been completed without the sacrifice, support and encouragement of many people. I am much indebted to Professor Francis Kwabena Obeng and Professor Hamza Adam, who in spite of their very busy schedules always found time to support, guide and advise me on how to go about this thesis. I am also grateful to the staff and students of the faculty for their pieces of advice, constructive criticisms and encouragement. I also wish to express special gratitude to my respondents who willingly provided all the information needed to produce the write up. My special gratitude goes to the Director, Meteorological Services Department, Tamale, Director and staff, Ministry of Food and Agriculture, Yendi, Director and staff, Ministry of Food and Agriculture, Wulensi and the Zonal Coordinator, Send Foundation of West Africa, Wulensi Office. I extend special gratitude to the executives of the Universal Developers Consultancy and Implementation Services for their support in providing office space for the data analysis.

## DEDICATION

This thesis is dedicated to my family for their support, patience and understanding.

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| | |
|---|---|
| AAGDS | Accelerated Agricultural Growth and Development Strategy |
| AgriBiz | Agribusiness |
| AMA | American Marketing Association |
| AMSECs | Agricultural Mechanization Services Enterprise Centers |
| C.C.C.C.C | Caribbean Community Climate Change Center |
| CBOs | Community Based Organisations |
| CEC | Commission of the European Communities |
| CEPS | Customs, Excise and Preventive Services |
| COP | Conference of Parties |
| CRI | Crop Research Institute |
| CSIR | Council for Scientific and Industrial Research |
| DCCEE | Department of Climate Change and Energy Efficiency |
| FAGE | Federation of Associations of Ghanaian Exporters |
| FAO | Food and Agricultural Organisation |
| FASDEP | Food and Agriculture Sector Development Policy |
| GASD | Ghana's Adaptation Strategy Development Policy Document |
| GEPA | Ghana Export Promotion Authority |
| GHG | Greenhouse Gas. |

| | |
|---|---|
| GNCCAPIS | Ghana National Climate Change Adaptation Policy Implementation Strategy |
| GROCTEU | Ghana Root Crops and Tubers Exporters Union |
| GSB | Ghana Standards Board |
| GYPEA | Ghana Yam Producers & Exporters Association |
| HFA | Hyogo Framework for Action |
| IEA | Institute of Economic Affairs |
| IFPRI | International Food Policy Research Institute |
| IITA | International Institute of Tropical Agriculture |
| IPCC | Inter Governmental Panel on Climate Change |
| MDAs | Ministries, Departments and Agencies |
| MEDA | Mennonite Economic Development Associates |
| METASIP | Medium Term Agriculture Sector Investment Plan |
| MoFA | Ministry of Food and Agriculture |
| MOTI | Ministry of Trade and Industry |
| MSG | Michigan Sea Grant |
| MTADP | Medium Term Agricultural Development Programme |
| NARS | National Agriculture Research Strategy |
| NCCAS | National Climate Change Adaptation Strategy |

| | |
|---|---|
| NGOs | Non-Governmental Organisations |
| NMTIP | National Medium Term Investment Programme |
| NOAA | National Oceanic and Atmospheric Administration |
| NRCR I | National Root Crops Research Institute |
| NYEPH | National Yam Export Pack–House |
| PMT | Protection Motivation Theory |
| PPRSD | Plant Protection & Regulatory Services Directory |
| PSIA | Poverty and Social Impact Analysis |
| SARI | Savanna Agricultural Research Institute |
| U.S | United States |
| UK | United Kingdom |
| UN | United Nations |
| UNDP | United Nations Development Programe |
| UNFCC | United Nations Framework Convention on Climate Change |
| ViCAARP | Visayas Consortium for Agriculture, Aquatic and Resources Program |
| WMO | World Meteorological Organisation |
| YIIFSWA | Yam Improvement for Income and Food Security in West Africa |

# CHAPTER ONE

# GENERAL INTRODUCTION

## 1.0 Introduction

The present chapter covers the background to the study, problem statement, research questions and objectives, rationale for the study as well as the scope and organization of the study.

## 1. 1 Background to the Study

Yam is a tuber crop and consist of several species. It is grown in Africa, Asia, parts of South America, the Caribbean, and South Pacific islands. It is one of the most important food crops in tropical climates, especially in areas with moderate rainfall. Worldwide, over 600 yam species are grown (IITA, 2001). Over 95% of the world's share of yam comes from Sub-Saharan Africa, with the remaining 5% grown in the West Indies and parts of Asia and South and Central America (IITA, 2001). There are three main yam species that are widely grown in West Africa. The *Dioscorea rotundata* (white yam) and the *Dioscorea cayenesis* (yellow yam) ( IITA, 2001). Sub-Saharan African output slightly exceeds global average (Mignouna, Abdoulaye, Akinola, & Alene, 2015). According to Scott et al (2000), cited in  Simpa (2014) more than half of the output growth for yam in the region came from area expansion rather than from productivity growth.

Africa is the major producer of yam accounting for over 90 percent of global output (Mignouna et al. 2015). In 2010, Burkina Faso, Ghana, Mali, and Nigeria accounted for over 85 percent West African output (Mbabu, 2015; Elijah, Emeka, & Osuafor, 2018). Nigeria is the lead producer of yam in West Africa, producing over 26,587,000 metric tons, followed by Ghana with over 3,892,300metric tons (Aidoo, 2009).

Yam cultivation complements food security and is a major source of calories for a majority of people in tropical and subtropical regions (Obidiegwu & Akpabio, 2017). It is a major source of micronutrients and is widely used in cultural and social activities in African societies (Obidiegwu & Akpabio, 2017; Diby, Tie, Girardin, Sangakkara & Frossard, 2011). In terms of nutritional value, yam contains more calories than cassava and other root and tuber crops (Nweke, 2016). Yam has a high protein content compared to other root crops like cassava (Mignouna, Akinola, Suleman, Nweke, & Abdoulaye, 2014a). Yam production in West Africa is largely for commercial purposes rather than for home consumption (Mignouna, et al. 2015). More than 60 percent of output in both Nigeria and Ghana is sold with only 40 percent preserved for home consumption (Mignouna, et al. 2014)

The FAO (2005) estimated that 96 percent of the 38 million tons of world yam output in the year 2000 came from Africa. Nigeria alone accounted for over 26 million tons, making it the lead producer. Ghana and the La Côte d'Ivoire accounted for over 3.3 million tons, 2.9 million tons respectively (Anaadumba, 2013). In year 2000, yam fields occupied nearly 4 million hectares of land throughout the world (Anaadumba, 2013). Over 69% of the cogenesis area cultivated is located in Nigeria, producing an average of 10 tons per hectare (Anaadumba, 2013). It is estimated that world annual yam output stood at 17 million tons in 1970 and by 1990 production had risen to 21.1 million tons and further rose to 38 million tons in 2000 and 40 million tons in 2004 (Anaadumba, 2013; Aiddo, 2009). In the period 2005-2010, yam constituted 24 percent of total roots and tubers production in Ghana (MoFA, 2010 cited in Anaadumba, 2013). Production increased from 2.1 million tons in 1995 to 3.9 million tons in 2002 (Aidoo, 2009). Yam production however dropped to 3.8 million tons in 2003 (Aidoo, 2009).

Yam production further dropped from 2.7 million tons to 1.7 million tons between 1993 and 1994 (Tetteh, & Saakwa, 1994). Between 2006 and 2011 however, Ghana's yam output again rose up to 5,855,137.971 tonnes (Bergh, Kpaka, Orozco, Gugerty, & Anderson, 2012). Northern and Brong Ahafo Regions are the major centres of production (Bergh et al. 2012). On average, yam had the second highest output in Ghana with an average output of 13.2% per year between 1980-2002 (Bergh et al. 2012). Ghana emerged as the second largest producer of yam in the world by volume in 2010 (Bergh et al. 2012). Yam accounted for the largest proportion of any crop production in 2010 with the gross agricultural production value of USD$1,654,000 (Bergh et al., 2012).

Yam is a major staple food in most parts of Ghana and is widely prepared into many dishes and consumed among people in major producing areas (Aidoo, 2009). FAO (2013) estimated that about 5,517,000 metric tons of yam was available for home consumption in 2009, an increase from 2,267,000 metric tons in 1996.

Total export of yam peaked at 21,323 tons in 2007 but declined to 14,666 tons in the subsequent two years (Donkoh, Danso-abbeam, Karg, & Akoto-danso, 2018 & Anaadumba, 2013). The decline however did not affect the nations' position in global yam export though the commodity accounted for only 0.3% of average domestic production from 1996-2009 (Bergh et al. 2012).

According to estimates of the Ministry of Food and Agriculture (MoFA, 2011), Northern Region topped the list as the leading producer in terms of crop area in 2011, cultivating 138,553 hectares followed by Brong Ahafo region with 125,473 ha. In terms of total output, however, the region came second after Brong Ahafo, producing 2,005,607.445 metric tons as against 2,171,341.28 metric tons in the Brong Ahafo region (Anaadumba, 2013; MoFA, 2011). The region, however, placed 5$^{th}$ in terms of average yield per hectare, producing about 14.5 MT/ha as against 17.97 MT/ha by the Upper West, the highest in the country (MoFA, 2011). The lead producing districts are the Nanumba South accounting for 13,400 metric tons, followed by Nanumba North with 13,200 metric tons, Zabzugu/Tatale, 9,562 metric tons, Yendi Municipality, 8,400 metric tons and Savelugu/Nanton Municipality – 7,430 metric tons (MoFA, 2011).

The productivity of yam, like any other food crop, is greatly influenced by climate variability and change (Chukwuone, 2015; Kumar, Gaiser, Paeth & Ewert, 2012; Elijah et al. 2018). Climate change is a complex problem to the world (Grenier, 1998) and has been defined by the UNFCC (2001) as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere. Similarly, the United Nations Inter Governmental Panel on Climate Change (IPCC, 2014) identifies Climate Change as denoting "long-term change in the statistical distribution of weather patterns (for example temperature, precipitation, etc.) over decades to million years of time".

Climate change is becoming a global menace and constitute a threat to the environment. The change is associated with an increased variability and uncertainty of precipitation and rise in temperature (Jian-bin, Shao-wu, Yong, Zong-ci & Xin-yu, 2012). The interaction of temperature increase and changing precipitation patterns directly influence soil moisture and suitability for cultivation purposes (Alemayehu & Bewket, 2017a). High temperatures are expected to accelerate evaporation, transpiration and precipitation (Fadina & Barjolle, 2018). The rise in evaporation and its effect on moisture will have serious repercussion for agricultural productivity (Ashish, 2014).

Yam production in the Northern Region is susceptible to climate variability due to low level of capital investment, a situation that makes the production system less resilient (Ayanlade, Radeny, & Akin-onigbinde, 2017). Second, yam cultivation and agriculture in general are the main sources of livelihoods for a majority of the population (Amadou, Villamor, & Attua, 2015).

Agriculture in the Northern Region is rain-fed and therefore productivity is dependent on form, intensity, distribution and timing of rainfall (MoFA, 2017). Rainfall both in terms of duration and distribution significantly affects agricultural productivity in the region (Amadou et al., 2015).

Among smallholder farmers in Africa, climate change is generally perceived as a change in the conditions of their farming environment (Obinna, Thomas, Jenkins, Phillips & Kantamaneni, 2017; Nyanga, Johnsen & Aune, 2011). Van den Ban & Hawkins, (2000) defined perception as "a process of receiving information and stimuli from our surroundings and converting them into psychological responsiveness". Many smallholder farmers attribute climate change to a change in rainfall and temperature patterns observed over a particular time period (Ole Mertz, Mbow, Reenberg, & Diouf, 2009; Obinna et al., 2017) or reduction in yields (Mertz, Mbow & Reenberg 2009; Nyanga et al. 2011). The impacts of climate change may vary across space but on the whole, most studies (Harvey et al. 2018; Claessens, Antle, Stoorvogel, Valdivia, Thornton, & Herrero, 2012; Dare, 2013; Ike, Ezeafulukwe and Campus, 2015) indicate that farmers generally attribute persistent droughts, excessive rainfall, floods and declining yields to climate change.

Yams thrive in productive soils and require minimum of five months of rainfall (Diby et al., 2011); Sagoe, 2006). To do well, yams require a well distributed annual rainfall of 1,000mm to 1,500mm (Anaadumba, 2013). Soil and air temperatures affect the developmental stages more than any other factor (Elijah et al. 2018). Due to these unique characteristics, yam cultivation demands an adequate knowledge of the climatic and weather patterns especially in growing areas (Osberghaus, Finkel & Pohl, 2010). Farmers all over the world have different levels of knowledge on climate variability and change. This perception is what reinforces farmer's resilience, coping and adaptive strategies in the face of negative climatic effects (Tripathi & Mishra, 2017).

Yam is one of the most delicate crops vulnerable to climate variability since its cultivation, storage, transportation and even marketing are largely carried out in a more traditional manner and this exposes the commodity to vagaries of the weather (Chukwuone, 2015). The fact that yam farmers have remained resilient to the changing climate presupposes that they might have undertaken certain adaptation strategies to survive the menace. This study will examine smallholder yam farmers' perception and adaptation strategies to Climate variability in Northern region of Ghana**.**

## 1.2 Problem Statement

The impact of climate change on agriculture is well documented (Kumar, Gaiser, Paeth, & Ewert, 2012; Abubakari, 2016) . It thwarts national efforts of raising productivity in the face of growing populations and ensuring environmental sustainability (Ministry of Environment, Science, Technology and Innovation, 2015). Agricultural productivity will decline if we continue to witness extreme and frequent weather conditions (CEC, 2009). Ghana's mean temperature has been increasing at the rate of $0.21^{o}C$ per decade since 1960 and has increased by 1% (Dare, 2013; Agyeman-Bonsu, et al 2008). The rate of increase is higher in the northern parts of the country where day time temperature sometimes rises above $40\ ^{0}C$ (MoFA, 2017). Mean annual temperature is projected to increase by about 1.0 to

40$^{o}$C by 2080 (Dare, 2013). The result is that the frequency of warm days and nights are expected to increase. The projected rate of warming will greatly affect the northern inland regions than those in the southern and coastal areas (Owusu et al., 2015).

Mean annual rainfall shows decreasing trend in both northern and southern Ghana except the rain forest and the forest transition zones, which recorded increases (Owusu et al., 2015). The projected rainfall for all ecological zones is likely to decrease by about 10% in the rainy seasons (Dare, 2013). Variations in the projected rainfall pattern in May, June and July will be more prominent than September, October and November (less 10% in the next 10 to 60 years) (Ghana Climate Change Report, 2015).

Climate change has accelerated the frequency and severity of extreme weather events, such as droughts and floods (Chukwuone, 2015). This has significantly impacted on food crop productivity (Tadesse, Hassan, Ringler, Alemu, & Yesuf, 2009; Nte & Awoke, 2014).

Smallholder farmers, who bear the brunt of climate change impacts, are the backbone of the rural economy (Alemayehu & Bewket, 2017b; Alemayehu & Bewket, 2017a). According to the International Fund for Agricultural Development, IFAD (2009), cited in Owusu, Asare-Baffour & Obour, (2015), there are about 500 million smallholder farms supporting nearly 2 billion people worldwide . Close to 80% of the food consumed in Asia and sub-Saharan Africa are provided by smallholders (Owusu, Asare-Baffour & Obour, 2015). While climate change is expected to enhance agricultural production, especially in higher-latitude regions, the net impact of climate change on sub-Saharan Africa would be negative (CEC, 2009).

The yam sector is dominated by smallholder farmers who practice traditional farming systems that are largely dependent on rainfall (Morse & Mcnamara, 2018; Verter, & Bečvářová, 2015; Bergh et al. 2012). Data on agricultural production shows a significant variability due to wide variation of rainfall both in amounts and distribution across space and time (Diby et al. 2011). The impact of climate variability and change on smallholder rain-fed farming is well documented (Elijah et al. 2018; Ashish, 2014; Ike et al. 2015; Obinna et al. 2017). Despite this depth of literature, not much is known about the smallholder yam farmers' perceptions on the effects of climate variability and change on productivity. Further still, there has been little focus on how yam farmers in the Northern Region perceive and respond to climate variability and change. Existing studies concentrated on Growth and Nutrient Use Efficiencies of Yams (Diby et al. 2011), Yam Value Chain analysis (Bergh et al. 2012), Yam Consumption Patterns (Aidoo, 2009) and Socioeconomic Analysis of Smallholder Yam Production (Zakaria, Abujaja, & Adam, 2014).

The few studies on farmer perception of climate variability and change have been done outside the country (Mertz et al. 2009) or concentrated on cereal crops (Nyanga et al. 2011). Meanwhile, investigating the perception of climate variability and change by yam farmers in the northern region will contribute to an understanding of how farmers are responding and adapting to long-term changes and variability in climatic conditions at local level. This understanding will contribute to reshaping research and policy agendas aimed at finding practical solutions to the menace of the changing and variable climate.

The paucity of literature on climate change perception and adaptation strategies by smallholder yam farmers has necessitated this study which intends to fill the existing gap by examining smallholder yam farmer's perception of and adaptation to climate variability and change in the Northern region.

### 1.3 Main Research Question

How do smallholder yam farmers in the Northern Region perceive and respond to climate variability and change?

#### 1.3.1 Specific Research questions

1. How do smallholder yam farmers in the Northern Region perceive climate variability and change?

2. What are the perceived effects of climate variability and change on yam production by smallholder farmers in the Northern Region?
3. What adaptation strategies are undertaken by the smallholder yam farmers to mitigate the effects of climate variability and change?
4. What factors influence the choice of adaptation strategies by the smallholder yam farmers?



### 1.4 Main Research Objective

To examine smallholder yam farmer's perception and response to climate variability and change in the Northern Region.

#### 1.4.1 Specific Research Objectives

1. To examine the perception of climate variability and change among smallholder yam farmers in the Northern Region.
2. To assess the perceived effects of climate variability and change on yam production by smallholder farmers in the Northern Region.
3. To examine adaptation strategies undertaken by the smallholder yam farmers to mitigate the effects of climate variability and change.
4. To examine the factors that influence the choice of adaptation strategies by the smallholder yam farmers.

## 1.5 Rationale for the study

Climate change and variability and its associated effects have caught worldwide attention due to the largely negative impact the phenomenon has had on the lives of the people (Thiele et al. 2017). Currently our planet is the only known one in the entire universe that supports life (Goswami, 2018). This is because it is the planet that contains the right balance of all life support substances like atmospheric gases and water bodies (Goswami, 2018; Moskowitz, 2008). Human activities are gradually altering the balance mix of these life supporting substances resulting in climate variability and change (Larminat, 2016).

Man-made climate change is negatively affecting livelihoods, triggering floods in coastal and urban cities as well island nations, and aggravating dangerous weather events (Rosenstock & Nowak, 2019). To reverse or lessen climate disruptions, scientists have proposed that restrictions must be set on man-made sources of greenhouse gas emissions including adapting to changing global conditions (Bodansky, 2016). Evidence shows wide range of adaptations to the changing climatic conditions. Modes of adaptation vary from simply coping, engaging in adaptive change, to transformative shifts (Allen, Angeler, Garmestani, Gunderson & Holling, 2014; Malik & Smith, 2014).

An Understanding of perceived changes in the climate and how that perception influences adaptation could enrich our understanding of the initiatives taken by farmers to enhance productivity at the local level. This could enlighten us on how farmers are managing long-term effects of climate variability and change relative to their adaptive capacity. Data generated from such study will prove invaluable to academics and policy makers by giving them insight into home grown adaptation initiatives undertaken by farmers to sustain local level productivity (Kalungu, Filho, & Harris, 2013). Knowledge generated from the study will arm academics, agricultural technical officers and farmers with information that will enable them approach local level adaptations from practical and realistic perspective.



### 1.6 Scope and Limitations of the Study

The study investigated the perception of climate variability and change, the perceived effects and adaptation strategies adopted by smallholder yam farmers and also assess factors that influence farmers' choice of adaptation strategies. A wide range of data as related to farm households' demographic characteristics (age, sex, level of education, marital status), institutional factors (access to extension service, access to credit, access to market), farm level and land ownership factors (ownership of land, farm size, farm distance) as well as weather variables perceived as climate variability and change indicators and its trends will be secured from relevant sources using different data collection tools. The analysis of the study will focus largely on assessing climate change perception and adaption strategies followed at the household and community level and, also the internal and external factors that influence farmers' perception and choice of adaptation strategy.



### 1.7 Organization of the Study

This study is structured to contain five chapters supplemented with a list of references and appendices. In the first chapter, the introduction, background of the study, statement of the problem, research questions, research objectives the rationale for the study, as well as the scope and organisation of the study are presented. Chapter two presents review of related literature. Under this part basic concepts related to climate change and climate variability, its perception, impact on agricultural adaptation strategies practiced by rural households is documented. Chapter two also discusses the theoretical and conceptual frameworks.

The third chapter deals with description of the study area in the context of the research objectives to develop an understanding of socioeconomic characteristics of the rural communities and also to have insight on the physical environment, the land use, land cover, development interventions and the farming systems. It also addresses the research design that guides the overall research activity and the research method that depicts the techniques and tools applied to collect data and the data analysis methods.

The fourth chapter presents major findings and discussions on the demographic and other socioeconomic attributes of the sample respondents in the context of the study. Chapter five contains the summary of major findings, conclusion and recommendations.

### 1.8 Chapter Conclusion

The chapter captured the background of the study, statement of problem, research questions and objectives, the rational of the study, the scope and limitations as well as the organisation of the study. The next chapter will discuss the relevant literature that informs the present study.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.0 Introduction

The previous chapter outlined the background to the study, statement of the research problem, the research questions, objectives, the rationale and scope as well as the organisation of the study. This present chapter explores the concepts of climate variability and change, concept of adaptation and adaptive strategies, as well as global and national climate change and adaptation policies. The literature also explores the perception and adaptation to climate variability and change and yam productivity in Ghana. Finally, the chapter reviews literature on global, national and regional perspectives of farmer's perception and adaptation to climate variability and change.

## 2.1 The Concepts of Climate Variability and Climate Change

The World Meteorological Organisation defines climate variability as variations in the mean state and other statistics of the climate on all temporal and spatial scales, beyond individual weather events (WMO, 2019). The Michigan Sea Grant – MSG (2010) also views climate variability as the way climate fluctuates yearly above or below a long-term average value.

With regards to climate change, any homogenous definition of the concept has been elusive. In the numerous empirical studies, all over the world a large variety of definitions have been used. Whereas the Michigan Sea Grant defines Climate change as “a long-term continuous change (increase or decrease) to average weather conditions (e.g. average temperature) or the range of weather (e.g. more frequent and severe extreme storms)” (MSG, 2010), the United Nations Framework Convention on Climate Change - UNCFCC (1992) for instance defined the phenomenon 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”. Similarly, the Australian Government’s Department of Climate Change and Energy Efficiency (DCCEE) in its website described Climate Change as follows – “our climate is changing, largely due to the observed increases in human produced greenhouse gases. Greenhouse gases absorb heat from the sun in the atmosphere and reduce the amount of heat escaping into space. This extra heat has been found to be the primary cause of observed changes in the climate system over the 20th century” (Rahman, 2013).

Both the UNFCCC definition and Australian DCCEE description have been strongly contested by climate scientists (Larminat, 2016). Andresen (n.d.) for instance argued that climate change is not a recent occurrence and that earth’s climate has witnessed several changes in the past, most of which predated human activities. It will therefore be inaccurate as Folland, Karl, & Salinge (2002) argued, to attribute the causes of climate change solely to direct and indirect causes of man. The Michigan Sea Grant in its website identified El Niño and La Niña events, volcanic eruptions and sunspots as major drivers of climate variability and change (Michigan Sea Grant, 2010). It was in the context of these criticisms that the Intergovernmental Panel on Climate Change (IPCCs) definition seems to have gained a wider acceptance. The definition identifies 'Climate Change' as denoting to long-term change in the statistical distribution of weather patterns (for example temperature, precipitation etc.) over decades to millions years of time ((Metz and Davidson, 2007 & IPCC, 2007b). Climate change has thus been described by different stakeholders in the environmental science discourse as the change in modern climate augmented by human activities (WMO, 2019; Jian-bin, Shao-wu, Yong, Zong-ci, & Xin-yu, 2012; Vlassopoulos, 2014). Rahman (2013) noted that the adverse human activities for example burning of fossil fuels and deforestation are most likely to bring changes to the current climatic conditions.

However, the official definitions and the policy orientation of it still holds human activities culpable of climate change. According to Rahman (2013), the intellectual discourse of climatic change is said to have been initiated by Jean Fourier in 1824. He described greenhouse effect in an article published in the 'Annals of chemistry and physics (Arrhenius) in 1896. Jean Fourier was also the publisher of the first calculation of global warming by carbon emissions from human sources. The first but accurate measure of $CO_2$ concentration in the atmosphere was however undertaken by Keeling in 1960 (Weart, 2009). Initially the discourse did not highlight the detrimental effect of the menace (Vlassopoulos, 2012).

Whereas climate variability is concerned with short term variations of the weather conditions (a month, season or year), climate change is about long-term variations, spanning three decades or longer (WMO, 2019).

An important difference between the two is that with climate change the unusual conditions persists for much longer time whereas in the case of climate variability the deviations are on short term basis (WMO, 2019). According to the MSG (2010), climate change is slow and gradual, and unlike year-to-year variability.

Although scientists differ in their understanding of what causes climate change (Oktyabrskiy, 2016 & Jian-bin, Shao-wu, Yong, Zong-ci, & Xin-yu, 2012 & Hume, 2009), there is near consensus that the main driver of climatic change and variability is temperature (Mertz et al. 2009, Ibeabuchi, et al. 2017 & Harvey et al. 2018). Koehler-Munro and Goddard (2010) observed that the atmosphere behaves like a greenhouse on the earth. The National Oceanic and Atmospheric Administration - NOAA (2018), observed that earth bound solar energy is offset by energy emitted back to space. Some of the energy emitted back to space is trapped by Greenhouse gases (GHGs) and then serve as control system for the earth's climate (NOAA, 2018; Treut et al. 2007; Rahman, 2013). Rahman, (2013) noted that but for the natural greenhouse effect, the average temperature on earth would have been as low as –18$^{o}$C instead of the current +15$^{o}$C. The mediating effect of these natural greenhouse gases is what is maintaining the balance effect that is conducive for life support systems on earth (Rahman, 2013 & IPCC, 2001). Human activities over the years have introduced artificial chemical substances that has disturbed the natural atmospheric greenhouse balance (IPCC, 2001; Lashof & Ahuja, 1990). This, many scientists believe has led to a build-up of heat within the lower atmosphere changing the natural atmospheric conditions (NOAA, 2018; Lashof & Ahuja, 1990). Climate change is thus the slow transformation of the atmospheric composition as a result of human activities combined with natural climate variability (Koehler-Munro and Goddard, 2010).



Water vapour, carbon dioxide (CO2), methane (CH4) and halocarbons are the major Greenhouse Gases in the earth's atmosphere. These gases have cooling effect on the earth's atmosphere (NOAA, 2018). Anthropogenic emissions have increased the concentration of GHGs (carbon dioxide, methane and nitrous oxide by approximately 31%, 151%, and 17%, respectively) since 1750 (Treut et al. 2007). The increased in the levels of Greenhouse Gases is attributable to rapid industrialisation and changing lifestyles (Treut et al 2007). Carbon dioxide for instance has increased by 0.5%, methane by 0.6% and nitrous oxide by 0.3%. The IPCC concluded based on its 2001 scientific assessment that there is a clear evidence of human influence on climate change (Koehler-Munro & Goddard, 2010) and pointed out that 90-95% of climate change could have been triggered by human activities (IPCC, 2007b).

Natural sinks like the forests help in maintaining atmospheric balance by absorbing excess carbon dioxides introduced into the atmosphere (Lashof & Ahuja, 1990). However, Human activities increase the Greenhouse Gas levels in the atmosphere by introducing new sources or removing these natural sinks, such as the forests (Lashof & Ahuja, 1990). Koehler-Munro & Goddard, (2010) defined sources as the "processes or activities that release greenhouse gases and sinks as processes, activities or mechanisms that remove greenhouse gases". The net effect of the interaction between sources and sinks defines the amount of greenhouse gases in the atmosphere.

However, Oktyabrskiy (2016), has disputed the concept of greenhouse effect arguing that per the nature of their compositions, chemical properties and absorptive capacities, carbon dioxide (CO2), methane (CH4), halocarbons, and nitrous oxide (N2O) do not actually perform the function of greenhouse effect. The absorption of solar radiation by water vapour and the thermal back radiation are responsible for the warming of the global atmosphere (Oktyabrskiy, 2016: 2).

### 2.2 Concept of Adaptation

The concept of adaptation has had wide range of meanings. In the context of climate change, the IPCC defined adaptation as ‘‘the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences” (IPCC, 2007b: 21; Abdul-razak & Kruse, 2017: 2).

Adaptation to climate change is as old as the human civilisation. Throughout history civilisations have repeatedly adapted to changing climate by either migrating (Vlassopoulos, 2011), manipulating agricultural systems (Jiri, Mtali-chafadza, & Mafongoya, 2017; IEA, 2013), and making adjustments to their habitations (Anselm, Ignatius, Josephat & Anthony, 2015; Malik & Smith, 2014). However, in the context of climate change both as academic and policy discourse, public attention on adaption gained momentum in 1960s and 1970s (Adger et al. 2007). The renew interest in the topic was based on the realisation that people are not just victims of climate change, they are active contributors to climate change an important agents stimulating climatic disruptions (IPCC, 2007a). The understanding that people play a central role in in the processes of climate change has contributed in reshaping policy directions on climate change (Malik &

Smith, 2014). The renewed interest in the study of climate change and adaptation strategies can be credited to Bertalanfy's (1940) general systems theory (Malik & Smith, 2014).

Referring to the systems theory, Gunderson and Holling (2001) maintained that societies together with their environments maintain their interdependent functions through series of creative destruction and resort to various states of equilibrium. Proponents of this view argued that the trajectory of change is determined by the existence and collaboration of the potential resources for tactical action, connectivity and resilience (Allen et al. 2014).

As a global phenomenon climate change is experienced across the world (Dodman & Satterthwaite, 2008). People all over the world experience climate change according the nature of their physical environment (Vaughan, 1993). The differences in the experiences of climate variability and change is what influences adaptation strategies among societies (Vaughan, 1993). Malik & Smith (2014) identified various types of adaptation strategies, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation strategies. They however classified these adaptation strategies based on three broad purposes; on intent/purposefulness, based on timing and based on agents undertaking or initiating the adaptation. Based on intent and purposefulness

Malik & Smith (2014) identified autonomous and planned adaptation strategies. Individual or autonomous adaptations are adaptations taken by private individuals. They are usually reactive and adopted in response to perceived climate induced effect (Klein, 2001). Autonomous adaptations are usually not based on deliberate planning. A planned adaptation on the contrary is based on deliberative policy decision against potential change that requires action to revert to, to sustain, or to attain a desirable state of life (Malik & Smith, 2014).

The type and form of adaptation strategy could also be based on timing (Malik & Smith, 2014; Adger et al. 2007). For instance, an anticipatory adaptation is an adaptation that precedes the impact of climate change and is normally known as proactive adaptation (Kuruppu & Liverman, 2011). Reactive adaptation, on the other hand, takes place in response to climate change effect. Adaptation strategies can also be classified based on the actors undertaking the adaptation (Eisenack & Stecker, 2010; Dang, Li, & Bruwer, 2012). Private adaptation is an adaptation strategy initiated and executed by ordinary persons or private entities. This type of adaptation is informed by individuals private interest (Dang, Li, & Bruwer, 2012; Kuruppu & Liverman, 2011). On the other side is the public adaptation which is an adaptation that is instigated and executed by governments at all levels (Malik & Smith, 2014).

Malik & Smith (2014) also classified climate change adaptations on the basis of temporal dimension. Hence, we have Short-Run Adaptation in which the decision maker's response to climate change is constrained by a fixed capital stock, in which case the major options available are limited to variable inputs to production (Stern, 2007) and the Long-Run Adaptation in which the decision maker can adjust capital stock in response to climate change.

The most important to this study in context of yam farmers in the Northern region is the autonomous adaptation. It is however imperative to note that the types of adaptation strategies are interlinked and have profound influence of the adaptation decisions of individual farmers. These types of adaptations are usually regarded as an afterthought measures (Osberghaus, Finkel & Pohl, 2010). They are privately initiated as opposed to planned or public adaptations (Osberghaus et al. 2010 & IPCC, 2007a). In this study, smallholder farmers are considered not to be in position to make accurate scientific prediction of future climate changes since they either lack the technical knowhow or do not have sophisticated scientific equipment to enable them do so. In that regard smallholder farmers often have to resort to reactive measures to mitigate the effects climate hazards.

### 2.3 Global Conventions on Climate Change

The renewed interest in climate change and its associated effects in the latter part of the 20th century culminated in the establishments of several global conventions and protocols to deal with climate change and Greenhouse Gas (GHG) emissions (Bodansky, 2016; IPCC, 2007). Among the aims of these conventions were to cut down GHG emissions, reduce global carbon emission and ensure climate resilient future and propose national actions/conventions to deal with climate change challenges (IPCC, 2007). To this effect, the world body took two bold decisions in the 1990s. First, the 1992 conference in Rio-de-Janeiro which produced UN Framework Convention on Climate Change and secondly the 1997 International Conference which produced the Kyoto Protocol that set targets for industrialized nations to reduce greenhouse gas emissions (Weart, 2009). The Kyoto Protocol was considered the most comprehensive commitment in tackling Global Climate crisis (Rahman, 2013). That was why at its expiry at the end of 2012, through different conventions, from UNFCCC to the latest Conference of the Parties (COP-17) was held in November–December 2011 in Durban, South Africa (Olmstead & Stavins, 2012). Since then the world nations continued to engage in negotiations which eventually paved the way for wider deliberations on the bottom up approach to emission trading (Olmstead & Stavins, 2012). In spite of its significance, the Kyoto protocol had several fundamental flaws; first, was the failure of world leading emitters to ratify the treaty or commit to specific targets that would restrict emissions (Olmstead & Stavins, 2012). The United States, which until very recently used to be the global leading carbon emitter failed to ratify the Kyoto protocol and similar subsequent agreements (Gregg, Andres & Marland (2008) cited in Olmstead & Stavins, 2012). Countries like China, India, Brazil, South Africa, Indonesia, South Korea, and Mexico, which are among the world's largest growing economies did not take on targets (Olmstead & Stavins, 2012). Current statistics indicate that the developing countries are rapidly surpassing the developed countries in world's total emissions (Han-cheng, Hai-bin; Wen-tao, 2017). Indeed, China have already overtaken the United States in terms of CO2 emissions (Gregg, Andres & Marland, 2008 cited in Olmstead & Stavins, 2012). Given the rapidly growing nature of the country's industrial sector, the current development is not expected to end anytime soon (Blanford, Richels & Rutherford, 2010 cited in Olmstead & Stavins, 2012). According Rahman (2013) the world's target of stabilizing atmospheric CO2 concentrations at or below 450 ppm by 2030 will not materialised unless China and India significantly cut down emissions. He noted that even if all the major emitting countries, together with the United States were to completely stop carbon emissions, China and India's emission rates can still create significant problems for the world (Rahman 2013).

The fact that only 40 countries had agreed to take action under the Protocol indicted another flaw (Reciel, 2012). In the view of Olmstead & Stavins, (2012), this approach could push up the costs of producing carbon-intensive goods and services in countries taking on targets. The approach could favour countries who do not have binding emission targets who will then produce more carbon-intensive goods and services for the international market (Olmstead & Stavins, 2012).

This way carbon emissions could shift from participating nations to nonparticipating nations, resulting in what is termed ‘‘carbon leakage’’ (Olmstead & Stavins, 2012). Such a carbon leakage will water down the impact of the agreement and create a fertile ground for developing countries to rely on carbon-intensive production rather than embarking on environmentally friendly growth paths. Such countries may later be unwilling to cut down emissions (Olmstead & Stavins, 2012).

The very nature of the Kyoto Protocols' emissions trading elements presented additional weakness (Bodansky, 2016). Article 17 which provided for international emissions trading is unlikely to be effective because it deals with national governments rather than private businesses or firms (Olmstead & Stavins, 2012). The fact that nations are not business entities means that the cap-and-trade system will not be effective in reducing carbon emissions. This is based on an assumption that private firms are those producing much of the carbon emissions but are not at the forefront in negotiations aimed at emission reductions. Nation-states who are directly responsible for these high level negotiations are not simple cost minimizers as many other objectives affect their decision making (Rahman, 2013).

The latest global commitment to mitigate the impact of climate change is the Paris Agreement signed in 2016 by 195 countries (Tachie-Obeng, 2016). For the first time, all nations were prepared to commit themselves to the agreement (Tachie-Obeng, 2016). Unlike the previous pacts, this global legally binding agreement was set out as a replacement to the Kyoto Protocol set to expire in 2020 (Tachie-Obeng, 2016). As at June 27, 2019, the United Nations Framework Convention on Climate Change (UNFCCC), a parent treaty of both the 2015 Paris Climate Change Agreement and the 1997 Kyoto Protocol had 197 members making it one of the agreements that has achieved near universal membership (UNCFCC, 2019). A major goal of the Paris Agreement is to maintain a global average temperature increases below 2 degrees Celsius and to double efforts to further limit the temperature increase further to 1.5 degrees Celsius above pre-industrial levels (UNFCCC, 2019; Han-cheng, Hai-bin & Wen-tao, 2017).

The Paris Agreement is seen as a marked improvement over the Kyoto because it has a legally binding instrument as opposed to the Kyoto protocol which was a political deal (Bodansky, 2016). Secondly, the Paris agreement is a global binding instrument and applies to both the developed countries and the developing countries. The developing worlds' share of carbon emission is growing rapidly, a situation that justifies the specification of the same core obligations for all countries (Bodansky, 2016). By specifying the same obligation for all countries, the Paris Agreement has set aside the Kyoto Protocol which required only some few countries to take on emission targets and replaced it with a more realistic and calibrated approach. This approach considers the economic status and capabilities and is calibrated differently for different countries (Bodansky, 2016). Finally, the agreement seems to enjoy universal acceptance. By March 15, 2016, 188 nations stated their intention to cut down emission by 95% (Bodansky, 2016).

Like the Kyoto protocol, the Paris Agreement is also faced with several challenges. Studies showed that compared with the current policy scenario, though the agreement helps in reducing global greenhouse gases (GHGs), its current level of implementation is not sufficient to achieve the desire 2 $^{o}$C target (Rogelj et al. 2016 cited in Han-cheng et al. 2017). The U.S. withdrawal from the Paris Agreement in June 2017 has put the success of the Paris Agreement in the balance. According to Han-cheng et al. (2017), the withdrawal could win the U.S. substantial additional carbon emissions space and lower carbon prices and compress the emissions space thereby pushing up the macroeconomic costs for other regions. This situation has the potential to derail the implementation of the Paris Agreement and global climate governance (Han-cheng et al. 2017).

On climate change adaptation, the Paris Agreement as expressed in article 7 held the view that unlike mitigation efforts which are of public interest, adaptation is largely a private issue and its benefits are local and so countries are at liberty to develop their own adaptation policies, notwithstanding what other countries are doing (Bodansky, 2016).



## 2.4 Ghana's Commitment to Global Conventions on Climate Change and Adaptation

Ghana became a member of United Nations Framework Convention on Climate Change in June 1992 in Rio de Janeiro and follow through with the ratification of the Convention on 6 September 1995 (Owusu, Obour & Asare-Baffour, 2015). On 26th November 2002, Ghana's Parliament also ratified the Kyoto Protocol and submitted the instruments for ratification in New York in March 2003 (Tachie-Obeng, 2016). In furtherance to ensuring international commitment to climate change mitigation, Ghana again ratified the Paris Agreement on Climate Change on 4th August 2016 (Tachie-Obeng, 2016).

## 2.5 The Ghana National Climate Change Adaptation Policy Implementation Strategies

As signatory to the United Nations Framework Convention on Climate Change (UNFCCC), member states have an obligation to mainstream climate change issues into their national development plans (UNCFCC, 1992). The Hyogo Framework for Action (HFA) 2005-2015, provides a comprehensive action plan to global concern on the growing incidences of disaster and its impact on societies. It also provides a road map of action to significantly reduce the loss of lives and minimize the socio-economic and ecological impact of climate change on communities (UNDP, 2013). According to National Climate Change Adaptation Strategy (2011), the focus of the national strategy is to provide, co-ordinate and guide all climate change programmes in Ghana.

Since signing the UNFCCC, Ghana has taken a number of steps to implement some of its directives. One major step the country has undertaken is the formulation of Ghana's Adaptation Strategy Development policy document - GASD (Dare, 2013). The main aim of this document was to enhance Ghana's capacity to withstand and minimised the adverse impact of climate change (NCCAS, 2011; Owusu, Obour & Asare-Baffour, 2015).

### 2.5.1 Policy objectives of the Ghana National Climate Change Adaptation Strategy

The policy strategy of the Ghana National Climate Change Adaptation as spelt out by the NCCAS policy document (2011) is anchored on five broad objectives as follows:

1 Climate change awareness creation;

2. Accelerate the incorporation of climate change into national development Plans;

3. Improvement in infrastructure and investments;

4. Increase resilience of fragile ecological and social systems.

5. Enhance the teaching of science and technology to ensure competitiveness.

The country has outlined several policy strategies in order to achieve the stated objectives. These strategies centered on Livelihoods, Energy, Agriculture, Health, Early Warning, Fisheries Management, Land Use and Water.

Two major policy strategies that are of relevant to this study are highlighted below.

**Livelihoods**

Under the livelihoods enhancement policy, several policy objectives were outlined to improve the living standards of the people. Some of these objectives were to:

1. Improve the productivity and living standards of vulnerable groups

2. Create climate change awareness among the citizenry.

3. Educate communities on the use of modern technologies

4. Link producers to credit facilities

5.Facilitate the blending of scientific knowledge and traditional knowledge

**Agriculture**

Policy objectives to improve resilience under the agricultural sector were to:

1. Enhance agricultural productivity by building and strengthening the capacity of smallholder farmers.

2. Strengthen the capacity of extension agents on modern farming Technologies.

3. Supporting vulnerable to explore alternative livelihoods sources

4. Ensure environmental protection by encouraging agricultural biodiversity

5. Take records of all indigenous knowledge and best practices

7. Reduce post-harvest losses by introducing technologies.

### 2.5.2 Decentralized Implementation Strategy of the National Climate Change Adaptation

The implementation of the NCCAS was to be mainstreamed into the decentralized planning and implementation system. The central government was to be responsible for policy, planning, monitoring and evaluation of development programmes and projects while the actual implementation was to be executed by the Metropolitan, Municipal and District Assemblies, as well as other government agencies at the local level (NCCAS, 2010).

### 2.5.3 Institutional Arrangements for the Implementation of the National Climate Change Adaptation Strategy

To develop a sense of ownership, the implementation of the strategy assumed a multi-stakeholder approach involving the efforts of governments NGOs, the private sector and civil society organizations. Staff of the of such implementing agencies were to be trained to enhance effectiveness (NCCAS, 2010).

This study will be concerned with the Community and District levels implementation arrangements as it will enhance an understanding of how public sector adaptation strategies affect local level and individual adaptation decisions.

According to the NCCAS (2010), the local structures are crucial for the strategy implementation. The National Climate Change Committee is expected to produce climate change adaptation guidelines and make them available to the District Assemblies. The guidelines will detail how to prepare climate change adaptation programmes and projects at the district level, as well as the selection of programmes and projects and the sharing of implementation responsibilities between the District Assemblies and the sub-district local authorities at the community levels.

The District Environmental Committees will play key role in the implementation of the climate change adaptation strategy. To this end, the District Assemblies have been tasked to strengthen them to enable them function effectively. At the district level the Assemblies are expected to collaborate with local governance structures to prepare detailed action plans for implementation. Programmes and projects of district disaster plans are to be mainstreamed into the Assembly's adaptation plans.

The Assemblies are to be responsible for district-wide adaptation programmes whilst the community level programmes and projects are to be handled by the district sub-structures.

The Town or Area councils as well as the unit committees at the community level are to initiate their climate change adaptation programmes and submit same to the Assemblies to be mainstreamed into the District Plans. The sub-structures at this level are to be supported by Government agencies, NGO's, CBOs, FBOs, religious organizations and traditional authorities in preparing their action plans.

## 2.6 General Impact of Climate Change on Agriculture

The UNCFCC report (2019) observed that climate change is threatening sustainable development globally and that the poorest and most vulnerable sections share a disproportionate burden of the menace. The UNCFCC report further observed that global temperature levels have risen by an average of one degree Celsius. A situation that has called for prompt action to prevent possible increase beyond 1.5C degrees (Otitoju, 2013).

Obinna et al. (2017) and Han-cheng et al. (2017) noted that the effect climatic change on the ecological processes that support agricultural could be both constructive and destructive to food production. The combine effect of increased atmospheric concentration of CO2, high temperatures, changes in rainfall pattern as well as the regularity of extreme events are likely to jeopardise food production including the natural environment which forms the basis of agriculture (CEC 2009). These variations in the climate could have negative impact on the quality and availability of water, development of pests and diseases and soil quality. The net effect of these could result in significant changes in the environment in which production takes place (Müller-Kuckelberg, 2012). Since agricultural production is largely driven by favourable weather conditions, the degradation of ecosystems and the occurrence of bad weather conditions and variability of the seasonal rainfall are likely to have grave consequences for crop production (Fadina & Barjolle, 2018; C.C.C.C.C, 2015; Müller-Kuckelberg, 2012; CEC, 2009).

According to IPCC (2018), Climate change induced global warming have both a negative and positive implication for agriculture. Whilst it is projected to enhance crop productivity in the middle and high latitudes, crop productivity is projected to decrease at the lower latitudes including those in the tropical regions (IPCC, 2018; IPCC, 2007a). IPCC (2018) has projected that Global food production is likely to increase with local average temperature over a range of 1-3$^{o}$C whilst temperature increases above 3$^{o}$C is likely to result in decreases in yield. Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes (Metz and Davidson, 2007 & Sagoe, 2006). Taken together and considering the influence of rapid population growth and urbanization, Khanal (2009) projected that the risk of hunger will continue to remain very high in several developing countries. Nyanga et al. (2011) observed that global warming and associated increased carbon concentration in the atmosphere are likely to enhance crop productivity in some parts of the world. IPCC (2018) for instance noted that this will lead to increases in yield and widen the range of possible arable crops in the higher latitudes. However, extreme warming will impact negatively on productivity since plant yields tend to decrease beyond certain temperature ranges (IPCC, 2018). Increased inter-annual rainfall variability and seasonality are likely to seriously affect agricultural productivity (Nyanga et al. 2011). CEC (2009) warns that heat waves and droughts can cause severe disruption to agricultural productivity.



## 2.7 Climate Trends in Ghana

Climate change is represented by soaring temperatures, increased rainfall variability and decline, rising sea levels and increased incidence of weather extremes and natural disasters (Tachie-Obeng, 2016). Data for Ghana from 1961 to 2000 for example, has shown a progressive rise in temperature with corresponding decrease in mean annual rainfall in all the agro-ecological zones (NCCAS, 2011). Mean annual temperatures have risen by 1°C within 30 years (NCCAS, 2011). Minia (2004) predicted that all agro-ecological zones in Ghana will experience increases in temperature and reductions in rainfall amounts (Abdul-razak & Kruse, 2017). Analysis of historical data in the West African sub-region indicate a high rainfall variability that is associated with climate change (IEA, 2013). The records show a consistent rise in mean annual temperatures. This soaring temperatures are projected to remain for a long time (Dare, 2013). It is further projected that temperature levels will increase by 0.8°C in 2020 and 5.4°C by 2080 (Dare, 2013). Minia, (2004) indicates rainfall totals are estimated to decline by between 1.1%, and 20.5% within the same period. In the Guinea Savannah zone rainfall amounts are likely to reduce by -1.9% by the year 2020, -7.8%

by the year 2050 and -12.8% by 2080 whilst temperatures are estimated to rise by 0.8 $^{0}$C by 2020, 2.5 $^{0}$C by 2050 and 5.4 $^{0}$C by 2080 (Minia, 2004).

### 2.8 Ghana's Vulnerability to Climate Change

The burden of climate change is felt largely by the poor, living mostly in marginal areas and depend solely on nature for survival (Dare, 2013). Such groups include smallholder farmers, women, fishermen and fishmongers and livestock operators (Anselm, Ignatius, Josephat, Anthony, 2015; Ashish, 2014). Their vulnerability is as a result of institutional weaknesses, legal and regulatory frameworks, lack of capacities and imperfections in the market systems (Anselm et al. 2015; Herrero, Ringler, Steeg, Koo, & Notenbaert, 2010). These vulnerabilities determines peoples access to productive resources which influence farmer's resilience and adaptation behaviour (NCCAS, 2011 & NCCAS, 2010).

What makes these group more prone to climate stresses are their over reliance on nature and use of rudimentary technology (Dare, 2013). Chronic poverty arising from unequal access to productive resources, institutional weaknesses, market failures and poor physical infrastructure are the causes of their poor adaptive capacities (NCCAS, 2010).

Shepherd et al. (2005) observed that Ghana's future depends on its ability to cope with these climate stresses and take advantage of the country's many resources to propel growth, improve the livelihoods of its people and reduce poverty. Failure to reduce Ghana's exposure to the risks of climate change and build the capacities of communities will affect the nation's food security, increase poverty and affect sustainable growth and livelihoods (Shepherd et al. 2005). The net effect will be an increased exposure of human and physical systems to severer impacts of climate change (Dare, 2013).

Local communities in Ghana have long been relying on the indigenous knowledge for managing local resources to support their livelihoods (Dare, 2013). In spite of the effectiveness of traditional knowledge in facilitating traditional coping mechanisms at the local level, its impact in building strong resilience to climate change has remained questionable (IITA, 2001; Grenier, 1998). Worst still, the impacts of climate change in terms of the destruction of properties and fatalities has been disproportionately high (Callo-concha, 2018). This is because the reliance on the indigenous knowledge as a mechanism for coping and adapting to changes in the climate is largely scattered and undocumented (Dare, 2013). Nonetheless, the use of indigenous knowledge as a coping mechanism is relatively cheaper than the importation of foreign technology. The blend of indigenous knowledge with scientific knowledge, could lead to a cheap and sustainable adaptive mechanism and improve resilience capacity of local communities in particular and the nation in general (Tachie-Obeng, 2016 & Grenier, 2009).

### 2.9 Impact of Climate Variability and Change on Ghana's Economic Sectors

Agriculture is one of the economic sectors which heavily relies on the physical environment and bears the brunt of climate change, (CARE International, 2013). The success of agriculture depends to a greater extent, on the amount and distribution of rainfall (CARE International, 2013; Abdul-razak & Kruse, 2017) . The growing unpredictability of the rainfall pattern arising from increased variability have increased the risk of farming (CARE International, 2013; Nyong, Adesina & Osman, 2007). Scientists have predicted that rainfall amounts are expected to fall further or experience extreme variability with dire consequences on crop production and the livelihoods of many in rural areas (Tachie-Obeng, 2016 & CARE International, 2013). This is expected to affect land tenure arrangements and social relations, trigger rural-urban migration and subsequently increase urban vulnerability (Harvey et al. 2018; Sadiq, Kuwornu, Al-Hassan & Alhassan, 2019). Agricultural production is largely rainfall dependent and slight changes in the pattern of the rainfall would have serious impact on productivity (Anselm, et al. 2015). It is projected that the rising temperatures and increased incidents of droughts will further worsen the incidences of bushfires and accelerate environmental degradation, making investments in agriculture more expensive, risky and less profitable (NCCAS, 2011; Sagoe, 2006).

## 2.10 Global Perspective of Farmers' Perception of Climate Variability and Change

Van den Ban and Hawkins (2000) defined perception as a "process of receiving information and stimuli from our surroundings and converting them into psychological responsiveness". According to Van den Ban and Hawkins (2000), perception is a necessary prerequisite for adaptation. Tripathi & Mishra (2017) stated that adapting agriculture to climate change depends on whether farmers perceive it and that how farmers perceive the risks associated with climate change is essential for motivating farmers in their decision to adapt. There is wide array of literature on farmer's perception of climate change including the perceived form of climate variability and change, perceived causes, and perceived consequences and of climate variability and change (Mngumi, 2016). Adger et al. (2009) for instance noted that perception strongly affects how farmers deal with climate-induced risks and opportunities. Debela, Mohammed and Bridle (2015) noted that the precise nature of farmers behavioural responses to this perception will shape adaptation options, the process involved and adaptation outcomes. In the same vain misconception about climate variability and its associated risk may result in no adaptation or maladaptation thus increasing the negative impact of climate risk

(Grothmann & Patt 2005 cited in Debela.et al. 2015). The succeeding section will review farmers perceived indicators of climate variability and change as expressed in the form temperature and precipitation.



### 2.10.1 Rainfall as an Indicator of Climate Variability and Change

Many researchers have observed that farmers generally associate changes in rainfall pattern to climate variability and change (Mertz et al. 2009; Ishaya & Abaje, 2008). Mertz et al. (2009) did a study on farmer perception of climate change and variability in Senegal and concluded that farmers generally perceived climate variability in the form of a decreasing trend of rainfall. According to the study, farmers have observed that the rains simply vary too much to determine the trend and that the intensity of rainfall events has decreased (Mertz et al. 2009). Similar findings have been made by Ibeabuchi & Kantamaneni (2017), Nyanga, Johnsen, & Aune (2011) and Harvey et al. (2018). However whilst farmers in Senegal observed a decreasing trend of rainfall (Mertz et al. 2009), their counterparts in Nepal (Ashish, 2014), Nigeria (Ibeabuchi et al. 2017 & Chukwuone, 2015) and the Central America (Harvey et al. 2018) reported rainfall increases. Mertz et al. (2009) noted that in spite of the general perceived decreases in rainfall amounts, there is a general perception that rainfall intensity has increased. Farmers in Zambia and Ethiopia noted a general reduction in the duration of the rainy season (Nyanga et al. 2011 & Lemma, 2016) as compared to their counterparts in Central America and Senegal who held the view that there is an increase in the duration of rainfall (Harvey et al. 2018 & Mertz et al. 2009).

Nigerian farmers also observed general increases in groundwater levels and in runoff and attributed same to increased intensity of heavy rains (Chukwuone, 2015) whereas their counterparts in Bangladesh (Uddin, Bokelmann, & Dunn, 2017), Central America (Harvey et al. 2018), Senegal (Mertz et al. 2009) and Ethiopia (Lemma, 2016) observed increases in floods, hurricanes and an increased inundation of fields and villages.

### 2.10.2 Temperature Change and Variability as an Indicator of Climate Variability and Change

In terms of temperature and desiccation, most farmers in Senegal for example have observed an increase in length of hot periods, increased intensity of dry season as well increases in length of dry spells (Mertz et al. 2009), increases in frequency of droughts were noted by farmers in Bangladesh (Uddin et al. 2017) and Nigeria (Bauchi et al. 2017 & Mngumi, 2016). Similarly, increases in hotness was observed by farmers in Central America (Harvey et al. 2018), Nigeria (Chukwuone, 2015) and Zambia (Nyanga et al. 2011). Farmers in Zambia and Nepal have noted reduction in coldness and the disappearance of ice falls ( Nyanga et al. 2011; Ashish, 2014). Though not new to the farmers, the frequency of all these phenomena appeared to have increased (Nyanga et al. 2011). According to Mertz et al. (2009), Senegalese farmers have observed a reduction in length and intensity of cold spells and noted that clouds now produce more wind than rain and that winds are much stronger, more frequent and carry more dust. Farmers in Zambia noted an increased unpredictability of the weather noting that there are no longer clear cut differences between the cold and hot seasons (Nyanga et al. 2011).

Apart from changes in trend of both temperature and precipitations, farmers in Central America and Ethiopia observed increases in incidence of pest and disease outbreaks (Harvey et al. 2018), loss of some crop varieties and decline of agricultural yield (Lemma, 2016).

The prevalence of adequate perception of climate variability and change principally on temperature and rainfall patterns by farmers is assumed to be an important element that guide and influence their response mechanisms and future actions on climate adaptation endeavours. Understanding these perceptions has therefore become a prerequisite for reducing the negative effects of climate variability and change (Dang et al. 2012).

### 2.10.3 Perceived Drivers of Climate Variability and Change

Farmers across the globe differ in their perception on the causes of climate viability and change. Whilst some farmers may view climate change as a natural consequence of the abuse of the natural environment, others attribute the situation to supernatural intervention to warn or punish immorality. In a study in Zambia by Nyanga et al. (2011), for example, most smallholder farmers pointed to supernatural forces as the main cause of climate change. Referring to the Bible, they argued that disobedience of humankind to God's principles and lack of respect to ancestral spirits and other customs caused climate change. Similar findings were made by Tesfahunegn, Mekonen & Tekle (2016) in their study on farmers' perception on causes, indicators and determinants of climate change in northern Ethiopia.

The second most common perceived causes of climate variability and change is the one associated with environmental explanations. Farmers in Zambia, Ethiopia and Malaysia identified deforestation, pollution from industries and modernization as major causes of climate variability and change (Nyanga et al. 2011; Tesfahunegn, Mekonen & Tekle, 2016; Akhtar, Masud, & Afroz, 2019; Alemayehu & Bewket, 2017b) whilst a few believed that climate change was a natural and normal process" (Akhtar et al. 2019). Farmers in Ghana attributed the causes of climate variability and change to unbridled removal of vegetation cover, bush burning and the emission of vehicular and industrial fumes (Appiah, Akondoh, Tabiri, & Donkor, 2018).

### 2.10.4 Perceived Indicators of Climate Variability and Change by Smallholder Farmers in Ghana

Most studies in Ghana depict farmer's perception of climate variability and change in the form of changes in trend of temperature and precipitation. Kolleh (2015) studied the perception of rice farmers in the Volta Region of Ghana. His findings revealed that most of the farmers perceived a decreasing trend in precipitation and its increasing irregularity. Majority also perceived increases in temperature and even described the perceived climate risk as a severe (Kolleh, 2015). A similar findings by Appiah, Akondoh, Tabiri, & Donkor (2018) on smallholder farmers in Offinso Municipality revealed that most farmers have noticed increasing erratic rainfall pattern, windstorms, increase in temperature and floods and attributed the phenomenon to signs of climate variability and climate change. Owusu, Obour, & Asare-baffour (2015) did similar studies in Akuapem North District where farmers expressed concern over unpredictable patterns of rains and the resultant high incidence of crop failures. Similar findings have been made by Adiku, Nelson, Dovie, Codjoe, & Awuah (2018).

### 2.10.5 Perceived Effect of Climate Variability and Change by Smallholder Farmers in Ghana

The effect of climate variability and change has been felt differently by smallholder farmers. These variations in terms of farmer's perception can be attributed to the environmental and social context within which farmers live (Harvey et al. 2018; Nyanga et al. 2011 & Mertz et al. 2009). Appiah et al. (2018) studied farmers perceived effects of climate variability and change in the Offinso Municipality and concluded that the most widely perceived effect of climate variability and change among smallholder farmers in the area are food crop losses, health and housing hazards. Majority of respondents indicated that their households had already been adversely affected by climate variability and climate change (Appiah et al. 2018). In a publication titled "Climate Change in Ghana: Impacts on Agriculture and the Policy Implications" The *Institute of Economic Affairs* identified maize yield loses attributable to climate variability to be significantly high as 19 to 41% (IEA, 2013). According to Pinto, Demirag, Haruna, Koo, & Asamoah (2014), estimates of yield change of cereals and groundnuts through modelling indicate an overall small decrease, mostly below 25 percent in most parts of Ghana. Abdoulaye, Bamire, Akinola, & Etwire (2017) however attributed the yield decline to droughts. However the Centre National de Recherches Météorologiques (CNRM) model has predicted that climate change is likely to induce grain yield increases in the Upper East, Upper West, and Northern regions ( Pinto et al.et al. 2014). Similar findings have been made by Abubakari (2016). Teye, Yaro & Bawakyillenuo (2015), Kumasi, Obiri-Danso & Antwi-Agyei (2017) and Abdoulaye, Bamire, Akinola, & Etwire (2017).

### 2.10.6 Perceived Indicators of Climate Variability and Change by Smallholder Farmers in Northern Ghana.

Farmers in northern Ghana like elsewhere in country are aware of climate variability and change through changes in temperature and precipitation (Abubakari, 2016). Amadou et al. (2015) interviewed some farmers in the Upper East Region on their awareness of climate variability and change. Eighty-two percent (82%) of respondents said they have noticed a gradual and long-term changes in temperature whilst about 71% of them perceived temperature to be increasing. In the same study about 96% of the farmers perceived the long-term changes in rainfall pattern over the last 20 years whilst 95% claimed that they observed a decrease in the amount of rainfall and in the length of the rainy season (Amadou et al. 2015). In a related study in the Upper East Region, 70% of farmers interviewed have observed a decreasing rainfall pattern whilst 64% and 66.6% noted temperature increases as well as increased incidence of droughts (Kumasi, Obiri-Danso and Antwi-Agyei, 2017). Abdoulaye et al. (2017) did similar studies in the Upper West and Brong Ahafo Region and came out with similar conclusions.

In a related study in the northern region, farmers across all the study communities except Nyangua reported experiencing increasing trend of temperature (Teye et al.et al. 2015). Majority of the respondents in Nyangua however reported general stability in temperature. In a study by Abubakari

(2016) on "gender and climate change adaptation strategies" farmers in the Tolon district said they have experienced an upsurge in temperature. A related findings were made by Kwame Adusei on rice farmers in the Ashanti and Northern regions (Adusei, 2016).

With regards to perception, there is an apparent inverse relationship between temperature and precipitation. Whilst farmers in northern Ghana generally have perceived an upward trend in temperature, they have at the same time think that precipitation is on the decrease (Carolyn et al. 2017; Teye et al. 2015 & Amadou et al. 2015).

### 2.10.7 Perceived Drivers of Climate Variability and Change by Smallholder Farmers in Northern Ghana

It has been scientifically proven beyond doubt that climate change has been exacerbated by human activities in the form of uncontrolled emissions, removal of vegetation covers among others (Bodansky, 2016; Owusu, et al. 2015; IPCC, 2007b). Farmers perception of the causes of climate variability ranges from that of being a spiritual, scientific or human induced phenomenon (Abdoulaye et al. 2017). A section of smallholder farmers in the Upper West and Brong Ahafo regions believed climate variability and change are spiritually induced phenomena and attribute it to signs of the "end time" or punishment for human sins (Abdoulaye et al. 2017). However, the distortion of atmospheric composition, indiscriminate bush burning, deforestation, overgrazing, wood harvesting, application of agrochemicals, emissions from automobiles and automated machine generators and waste disposal have also all been cited by farmers as major drivers of climate variability and change in Northern Ghana (Teye, et al.et al. 2015 & Abdoulaye et al. 2017).



### 2.10.8 Effects of Climate Change on Crop Productivity in Northern Ghana

Several forms of climate change impacts have been identified in climate change literature. The negative impacts mentioned by farmers in Northern Ghana include, decreasing agricultural output and food insecurity (Abubakari, 2016), poverty, water stress and poor health (Teye et al. 2015 & Abdoulaye et al. 2017), floods and drought (Abdoulaye et al. 2017) as well as declining yield and farm profitability (Adusei, 2016).

## 2.11 Global Perspective of Agricultural Adaptation Strategies to Climate Change

In the previous sub section, the influence of temperature and precipitation variables on the state and conditions of climate were highlighted. It was noted that small holder farmers have observed a declining trend of rainfall and rising temperature levels. This subsection will discuss strategies adopted farmers in response to the changing and variable climate.

Pinto et al. (2014) defined climate change adaptation as "a set of actions, strategies, processes, and policies that respond to actual or expected climate changes so that the consequences for individuals, communities, and economy are minimized". Because climate change is a long time phenomenon, smallholder farmers have over the years put in place measures that enable them cope and adapt to both adverse climatic and non-climatic stresses which increase their vulnerability (Owusu, Asare-Baffour & Obour, 2015).

According to Nhemachena & Hassan (2007), agricultural adaptation to climate change includes changes in agricultural management practices in response to changes in climate conditions. Based on an assumption that farmers have access to alternative practices and technologies, adaptation starts at the farm level involving a combination of various individual responses (Nhemachena & Hassan, 2007). There is ample knowledge about agricultural adaptation systems that could help safeguard production (Fadina & Barjolle, 2018; Srivastava, Gaiser, & Ewert, 2015 & Ayanlade, Radeny, & Akin-onigbinde, 2017).

Johnston, Hoanh, Lacombe, Noble, Smakhtin, Suhardiman, Kam Suan Pheng & Sze (2010) recommended the promotion of broad-based agricultural development as an effective adaptation strategy. According to Dang et al. (2012), climate change adaptive capacity is largely influenced by farmers' socioeconomic factors like income status, livelihood diversification, level of education, and access to infrastructure and technology. As observerved by Kuruppu & Liverman (2011) and IITA (2017), historically, farmers have always coped with climate variability and have fashioned out strategies for dealing with droughts and floods. Kuruppu & Liverman (2011) has suggested that this traditional coping mechanisms should form the basis for future adaption to climate change. Many of these adaptation measures are environmentally friendly and are effective in reducing greenhouse gases emissions (Otitoju, 2013).

The most common adaptation practices used by smallholder farmers include indigenous planting techniques, watering, planting more resistant varieties of crops, and adjusting to rainfall variability, especially during the minor season (Owusu et al. 2015; Pinto et al. 2014 & Yamba, 2016). Smallholder farmers have also adapted to the climate menace by rearing farm animals and trading in bush meat and fruits (Owusu et al. 2015), farm intensification and application of fertilizers and clearing of forest for new farmland (Yamba, 2016) and using improved crop varieties and adoption of recommended agricultural practices (Sadiq, Kuwornu, Al-Hassan and Alhassan, 2019).

**2.11.1 Global Perspective of the Determinants of Smallholder Farmer's Choice of Adaptation Strategies to Climate Variability and Change**

Farmers intention to undertake adaption does not necessarily lead to adaptation decision (Dang et al. 2012). As Dang et al. (2012) noted, framers adaptation behaviour is affected by demographic, institutional and farm level/land ownership factors support.

**Age**

The influence of a farmer's age on particular adaptation strategy have been amply demonstrated by a number of research findings.

Alhassan, Kwakwa & Adzawla (2019) used the multinomial logit regression to determine the factors that influence farmers' choice of adaptation strategies to climate variability and change in the Savelugu municipality and Nanton district. Their findings indicate that a farmer's age influenced his' his choice of change crop varieties by 10% and soil conservation by 10%.. In a similar study, Tadesse, Hassan, Ringler, Alemu, & Yesuf, (2009) found that age significantly influences the choice of planting trees and irrigation as adaptation strategies by 1% respectively. In a study in Ashanti and Northern Regions, Adusei, (2016) found that age significantly influence the choice of irrigation and collection diversification by 1% each.

**Educational level**

In a study Benin, Fadina & Barjolle (2018) used multinomial logit model and identified educational level as one of the most significant factors affecting the adaptation choice of farmers in the Zou Department of South Benin. According to the study a farmer's level of education positively influence the choice of crop and livestock diversification by five 5%, use of improved varieties, chemical fertilizers and pesticides by 1% as well as agroforestry, income diversification and multiple cropping by 1%, 5% and 1% respectively. According Tadesse et al., (2009), education level influences the choice of soil conservation by 10% and changing planting date by 1%.

Otitoju, (2013) also observed that years of formal education influences the choice multiple planting dates, crop diversification and off farm employment by 5%, 10% and 10% respectively.

**Access to Extension Service**

According to Tadesse et al., (2009), access to extension significantly influence the choice of planting trees as an adaptation strategy by 1%. Similar findings by Otitoju (2013) indicate that access to extension services influences the choice of multiple cropping by 10%, land fragmentation by 10% and crop diversification by 10%. Alhassan, et al,. (2019) shows that access to extension services influence the choice of changing cropping varieties by 5% and also mixed cropping by 5%. Access to extension also influence the choice of irrigation and collection diversification by 5% each (Adusei, 2016). Similar findings have been made by Alemayehu & Bewket (2017)



**Access to Institutional credit**

Access to credit is found to positively influence the choice of soil conservation at 1% significance level and negatively influence irrigation as an adaptation strategy by 5% and changing planting date by 10% (Tadesse et al., 2009). Similar findings by Alhassan, et al,. (2019) show that credit access positively influences soil conservation at 10% level of significance. In his studies in South Western Nigeria, Otitoju (2013), found out that the influence of a farmer's access to credit is negative and significant at 5% for multiple cropping varieties, 5% for land fragmentation, 5% for crop diversification and 10% for multiple planting dates.

**Farm Size**

Using the Multinomial Logit Adaptation Model, Adusei, (2016) observed that the influence of farm size on farmers decision to adopt irrigation as an adaptation strategy is negative at 10% significant level. Using the same model, Otitoju (2013) found that farm size negatively influence farmers adaptation of multiple crop varieties at 5% level of significance but positively influence the adoption of land fragmentation and crop diversification by 5% each respectively.

**Farm Distance**

The influence of farm distance on farmers decision migrate is negative and significant 10% (Adusei, 2016). Similarly, Otitoju found that average farm distance influence the off farm employment as adaptation strategy negatively and at 1% level of significance.

Other studies like Jiri et al. (2017) also employed the multinomial logit model in a study of adaptation options of smallholder farmers in Zimbabwe and concluded that resource endowment of the farmer, farmer characteristics, farmer's yields and perception of environmental changes were the major influencing variables that affect farmers choice of adaptation strategy. In a similar study in Ethiopia, Alemayehu & Bewket (2017) identified perceived soil fertility status, perception of land tenure security, access to extension service and ages of household heads as factors that influence the choice of adaptation strategies in the area.

In another study, Chukwuone (2015) found that the elderly and male-headed households, as well as rich households were more likely to grow pest- and disease-resistant crops. The findings established that members of larger household sizes were more likely to practice all the land management practices, namely growing cover crops, use of organic manure, increased fertilizer, land and crop rotation, as well as intercropping (Chukwuone, 2015)

Using the binary logistic regression model, Mabe, Sienso, & Donkoh (2014) concluded that farmer's experience, income, access to phones, mixed farming, perception on reduction in rainfall amount and access to weather information significantly and positively influence the choice of at least five climate change adaptation strategies in the area (Mabe et al. 2014). In a related development, Otitoju (2013) studied adaptation choices of farmers in South Western Nigeria and concluded that there is a negative relationship between the level of education of the household head and the probability of adopting multiple cropping and different planting dates. The findings also revealed that male headed household are more likely to choose multiple cropping, multiple planting dates and non-farm work than female headed households (Otitoju, 2013).

Similar findings by Kumar et al. (2012) indicate that age, gender of household head, number of years in school, household size , occupation and amount of previous loss due to climate variability significantly influenced adaptation decisions of yam farmers in Southern Nigeria. In their findings, Kumar et al. (2012), noted that age, gender of household head and amount of previous loss due to climate change were found to significantly influenced farmers decision to plant pest- and disease-resistant crops as an adaptive farm management practice.

## 2.12 Adaptation to Climate Variability and Change by Farmers in Northern Ghana

Farmers in Northern Ghana, like anywhere in the world are affected by climate variability and change. Some of the negative effects have already been stated earlier and include declined in yield, loss of farm produce due to droughts and floods (Abdoulaye et al. 2017). Confronted with climate related crisis smallholder farmers in northern Ghana have employed different strategies to mitigate the harmful effects of climate variability and change (Kumasi et al. 2017). Studying in the Tolon District, Abubakari (2016) identified a number of adaptation strategies including the planting of different crop varieties, early and late planting and timing of rainfall. Kuwornu (2013) made similar findings in his study of farmers in Northern Ghana. Other adaptation strategies identified by researchers include adopting new planting dates and densities (Kumasi, et a , 2017) and changing of planting dates (Abdoulaye et al. 2017) were reported in the Brong Ahafo, Northern and Upper West regions. Abdoulaye et al. (2017), Abdul-razak & Kruse (2017) and Abubakari (2016) reported that farmers in the Tolon District, Brong Ahafo and Upper West Regions responded to climate variability and change by adopting mixed and multiple cropping as well as planting improved varieties and breeds. Farmers in the Tolon District and the Upper East Region are reportedly resorting to the use of fertilizer and other agrochemicals as soil management practices (Abubakari, 2016 & Carolyn et al. 2017). Additionally, smallholder farmers in the

Ashanti and Northern Regions including the Tolon District are reportedly engaging in off-farm jobs, alternative livelihood activities as well as out migration as adaptation mechanisms (Adusei, 2016 & Abubakari, 2016). In the dry Upper East, some parts of Upper West , Brong Ahafo, Ashanti and Northern Regions, farmers have adopted water harvesting and conservation techniques and irrigation farming as mitigation measures against climate variability and change (Carolyn et al. 2017; Adusei, 2016). A similar findings by Abdoulaye et al. (2017) indicate that smallholder farmers in the Upper East Region are increasingly using drought resistant and early maturing crop varieties, changing of farming techniques from crops to livestock rearing and planting trees for shading and shelter in an effort to minimize the effect of climate variability and change.

**2.13 Global Literature on Yam Production**

The previous sub section discussed strategies adopted by farmers against the effects of climate variability and change. The current and ensuing subsections will assess literature on yam production along the yam value chain. It will also review literature government policies on yam production and marketing.

Studies on the perception and adaptation to climate variability and change by yam farmers will not be complete without a detail understanding of the agronomic practices associated with the production of yam. That being the case, this study will be highlighting the cultural practices associated with the cultivation of the crop and the activities along the yam value chain in the context global production.

There is ample literature on yam production in West Africa. Much of these studies have been done in Nigeria and largely devoted to agronomic practices (Morse & Mcnamara, 2018), entrepreneurship development (Morse & Mcnamara, 2016), and production challenges (Udemezue & Elc, 2017). Udemezue & Elc (2017) for example identified a number of production challenges including inadequate extension service, pest/disease attack, high cost of hired labour, high cost of seed yam, use of unimproved seed yam, climate condition and bad road network that affect the production of yam in the Anambra State of Nigeria. In a similar study, Morse & Mcnamara (2016) did an assessment on the "Yam Improvement for Income and Food Security in West Africa" (YIIFSWA) and concluded based on their findings that the significant financial outlay required for yam production (both seed and ware) is a limiting factor in the growth of the industry. The study observed that about 70% of the costs of production is associated with the purchase of yam tubers for setts, adding that given the relatively high cost of yam planting material compared to other crops, risk is a special concern and this applies to seed yam as well as ware yam (Morse and Mcnamara, 2018 & Morse and Mcnamara, 2016).

Similarly, Verter & Bečvářová (2015) identified lack of finance, inadequate farm inputs, storage facilities and high cost of labour as the primary constraints to yam production in the Nigeria and recommended the creation of yam processing industries to accelerate yams value added chain for the betterment of smallholder farmers and traders.

### 2.13.1 The Concept of Yam Value Chain

There are different definitions and several distinct approaches to value chain research. However, in the context of yam production, Donkoh, Danso-abbeam, Karg, & Akoto-danso (2018), defined a value chain as consisting of all stages of a technical production process as well as of the interaction between these stages. According to Donkoh et al. (2018), yam production process begins with input supply, then goes through production, processing, marketing and ends with the consumption of the product. Donkoh et al. (2018) separated the production process into five stages: input supply, primary production, processing, marketing and consumption. Every stage of the process involved several different actors ( Donkoh et al. 2018 & Bergh, Kpaka, Orozco, Gugerty, & Anderson, 2012). Actors in the yam value chain include yam producers, wholesalers, yam retailers and cross-border traders (Anaadumba, 2013).

Bancroft (2000) observed that in Ghana yam is traded in its raw state and is not processed into a secondary product. Yam traders often buy the product for sell whilst owners of chop bars (small restaurants) prepare it into dishes for consumers directly (Bancroft, 2000). Yam trade in its raw form is not limited to internal transaction. As Anaadumba (2013) noted, exporters often wrapped yam in newsprint and pack them in 25 kg boxes before shipment.

### 2.13.2 Yam Production Input Supply

Yam production process begins with input supply (Bergh et al. 2012). The inputs ranged from setts to the technical equipment that is needed for the production of the product (Verter and Bečvářová, 2015). Input suppliers ranged from small, medium to big sized enterprises (Aidoo, et al. 2012). Seed yam, land, labour, equipment for land preparation, staking materials and agrochemicals are the major inputs required for the production (Bergh et al. 2012). Local markets are major sources of yam inputs (Adam et al. 2014 cited in Donkoh et al. 2018),

### 2.13.3 Seed Yam Input Supply

Access to improved seed yam remain a major challenge to yam farmers as they aspire to increase production (Asante, Villano & Battese 2013). Most farmers (both Commercial and small scale) in West Africa use traditional methods of generating planting materials and depend on their own produce rather than buying setts for planting (Mignouna, Akinola, Suleman, Nweke, & Abdoulaye, 2014a).

Relying on or obtaining yam setts either from their own farms or from neighbouring farmers through purchasing arrangements have compromise seed quality as many of such seeds are fungal, viral or nematode infected (Osei-adu, 2016 & Aighewi, Maroya, & Robert, 2014). According to Aighewi et al. (2014) seed yam obtained through these methods have low multiplication ratio, is very costly and the quality is not always guaranteed. Setts obtained from traditional methods are susceptible to diseases and pests (Aighewi et al. 2014). In response to these challenges, the mini-sett technology have been developed by West African scientists to overcome the problem of the unavailability of good quality seed yam (Aighewi et al. 2014).

#### 2.13.4 The Development of Yam Minisett Technology

The Minisett Technology was introduced in Nigeria in 1985 by the Nigerian National Root Crops Research Institute (NRCRI) at Umudike, with the collaboration of IITA, Ibadan (Aighewi et al. 2014). A similar technology was introduced in Ghana through the collaboration of the Savanna Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR), the Crop Research Institute (CRI) in Kumasi and the International Institute of Tropical Agriculture (IITA) (Graphic Online. Com, Sep 12 , 2018). Through this technique, the 'mother' yam tuber is cut into small setts (minisetts) of 25-100g with a reasonable amount of peel (periderm) from which sprouting can occur (Graphic Online. Com, Sep 12 , 2018). To prevent damage from diseases and pests the minisetts are treated with chemicals, then planted, and managed to produce small whole seed tubers; these in turn are planted to produce ware tubers for food (Aighewi et al. 2014).

Among the many advantages of the minisett technology over the traditional seed yam technology include a rapid multiplication of disease-free seed yam (Graphic Online. Com, Sep 12 , 2018 & Morse & Mcnamara, 2018), elimination of the cost of cutting and reduction of the spread of diseases (Aighewi et al. 2014), resulting in higher returns (Zakaria et al. 2014), and production of better quality tubers (Balogun, 2015).

In spite of the numerous advantages of the yam minisett technology, its adoption by farmers across West Africa have been generally slow and disappointing (Frossard, Aighewi, Aké, Barjolle, Baumann, Bernet, Dao, Diby, Floquet, Hgaza, Ilboudo, Delwende, Kiba, Mongbo, Nacro, Nicolay, Esther and Traoré, 2017; & Ofem, Ndifon, Ogbonna, & Ntui, 2011). Farmers reluctance to adopt the new technology is largely attributed to high cost of seeds (Bergh et al. 2012), inadequate awareness and unavailability of training on seed yam multiplication (Ofem et al. 2011). According to Sam and Dapaah (2009), the first ever improved varieties were only released in 2005.

### 2.13.5 Varieties of Seed Yam Produced in Ghana

The white yam and the water yam (*Dioscorea rotundata and Dioscorea alata*) are the dominant varieties grown in Ghana (Bergh et al. 2012). With the Dioscorea *rotundata* the "Kpono" and "Labako" were the most popular varieties of white yam grown in one survey of Northern region due mainly to their good taste. Farmers however claimed that those varieties were among the lowest yielding and did not store well (Bergh et al. 2012). "Ziglangbo", which stores for a longer period of time was another popular variety because of its availability during the lean season when other varieties were not available (Bergh et al. 2012). Household eating habits, availability and market value were the major determinants of the choice of variety cultivated (Bergh et al. 2012).

### 2.13.6 Farm Level Production of Yam in West Africa

To be successful in yam production farmers are expected exhibit some knowledge on conditions favourable for growth of the commodity and the routine cultural practices (Diby et al. 2011). For instance, yams do well in a well-drained upland fields (IEA, 2013). Yam thrives well Optimum on sandy-loam and silty-loam soils. Loamy soils with high in organic matter also produces good yield (Ennin, Otoo, & Tetteh, 2009). Stony and highly compacted soils are not favourable for yam growth (ViCAARP, 1987).

According to Mignouna et al. (2014), farmers in Ghana and Nigeria mostly own one yam field each. Farmers owning more than one field are less than

5%. The study also estimated an average yam field size of 1.82 ha per household in Nigeria and 1.60 ha in Ghana. Where land is available one of the major requirements for yam growth is virgin land and for this reason yam production is usually concentrated in areas remote from urban centres and in less densely populated zones (Mignouna et al. 2014a). The major aspects of yam cultivation and production include land preparation, planting, staking, weeding, and harvesting (Mignouna et al. 2014 & ViCAARP, 1987).

**2.13.7 Land preparation for Yam Cultivation**

According to Bergh et al. (2012) yam production is generally done under a shifting cultivation system in Ghana. The method involves the farmer moving from one virgin land to another every year in search of suitable land for yam production. Suitable land must have highly fertile soils, yam pests and diseases free, and the availability of sticks and shrubs (Bergh et al. 2012). Land is usually prepared manually, involving the use of hoe and cutlass or mechanically by clearing the land area, ploughing and harrowing (Osei-adu, 2016). AgriBiz (2017) observed that in order to ensure maximum tillage farmers usually ploughed the cleared debris into the soil to ensure adequate drainage, aeration, nutrition and room for tuber growth. During the dry season, farmers burn the small trees on their fields by collecting the residue around them. When they die, the yam vines are guided to twine on them. Farmers in the past used hoe, machete, and digging sticks without any form of a labour-saving technology (AgriBiz, 2017).

Herbicides have now replaced hoe and cutlass for land clearing more in Ghana than in Nigeria, as 46% of fields surveyed in Ghana used herbicides compared to 17% in Nigeria (Mignouna, et al.et al. 2015 & Osei-adu, 2016).



### 2.13.8 Preparation of Yam Mounds

Mignouna et al. (2014) noted that both Nigerian and Ghanaian farmers grow yam in mounds. Whereas mounds in Ghana are almost of uniform size mound size varies in Nigeria depending on soil depth (Mignouna, et al.et al. 2014b). Both AgriBiz (2017) and Mignouna et al. (2014) observed that in Ghana especially, where mounds are usually of the same sizes tuber development is affected. In areas where the soil is too shallow for standard mound size, the shape and length of the tuber is affected. Yam mound making is both laborious and backbreaking and as a result most farmers in Ghana and Nigeria rely on their family or household labour or better still hired labour for raising yam mounds (Zakaria et al. 2014 & Mignouna et al. 2014). Activities ranging from mound making to all other yam production operations are also labour intensive because all of them are performed with the hand (Donkoh et al. 2018). Cutting tubers to between 6 cm-8 cm pieces, dipping in a rooting hormone and placing them in a propagating bins are all labour intensive (AgriBiz, 2017).

### 2.13.9 Planting and Mulching

According to AgriBiz (2017), there are four ways of propagating yams. Planting by tubers, cuttings and the tissue culture are however the most common planting methods amongst farmers in West Africa (Aidoo et al. 2011). By planting with tubers, the planting material is called a "sett" and the size of each set should be between 400 grams to 500 grams (AgriBiz, 2017). With Basal vine cuttings, 6 cm-8 cm pieces are dipped in a rooting hormone and place in a propagating bin (AgriBiz, 2017). Because of its many buds, the head portion of yam tuber shoots up more easily than the middle and tail portion and is therefore the most preferred planting material by farmers (Aidoo et al. 2011).

AgriBiz (2017) identified four main methods of planting yams, namely planting in ridges, mounds, holes and flat or minimum tillage. Planting in mounds is the most popular in West Africa. Farmers usually collect soil into heaps of mounds and sometimes add compost before planting.

Sunny conditions with average temperatures of 25ºC – 30ºC are the right conditions for yam growth. Yams don't do well in freezing environment hence, its cultivation is restricted to the tropics (Sam & Dapaah, 2016). Annual rainfall of 1200mm or more, which are evenly distributed are required for successful yam cultivation (Sam and Dapaah, 2016). Yams are also known to respond to the duration of daylight periods (ViCAARP, 1987). Short daylights tend to favour tuber formation while long daylights favour vine growth (ViCAARP, 1987). The implication of this is that any change or variation of the climate or changes planting pattern such that the time for tuber formation corresponds with long duration of daylight can result in poor yield (ViCAARP, 1987. Because yams are usually planted in the dry season, mulching which involves capping of mounds with grass stocks or shrubs is necessary to maintain and conserve soil moisture and provide optimum condition for growth (ViCAARP, 1987).

**2.13.10 Staking of Yam Vines**

Sam & Dapaah, (2016) defined Staking as "the provision of support structure so as to enable yam vines expose their massive canopy to maximum sunlight throughout its growth". Farmers clearing virgin lands or wooded areas for yam cultivation, usually burn the small trees on their fields and used them as platforms for their yam vines to get exposure to sunlight (AgriBiz, 2017). Others cultivating on already cultivated lands have to transport sticks to their farms (Mignouna et al. 2014b). The modes of staking usually range from individual staking, that is one stake per plant, pyramidal staking where vines of several mounds are guided to twine on the support structure (Agribiz, 2017; Obidiegwu & Akpabio, 2017). Staking exposes yam plants to sunlight for enhanced photosynthesis and tuber yield and secondly staking also reduces the exposure of yam foliage to soil-borne diseases (Aighewi et al. 2014; Mignouna et al. 2014b).

### 2.13.11 Weed Control

According to Agribiz (2017) farmers desirous of better yields should always make sure their farms are kept clear of weeds at least for the first four months. Traditionally farmers control weeds using the hoe and cutlass (Zakaria et al. 2014). With this method, the farm is weeded on the 3rd, 8th, 12th and possibly 16th week after planting. With the advent of herbicides, most now rely on the method for weed control (Sam, J. and Dapaah, 2016). Morse & Mcnamara, (2016) observed that to avoid weed interference weeding must done before week 16 after planting in the case of the minisett technique and between 4 and 16 weeks with respect to ware yam. Some farmers rely on both the manual method and the use of herbicides for effective weed control (Zakaria et al. 2014). With this method selective herbicides are used to control grass weeds whilst the manual methods are used to control broad-leaved weeds (AgriBiz, 2017).

### 2.13.12 Fertilizer Application

Ghanaian farmers generally do not to apply fertilizer on their yam farms (Sam & Dapaah, 2016). This is attributed to the high cost of fertilizer as well as the availability of previously uncultivated lands (Ofem et al. 2011). Farmers in Nigeria however widely used fertilizer to enhance yam output (Sam & Dapaah, 2016). The decision to rely on fertilizer application to enhance yield probably arose out the persistent decline in virgin land rendering the practice of shifting cultivation unsustainable as well as decreasing fallow periods (Mignouna et al. 2014; Mignouna, Abdoulaye, Akinola & Alene, 2015). AgriBiz (2017) however recommends that soil test should always be done first to determine fertilizer types and rates and also any limestone requirements. It is recommended that two months after emergence farmers should apply 85 gm–114 gm of 16:8:24 NPK fertilizers placed 15 cm – 20 cm away from the base of the plant (AgriBiz, 2017). AgriBiz (2017) further recommends that six months after planting, a similar amount of potash fertilizer like Muriate of Potash be applied to encourage optimum tuber bulking. Best yields according to AgriBiz (2017), are achieved using high levels of organic manures and high levels of potash. Fertilizer application has also been found to suppress nematodes, particularly without Hot Water Treatment - HWT (IITA, 2001).

**2.13.13 Pest and Disease Management**

The Caribbean Community Climate Change Centre - C.C.C.C.C (2015) predicted that Climate change is likely to change the physical composition of host-pest interactions and change the rate of their development at various stages. This will affect the ability the host to resistance the pests. The Centre noted for example that increases in temperature could affect the growth pattern of host and length of growing season which may reduce or increase risk for pest damage (C. C. C. C. C., 2015).

The Mennonite Economic Development Associates – MEDA (2011) and Aidoo et al. (2011), have identified pest and disease infestation as one of the main challenges confronting yam farmers. According to Mignouna et al. (2014) high incidence of destructive yam pests and diseases pushes production costs making yam production even more expensive. Destructive pets and diseases like the nematodes, viruses, fungi, scale insects and beetles both affect yams both at the pre-harvest and postharvest stages. Anthracnose for example has been identified as one of the major disease problems (Mignouna et al. 2014b). Known scientifically as "Colletotrichum gloeosporioides" anthracnose is normally seen as small, black spots between the leaf veins (Mignouna et al. 2014b). According to Aidoo et al. (2011), pest and disease infestation affect seed productivity and viability, reducing germination, plant vigour and yield.



### 2.13.14 Maturity and Harvesting of Yam

Yams are annual crops and take about 8-10 months to reach maturity (AgriBiz, 2017). June to August used to be the normal periods of harvest and from August to October yams became abundant in Ghana. Due to weather changes yams are now harvested between July and September (Bergh et al. 2012). Signs of maturity are the natural dieback of Yam vines, dark greening and yellowing of leaves signifies early and late maturity (AgriBiz, 2017). The early crop matures at the end of July, main crop from the month of October to January(Diby et al. 2011). Farmers harvest their tubers by first removing the vines, after which they lift the tubers using hand forks taking care to do as little damage to the tubers (AgriBiz, 2017 & Bergh et al. 2012). Mode of harvesting yam vary depending on local context and circumstances (Diby et al. 2011). In a study of 174 yam famers in the Brong Ahafo and Northern regions of Ghana, about 36% of farmers reportedly harvested their yams using sticks, and 26% reported using sharpened sticks and cutlasses (Bergh et al. 2012). In terms of tuber quality, 95% said the harvesting tools injures the tubers. About 50% Ghanaian farmers consumed their injured tubers to avoid losses. Close to 25% either sold the tubers immediately or consumed them, whilst the remaining farmers reportedly used wood ash to treat injured tubers before storage (Bergh et al. 2012).

**2.13.15 Storage and Preservation of Yam in West Africa**

Yam is a delicate commodity which cannot be handled like commodities such as cereals or cassava. Besides, production is not all year round. This makes long-term storage critical if production is to remain sustainable (Banson, 2013). Types of storage techniques depend on circumstances such as security and agro-ecology (Nweke, 2017). Heaping in mud structures with thatched roofs with ventilated walls, tying on stands and piling up in dry material covered heaps are common yam storage techniques used ( Nweke, 2017 & Banson, 2013).

According to Donkoh et al. (2018), storage losses which is attributed to the over dose of chemicals by farmers on yam in the production activities, have been rated as high as 30% by yam wholesalers in West Africa. MEDA (2011), however contradicted this finding and argued that traders rarely keep stock long enough to incur losses greater than 10%. According to Balogun (2015) nematodes, which facilitate fungal and bacterial attacks also account for about 11 million tons of annual yam losses in West Africa. Damage caused by nematodes has effect on tuber quality, yield reduction, field and in storage losses (Verter & Bečvářová, 2015).

Bergh et al. (2012) noted that because tubers are not dehydrated during storage, yams sprout in storage due to the continuity of active metabolism. For yams harvested for sale and consumption, sprouting is not desirable as it affects quality and taste (Otoo, 2017). Ninety-eight percent (98%) of farmers interviewed in a study on yam transportation & storage, for example were of the view that pests, dehydration, sprouting and rot are responsible for storage losses (Bergh et al. 2012).

In the case of yam setts however, production is stalled by long periods dormancy, resulting in the delay of planting, compelling farmers to single cropping cycle (Otoo, 2017). Attempts to regulate dormancy which could pave the way for farmers to engage in more than one cropping cycle per year have not yielded the desire results as researchers have only been able to change the rate of shoot development, but have not able to break dormancy (Bergh et al. 2012).

### 2.14 Yam Farmers Awareness of Climate Variability and Change

Haven discussed the processes of yam production and marketing in the previous sub sections, the discoursed will now focus yam farmer's awareness, perception and adaptation to climate variability and change.

According to Tripathi & Mishra (2017), perception is a cognitive process that involves receiving sensory information and interpreting it. The accuracy of perception is a necessary condition for a meaningful response, which eventually depends on knowledge and experience (Tripathi & Mishra, 2017). Farmers' knowledge of climate change is therefore very fundamental for success in climate change adaptation (Yaro, 2013 cited in Dimmie, 2016). However, the complexity of climate variability and change makes it difficult for ordinary farmers in developing countries, most of whom are illiterates, to be able to offer scientific explanations to the phenomenon (Metz and Davidson, 2007). Studies show that most famers rely on their personal experiences and the media as sources of knowledge of climate variability and change (Dimmie, 2016). Chukwuone (2015), for example observed that about 90.2% of yam farmers in Southern Nigeria have heard of climate change before and that 45.71% of those who had heard about climate change know little about it.

Oluwatayo & Ayodeji (2016) also revealed that only 3% of farmers in the Oyo state of Nigeria are aware of climate change. Similar studies by Dimmie (2016) reveal that yam farmers in the Sissala East District of Ghana have knowledge of climate change through local experience and awareness creation by radio and mobile phones. Dimmie (2016) also observed that wealthy farmers tend to be more knowledgeable of climate change than poor farmers since the former have closer contacts with extension agents. In a similar studies in Ghana, Adusei (2016) noted that famers with longer years of farming experience tend to be more knowable of climate change than those with few years of farming experience. It has also been established that farmers with educational experience are more knowledgeable of climate change and are have already adopted various techniques and management practices to avert the negative impact of climate variability and change (Onubuogu and Esiobu, 2014).



### 2.14.1 Perceived Indicators of Climate Variability by Smallholder Yam Farmers

According to Dang et al. (2012) an awareness of climate variability and change in itself is not enough to illicit adaptation intension. What is required to motivate farmers to undertake adaption strategies are the awareness of climate risks as expressed in form and nature of climate variables (Dang et al. 2012). That being the case, any adaptation intension could be linked to the outcome of farmers' assessment of risk indictors of climate variability and change (Dang et al. 2012). Most studies on famers perceived indicators of climate variability and change indicate that most farmers generally perceived climate variability and change in the form temperature and precipitation fluctuations or changes (Rosenstock & Nowak, 2019; Harvey et al. 2018 & Nyanga et al. 2011). Chukwuone (2015), for example studied the perception of yam farmers in Southern Nigeria. His findings revealed that the majority (92.29% and 96.76%) of the respondents have noticed a significant temperature change and a significant change in rainfall. A majority (97.97%) of the yam farmers observed the signs of climate change in the form of delayed on-set of rains, 68.81% think there is too much rain whilst 65.59% has observed higher temperatures (Chukwuone, 2015). A similar study by Sagoe (2006) indicates that most communities in Ghana are aware of climate variability and attribute its form to unreliable, irregular and unpredictable rainfall pattern. In the same study, community members have expressed worry about the shortening duration of rainfall and steady increase in temperature (Sagoe, 2006). Ume, Ezeano & Okeke (2018) carried out similar studies and concluded that climatic variables that significantly influenced crop productions were rainfall, temperature, sunshine, wind and relative humidity.

### 2.14.2 Perceived Effects of Climate Variability and Change on Yam Productivity

This particular subsection will review literature on the effect of the variation of temperature and precipitation on yam productivity. Both the IITA (2017) and IEA (2013) have observed that one of the productive areas that is very sensitive to climate variability and change is agriculture. Nteranya and Mbabu (2015), for example, noted that climate change is expected to have its most severe impact on food production, especially yam. Studies indicate that yam yield response to climate change differ depending on species or cultivar, soil properties, pest and pathogens (Elijah et al. 2018). In a study in Southern Nigeria, a majority (71.29%) of respondent yam farmers viewed flooding and inundation of crop lands as major threats of climate change to yam production. Sixty-five percent (65.1%) attributed the phenomenon to a decline in yam yields leading to food price increases (Chukwuone, 2015).

Using an Environmental Policy Integrated Climate (EPIC) modelling, Kumar et al. (2012) observed a general decline in yam yields in savannah zone of West Africa and predicted a significant decline ranging between 18 to 33% between the period 2041–2050. Using various temperature scenarios Kumar et al. (2012) further predicted that global warming will induce further temperatures increases by about 8% and 6.5%. They concluded that the decline in yam yield could not be explained by the change in temperature but could largely result from the decline in precipitation causing frequent dry spells (Kumar et al. 2012). The findings did not however rule out other climatic factors might be responsible for expected yield decline.

Contrary to these findings, Chukwuone (2015), Kumar et al. (2012) & Elijah et al. (2018) studied yam famers in the Cross River State of Nigeria using multiple regression analysis. Their findings show that climate variability has no significant effect on the production of certain root crops in the study area.

### 2.14.3 Adaptation to Climate Variability and Change by Yam Farmers in West Africa

Studies on effect of climate variability and change on yam production is well documented (Chukwuone, 2015; Kumar et al. 2012 & Elijah et al. 2018). Whilst some of these studies did not reveal any significant effects (Elijah et al. 2018), others revealed that the effects of the menace on yam productivity could generally be negative (Chukwuone, 2015), still others have predicted a more damning consequences of the climate variability on productivity (Chukwuone, 2015). In response to the climate menace most yam farmers have undertaking a number of adaptation strategies such as planting pest and disease resistant crops, using multiple crop varieties, proper preservation of seeds and plant seedlings, mixed farming practices, fallow, mulch/use surface cover, intercropping and the use of farm yard manure (Tripathi & Mishra, 2017; Nyong, Adesina & Osman, 2007).

A study of yam farmers in Southern Nigeria has revealed a number of strategies aimed at mitigating the effects of climate change (Chukwuone, 2015). According to the findings of the study, 45% of the farmers bought food, 37.62% started using new farm management practices whilst 29.95% engaged in off-farm activity as mitigation strategies. In terms of land management practices used, the result shows that a majority (74.34%, 83.55%, 72.37%, and 60.53%) practiced land fallowing, mulching or used surface cover. Others intercrop and use farmyard manure, respectively. In addition, 56.68%, planted pest- and disease-resistant crops, 48.27% used crop varieties that are well-acclimated, 49.75% adopted proper seed preservation methods whilst 49.01% adopted mixed farming practices as mechanisms for climate change adaptation (Chukwuone, 2015). In a similar study, Oluwatayo & Ayodeji (2016) found that famers in Oyo state of Nigeria have resorted to mixed cropping, irrigation, diversification and change in planting dates as adaptive mechanisms against climate variability and change.

Al-hassan, Kuwornu, & Etwire (2013) observed that field rotation and spacing of planting materials are the two major adaption strategies adopted by yam farmers against the climate uncertainty. Hitherto, yam framers used to practice shifting cultivation (Anaadumba, 2013). Similar findings have been made by Obinna et al. (2017), Dimmie (2016) & Ishaya & Abaje (2008).

## 2.15 Theoretical Framework

### 2.151 Protection Motivation Theory (PMT) of Climate Change Perception and Adaptation

Climate change is a complicated phenomenon whose risk domain, and impacting processes has serious ecological and social consequences. The study of the phenomenon therefore requires a combination of perspectives and models from varied sources of knowledge. To sufficiently communicate and elucidate the psychological dimensions of climate change, there is the need for a multidisciplinary perspective that draws from all aspects of human life (Reser, Joseph & Swim, 2011). Most of the current models have not been successful in addressing all aspects of adaptation in a holistic manner, especially issues bothering on socio-psychological adaptation processes (Reser, Joseph, & Swim, 2011). The Protection Motivation Theory was therefore developed to fill the gap and to properly address issues of climate change perception and adaptive responses.

### 2. 15.2 Origins and Practical Applications of the Protection Motivation Theory (PMT)

The Protection Motivation Theory was originally established by Rogers (1975) to study health related risks (Westcott et al. 2017 & Le, Li, Nuberg & and Bruwer, 2014). The PMT has since been used to study risk behaviours in several fields namely, in an emergency bushfire response and schistosomiasis (Westcott et al. 2017 & Xiao et al. 2014), farming (Le et al. 2014), water management (Kuruppu & Liverman, 2011) and protective technology adoption (Chenoweth, 2014). PMT has also been used in the research on Information System Adoption (Lee, Lee, & Lee, 2007).

**2. 15.3 Assumptions and Application of PMT in Climate Change and Adaptation**

The theory is based on an assumption that two cognitive processes, *threat appraisal* and *coping appraisal* influence protection motivation in response to climate change. According to this theory risk perception indicates how individuals assess a threat to themselves in terms of perceived likelihood of experiencing a particular threat and perceived severity without behavioural change whilst perceived probability refers to individuals' expectation of being exposed to a threat (Grothmann and Patt 2005 cited in Dang, Li, & Bruwer, 2012).

Adaptation assessment occurs after the individual has perceived a particular risk and consists of what Dang et al. (2012) termed the perceived *self-*

*efficacy*, *perceived adaptation efficacy* and *perceived adaptation costs* (Grothmann and Patt, 2005 cited in Dang et al. 2012). They defined the perceived self-efficacy as *an individuals' perception of their own ability to actually conduct adaptation measures* and perceived adaptation efficacy *as individuals' belief in the effectiveness of adaptation measures.* Perceived adaptation costs *are the assumed costs of conducting adaptation measures in terms of money, time and effort* (Grothmann and Patt, 2005 cited in Dang et al. 2012).

Following risk and adaptation assessment, individuals decide on adaptation or maladaptation (Patt,Siebenhüner, 2005). Adaptive responses help prevent damage while maladaptive responses such as fatalism, denial, wishful thinking, on the other hand, prevent 'negative emotional consequences of the perceived risk, such as fear' (Grothmann and Reusswig, 2006). Individuals would choose maladaptive responses if they perceive high risk related to the threat but their adaptation assessment ends with low perceived adaptive capacity (Patt & Siebenhüner, 2005). If adaptive responses are chosen, individuals start with the intention to conduct adaptation measures (Grothmann & Reusswig, 2006). Whether adaptation intention is translated to the decision to adapt is influenced by objective resources (Patt & Siebenhüner, 2005; Grothmann & Reusswig, 2006).

Risk perception, adaptation assessment, and adaptation intention are influenced several factors. Osberghaus (2013) identified four groups of influential factors of perceived risk: (1) characteristics of risk, (2) psychological issues of decision-making (e.g., habit, belief), (3) speculative judgement (i.e., guessing, not based on the facts), and (4) who perceives the risk. In this theory, trust in public adaptation is assumed to influence how climate change risk perceive by farmers. This factor is an influential factor of risk appraisal in the model of Grothmann and Patt (2005) cited in Dang et al. (2012) while it is hypothesised to influence adaptation intention in the model of (Grothmann & Reusswig, 2006).

Another factor that may affect risk perception and behaviour is risk experience. Risk experience is assumed to positively influence risk perception (Grothmann and Patt, 2005 cited in Dang et al. 2012), and has been shown to motivate adaptation intention against flood risk (Grothmann & Reusswig, 2006). Weinstein (1989) proposed that risk experience tends to make people perceive themselves as potential victims and think of the risk more often; hence, protective behaviour is likely to increase. What people choose as their future protective measures are the ones they consider as relevant in their experienced of risk (Weisner, Schernewski, Weisner, & Schernewski, 2013).

Cognitive bias, which is anticipated to influence both risk perception and adaptation assessment, is essential in a decision-making model under uncertainty. It is assumed to be influenced by risk experience (Grothmann and Patt, 2005 cited in Dang et al. 2012). People from different cultures have different levels of cognitive bias relating to their perceived threat (Heine & Lehman, 1995). Intuitive judgement bias occurs not only for lay people but also experienced researchers (Tversky, 1992).

Social interaction is assumed to affect both risk perception and adaptation assessment. This concept is partially captured by social discourse in the model of Grothmann and Patt (2005) cited in Dang et al. (2012). It covers the influence of not only information observed from public media, friends, neighbours, relatives but also the interaction between farmers and other stakeholders on farmers' perception regarding climate change and adaptation. Although the contribution of cognitive factors to an understanding of the linkages among risk perception, adaptation assessment, adaptation intention and behaviour has theoretically been demonstrated, it could be unrealistic if objective resources such as money, knowledge, entitlement, and institutions are ignored. Those factors are hypothesised to influence both adaptation assessment and adaptive behaviour.

Demographic factors are expected to influence both risk perception and adaptation assessment. The relationships between demographic variables such as age, education, income, gender, and risk perception and adaptive behaviour have been widely discussed (Wu, Qu, Li, Xu & Zhang, 2018; Uddin, Bokelmann, & Dunn, 2017).

Belief in climate change has popularly been demonstrated as one cognitive factor contributing to adaptation intention. The strength of belief in climate change has empirically been justified to significantly influence the adaptive behaviour of smallholder farmers (Uddin et al. 2017). One of the personality factors which is proposed to affect adaptation intention is habit. The role of habit in understanding human behaviour is still under debate. Habit should not be treated as a no-value construct (Verplanken & Orbell, 2003). Habit, a psychological construct according to Verplanken and Orbell (2003), is shown to mediate the linkage between past and later behaviour.

Subjective norm, defined as perceived social pressure in the theory of planned behaviour (Chatzisarantis & Biddle, 1998), is hypothesised to influence adaptation intention in this theory. What people think and do is influenced by the pressure they perceive from their society. The importance of social norm in individuals' decision making has been indicated by Patt (2005) with several experimental evidences. The other two concepts: attitude and perceived behavioural control appear to be captured in individuals' adaptation assessment, hence not being distinguished in this framework.

Kuruppu & Liverman (2011) conducted a study to test the applicability of cognitive model of the protection motivation theory in the assessment of adaptation to water management by the people of Kiribati, in the Central Pacific. They interviewed 132 respondents and their findings indicate that it was easier for participants to conceptualise the process of climate change in relation to "water resources" rather than the science of "climate change". Kuruppu & Liverman (2011) attributed the findings to the ease of observing secondary drivers of climate change such as sea level rise and its impacts on water resources. On the contrary, the researchers were of the view that the respondents may not be able attribute increases in Green House Gases (GHGs) to rising sea levels because of their inability to see GHGs physically.

Yan, Jacques-Tiura, Chen, Xie, Chen, Yang, Gong, & MacDonell (2015) studied cigarette smokers in vocational high school in Wuhan, China. Their findings revealed that stronger smoking intentions were significantly associated with past smoking behaviour. Relying on these findings, Yan et al. (2015) suggested for the consideration of self-efficacy as an effective tool to discourage health risk behaviours and to encourage health protective behaviours.

For short the PMT states that in order for an individual to engage in adaptive behaviour, they need to believe that there is severe threat that is likely to occur and that by adopting adaptive behaviour they can effectively reduce the threat. The individual should also be convinced that he is capable of engaging in the behaviour which should not cost him much.

The present study, "Farmer perception and adaptation to climate variability and change; a study of smallholder yam farmers in Northern region." will be guided by protection motivation model. The constructs for the study are modelled using the PMT scale for yam farming household heads in sixteen sample communities across two districts in the northern region.

## 2.16 Conceptual Framework for the Study

Reichel and Ramey (1987) described conceptual framework as "a set of broad ideas and principles taken from relevant fields of enquiry and used to structure a subsequent presentation". The framework is a guide aimed at assisting a researcher to gain an understanding of the problem in question and articulate clearly what is going to be done (Guba & Lincoln, 1989). Clearly articulated conceptual framework guides the researcher and assists him make meaning of subsequent findings (Smyth, 2004).

The present study reviews three conceptual models on climate change and adaptation, that is, the Stimulus Response Model, the Culture Theory of

Risk (CRT) Model and a modified Integrated Conceptual Model derived from the Protection Motivation Theory.

### 2.16.1 The Stimulus Response Model

According the stimulus response framework, adaptations are processes within entities and systems, or adjustments made by human systems. This approach specifically refers only to human systems, individuals and collective actors (Eisenack & Stecker, 2019.). According the model, action requires actors and an intention. The intention is directed towards an impact of climate change. Furthermore, adaptations require the use of resources as means to achieve the intended ends. In the framework, a *stimulus* is defined as a change in biophysical (in particular meteorological) variables associated with climate change (Eisenack & Stecker, 2019.).

A stimulus is only relevant for adaptation when it influences an *exposure unit*. The latter term broadly refers to all those actors, social, technical or non-human systems that depend on climatic conditions, and are therefore exposed to stimuli (IPCC 2001). The abstract term is necessary to encompass the broad diversity of affected entities or systems that may be considered in an adaptation assessment. The model does not restrict exposure units to human systems. By an *impact* of climate change is to be understood as a combination of a stimulus and an exposure unit. More broadly, it can be a set of stimuli with an associated set of exposure units (Eisenack & Stecker, 2019).

In the framework, the individual or collective actor that exercises the response is called the *operator*. This distinct term is employed because actors will also play other roles in the framework. An operator can be, for example, a private household, a firm or a governmental actor. But in all cases it is a social entity, so that machines, artefacts and natural systems are ruled out as operators (Eisenack & Stecker, 2019). Not all activities of an operator are actions. Only those activities with a *purpose* qualify for this term. The operator tries to achieve intended ends that are associated with (other) actors, social or non-human systems whose ends are ultimately targeted at impacts.

The actor or system that is the target of an adaptation (the purpose) is called the *receptor*. Receptors can be both biophysical entities (e.g. the crops of a famer) and social systems (e.g. the farmer household), depending on the objective of analysis. It is further not required that the receptor of an adaptation is an exposure unit at the same time (Eisenack & Stecker, 2019). The operator is a public body that runs the system. It receives weather forecasts and transmits them to the public in an accessible way. The purpose of that adaptation is to reduce harm to individual users. The intention is to change behaviour of users, making them the receptors. The public body is not the exposure unit; the receptors of the early warning system are the exposure units (Eisenack & Stecker, 2019).

The framework acknowledges that there are many social phenomena that are not actions, but mere processes. *Processes according to the framework* are sequences of events in time that may occur in a biophysical, technical or social entity or system. They can be framed as being linked through causality, that is, in a mechanistic way. Actions are a special class of social processes that additionally have a teleological component (Weber 1922 cited in Eisenack & Stecker, 2019)).

To implement the adaptation, the operator needs resources, here called *means*. These could be access to financial or other material resources, legal power, social networks, knowledge, or availability of information. Action is further shaped by constraints and resources that cannot be controlled by the operator. These are called the *conditions* (Parsons 1937 cited in Eisenack & Stecker, 2019)). For example, the primary means employed by the operator of the early warning system is the information that is provided to the receptors. Further means involved are the public funding and the education of the people running the system. As an example of a condition, we can cite the attitudes of the receptors toward the early warning system: Do they actually listen to the forecasts? Do they trust the forecasts? Does the information they are given lead to behavioral change (Eisenack & Stecker, 2019)?

Another is the institutional and legal context: Is there stable funding for the early warning system? Are operators liable if forecasts are incorrect? It is helpful to further differentiate three notions of means: *available means, employed means* and *necessary means*. Available means are those that are disposable by the operator, while the employed means is that part that is actually used for a specific adaptation. That does not imply that the adaptation is effective, since success requires the use of the necessary means which might be available or not. It is important to note that these three types of means are not necessarily identical (Eisenack & Stecker, 2019).

The present study discusses farmers' perception of and adaptation to climate variability and change. Farmers decision to adopt particular adaptation strategies is determined by a number of factors namely, socio-demographic, institutional and farm level or land ownership factors. This means that farmers are not just mere responders to environmental stimuli and that their decision to respond and level of response are determined by a myriad of factors. Therefore, the stimulus response model cannot be used for this this particular study.

### 2.16.2 The Culture Theory of Risk (CTR) Model

The types of worldviews in CTR are derived by understanding social organization along two dimensions: that of ‘‘group,’’ or social bonding, and that of ‘‘grid,’’ or social rules (Douglas 1982; Schwarz and Thompson 1990 cited in Mcneeley & Lazrus, 2014). The group dimension describes the degree to which people affiliate themselves with a bounded social unit. The group dimension charts a continuum between a low group position where people are autonomous, self-reliant individuals unattached to a bounded social unit and a high group position where social bonds and group identity are emphasized. The grid dimension describes the degree to which groups ascribe and accept externally imposed rules, regulations, or prescriptions on social relations. The grid dimension draws a continuum between a low grid position in which there are few accepted rules and regulations and a high grid position in which there is significant social stratification and rule-based structure (Gross and Rayner 1985; Tansey and O'Riordan 1999; Spickard 1989 cited in Mcneeley & Lazrus, 2014)).

Culture and nature are co-constitutive and mutually influencing systems and therefore must be analyzed in tandem (van der Leeuw and Redman 2002; van der Leeuw 2000 cited in Mcneeley. & Lazrus, 2014). This is particularly evident in cultural perceptions of environmental risks. In the mid-1980s, there was an important development in CTR. The four worldviews were mapped to four corresponding myths of nature based in large part on the work of ecologists such as C. S. Holling and P. Timmerman (Holling 1986; Thompson et al. 1990; Timmerman 1986 cited in Mcneeley & Lazrus, 2014). As stated above, myths here are not falsehoods, but are rather social constructions or models of reality, each of which is a partial representation of the whole. Bringing the myths of nature into CTR served to broaden the understanding of perceptions of environmental risks to include conceptual models about how the natural world actually works and how society and nature interact that correspond to each of the worldviews and institutional structures (Mcneeley & Lazrus, 2014).

The market individualist worldview is low group and low grid with weak social bonds and little need for social structure. The corresponding myth of nature is that nature is benign and will auto-adjust to human actions. They tend to view climate as naturally variable and that humans cannot change this natural process (Thompson and Rayner 1998 cited in (Mcneeley & Lazrus, 2014). The fatalist worldview is low group and high grid with weak social bonds and resigned to a stratified society governed by rules. Fatalists tend to be the disenfranchised in society and some of the most vulnerable (Thompson and Rayner 1998 cited in Mcneeley & Lazrus, 2014). As such, they are typically not involved in policy or resource management processes (hence, the three instead of four institutional cultural types herein). For them, nature and climate are capricious and fundamentally random and unpredictable (Mcneeley & Lazrus, 2014). The hierarchist bureaucratic worldview is high group and high grid with strong social bonds that are primarily vertical and governed by numerous rules. Accordingly, nature (and climate) is manageable and tolerant of some human influence and will thus accommodate human action to a point and such ‘‘tipping points’’ can be identified by scientific experts (Mcneeley, S. M. & Lazrus, 2014). The egalitarian group worldview is high group and low grid with strong, communitarian social bonds between people subscribing to few strict rules and a general philosophy of collectivity. The corresponding myth of nature is that nature is fragile and in a precarious balance with society (Jones 2011; Douglas 1996 cited in Mcneeley & Lazrus, 2014). They tend to view the relationship between humans and nature as lying in a delicate balance, prone to human influence leading to a collapse.

CTR offers an analytical framework for identifying and examining culture clashes, such as those between groups of climate change ‘‘believers’’ and ‘‘deniers’’ and exposes how risk perceptions form that align with values and ways of life. This can then inform understanding about how and why climate change is embedded in the ‘‘culture wars’’ in the United States (and elsewhere) that leads to gridlock on climate policy issues (McCright and Dunlap 2003; Hunter 1991; Ellis and Thompson 2000; Kahan et al. 2011; Brunner and Lynch 2010 cite in Mcneeley & Lazrus, 2014).

Policy preferences are most strongly influenced by value commitments derived from grid-group orientation, which has been found to be stronger predictors of policy preferences than political party or ideology or other sociodemographic variables (Leiserowitz 2006; Pendergraft 1998 cited in Mcneeley & Lazrus, 2014).

Whereas the CTR views climate change adaptation as a collective action, the present study sees adaptation as private reasonability exercised by private actors. Climate change adaptation choices are made by individual farmers and not by groups of social actors. Hence, adaptation decisions are affected by the individuals socio-demographic status, institutional and farm level factors. That being the case, the CTR may not be an appropriate model to guide this study.

### 2.16.3 The Integrated Conceptual Framework

The conceptual framework guiding this study is a modified form of the integrated conceptual frameworks adapted from the models of Grothmann and Patt (2005) and Grothmann and Reusswig (2006) and used in Dang et al. (2012). Both models employ protection motivation theory in explaining individual's adaptive behaviour.

The framework is structured into four major components. These include individual farmer's perception of climate change, adaptation intention, mal-adaptation and adaptation options or choice of adaptation response.

According to Grothmann and Patt (2005) climate change perception is the knowledge and awareness of climate change and the risk associated with climate change. It also includes the perceived severity of climate change and the perceived probability of being affected by climate change.

A farmer may either perceive or not perceive climate change because of his own personal beliefs or information that is available to him. Farmers who do not perceive climate change may not contemplate taking adaptation measures (mal-adaptation). On the other hand, farmers who believe in or are aware of climate change will intend to take adaptive measures.

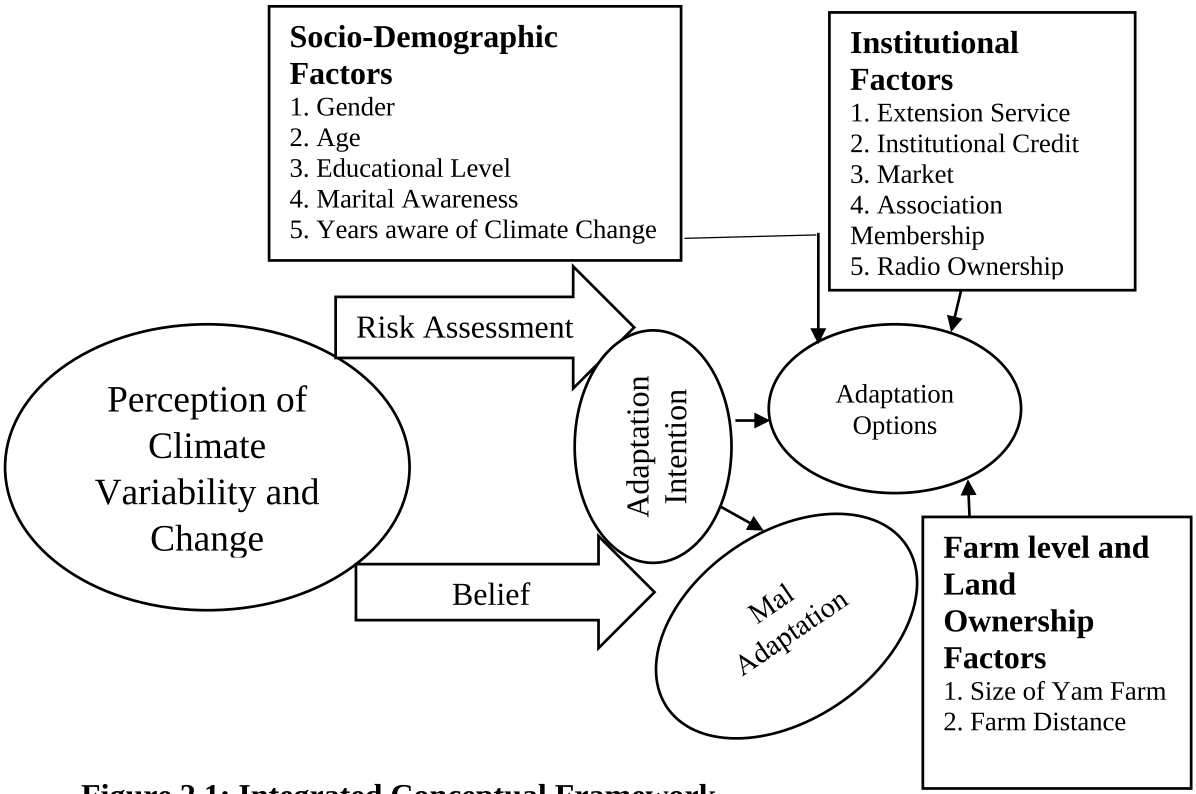


**Figure 2.1: Integrated Conceptual Framework**

Source: Adapted from Dang, Li & Bruwer (2012)

A farmer's intention to adapt or not to adapt (mal adaptation) is influenced by climate risk assessment and the believe that climate change is real. Risk assessments is how individual farmers evaluate a threat to themselves in terms of perceived probability and perceived severity without behavioural change (Grothmann and Patt, 2005).

Belief in climate change has popularly been demonstrated as one cognitive factor contributing to adaptation intention. The strength of belief in climate change has empirically been justified to significantly influence the adaptive behaviour of smallholder farmers (Uddin et al. 2017)Risk experience is assumed to positively influence risk perception (Grothmann & Patt, 2005). Weinstein (1989) proposed that risk experience tends to make people perceive themselves as potential victims and think of the risk more often; hence, protective behaviour is likely to increase.

Whether risk assessments and the believe in climate change led to the decision to conduct adaptation measures is influenced by three major factors, socio-demographic factors, institutional factors and farm level/ land ownership factors.

Socio-demographic factors expected to affect adaptive behaviour are gender, age, marital status level of education and number of years of climate change awareness, whilst the institutional factors affecting farmer's choice of adaptation include access to extension service, access to credit and access to market. Farm level/land ownership factors include farm size, major cultivated crop, distance of farm from the house, ownership of farmland and farm size.

Risk experience and access to information media are also likely to influence the choice of adaptation measures.

## 2.17 Chapter Conclusion

This chapter reviewed literature on the concepts of climate variability, climate change and adaptation. It also highlighted some of the major contrasting views and opinions on the definitions and cause of climate change. Spiritual, natural and human action identified as major perceived drivers of climate variability and change were equally reviewed. Smallholder farmers also perceived the declining precipitation and increasing temperatures as evidence of climate variability and change. Farmers actions to mitigate the impact of extreme the weather challenges such as multiple cropping, changing planting dates, crop diversification and off farm employment to cushion themselves against climate variability and climate change were all discussed. Government's role in the mitigation and adaptation to climate variability and change have also been highlighted. The next chapter will highlight the characteristics of the study area and detail outline of the study methodology and analytical framework.

# CHAPTER THREE

# STUDY AREA AND METHODOLOGY

## 3.0 Introduction

In the previous chapter the concepts of climate variability, climate change and adaptation were reviewed. It also highlighted some of the major contrasting views and opinions on the definitions and cause of climate change. Farmers perception on the causes, forms and effects of climate variability and change as well as farmer adaptation strategies were equally reviewed. This chapter highlights the profile of the study districts such as the major socio-economic conditions, physical features and population characteristics in order to situate within the context of the study. It also discusses the methodological processes followed in carrying out the study. The research design, the research paradigms, the study tools and techniques, sampling methods and sample design as well the analytical framework for the study have all been discussed in detail.

## 3.1 The Nanumba South District

### 3.1.1 Location and Size

Formally part of Nanumba District the Nanumba South District was created on August 27, 2004. The district can be found between Latitudes 8°.5’ N & 9°.0 N and Longitudes 0°.5’ E & 0°.5’ W of the Greenwich Meridian. The District shares boundaries with the Zabzugu Tatale District and the Republic of Togo to the east, East Gonja to the west, the Kpandai District to the south, Nkwanta District to the south-east and Nanumba North District to the North.

After the District was carved out of the then Nanumba District, no professional survey has been done to determine its actual size. However, according authorities of the Nanumba South District, the District is about two-fifths (2/5) of the parent Nanumba District which was 3,220 sqkm. Accordingly, the District is estimated to be around 1,300 sqkm



**3.1.2 Climate**

Located within the tropical zone, the Nanumba South District experiences the Tropical Continental type climate with consistent overhead mid-day sun. Temperatures range between 29$^{o}$C and 41$^{o}$C, sometimes reaching as high as 45$^{o}$C. Weather conditions in the district is influenced by the Southwest Monsoon and the Northeast Trade winds resulting in the alternation of wet and dry seasons.

The district is located in the transitional zone of Ghana and used to experience double rainfall maximum but because of the changing climate, the rainfall regime has now changed to a single maximum. Rainfall duration generally lasts within six months, that is, from May to October. The rest of the year remain dry resulting in high rate of evaporation and transpiration (Nanumba South District Assembly, 2015).

### 3.1.3 Vegetation and Drainage

Tall grass known as "elephant grass" intermingled with trees capable of withstanding draughts and fire constitute the main vegetation of the district. Some of the tree species are the shea, dawadawa and a few baobabs trees.

The district is located between two major rivers, the Daka and Oti rivers. River Daka forms the District's western border with the East Gonja, stretching approximately 145km. The Oti River, on the other hand flows from the north and meanders southwards across the eastern part of the district. Together with their tributaries, small streams and some man-made dams these water bodies formed the drainage system in the district. The environment tends to favour the cultivation of yam which does well in areas where virgin land is still available (Nanumba South District Assembly, 2015)

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### 3.1.4 Soil Characteristics

Soils, most of which are suitable for agriculture are the savannah ochrosols, savannah glysols and ground water laterite. The savannah glycols are of alluvial-colluvial origins found along major rivers and drainage courses and are located mid-south through to the north. They are medium size textured moderately well drained soils suitable for wide range of crops such as cereals, roots and tubers and legumes generally.

The Savannah ochrosols are well-drained soils with the surface being sandy loam or sand textured material with good water retention. These soils are found to the east (beyond the Oti River) and the southwest of the district. Ground water laterites are shallow sandy or loamy soils composed of rock fragment found on summit of upland areas; they are suitable for forestry and conservation programmes.



### 3.1.5 Impact of Human Activities

Annual bush fires, deforestation and charcoal burning are the major human activities impacting negatively on the land. They are reducing the once woody luxuriant environment to treeless grassland on very fragile soils thereby enhancing the effect of climate change.

### 3.1.6 Population: Size, Growth Rate, Spatial Distribution and Density

The 2021 Population and Housing Census places the district's population at 106,374. There are 22,363 people living urban areas. The rural population is about 84,011. The rural population constitute 79% of the District population making Nanumba South District a predominantly rural. Population density is 61.8 persons per square kilometre with sex ratio of 49.4 males to 50.6 females. *(*GSS, 2012).

### 3.1.7 Household Sizes/Characteristics

Household sizes are generally large averaging 7.9 *(2010 Population and Housing Census*). The large household sizes are due to the continue adherence to the extended family system. The large household size is expected to affect household access to and utilization farming resources such as labour and land which in turn is likely to affect household choice of climate change adaption measures.

### 3.1.8 Religious Composition

The two dominant ethnic groups in the district are the Nanumba and the Konkombas. Most Nanumba adhere to Islamic religion whilst Konkombas are largely Christians. Religious believes are expected to affect the perception of complex environmental factors including climate variability and climate change.

### 3.1.9 Age and Sex Composition

Nanumba South District has a youthful population with 52.1% of the population aging 18 years and below. The sex ratio is 49.4% male to 50.6% female. As a result, there is a slight change in the rate of growth i.e., from 2.8% to 2.7% per annum. The youthful nature of the population means that majority are not likely to adequately experience climate change.

### 3.1.10 Occupation Distribution

Agriculture alone engages about 85% of the population with fishery and manufacture also taking care of the remaining 15%. Unemployment rate of the district is 3.6% with 76.4% largely employed in agriculture whist remaining 20% are inactive or in other sectors.

## 3.2 The Yendi Municipality

### 3.2.1 Location and Size

Also located in the eastern part of the Northern Region, the Yendi Municipality lies between Latitudes 9º 0'–9º 50 North and 0º–3 0' West and 0 º –15 º East. The Greenwich Meridian passes through a number of settlements in the Municipality– Yendi, Bago, Laatam, Lumpua, Gbetobu, Gbungbaliga and Nakpachei. The Municipalility shares boundaries with the Saboba District to the east, Zabzugu and Tatale Districts to the south east, the Nanumba North District to the south and the Mion District to north and west.

The Municipality has a landmass of 1,446.3 sq. km. (Source: Ghana Statistical Service, 2010 Population and Housing Census). Yendi, the capital of the Municipality is about 90 km from the Northern Regional capital, Tamale.

### 3.2.2 Climate and Vegetation

The Yendi Municipality records an average of 1,125mm of rain annually the wet and dry seasons record an annual average of 1,150 mm 75mm of rain respectfully. Rainfall is seasonal and unreliable with annual deficits ranging from 500 mm to 600 mm. Temperatures are generally high ranging from 21ºC to 36ºC. In its natural state, the vegetation is woodland savannah type. Much of this vegetation has however been heavily degraded by agricultural activities and human settlements. Constant bush fires have significantly affected the vegetation and consequently the climate. Among the vegetative cover of the Municipality are economic trees like the shea, dawadawa, mango and cashew (Municipal MTDP 2010-2013).

### 3.2.3 Soil Characteristics

Soils in the Municipality are of sedimentary origin mainly from voltaic sandstone, shales and mudstones. They basically ranged from laterite, ochrosols, sandy soils, alluvial soils and clay. These soils have low organic content and this has been exacerbated by constant bush burning and bad agricultural practices. This has affected agricultural productivity and yield.

### 3.2.4 Ethnicity and Religion

The Yendi Municipality has a total of 154,421 people (GSS, 2021). The population is made up of Dagomba who are in the majority. Others are the Konkomba, Akan, Ewe, Basare, Moshie, Chokosi and Hausa. About 74,545 people live in rural areas while 79,876 live in urban communities. Males comprise 76,142 as against 78, 279 females (GSS, 2021). Moslems constitute the major religious' groupings with 67.2%, Christians -17.4%, Traditionalists -13.2%, No Religion -1.8% and others - 0.3% (Yendi Municipal Assembly 2013). Religious believe are expected to affect the perception of complex environmental factors including climate variability and climate change.

### 3.2.5 Household Size, Composition and Structure

There are 28,663 households in the Municipality with a household population of 151,467. Average household size is 5.3 persons (GSS,2021).

### 3.2.6 Marital Status

Nearly 54.6% of the population of marriageable age are married. Thirty-nine percent (39%) of the population within the same age category have never been married. One percent (1.1%) were divorced, 0.7% separated with 3.9%. widowed. The high marital rate could be attributed to the dominance of Islam in the Municipality are Moslems.

### 3.2.7 Literacy and Education

Literacy rates are quite low with close to 63% of the population aged 11 years and older being illiterate. The high rate of illiteracy means that majority of the population may not be able to access climate change information in printed text.

### 3.2.8 Agriculture

Agriculture is the major economic activity and is largely practiced on subsistence basis. About of 481,000 hectares (90%) of the total land area of is arable and 15 percent of that is being cultivated (Municipality MTDP 2010-2013). Non-farm activities include weaving, agro-processing, meat processing, fish mongering, wholesale and retail of general goods, transport and many others.

Manufacturing activities albeit on small scale basis include smock weaving, blacksmithing, baking, mechanics, shea butter extraction and groundnut oil extraction.

### 3.2.9 Banking

There are four banking institutions in Yendi town. These are branches of the Ghana Commercial Bank Limited (GCB), Agricultural Development Bank (ADB), Bonzali Rural Bank Limited and First National Bank. Other financial institutions include Bayport Financial Services, Yoli Financial Services, Consumer Finance Company and African Financial Business. Though these financial institutions provide loans, the fact that agriculture is regarded as high-risk business coupled with the fact that most of the farmers lacked collaterals means that they may not significantly benefit from their existence.

### 3.2.10 Market

The municipality has Eleven (11) markets located at Yendi, Bunbonayili, Gnani, Nakpachei, Adibo, Gbungbaliga, Pion, Kpalgagbeni, Kulkpeniduli, Sunsong and Wanbung. This means that farmers have access to market outlets where they can easily dispose of their farm produce.

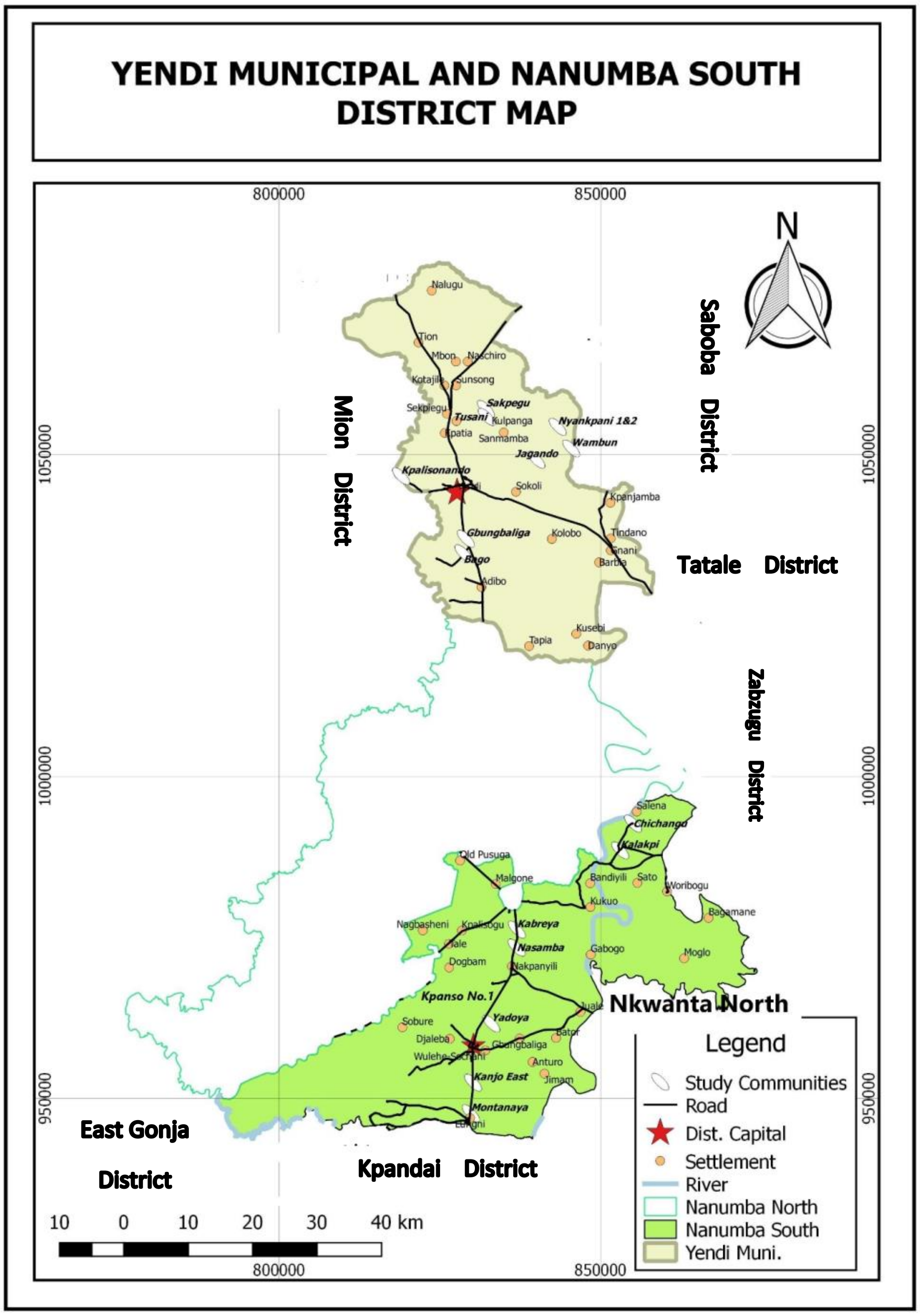



**Figure 3.1: Map of Yendi Municipality and Nanumba South District Showing Study Communities**

Sources: Author's Construct, 2020

### 3.3 Research Paradigm

Social science researchers generally employ basic philosophical paradigms to guide their study. The basic philosophical paradigms commonly used by social science researchers are positivism, post-positivism, pragmatism and interpretism (Creswell, 2014; Creswell, 2003). These philosophical worldviews in social science research inform the epistemology, ontology, methodology and methods a researcher employs and constitute the building block of the study. The present study is guided by the pragmatists paradigm. The pragmatists paradigm, unlike the positivists and the interpretivists paradigms, is not bound to any system of philosophy and reality (Creswell & Plano Clark, 2007). For pragmatists, truth is what works at the time and therefore, reject any form of dualism (Fay, 1987; Creswell, 2014). Pragmatics believe in the existence of external world independent of man. Advocates of the pragmatic approach blend the quantitative and the qualitative methods (Field & Hole, 2003; Creswell, 2003). Due to the flexibility with the mixed methods, it is possible for researchers to select a wide array of techniques and procedures capable of addressing research problems. The pragmatic approach permits the application of statistical and non- statistical methods for analysis.

The study adopted the pragmatic paradigm because climate change and adaptation studies focus strongly on socio-economic analysis, relying largely on qualitative and quantitative data collection and analysis. That being said, it also pertinent to know that issues bothering on climate change adaptation are strongly determined by people's experiences, perceptions, assumptions and believes whose analyses can be better handled by using both quantitative and qualitative data concurrently. It is on the basis of this arguments that, the pragmatic paradigm was chosen as the philosophical basis for the study.



### 3.4 Mixed Method Designs

This research adopted an Explanatory sequential mixed method approach. With this method the researcher initially carries out quantitative study, analyses the results and then uses a qualitative research for in-depth explanation (Creswell, 2014b). It is considered explanatory because the initial quantitative data results are explained further with the qualitative data. It is considered sequential because the initial quantitative phase is followed by the qualitative phase (Creswell, 2014b). The motivation to combine both qualitative and quantitative methods is that no single one method is capable of capturing the multi-layered issues of climate change and climate variability (Green et al. 2015). The methods are intended to complement each other, enhance the integrity of findings and allow for comprehensive analysis (Green, Kennedy, & Mcgown, 2015; Berg, 2001; Bryman, 2012). Jick (1979) contended that the blend of qualitative and quantitative methods better complement each other rather than compete among themselves.

This study therefor employed both the qualitative (Focus group discussions, in-depth interviews, and observations) and quantitative (administration of questionnaires) methods for the data collection. The decision to use both methods –qualitative and quantitative was to enable an in-depth analysis of the many varied issues that bother on climate change perception and adaptation. The prospect of covering all aspects of climate change perception, which include both biophysical realities, as well as the socio-political dimensions of the environment can be daunting. For farming communities in rural settings, the way in which so many factors are interrelated makes it imperative for large data sets to resolve the numerous problems. It is therefore essential to adopt an interdisciplinary approach by drawing on both quantitative and qualitative data collection and analysis (Forsyth, 2015).

Questionnaires were administered to heads of yam farming households to obtain quantitative data on individual farmers' choice of adaptation strategies, the extent of farmer's agreement on existing perception of the causes of climate variability and change, and the farmers perception on the effects of climate variability and change on their farming activities. According to Bryman (2012), this technique allows for the standardisation of the questions being asked and the answers recorded. Errors arising from variations in the questions are corrected to ensure greater accuracy and eased the processing of data.

To obtain qualitative data, the study used FGDs, in-depth interviews and observations to gather in-depth information on farmer's perspectives, beliefs, perception on causes and consequences of climate variability and change. FGDs were also used in two of the study communities (Tusani in Yendi and Kpanso No. 1 in the Nanumba South) to generate community resources maps depicting both the current and past environmental conditions of the study areas. The size of the focus group was twelve for each community. The member of the group in Tusani was 85 years and the youngest 45 years. At Kpanso No.1 the oldest was 81 and the youngest 49 years of age. The groups at Kpanso No. 1 and Tusani had 3 and 1 members respectively. After explaining the purpose of the meeting, the groups were asked draw the maps of their communities and insert in it the following; houses, roads and foot paths, vegetation, water bodies, locations of yam farms among others. After the this was done the members were again asked to draw a similar map outline. The oldest individuals among the groups, that is, those who were 50 years and above were asked to insert the features mentioned above as they were 30 years ago. The two maps were copied on cardboards after which the team members together with the community members discussed the notable differences between the two maps.

At the FGDs held at the various communities, members were asked to explain the timing of the various cultural practices associated with yam cultivation. Interestingly, all groups mentioned an existing calendar system that that yam farmers depended on for their farming practices. This calendar system was recorded and further discussions were held as how climate change has affected it.

The FGDs were conducted in each of the study communities where group members openly discussed their personal experiences of climate variability and change from the group perspective. Members of FGDs were selected based on their knowledge and experience in yam farming. Where applicable, the gender composition of respondents was considered to make room for the participation of both men and women. This method has been chosen because it facilitates understanding of contentious issues identified during individual interviews (Mngumi, 2016). It is recommended that the sample size for a group discussion should be manageable to allow active participation of all members in the discussion (Grenier, 2009). That said, the study restricted membership of focus groups to a maximum number of twelve participants and a minimum of six in each discussion session.

Selected key informants in the community as well as government officials who hold various positions at the district level were interviewed. The method helped in the identification of different impacts of climate change on yam cultivation. It also facilitated the capture of data which were not evident during the questionnaire administration. Key informants were selected from the district offices of the Ministry of Food and Agriculture and in the study communities.

The study also employed field observations to gather information which may not have been adequately explained during FGDs, household surveys and in-depth interviews. Observations captured field activities like agricultural land uses and farming practices. For fieldwork that occurs on a short timescale, observation is more suitable, especially where interviews may not provide satisfactory results (Mngumi 2016). Yin posits that better and critical analysis can be achieved by matching empirically observed events to theoretically predicted events (Yin, 2014).



### 3.4.1 The Study Population

The study population comprised yam farmers in the Nanumba South District and in the Yendi Municipality

### 3.4.2 Sampling Methods and Sample Size Determination

Northern Region has a total of sixteen (16) districts. The major yam producing districts are located mainly to the eastern part of the region. The Nanumba North, Nanumba South and Yendi districts were initially selected because according to MoFA (2017) rating (Table 3.2) they are the leading yam producing districts in the Northern region and were also listed among ten top yam producing districts in the country based on three years' cumulative average yield performance.

Two districts, that is, the Nanumba South and Yendi Municipality were randomly selected for the study (Table 3.3). The district extension agents assisted in identifying MoFA operational zones in each of the study districts.

**Table 3.1: Average Yield Performance for Yam by District (Top 10 Districts)**

| Region | District | 2014 | 2015 | 2016 | 3-yr Avg. | Rank |
|---|---|---|---|---|---|---|
| Upper West | Wa Municipal | 24.75 | 26.21 | 24.25 | 25.07 | 1 |
| Northern | Nanumba South | 22.25 | 22.86 | 27.35 | 24.15 | 2 |
| Savanna | West Gonja | 22.81 | 23.43 | 23.52 | 23,25 | 3 |
| Upper West | Nadowli | 22.25 | 23.56 | 22.98 | 22.93 | 4 |
| Eastern | Afram Plains | 22.50 | 22.93 | 22.91 | 22.78 | 5 |
| Northern | Yendi | 20.52 | 21.08 | 25.93 | 22.51 | 6 |
| Northern | Nanumba North | 21.94 | 22.54 | 22.87 | 22.45 | 7 |
| Bono East | Kintampo South | 21.65 | 21.66 | 21.68 | 21.66 | 8 |
| Upper West | Wa East | 19.50 | 20.65 | 20.34 | 20.16 | 9 |
| Oti | Nkwanta North | 19.60 | 20.29 | 20.14 | 20.01 | 10 |

Source: MoFA, 2017

**Table 3.2: The Study Areas**

| District | Operational Zone | Operational Area | Community |
|---|---|---|---|
| Yendi Municipal | Yendi | Gamanzi | Kpalsonando and Jagando |
| | Malzeri | Sakpegu | Tusani and Sakpegu |
| | Gnani | Kunkong | Wambung and Nyankpani 1& 2 |
| | Adibo | Gbungbaliga | Bago and Gbungbaliga |
| Nanumba South | Wulensi | Wulensi | Kpanso 1 and Yadoya |
| | Nakpayili | Nasamba | Kabreya and Nasamba |
| | Kukuo | Chichangi | Chichangi and Kalakpi (Lambombo) |
| | Lungni | Kanjo | Montanaya and Kanjo East |

Source: Field Survey, 2020

On average an operational zone consists of about seven operational areas whereas an operational area consists of about seven communities. Using a multi-stage random sampling, one operation area was selected from each operational zone. In addition, two communities were randomly selected from each of the selected operational areas.

The number of yam farming households in each of the study communities were also identified to obtain a total sample frame. For the purposes of this study, a household is defined as a group of people who share a common dwelling place or compound. A household head in this study therefore refers to a compound head. The number of yam farming households in all the study communities amounted to 1245.

Based on the sampling frame, a sample size was determined using Cochran's (1977) formula. Sample size of households in the study communities was calculated from a sampling frame (number of HHs in the communities) to arrive at a sample size of 303 which was rounded up to 400. The formula used to calculate sample size is given as.

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

Where n = sample size.

N = Sample frame.

e = margin of error

$$n = \frac{1245}{1 + 1245\,(0.05^2)}$$

n = 303 = 400.

The proportional sampling technique was used to determine the sample size (n1) of each community using the total sample size of 400. That is

$$n1 = \frac{N1(n)}{N}$$

Where n1 = the sample size of a study community

N1 = Sample frame of the study community

N = Total sample frame for the study

n = Total sample size for the study.

Respondent households were selected using the simple random sampling technique where the names of the households were written on pieces of paper folded and placed in a jar. The jar was shaken a number of times and then a volunteer from the study community was asked to pick at a random a folded paper until the required number of sample for the community was obtained. The papers were then unfolded to reveal the names of households that were chosen for the study. This was done in each of the study communities. Household heads or representatives of the selected households were interviewed.

**Table 3.3: Sample Frame and Sample Size**

| District | Community | No. of yam Faming Households | Sample Size |
|---|---|---|---|
| Nanumba South | Chichangi | 75 | 24 |
| | Kalakpi (Lambombo) | 52 | 17 |
| | Kpanso No. 1 | 39 | 12 |
| | Yadoya | 124 | 40 |
| | Kabreya | 65 | 21 |
| | Nasamba | 78 | 25 |
| | Montanaya | 83 | 27 |
| | Kanjo East | 56 | 18 |
| Yendi Municipality | Gbungbaliga | 169 | 54 |
| | Bago | 54 | 17 |
| | Tusani | 101 | 32 |
| | Sakpegu | 49 | 16 |
| | Kpalisonando | 80 | 26 |
| | Jagando | 65 | 21 |
| | Wambun | 35 | 11 |
| | Nyankpani 1 &2 | 120 | 39 |
| **Total** | | **1245** | **400** |

Source: Field Survey, 2020

**Table 3.4: Number of FGDs and Key Informants**

| District | KIs -MoFA Officials/NGOs | KIs –Study Communities | FGDs |
|---|---|---|---|
| Nanumba South | 5 | 5 | 7 |
| Yendi | 3 | 8 | 6 |
| **Total** | **8** | **13** | **13** |

Source: Field Survey, 2020

*Minimum of 8 and maximum 12 members for each FGD

### 3.4.3 Data Sources and Types

Two main types of data – primary and secondary were collected for the study. Two types of primary data, that is, the quantitative and qualitative were collected directly from the study respondents. Whilst the quantitative data was obtained through the administration questionnaires, the qualitative data on the other hand was collected through interviews, FGDs and personal observation.

Secondary data was gathered from the reports of the Ministry of Food and Agriculture, the Meteorological Services Department and the District/Municipal Assembly reports.

**Table 3.5: Primary Data Sources and Types**

| Technique | Tool | Target | Justification |
|---|---|---|---|
| **Questionnaire Administration.** | Question-naire | Household heads | Given the limited time period for this study, questionnaire was more appropriate since it allows for the collection of a large set of quantitative data within a short span of time |
| **Focus Group Discussion** | FGD Guide | Experience yam farmers identified during the household survey | FGDs facilitated an understanding of contentious issues that that arose among the respondents during individual interviews |
| **Observation** | - | - | Captured on-farm practices, agricultural land uses and farming practices which could not be adequately explained using the above data collection methods |

**Table 3.5: Data Sources and Types Cont.**

| Research Technique | Tool | Target | Justification |
|---|---|---|---|
| **In-depth interviews** | Interview guide | Experienced yam farmers identified during the questionnaires survey and the district extension agents, district agricultural officers and Officials of NGOs. | The method yielded detailed information that could not be captured by questionnaires survey |

Source: Field Survey, 2021



### 3.5 Instruments Used for the Data Collection

The questionnaires were designed in "kobo" (a computer software) and downloaded into android phones. Eight research assistants, four for Yendi and four for the Nanumba South were employed to administer the questionnaires.

The focus group discussions, in-depth interviews were moderated by the researcher himself. The data collection started on 10th September, 2020 and ended on 30th October, 2020.

#### 3.5.1 Instrument Validity

Validity is concerned about the integrity and truth of the conclusions made. Internal validity relates to the causal relationship between independent and dependent variables, one having a causal impact on the other (Bryman, 2012). In this case the causality was whether the socio-demographic, institutional and land ownership factors (independent variables) lead to the adoption of a particular adaptation strategy (dependent variable).

External validity refers to whether results of a study can be generalised and applied to other contexts (Bryman, 2012). As previously explained the explanatory approach of this study gives a more general understanding of the matter and hence could be more transferable to other communities in similar contexts. Additionally, the study is ecologically valid since all the interviews took place in naturally occurring settings and environments.



### 3.5.2 Instrument Reliability

Reliability refers to whether a researcher has used consistent measures, and depending on how one has categorised the findings, if the results are stable or not. In other words, it relates to research trustworthiness and conformability (Bryman, 2012).

To ensure the reliability of the data, the questionnaires as well as the interview and focus group discussion guides were presented to the team of supervisors for their comments and inputs. They were also pretested in two communities, that is Manguli and Zoo in the Nanton District. This allowed the researcher to identified inherent errors and corrected them before proceeding to the field.

### 3.6 Methods of Data Collection

The questionnaires were administered by a team of 8 research assistants using a computer software known as “kobo”. The software generated GPS coordinates for each house/compound where the questionnaires were administered. The coordinates allowed the researcher to know whether the data collection personnel were actually in the field. This, together with Tape-recordings of all the interviews conducted and transcription was done to make the results of the study repeatable, so that one could go back and recheck the answers or reactions After each day’s work personnel synchronised their data to the research team to enable them crosschecked for errors and address them.

### 3.7 Analytical Framework

Both quantitative and qualitative analytical techniques were used for the data analyses. Quantitatively, the study employed descriptive and inferential statistics for data analyses. The descriptive statistics involve the use of means and percentages to describe the variables in the study while the inferential statistics relied on the Multivariate Discreet Choice Models to determine the factors influencing farmers’ choice of adaptation strategies to climate variability and change in the study area. Qualitative narratives based on focused group discussion and key informant interview results complemented the quantitative data analysis.

Objective 1 was to examine the perception of climate variability and change among smallholder yam farmers. To know how yam farmers perceive climate variability and change, A five-point Likert-type rating technique was developed to know the level of respondent's agreement with prior statements on climate variability and change perception. The 5-point Likert-type rating scale was graded as Strongly Agree SA = 1, Agree (A) = 2, Uncertain (U) = 3, Disagree (D) = 4 and Strongly Disagree (SD) = 5. The mean scores of the responses were thus computed. The Likert scale is the most universal method in survey data collection; therefore, they are easily understood (LaMarca, 2011). The responses are easily quantifiable and subjected to computation of some mathematical analysis.

Variables considered under this objective are the perceived drivers and perceived indicators of climate variability and change. Respondents were asked to indicate their level of agreement on the following statements; climate change is caused by spiritual forces; climate change is caused by human action; climate change is a natural induced phenomenon.

Respondents were again asked to indicate their level of agreement with statements like; indiscriminate bush burning contributes to climate change;

deforestation contributes to climate change; overgrazing contributes to climate change; wood harvesting contributes to climate change and application of agrochemicals contributes to climate change. On perceived indicators of climate variability and change respondents were asked to state their level of agreement that a decreasing trend of rainfall is an indicator of climate change. Respondents were also to indicate their level of agreement that increasing temperature levels is an indicator of climate change or whether increasing intensity of strong winds is an indicator of climate change. Thus, the study used the Likert-Type Rating Scale Technique to yield numerical data, and uncover information which can stimulate new explanations to contradict or support prior statements about the subject matter.

Meteorological data was collected from the regional office of the Meteorological Services Department in Tamale and compared with the Likert scale rating results. Narratives of personal life histories of experienced yam farmers and focus group results on the trend of temperature and precipitation data on perceived changes in windstorms and land cover issues complemented the quantitative analysis.

Results of the findings were presented in the form of tables, graphs, charts and narrations.

Objective 2 was to analyse the perceived effects of climate variability and change on yam production. Descriptive statistics (percentages) were used to characterize farmer perceptions of the effects of climate change on yam production. Variables such as emergence of new weeds, effect on planting time, increased incidence of droughts, floods and inundation of yam fields, effects on availability of staking materials, were analysed using descriptive statistics expressed in percentages, averages and frequencies and cross tabulations. One of the main advantages of descriptive analysis is its high degree of objectivity of the researcher (Creswell, 2014b). This type of analysis is best for describing relationships between variables. It is flexible in combining quantitative and qualitative data in order to discover the characteristics of the population. For example, researchers can use both case study which is qualitative analysis and correlation analysis to describe a phenomenon (Baha, 2016). This quantitative analysis was complemented by qualitative analysis using community resource mapping to analyse the change in vegetation cover and surface water bodies, seasonal calendars to analyse the timing for land clearing, mounding, planting among others and qualitative narratives on farmer's perception, feelings and emotions towards climate variability and change.

Results of the findings were presented in the form of tables, graphs, charts diagrams and narrations.

Objective 3 was to identify adaptation strategies undertaken by smallholder yam farmers to mitigate the effects of climate variability and change. The likelihood that the farmers engage in some actions to cushion the effect of climate change was determined using descriptive statistics expressed in the form of percentages and frequencies. Farmers were asked whether they have undertaken any action to mitigate the effects of climate variability and change. Famers were further probed on different adaptation options they have adopted. These were grouped under land management practices (land rotation, decrease in farm size and relocation of farms along valley and humid areas), soil management practices (capping of mounds and using tractors to plough before raising mounds), crop management (planting high yielding varieties, adopted multiple yam varieties, planting early maturing varieties, change in planting dates, planting heat tolerant varieties, planting drought resistance yam varieties as well as Planting new/improved yam varieties ). The data was analysed using descriptive statistics in the form of percentages, averages and frequencies and cross tabulations. This was complemented by pictorial presentations on observed adaptation measures as well as qualitative narratives. The relationship between the perceived severity of climate change and adaptation intension as well the relationship between the belief in the reality of climate variability and change and climate change adaptation intention were analysed using cross tabulations.

Results of the findings were presented in the form of tables, narrations and pictures.

Objective 4 was to examine the factors that influence the choice of adaptation strategies by smallholder yam farmers. It was analysed using the multivariate probit econometric model**.** The multivariate probit model was used to analyse the determinants of farmers' choice of adaptation measures. The multivariate probit model simultaneously models the influence of the set of explanatory variables on each of the different adaptation measures whilst allowing for the an observed and unmeasured factors (error terms) to be freely correlated (Golob & Regan, 2005). Complementarities (positive correlation) and substitutes (negative correlation) between different options may be the source of the correlation between error terms (Belderbos et al.et al. 2004). Another source of positive correlation is the existence of unobserved household specific factors that affect the choice of several adaptation options but are not easily measurable such as indigenous knowledge. The correlations are taken into account in the multivariate probit model.

The advantage of using this approach as opposed to univariate (single-equation) technique is that it explicitly recognizes and controls for potential correlation among adaptation options and therefore provides more accurate estimates of relationships between each adaptation option and its explanatory variables. The univariate technique on the other hand is prone to biases due to common factors in situations where there are unobserved and unmeasured common factors affecting the different adaptation options (Nhemachena & Hassan, 2007).

A multinomial discrete choice model is another alternative model to the multivariate probit model. However, with the multinomial model, the interpretation of the influence of the explanatory variables on each of the separate adaptation measures is difficult. The usefulness of a multinomial model is limited by the property of the independence of irrelevant alternatives. To overcome this, some researchers proposed the estimation of multinomial probit and a mixed of random coefficients MNL are useful and more appropriate and simulation methods can be used to estimate parameters of large MNP and mixed logic models (Golob & Regan, 2005).

The shortfall of this technique is that all multinomial replications of a multivariate choice system have problems in interpreting the influence of explanatory variables on the original separate adaptation measures (Hanley, 1983).

This study uses the multivariate probit model to overcome the shortfalls of using the univariate and multinomial discrete choice techniques. Following Lin et al.et al. (2005), the multivariate probit econometric approach used for this study is characterised by a set on *n* binary dependant variables yi (with observation subscripts expressed), such that

$$Y = 1 \text{ if } x' \beta i + \mathcal{E} i > 0$$

$$= 0 \text{ if } x' \beta i + \mathcal{E} i \leq 1, 2, \ldots, n. \quad (1)$$

Where x is a vector of explanatory variables, $\beta 1$, $\beta 2$, ...., $\beta n$ are comfortable parameter vectors, and random error terms $\mathcal{E}_1, \mathcal{E}_2, \ldots, \mathcal{E}_n$ are distributed as multivariate normal distribution with zero means, unitary variance and an $n^x n$ contemporaneous correlation matrix R = $[Pij]$, with density Ø ($\mathcal{E}_1, \mathcal{E}_2, \ldots, \mathcal{E}_n$; R). The likelihood contribution for an observation is the *n*-variate standard normal probability.

$$Pr \quad (y_i, \ldots, y_n) \quad = \sum_{\varpi}^{(2y1-1)x'\beta 1} \sum_{\infty}^{(2y2-1)x'\beta 2} \sum_{\infty}^{(2y1-1)x'\beta 1} \ldots \text{ X } \sum_{\varpi}^{(2yn-1)x'\beta n} \text{Ø} \; (\mathcal{E}_1, \mathcal{E}_2, \ldots, \mathcal{E}_n; Z'RZ) d\mathcal{E}n \ldots d\mathcal{E}2 \; d\mathcal{E}1'$$

**(2)**

Where Z = diag [2y1 -1….2yn – 1]. The maximum likelihood estimation maximises the sample likelihood function, which is a product of probabilities (2) across sample observations. The marginal effects of explanatory variables on the propensity to adopt each of the different adaptation measures is are calculated as follows:

$$\partial Pi \,|\, \partial Xi = \text{Ø} (X' \beta) \beta i, i = 1, 2, \ldots, n \quad (3)$$

Where *Pi* is the probability of (likelihood of event I (that is increased use of each adaptation measure), Ø (.) is the standard univariate normal cumulative density distribution function, x and β are vectors of repressors and model parameters respectively (Hassan, 1996).

Previous studies (Alhassan, Kwakwa & Adzawla, 2019; Sadiq, Kuwornu, & Al-hassan, 2019; Adusei, 2016 & Otitoju, 2013) show that farmer's age, education level, marital status, climate change awareness, access to extension service, access to credit, access to market, membership of association, farm size and farm distance as well as access to radio have an influence on choice of adaptation strategy. The present study seeks to confirm that these variables actually influence farmers' choice of climate change adaptation strategies.

Empirically, the model is specified as:

$Y1 = \beta0 + \beta1$ Gender + β2 Age of household head + β3 Education + β4 Marital status + β5 Climate change experience + β6 access to extension service + β7 access to institutional credit + β8 Access to market + β9 Membership of association + β10 Farm size + β11 Farm distance + β12 Ownership of radio + Ui

where Yi is the probability of ith farming household choosing a specific adaptation strategy, Ui is an error term.

**Table 3.1: Description, Measurements, and a Priori Expectations of the Variables used for the Multivariate Probit Regression**

| Variable | Description | Measurement | A-priori Exp'tion |
|---|---|---|---|
| X1 | Gender of respondents | Dummy: 1 = Male; 0 = Otherwise | + |
| X2 | Age of Household Head (HH) | Number of years of HH | - |
| X3 | Education level of household head | number of years of schooling of household head | + |
| X4 | Marital status of respondent | dummy 1 for married; 0 otherwise | + |
| X5 | Number of years of climate change awareness | dummy1for having previously experienced climate risk; 0 otherwise | + |
| X6 | Access to extension service | (Dummy 1 for access and 0 otherwise) | + |
| X7 | Farm size | Current farm size of household Measured in hectares | +/- |
| X8 | Access to institutional credit | access to formal credit (dummy 1 for access to credit; 0 otherwise). | + |

**Table 3.6: Description, Measurements, and a Priori Expectations of the Variables used for the Multivariate Probit Regression Cont.**

| Variable | Description | Measurement | A-priori Exp'tion |
|---|---|---|---|
| X9 | Access to market within 5km radius | dummy 1 for access; 0 otherwise | + |
| X10 | Membership of (farmers) association | dummy 1 for membership of association; 0 otherwise). | + |
| X11 | Distance of farm from home | dummy 1 for farms with more than 3 km distance; 0 otherwise | - |
| X12 | Access to Radio | dummy 1 for access; 0 otherwise | + |

Source: Field Survey, 2020. Footnote: Exp'tion = Expectation

Results of the findings were presented in the form of tables.

### 3.8 Chapter Conclusion

An explanatory sequential mixed method design, the framework of the study has been highlighted. The three principal research paradigms, namely positivism, pragmatism and interpretism have been discussed in this chapter. Also outlined in the chapter are the types and sources of data, data collection tools and techniques and the sampling procedure have all been extensively discussed. Analytical tools including descriptive and inferential statistics, narratives of qualitative information used for the analysis have been stated. The profile of the study districts has also extensively discussed highlighting the socio-economic and physical characteristics. The next chapter will be devoted to data presentation, analysis and discussion.

# CHAPTER FOUR

# RESULTS AND FINDINGS

## 4.0 Introduction

This present chapter discusses the findings of the study. It explores the main socio-demographic characteristic, institutional, farm level and land ownership factors that affect adaptation to climate variability and change. It further discusses farmers' perception on causes, nature and effects of climate variability and change. Finally, the chapter discusses yam farmers' adaptation to climate variability and change and factors influencing the choice of adaptation strategies.

## 4.1 Demographic Factors

The Demographic factors discussed in this section are the age category of respondents, sex, years of formal education, years of climate change awareness, marital status among others.

### 4.1.1 Age of Respondents

Age is a vital factor in considering climate change awareness, perception and adaptation among smallholder farmers. Since climate is a long-term average weather condition, the experience of its effect can only be felt over long period of time.

**Table 4.1: Socio- Demographic Factors**

| Characteristics | Yendi | | NS | | TS | | |
|---|---|---|---|---|---|---|---|
| **Age** | Freq. | % | Freq. | % | Freq. | % | Mean |
| 20 or lower | 3 | 1.39 | 2 | 1.09 | 5 | 1.25 | |
| 21 - 40 | 87 | 40.28 | 83 | 45.11 | 170 | 42.50 | |
| 41 - 60 | 77 | 35.65 | 83 | 45.11 | 160 | 40.00 | |
| 61 - 80 | 44 | 20.37 | 16 | 8.69 | 60 | 15.00 | |
| 81 - 100 | 5 | 2.31 | 0 | 0 | 5 | 1.25 | |
| **Total** | **216** | **100** | **184** | **100** | **400** | **100** | **45.51** |
| **Household Size** | | | | | | | |
| 1 -10 | 69 | 31.94 | 101 | 54.89 | 170 | 42.50 | |
| 11 - 20 | 87 | 40.30 | 68 | 39.96 | 155 | 38.75 | |
| 21 - 30 | 42 | 19.44 | 15 | 8.15 | 57 | 14.25 | |
| 31 - 40 | 13 | 6.01 | - | - | 13 | 3.25 | |
| 40+ | 5 | 2.31 | - | - | 5 | 1.25 | |
| **Total** | 216 | 100 | | 100 | 400 | 100 | 13.9 |
| **Level of Education** | | | | | | | |
| None | 174 | 80.56 | 77 | 41.85 | 251 | 62.75 | |
| Primary | 15 | 6.94 | 41 | 22.28 | 56 | 14.00 | |
| JHS | 23 | 10.65 | 52 | 28.26 | 75 | 18.75 | |
| SHS | 3 | 1.39 | 9 | 4.89 | 12 | 3.00 | |
| Tertiary | 1 | 0.46 | 5 | 2.72 | 6 | 1.50 | |
| **Total** | 216 | 100 | 184 | 100 | 400 | 100 | |
| **Years of CC Awareness** | | | | | | | |
| None | 4 | 1.85 | 35 | 19.02 | 39 | 9.75 | |
| 20 or lower | 116 | 53.70 | 146 | 79.35 | 262 | 65.50 | |
| 21 - 40 | 53 | 24.54 | 2 | 1.09 | 55 | 13.75 | |
| 41 - 60 | 27 | 12.50 | 1 | 0.54 | 28 | 7.00 | |
| 61 - 80 | 16 | 7.41 | 0 | 0 | 16 | 4.00 | |
| **Total** | 216 | 100 | 184 | 100 | 400 | 100 | 15.42 |

Source: Field Survey, 2020

**Footnote:** Yendi = Yendi Municipality, NS = Nanumba South District, TS = Total Sample, Freq. = Frequency, % = Percent, Mn = Mean, CC = Climate Change

It is therefore assumed that older people are more likely to have experienced climate change or variability than young people.

In Table 4.1, most (40.28%) of the respondents in the Yendi Municipality are aged 21 to 40 years. 35.65% of the respondents fall within the 41 to 60 age categories. Only 1.39% of the respondents are aged 20 years or lower whilst 2.31% are between 81 to 100 years. In the Nanumba South district however, 45.11% of the respondents are within the age range of 21 to 40. Respondent who are within the 41 to 60 age range also constitute 45.11%. Respondents who are 20 years or less constitute only 1%. The average age of the respondents is 45.51 years.

Ume, et al. (2018) for example, observed that households with more older members have been more successful in various adaptation strategies than those with fewer older members. Similarly, Mngumi (2016) observed that climate change awareness level is higher among older farmers than their younger counterparts.



### 4.1.2 Household Size

The size of a farm household plays a crucial role in farm decisions, especially with farming activities that are labour intensive in nature. Most households in rural northern Ghana, to a larger extent, draw a significant proportion of their farm labour from their household members. Yam farming being a labour-intensive venture, cannot be an exception. Similarly, climate variability and change adaptation strategies are influenced by not only the number of people who are directly fed by the household, but also the size and quality of labour that can easily and immediately be mobilized to counter or take advantage of either short term or long-term climatic conditions.

From Table 4.1, it can be seen that a majority of respondents (40.30%) in the Yendi Municipality live in households with 11 to 20 members. This contrasts sharply with that of the Nanumba South where a majority of respondents (54. 85%) leave in household with 1 to 10 members. Where as in the Nanumba South there are no households with more 30 members, 6.01% and 2.31% of respondents in the Yendi Municipality live in households with populations of between 31 to 40 and 41 to 50 members respectively. The unusual large household sizes are typical of the Northern Region since similar finding by Kuivanen (2015) indicate a maximum housed size of 37 persons. An average household size in the study area is 13.9. This is similar to the findings of Kuivanen (2015) in the Northern Region where an average houseld size of respondents was 15.2 persons.

The large sizes of households in the study area are not surprising because, as stated earlier, in typical farming communities, family labour is an indispensable part of farming resources and can easily and immediately be mobilized at the household level. What is surprising, however, is that the Yendi Municipality tends to have larger number of household sizes compared the to the Nanumba South. One would have thought that being a

Municipality, issues of land shortage for farming activities, youth outmigration to the Municipal capital and other urban related pressures could have forced down the sizes of households.



### 4.1.3 Effect of Respondents Level of Education on Years of Climate Change Awareness

In Table 4.1, a significant majority (80.56%) of respondents in the Yendi Municipality have had no formal education. Only 6.94% of the respondents have had some primary education with only 0.46% having a tertiary level education. In the Nanumba South District, however, 41.85% of the respondents have had no formal education, 22.28% have primary education whilst 2.72% have had tertiary level education. In effect only 37.25% of respondents in the study area have had some form of formal education. Studies by Alhassan, et al. (2019) in the then Savelugu/Nanton District of the Northern Region also found that only 37.2% of respondents had formal education.

### 4.1.4 Number of Years of Climate Change Awareness

From Table 4.1, it can be seen that 53.7%, representing a majority of respondents in Yendi Municipality had at most 20-years' awareness of climate change. Similarly, 79.35% of the respondents in the Nanumba South district had a maximum of 20 years' awareness of climate change. About 2% (1.85%) of respondents in the Yendi Municipality and 19.02%

of their counterparts in the Nanumba South district have no climate change awareness. Respondents' level education was expected to influence their awareness of climate variability and change because educated people are expected to have easy access to climate change information (Osberghaus. et al. 2010).

Table 4.2 shows the relationship between respondent's level of education and years of climate change awareness. It can be seen from Table 4.2 that there is no significant relationship between level of formal education and years of climate change awareness. It can be seen from Table 2 that 9.50% of the respondents without formal education did not have climate change awareness. When compared to 8.9% for respondents with primary education, 6.7% of respondents with JHS education years 8.30% of those with SHS and 0% of respondents with tertiary level education, it is realised that the level of climate change awareness is higher for respondents with formal education than those without formal education.

According to Osberghaus, et al. (2010) awareness of climate variability and change in itself influences how an individual perceives the risks associated with the phenomenon. Farmers with longer years of experience in climate variability and change are more likely to appreciate the magnitude of any unusual climatic variable and take appropriate actions to avert its impact. Research findings by Chukwuone (2015) show that the age of household head significantly influence the decision to adopt climate change adaptation strategies.

**Table 4.2: Distribution of Education level by categories of CC awareness**

| | Years of Climate Change Awareness | | | | | |
|---|---|---|---|---|---|---|
| **Level of Education** | None % | 1 -20 % | 21 -40 % | 41 - 60 % | 61 - 80 % | Total % |
| None | 9.5 | 57.4 | 15.9 | 11.6 | 5.6 | 100 |
| Primary | 8.9 | 76.8 | 10.7 | 1.8 | 1.8 | 100 |
| JHS | 6.7 | 84 | 9.3 | 0 | 0 | 100 |
| SHS | 8.3 | 91.7 | 0 | 0 | 0 | 100 |
| Tertiary | 0 | 100 | 0 | 0 | 0 | 100 |

Source: Field Work, 2020. JHS – Junior High School, SHS – Senior High School

This finding is consistent with Rosenstock & Nowak (2019) that education level is a fundamental issue in shaping and triggering the adoption of Climate Smart Agricultural practices and Chukwuone (2015) that number of years spent in school, which translates to more education, have higher chances of engaging in climate change adaptation and mitigation practices. The implication drawn from these analyses is that there is a relationship between formal education and level of climate change awareness and that higher levels of formal education exposes beneficiaries to climate change information and awareness.

### 4.1.5 Gender Composition of Respondents

In Figure 4.1.5, an overwhelming number of respondents (98%) in the two study districts are males. Females constitute only 2%. Ninety-seven percent (97%) of respondents in the Yendi Municipality are males with females constituting only 3%. In the Nanumba South district males constitute 99% whilst females constitute only 1%.

The gender disparity among the respondents is not surprising because it is an established fact that households in northern Ghana are male dominated. Secondly, according to Oluwatayo et al. (2016), yam farming is a male dominated activity because of the complexities associated with the processes of land clearing, raising mounds, and other cultural practices.

**Gender Composition of Respondents**

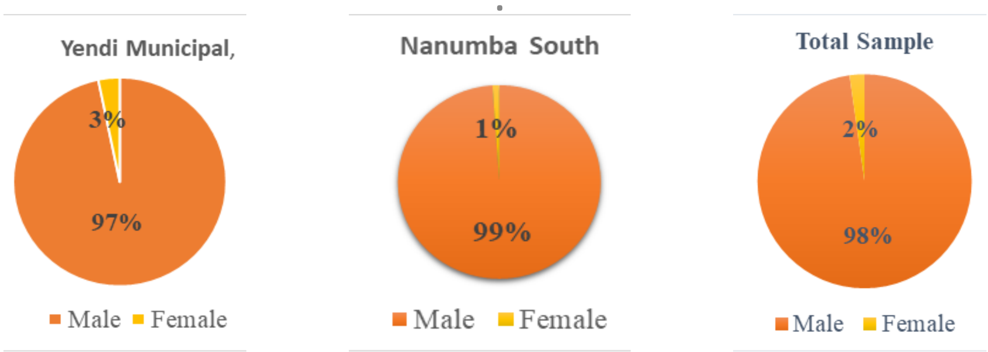



**Figure 4.1: Gender Composition of Respondents**

Source: Field Survey, 2020.

### 4.1.6 Marital Status of Respondents

From Figure 4.2, it can be seen that an overwhelming majority of respondents (96%) in both districts are married. Only 0.93% in the case of Yendi Municipality and 3.26% in Nanumba South were single. The rest were either divorced or widowed. Similar studies by Otitoju (2013) show that 92% of respondent farmers were married. The findings underscore the importance on marriage as a social event in the life of individuals, especially in farming communities.

Adimassu & Kessler (2016) for example noted that household heads who are married are less likely to migrate in times of crop failure or food shortage, since this responsible people are expected to remain at home to take care of the family. The marital status of a farmer also influences his production decisions which in turn affect climate related adaptation decisions.

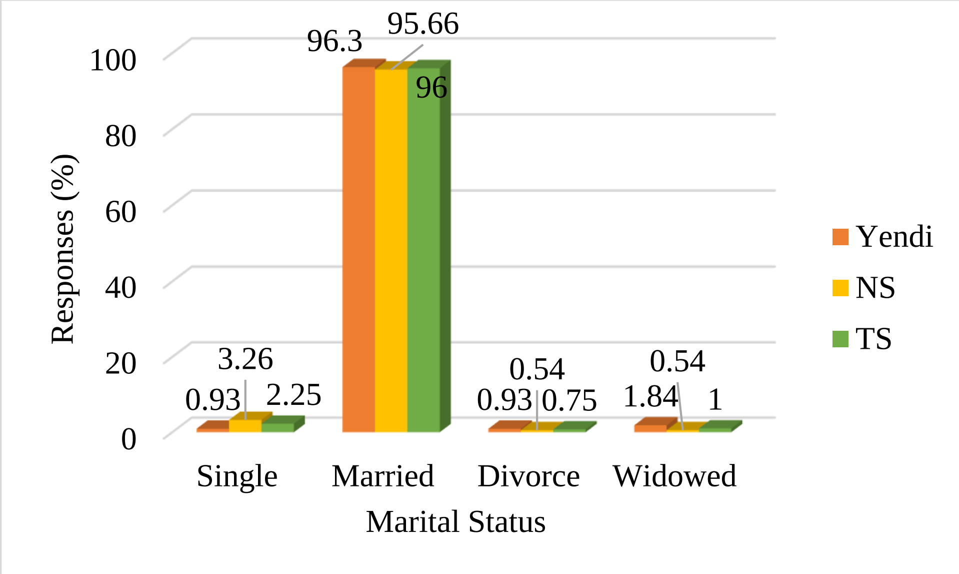



**Figure 4.2: Marital Status of Respondents**

Source: Field Survey, 2020

### 4.1.7 Ethnicity of Respondents

Figure 4.3 shows that a majority of respondents in the Yendi Municipality are the Dagomba who constitute 56.48% followed by Konkomba who constitute 42.59%. People from other ethnicities (Fulani and Nagbiba) constitute only 0.93%. In Nanumba South, Konkomba are the largest ethnic grouping, constituting 59.78% of the respondents, followed by Dagomba, 26.63%, other ethnicities (Bassare and Kabre), 10.33% and Nanumba 3.26%.

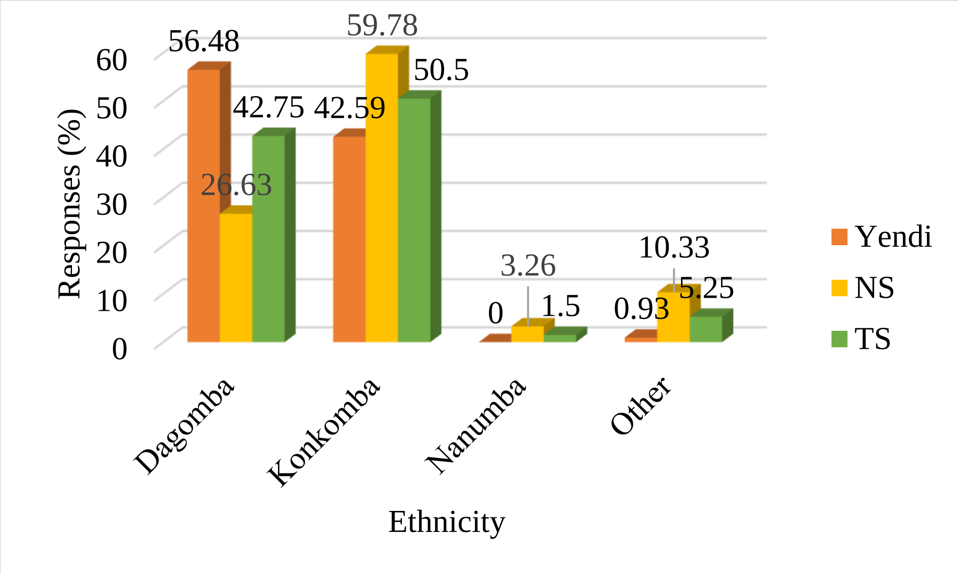



**Figure 4.3: Ethnicity of Respondents**

Source: Field Survey, 2020

On the whole, the Konkomba formed 50.50% of the total sample, followed by the Dagomba, 42.75%, the other ethnicities (Kabre, Basare and Fulani) constitute 5.25% with the Nanumba ethnic group constituting 1.5% of the total respondents.

Nanumba formed part of the larger Mole Dagbani linguistic grouping. Apart from few differences, their language and that of Dagomba are mutually intelligible. The cultural systems are almost the same. Because of this some Nanumba regard themselves as Dagomba and called themselves as such. This is probably the reason why Nanumba form the least ethnic grouping in the sample.

### 4.1.8 Religious Denomination of Respondents

From Figure 4.4, it can be seen that a majority (62.50%) of respondents in the Yendi Municipality are Moslems. Only 3.7% belongs to other religious faiths other than the three main religions. In Nanumba South, Muslims account for 34.78% of the respondents, closely followed by both Christians and Traditionalists with 32.61%, account for 32.60% each. With the total sample, Muslims constitute 49.75%, followed by 26% for Christians, 22.25% for Traditionalists, with 2% for other religions. Respondents who constitute other religions comprises those who do not belief in anything and those who warship spirits.

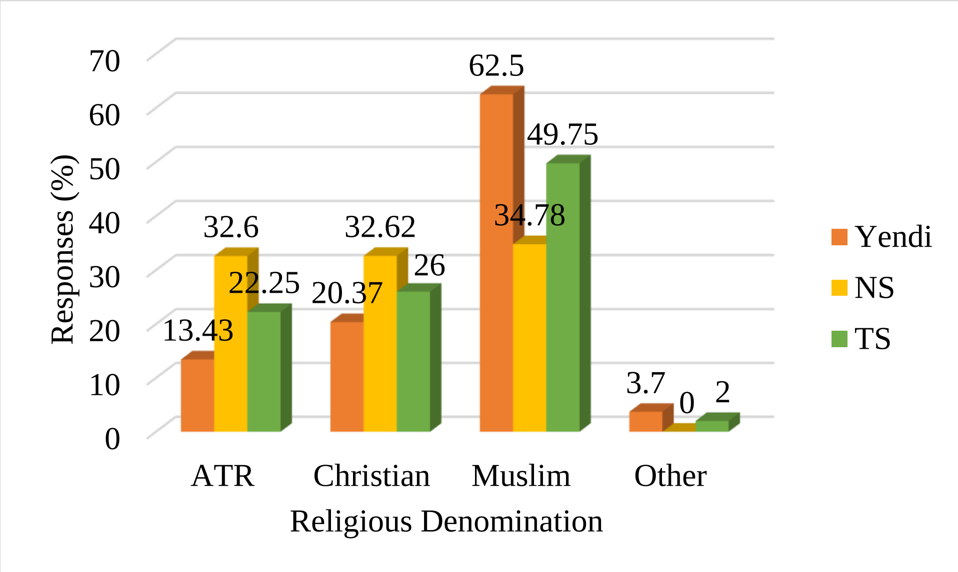



**Figure 4.4: Religious Denomination of Respondents**

Source: Field Survey, 2020

Religion plays a vital role in shaping the lifestyle of an individual. Apart from providing the spiritual needs, religion also shapes human character to conform with accepted societal norms it has prescribed. Religion other than science, attempts to attribute all aspects of human life to the will of divine power that exists independently of man and has the capacity and willingness to reward good deeds and punish bad deeds. Ghanaians generally subscribe to three main religions, the Islamic, Christian and Traditional religion. People's religious are likely affecting their perception and reaction to climate variability and change.

### 4.2 Institutional Factors

Institutional factors here refer to the linkages between farmers and support institutions that promote agriculture or climate change adaptation such credit institutions, service delivery institutions among others.

#### 4.2.1 Access to Extension Service

In Figure 4.5, it can be seen that access to extension service in Yendi Municipality is very low (11%) compared to 48% in the Nanumba South district. Only 28% of the respondents in both districts have access to extension service whilst 72% do not. This low access to extension service was confirmed by a key informant at Sakpegu in the Yendi Municipality, when a respondent was asked whether they received any support in terms of training and incentives from the extension agents. The respondent explained:

*We have not received any support from the agricultural extension concerning farming activities. The officers do not even visit us. Because if you visit only one or two people how can that benefit the whole community? So, I will say they don't come.*

Elijah, Emeka & Osuafor, (2018) did a similar studies in the Cross River States of Nigeria and concluded that lack of access to extension services is a major constrain to farmers. This implies that climate change education and awareness creation which is supposed to be championed by the district extension agents is likely to face a serious challenge and this could affect awareness level of farmers.

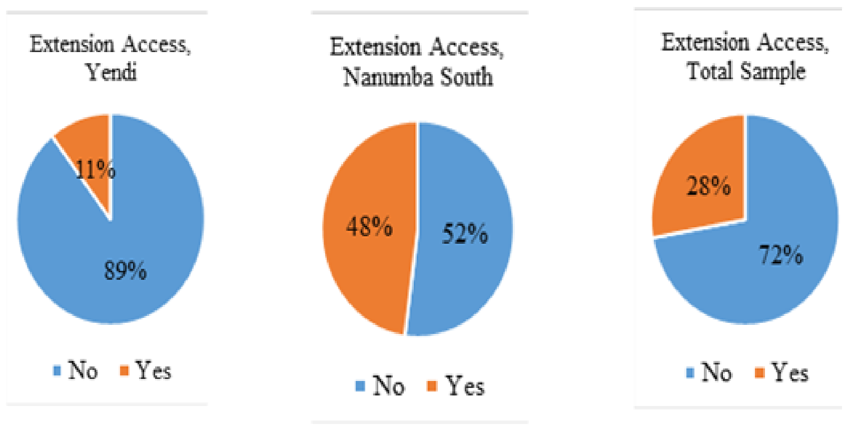



**Figure 4.5: Access to Extension Service**

Source: Field Survey, 2020

Access to Extension Service is vital for the understanding of climate related stresses and adaptation options available to farmers. Extension service delivery is a major source of information to farmers not only on climate change but the general agricultural activities as a whole. Extension agents train farmers on new and better techniques of farming, environmental conservation as well as climate change mitigation and adaptation. Farmers with access to extension service are more likely to be better informed on effective climate variability and change adaptation options than farmers without access to extension service. Consequently, farmers with access to extension service are more likely to adopt adaptation measures as against farmers without access to extension.

Poor extension service delivery has been found to impede the adoption of the climate change adaptation mechanisms (Osei, 2017).



### 4.2.2 Access to Institutional Credit

In Figure 4.6, only 4.89% of respondents in the Nanumba South district have access to institutional credit whilst 95.11% do not have access. The situation is worse in the Yendi Municipality. None of the respondents had access to institutional credit.

This finding supports that of Adam et al. (2014) that most yam producers in Ghana are constrained by the difficulty in accessing credit (Adam et al. 2014 cited in Donkoh et al. 2018), The poor access to credit could be attributed to agriculture being regarded by the financial sector as a risky venture.

In this study, institutional sources of credit include all formal banking sources, microcredit institutions, government agencies like the Micro Finance and Small Loan Centre (MASLOC), the District Assemblies Common Fund (DACF) and the Agricultural Mechanization Services Enterprise Centres (AMSECs) Programme.

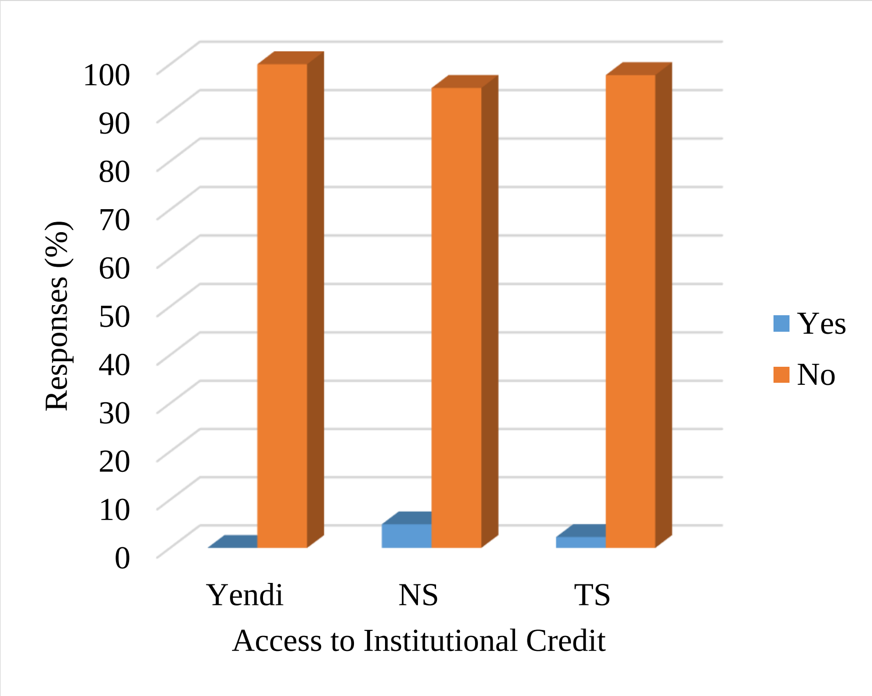



**Figure 4.6: Access to Institutional Credit**

Source: Field Survey, 2020

Institutional credit service delivery is very poor in the Nanumba South district and poorer in the Yendi Municipality.

### 4.2.3 Access to Market

Markets play important role not just as interface between sellers and buyers but also as centres of information sharing and dissemination. Farmers rely on markets to dispose of their produce in exchange for hard currency to purchase the needed inputs. Buyers serve as avenues of information on changing consumer taste and preferences and varieties that are of high market value. Most farmers also obtain new information, including information on climate change adaptation, from the markets which are then diffused to the various satellite communities. Access to market as used in this study refers to famers ability to get buyers of their produce within a 5 kilometre radius. Farmers with access to markets are therefore more likely to adopt climate variability and change adaptation strategies as against farmers without access to markets.

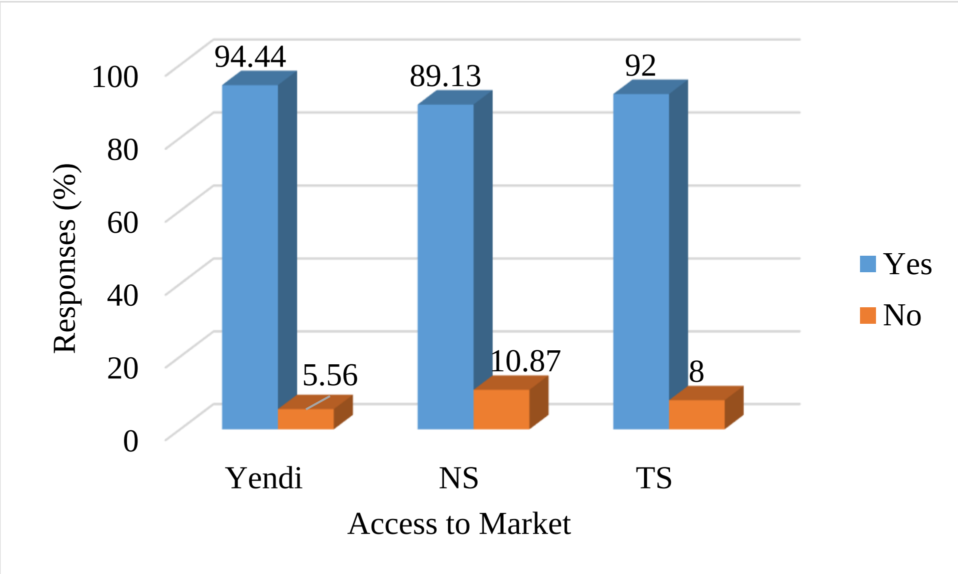



**Figure 4.7: Access to Market**

Source: Field Survey, 2020

Figure 4.7 presents results of market access. It ca be seen in Figure 4.7 that an overwhelmingly majority (94.44%) of respondents in the Yendi Municipality have access to market. Only 5.56% said they do not have access to market. Similarly, 89.13% of respondents in Nanumba South have access to markets as against 10.87% who said they do not have access to markets. This outcome is not surprising because apart from having some important markets, the districts are also surrounded by major markets in neighbouring districts. The Yendi Municipality for instance can boast of the Yendi market, the Gbungbaliga market, the Adibo and Nakpchie markets. It is also surrounded by the Sang market in the Mion district to the west, Gushiegu market in Gushiegu district to the north, the Saboba and Zabzugu markets to the east and Bakpaba market in the Nanumba North district to the south. Besides, Yendi, the district capital is just 96 kilometres away from the regional capital, Tamale.

Similarly, the Nanumba South district has the Wulensi, Nakpayili and Lungni markets. It is surrounded also by the Kpandai market to the south, the Bimbilla market to the north and the Chamba market to the west.

Studies by Ume, et al. (2018) point to a higher chance of farmers with access to input/output markets to implement climate change adaptation measures. The study further revealed that the likelihood of adopting farm level climate change adaptation is hindered by limited access to markets (Ume, et al. 2018).

### 4.2.4 Distance of Nearest Market

Nearness of market is very essential for both yam farmers and distributors. Yam is a perishable commodity that can easily spoil if closely parked in poorly ventilated trucks. Yams can also be easily damaged on a bumpy road over a long distance. Nearness of market does not only determine how much yam can be conveyed to the market, but also how many people can convey their produce to the point of sale. Nearness of market again affects transport cost which ultimately add up to production cost if farmers are unable to pass on the cost to consumers.

In Table 4.3, it can be seen that a majority of respondents (54%) travel more than 5 kilometres to the nearest market. Only 8% access markets within a kilometre radius or less. On the average, respondents travel 3.54 kilometres to get to their nearest market.

A similar trend is observed in the Yendi Municipality where 70% of respondents travel beyond 5 kilometres to the nearest market. On the contrary, respondents in Nanumba South tend to have more physical access to markets compared to their counterparts in the Yendi Municipality. Fifty percent (50%) travel 2 to 3 kilometres to the nearest market.

**Table 4.3: Distance of Nearest Market**

| Characteristic | Yendi | | NS | | TS | | Mn |
|---|---|---|---|---|---|---|---|
| Market Location | Freq. | % | Freq. | % | Freq. | % | |
| < 1km | 24 | 11.11 | 6 | 3.26 | 30 | 7.50 | |
| 2-3 km | 8 | 3.70 | 92 | 50.00 | 100 | 25.00 | |
| 4-5 km | 33 | 15.28 | 20 | 10.87 | 53 | 13.25 | |
| Above 5 km | 151 | 69.91 | 66 | 35.87 | 217 | 54.25 | |
| Total | 216 | 100.00 | 184 | 100.00 | 400 | 100.00 | 3.54 |

Source: Field Survey, 2020

### 4.2.5 Membership of Association

Social networking plays a critical role in accessing climate change and adaptation information. It is always much easier for actors promoting innovation and adaptation measures to deal with groups rather than individual farmers. Formal money lenders and credit providers also prefer to deal with groups or associations rather than individuals. This is especially the case with smallholder farmers who do not have collateral. Group collectivism is usually used as substitute for collateral for these smallholder farmers. Since they are engaged in the same occupation, members of associations generally discuss their experiences and share information on success stories.

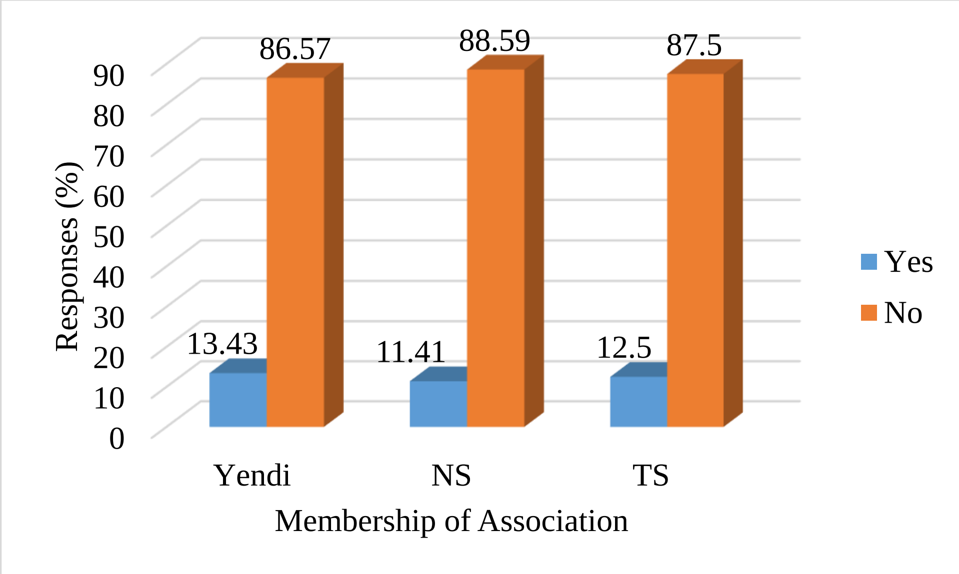



**Figure 4.8: Membership of Association**

Source: Field Survey, 2020.

In Figure 4.8, 87.5% of respondents in the study area do not belong to any association at all. Only 13.43% and 11.41% of respondents in the Yendi Municipality and the Nanumba South district respectively, belong to an association. This implies that the use of social capital as a climate change adaptation strategy could be limited by the inability of respondents to form viable support associations. According to Abdoulaye, et al. (2017), membership of association closely correlates with technology adoption since association memberships enhances access to social capital. This being the case, membership of association is more likely to affect both climate change perception and adaptation.

### 4.3 Farm Level and Land Ownership Factors

Farm level and land ownership factors that are expected to influence farmers' decisions to adopt climate change adaptations are; access to farm labour, major crops grown by the farmer, ownership of farm land, distance of farm from the homestead, farm size and the total size of landholding.

#### 4.3.1 Access to Farm Labour

In figure 4.9, respondents were asked whether they have access to farm labour (family, hired or both). In this section labour support from friends and neighbours are classified as part of family labour.

As can be seen in Figure 4.9, about sixty-one percent (61%) of total respondents have access to farm labour. However, in the Yendi Municipality, about 59% of respondents have access to farm labour as compared to about 63% of respondents in Nanumba South who said they have access to farm labour.

Yam farming is a labour-intensive activity. Mounding, capping of mounds, staking, harvesting and packing are all manually done. The extent to which farmers can take decisions greatly depends on the amount of labour that can immediately be marshalled.

Access to farm labour here refers to any form of labour other the farmers own effort. This include the total amount of labour force (both hired and non-hired) available to the farmer during the growing season.

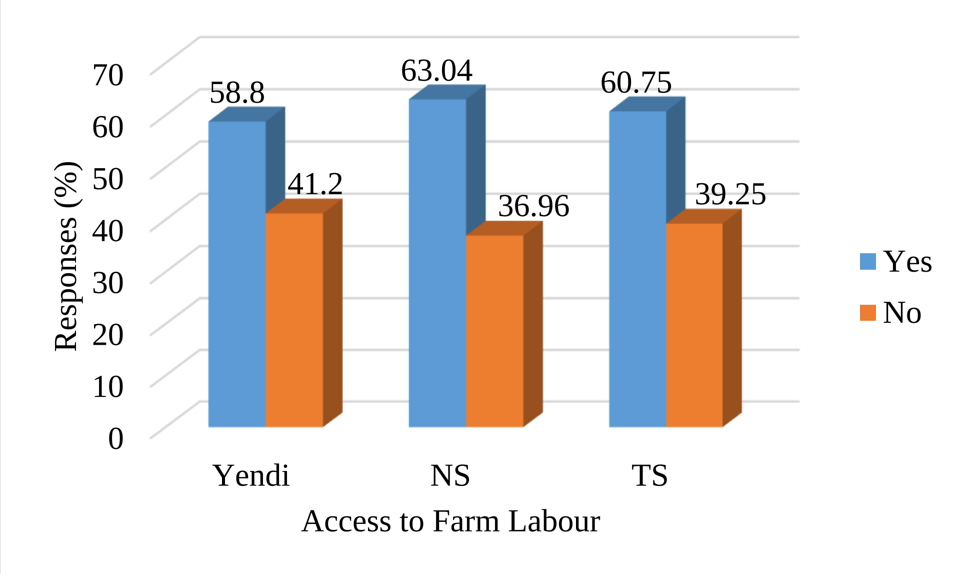



**Figure 4.9: Respondents Access to Farm Labour**

Source: Field Survey, 2020

### 4.3.2 Farm Distance

The overall average farm distance in the study area is 2.00 kilometres (km) as seen in Table 4.4. Overall, 95.25% of the respondents travel less than 2km to their farms with only 0.5% of respondents travelling beyond 8km to their farms.

Farm distance affects the number of man hours available for the actual farm work since part of the time will be used in travelling to and from the farm.

It also affects the cost of transporting farm inputs to the farm and carting farm produce to the house. Overall, it affects the choice of climate variability and change adaptation. Mngumi (2016) noted that long distance from the home to the farm limits farmers ability to adopt climate change adaptation measures.



### 4.3.3 Size of Yam Farm

Table 4.4 shows that an overwhelming majority (97.69%) of respondents in the Yendi Municipality cultivate 5 acres or less. This compares with 63.04% of their counterparts in Nanumba South who also cultivate a maximum of 5 acres. About two percent (2.31%) of respondents in the Yendi Municipality as against 28.80% in Nanumba South cultivate 5 to 10 acres. About eight percent (7.62%) and 0.54% in the Nanumba South cultivate 11 to 15 acres and 16 to 20 acres respectively.

Farmers in both districts cultivate on average 3.10acres of yam. Farm size affects the amount of resources, that is labour, inputs and technology used in production and hence affects climate variability and change adaptation decisions of the farmer. Rosenstock & Nowak (2019) established a significant relationship between agricultural innovation and farm size and concluded that farmers with a smaller farm size were more likely to adopt agricultural innovation.

From personal observation, labour for raising yam mounds is usually calculated per mound. Every additional mound attracts extra cost. Most farmers now use glyphosates (weedicide) for weed control and in the study area farmers use an average of one litre of glyphosates per acre. The number of glyphosates used by a farmer therefore depends on the number of acres cultivated. The same goes for yam setts.

### 4.3.4 Size of Land Holding

Land holding as used in this study refers to the total land area that is at the disposal of an individual farm household which is either partly or wholly cultivated. As shown in Table 4.4, a majority of the respondents, that is, 62.04% and 53.80% for Yendi Municipality and Nanumba South respectively, hold more than 31 acres of land. Only 1.85% and 2.72% of the respondents in the Yendi Municipality and the Nanumba South respectively, own 1 to 10 acres of land. An average size of land holding in the study area is 4.02 acres. Ali & Erenstein (2017), noted that households with more land implement more adaptation practices, possibly because they have a higher ability to adopt.

**Table 4.4: Farm Level and Land Ownership Factors**

| Characteristic | Yendi | | NS | | TS | | |
|---|---|---|---|---|---|---|---|
| | **Freq.** | **%** | **Freq.** | **%** | **Freq.** | **%** | **Mn** |
| **Hired Labour** | | | | | | | |
| 0 – 2 | 123 | 98.40 | 51 | 43.97 | 140 | 33.25 | |
| 3 – 4 | 2 | 1.60 | 33 | 28.45 | 160 | 38.00 | |
| 5 | 0 | 0.00 | 32 | 27.59 | 121 | 28.75 | |
| **Total** | **125** | **100** | **116** | **100** | **421** | **100.** | **1.63** |
| **Farm Distance** | | | | | | | |
| <2km | 211 | 97.69 | 170 | 92.39 | 381 | 95.25 | |
| 2-4km | 4 | 1.85 | 5 | 2.73 | 9 | 2.25 | |
| 5-7km | 0 | 0.00 | 7 | 3.80 | 7 | 1.75 | |
| 8-10km | 0 | 0.00 | 1 | 0.54 | 1 | 0.25 | |
| >10km | 1 | 0.46 | 1 | 0.54 | 2 | 0.50 | |
| **Total** | **216** | **100** | **184** | **100** | **400** | **100** | **2.00** |
| **Farm Size (acres)** | | | | | | | |
| 1-5 | 211 | 97.69 | 116 | 63.04 | 327 | 81.75 | |
| 6-10 | 5 | 2.31 | 53 | 28.80 | 58 | 14.50 | |
| 11-15 | 0 | 0.00 | 14 | 7.62 | 14 | 3.50 | |
| 16-20 | 0 | 0.00 | 1 | 0.54 | 1 | 0.25 | |
| **Total** | **216** | **100** | **184** | **100** | **400** | **100** | **3.10** |
| **Land holding (acres)** | | | | | | | |
| 1-10 | 4 | 1.85 | 5 | 2.72 | 9 | 2.25 | |
| 11-20 | 15 | 6.94 | 28 | 15.22 | 43 | 10.75 | |
| 21-30 | 63 | 29.17 | 52 | 28.26 | 115 | 28.75 | |
| >31 | 134 | 62.04 | 99 | 53.80 | 233 | 58.25 | |
| **Total** | **216** | **100** | **184** | **100** | **400** | **100** | **4.02** |

Source: Field Survey, 2020

Land holding is critical in climate change adaptation as it allows a farmer to explore several land management practices aimed at minimising the effect of climate variability and change. Since yam thrives well on virgin lands, the practice of shifting cultivation, land fallowing and rotation aimed at reviving soil fertility is only possible when the farmer has adequate amount of land to manage.

### 4.3.5 Ownership of farmland

As can be seen in Figure 4.10, close to ninety-seven percent (96.76%) of respondents in the Yendi Municipality and 95.25% of their counterparts in the Nanumba South own the lands on which they are currently farming.

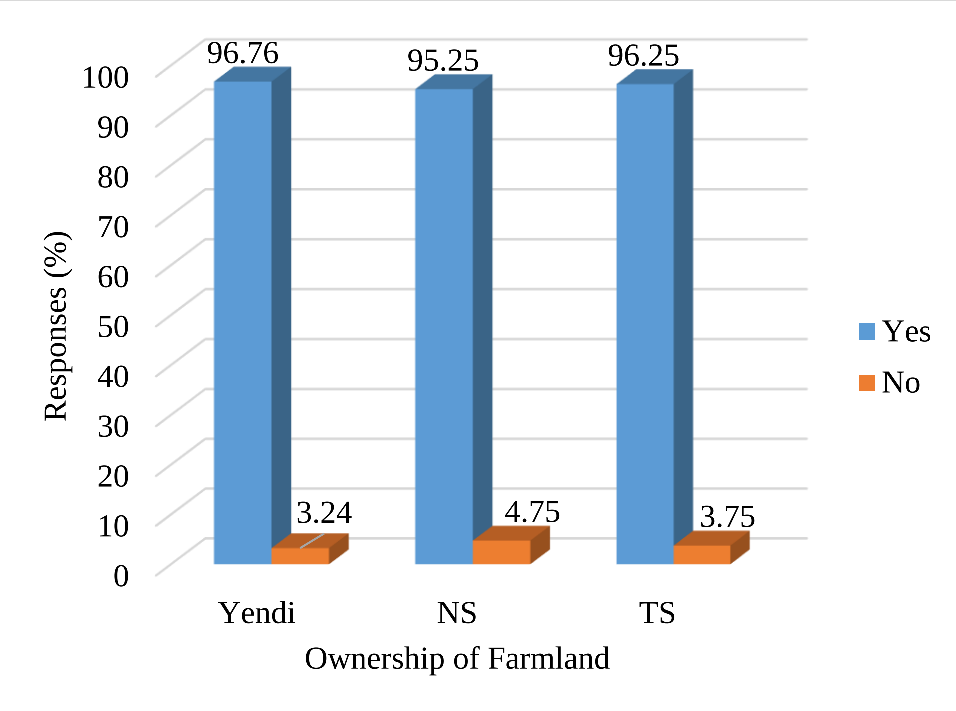



**Figure 4.10: Land Ownership**

Source: Field Survey, 2020.

Those farmers who do not own their farm lands constitute 3.24% and 4.75% of respondents in the Yendi Municipality and Nanumba South respectively.

Land ownership plays a vital role in climate change adaptation decision making. Findings imply that yam farmers in the study district are more likely to practice climate change adaptation as demonstrated by Ali & Erenstein (2017) that landowners practice more adaptation strategies compared to tenants. Farmers making long term investment on their farms will always consider tenure security and whether there is guarantee that they can recoup their investment without being asked to surrender the land. Nhemachena, et al. (2014) noted that ownership of private property increases the chance of adopting climate change adaptation and that there is correlation between secure tenureship and propensity to invest in adaptation.



**4.3.6 Adequacy of Land Holding**

In Figure 4.11, respondents were asked whether their current land holding is adequate for their need. A majority of them, that is, 85.18% and 83.70% from the Yendi Municipality and the Nanumba South district respectively, stated that their current land holding is adequate for their need. Only 14.82% and 16.30% from the Yendi Municipality and the Nanumba South respectively, indicated that their current land holding is not adequate for their needs. Overall, 84.50% of respondents have adequate land holding whilst 15.50% think otherwise.

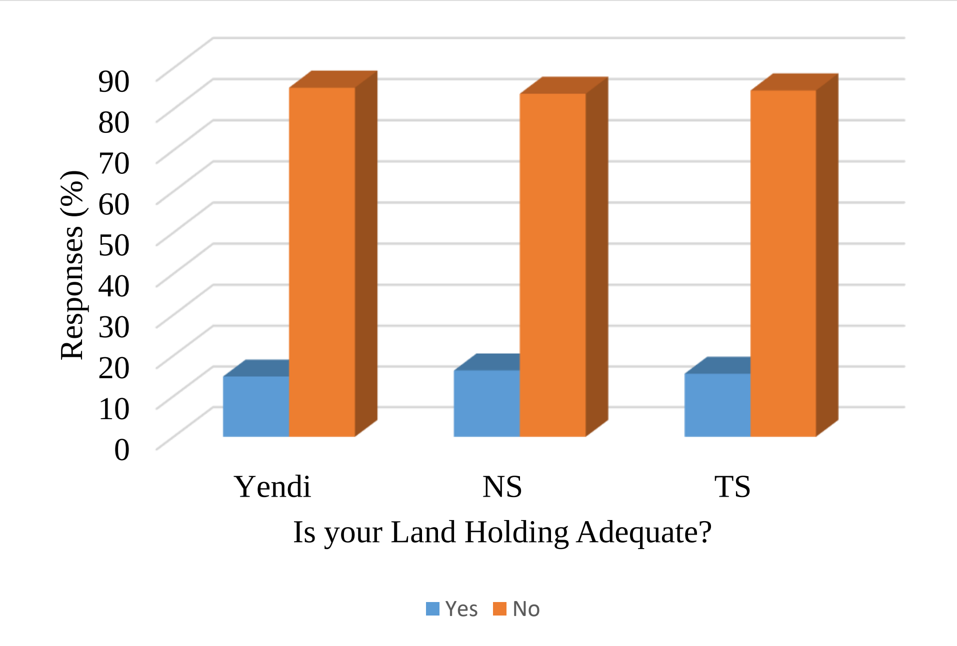



**Figure 4.11: Adequacy of Land Holding**

Source: Field Survey, 2020.

### 4.3.7 Size of Landholding Under Cultivation

This section discusses the amount of farmer's land that is currently being used for the growth of not only yam but all other crops that the farmer cultivates. As can be seen in Figure 4.12, a majority (67.39%) of respondents in the Nanumba South District said all their landholding is under cultivation. This compares with only 23.61% of respondents in the Yendi Municipality who have all their landholding under cultivation.

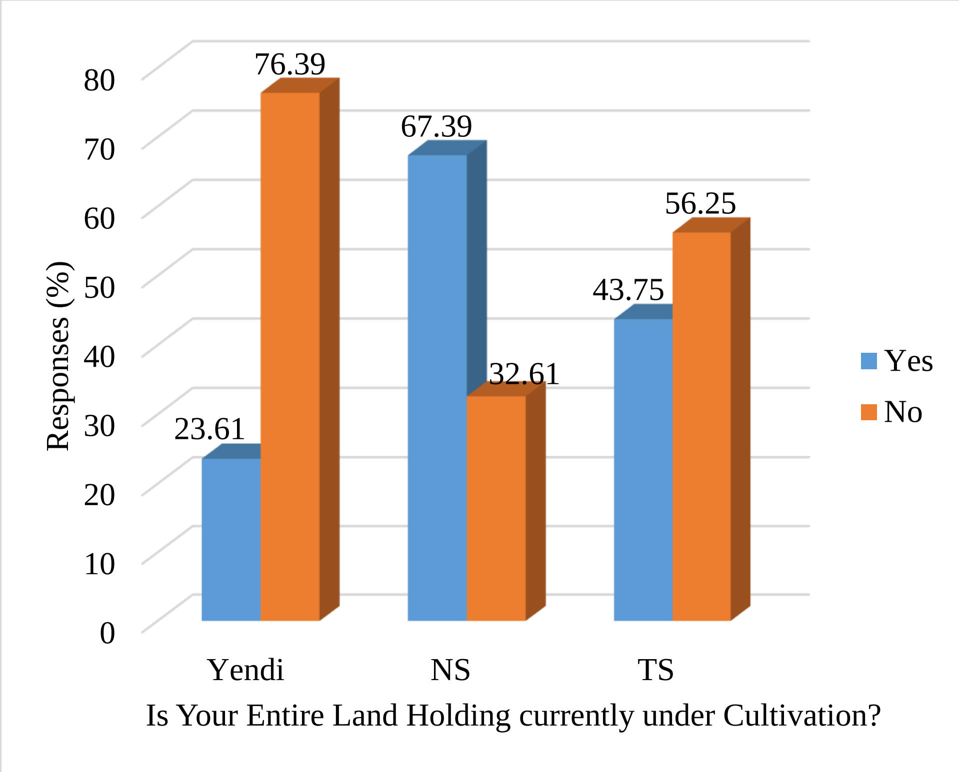



**Figure 4.12: Size of Land Holding under Cultivation**

Source: Field Work, 2020

On the contrary, a majority (76.39%) of respondents in the Yendi Municipality and only 32.61% of their counterparts in the Nanumba South said only a section of their landholding is currently under cultivation. Overall, 43.75% of the respondents currently cultivate all their landholding as against 56.25% who only cultivate a part of their land holding.

This implies that farmers in the Nanumba south generally would be restricted in terms of adaptation choices. This is because yam farmers generally practice shifting cultivation, land fallowing, land rotation and farm expansion. These practices require the availability of excess land that can easily be brought under cultivation to ease pressure on land that is already in use. Whilst majority of the respondents in Yendi appear to have enough uncultivated land, a similar majority of their counterparts in the Nanumba South already have all their lands under cultivation and therefore may not be able to practice the above-mentioned adaptation strategies without looking for land elsewhere.

### 4.3.8 Main Crop Cultivated

As can be seen in Figure 4.13, nearly all (99.46%) the farmers in the Nanumba South cultivate yam as their major crop whilst 56.95% of their counterparts in the Yendi Municipality also have yam as their major cultivated crop. Only an insignificant percentage (0.54%) of the respondents in the Nanumba South have groundnuts as their main cultivated crop. Respondents in the Yendi Municipality, however, have maize (37%), groundnuts (2.31%) and rice (0.93%), with 2.31% cultivating other crops (soya beans) as their major crop.

It is expected that a farmer will devote much resources to the crop that is more important to him and his household. Yam is the main cultivated crop in both the Yendi Municipality and the Nanumba South District. Yam farmer's choice of adaptation strategy is expected to be influenced by the value placed on yam crop. That being the case, farmers, whose major crop is yam are expected to adopt adaptation strategies to maintain or increase productivity than farmers whose attention is devoted to crops other than yam.

Evidence from Table 4.5, however, proved otherwise. From the Table it can be seen that out 306 farmers who have yam as their major cultivated crop, only 51, representing 16.67% have taken up adaptation measures. Compared with the other major cultivated crops it can be seen that 88.89% of farmers whose major cultivated crop is maize have taken up climate change adaptation measures, 83.33% of farmers cultivating groundnuts, 100% of farmers cultivating rice and 80% of those cultivating other crops as their major crop have taken up adaptation.

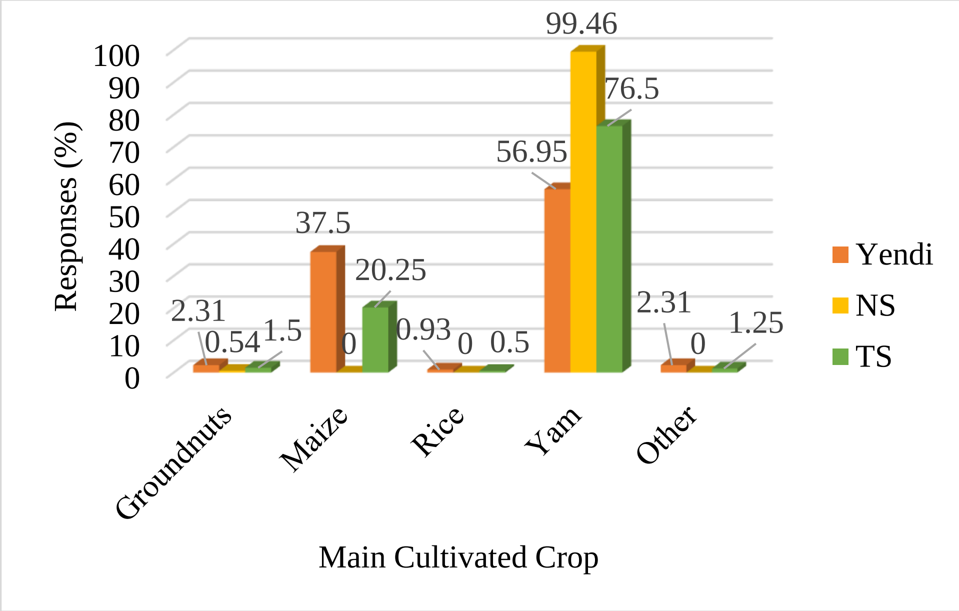



**Figure 4.13: Main Crop Cultivated by Respondents**

Source: Field Survey, 2020

**Table 4.5: Relationship between main cultivated crop and adaptation to Climate Variability & Change**

| | **Have you adopted any adaptation strategy to mitigate the effects of climate change** | | | | | |
|---|---|---|---|---|---|---|
| | Yes | | No | | Total | |
| **Main crop cultivated** | Freq. | % | Freq. | % | Freq. | % |
| Groundnuts | 5 | 83.33 | 1 | 16.67 | 6 | 1.50 |
| Maize | 72 | 88.89 | 9 | 11.11 | 81 | 20.25 |
| Rice | 2 | 100 | 0 | 0 | 2 | 0.50 |
| Yam | 51 | 16.67 | 255 | 83.33 | 306 | 76.50 |
| Other | 4 | 80 | 1 | 20 | 5 | 1.25 |
| **Total** | **134** | **33.50** | **266** | **66.50** | **400** | **100** |

Source: Field Survey, 2020

This implies that the uptake of climate change adaptation is low for farmers who cultivate yam as their major crop. The low uptake of climate change adaptation is partly because majority of smallholder yam farmers still cling on to outmoded implements in their farming activities (Verter, et al.et al. 2015; Bergh, et al. 2012).



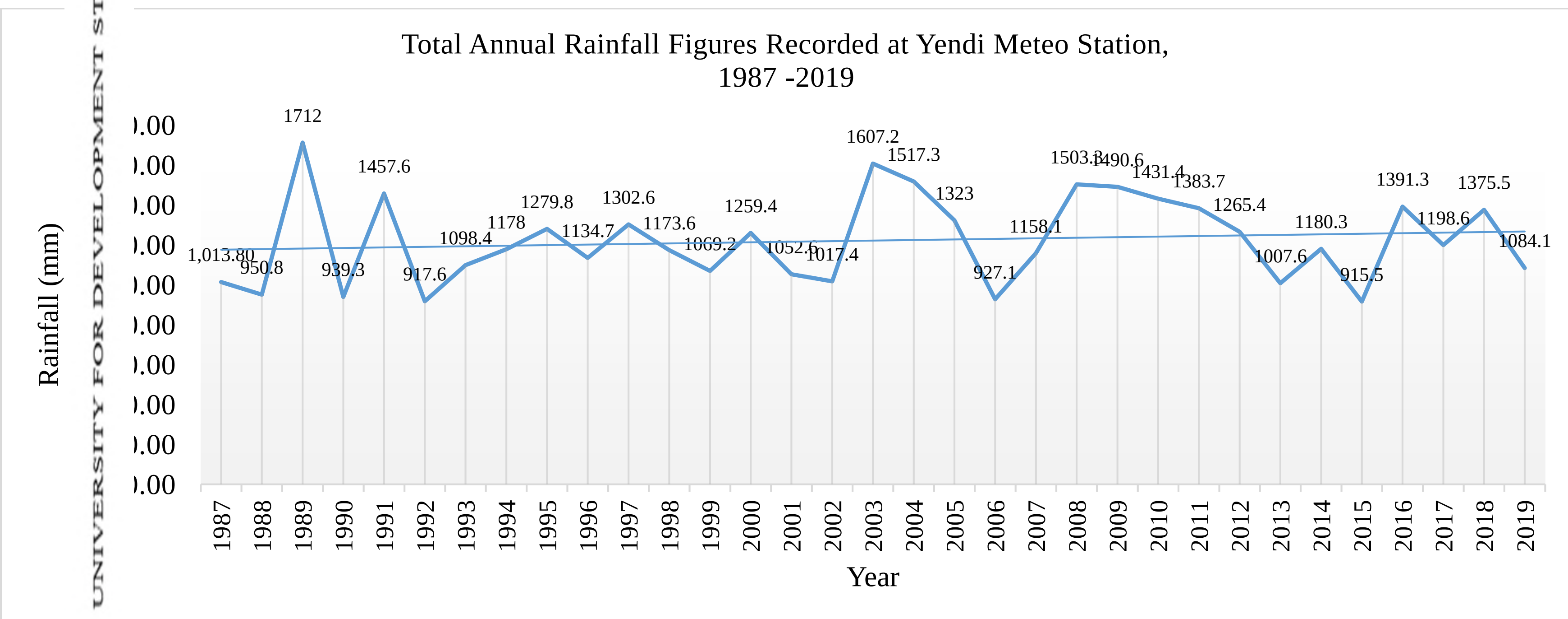
### 4.4 Rainfall and Temperature Trends in the Study Area

Discussions on the perception of climate variability and change can be understood within the context of existing climate data. That being the case, rainfall and temperature data which are the major parameters of the climate were obtained from the Meteorological Services Department to complement the primary data collected from the respondents. Whilst data for rainfall and maximum temperatures were largely available, data on minimum annual temperatures for some of the years were missing. Though efforts were made to obtain some of the missing data, they could simply not be found due to technical reasons. For instance, mean annual minimum temperature figures for 2001, 2002, 2013, 2014, 2015 and 2016 could not be obtained. Similarly, 2003 and 2016 have figures for four months and seven months respectively. The analysis of the data is presented below.

### 4.4.1 Annual Total Rainfall

Rainfall data for the Yendi Meteorological station was used in the analyses and subsequent discussions of the rainfall situation of the area. The Yendi station is the only meteorological station in the Eastern corridor of the northern region and exercises oversight over the Nanumba South district.

Figure 4.14 shows the total annual rainfall figures for the Yendi Municipality from 1987 to 2019. The figure shows clearly that the rainfall pattern has been very variable moving above and below the trend line. The 1989, 2003, 2004 and 2008 recorded 1712mm, 1607mm, 1517mm and 1508mm of rain respectively. For the rest of the years, the rainfall figures have been straddling the trend line with a record low of 915.5mm in 2015. From 2012, the records have fallen below the trend line with the exception of 2016 and 2018 where records move slightly above the trend line 1391.3mm and 1375.5mm respectively.






**Figur 4: Annual Total Rainfall (mm) – 1987 to 2019**

Sourc teorological Services Department, Northern Regional Office, Tamale

Though rainfall variability is obvious in the area as shown on Figure 4.14, the trend line clearly shows a slight increase in rainfall totals over the past thirty years. Rainfall anomaly, in terms of variability and decline has adverse consequences for crop production. *Yam, in particular, requires substantial amounts of moisture for growth* (District Director of Agriculture, Nanumba South).



#### 4.4.2 Mean Monthly Rainfall (1990 to 1999)

Figure 4.15: shows an average monthly rainfall distribution in the Yendi Municipality covering the period 1990 to 1999. It can be seen from the figure that the minimum rainfall figures within the period were recorded in the months of November, December, January, February and March with February recording the lowest of 2.2 mm. September was the peak of the raining season with an average of 243.9 mm. August, June and July also recorded significant amounts of rainfall, averaging 226.3, 180.8 and 151.2 mm respectively.

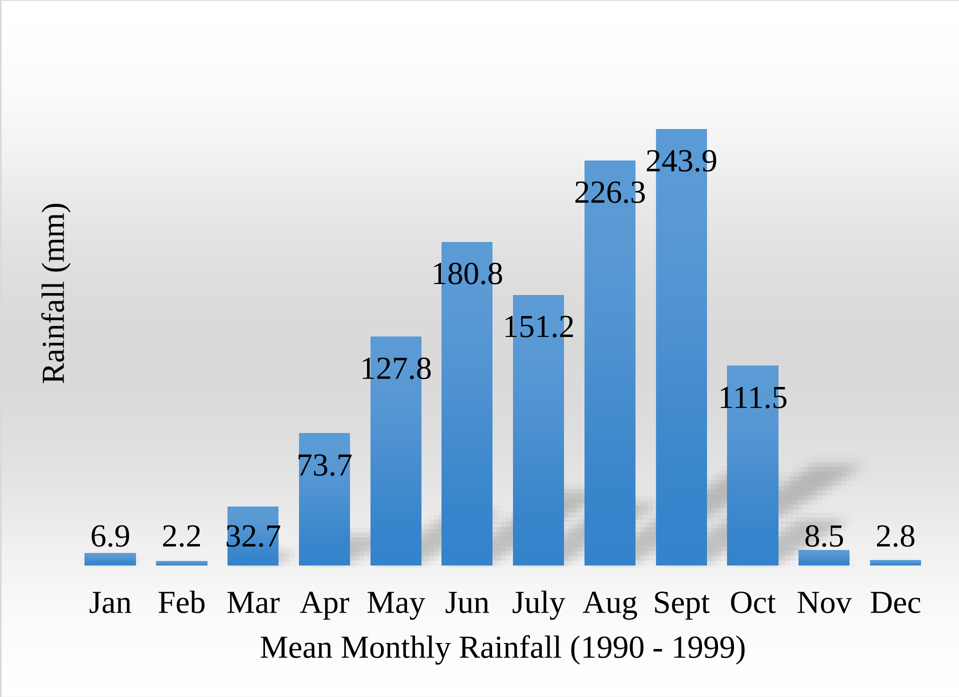



**Figure 4.15: Mean Monthly Rainfall (mm) – 1990 to 1999**

Source: Meteorological Services Department, Northern Regional Office, Tamale.

### 4.4.3 Mean Monthly Rainfall (2000 to 2009)

Figure 4.16 also shows an average monthly rainfall from the year 2000 to 2009. It is obvious from the figure that September is the peak of the rains recording an average of 297.9mm and followed by August 245.1mm, July with 194.2mm and June with 169.8mm. Compared to figure 4.15, the average rainfall amounts has increased within the period from 243.9 to 297.9 in figure 4.16 for September.

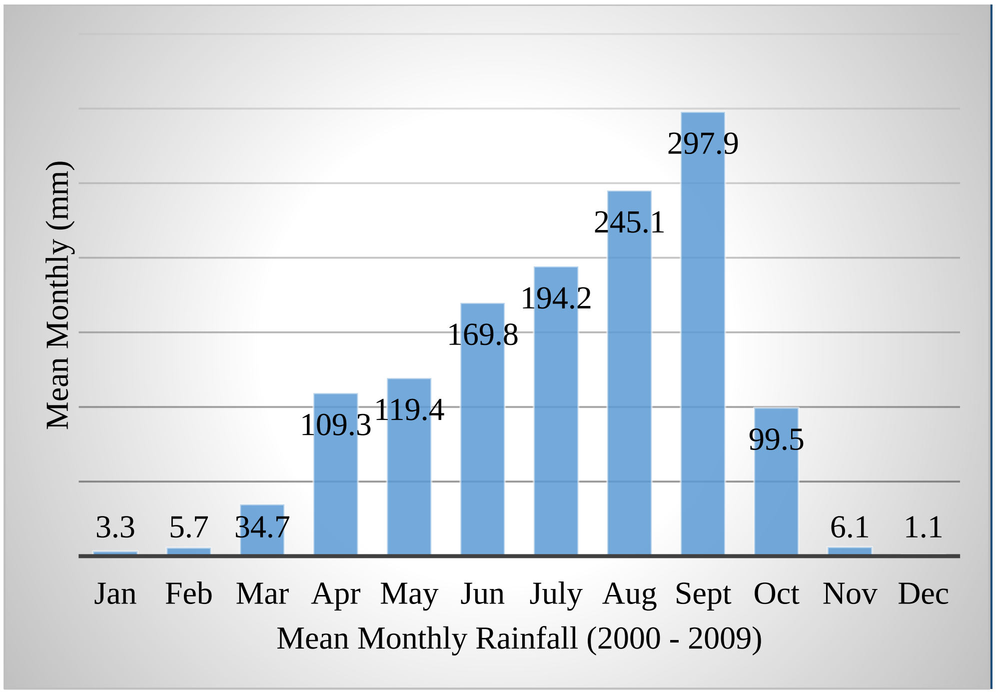



**Figure 4.2: Mean Monthly Rainfall (mm) – 2000 to 2009**

Source: Meteorological Services Department, Northern Regional Office, Tamale

Average rainfall for August has increased from 226.3mm to 245.1mm. October, November, December and January, however, recorded declining amounts of rainfall.

**4.4.4 Mean Monthly Rainfall (2010 to 2019)**

Figure 4.17 shows average monthly rainfall for Yendi covering the period 2010 to 2019.

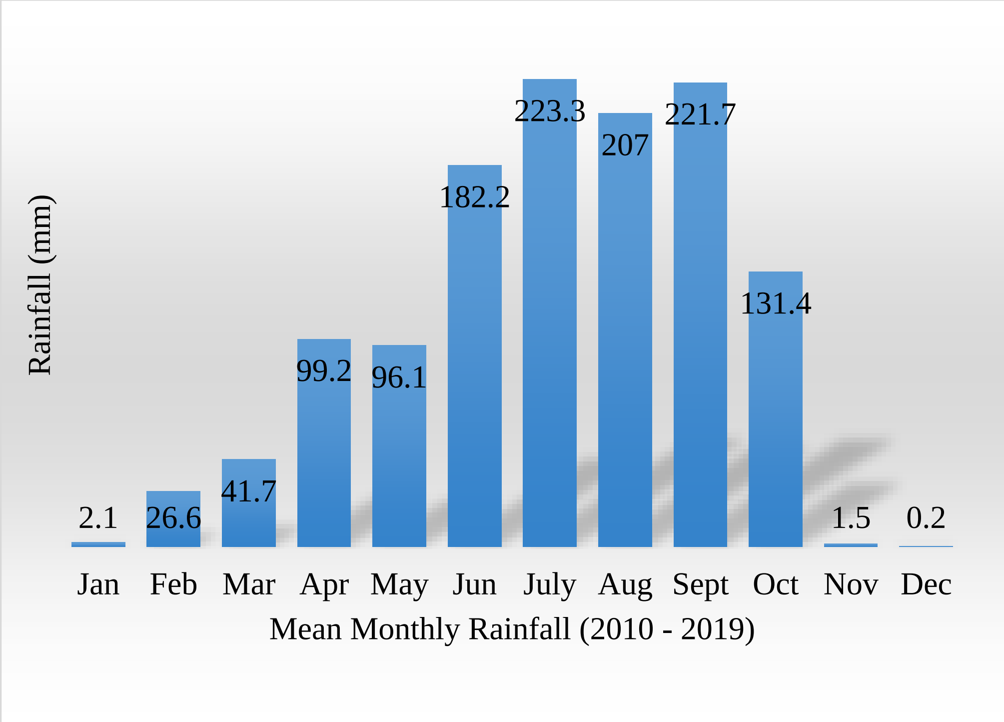



**Figure 4.3: Mean Monthly Rainfall (mm) – 2010 to 2019**

Source: Meteorological Services Department, Northern Regional Office, Tamale.

From Figure 4.17, it can be seen that the mean monthly distribution of rainfall has changed slightly compared to figures 4.15 and 4.16. September, which previously recorded the highest amount of rainfall has now been overtaken by July, recording an average of 223.3mm as against September which recorded 221.7mm. Figures for November, December and January, however, continue to decline. This implies that the months of November, December and January are becoming drier than before.

Yam farming is an all-year-round activity and as a result, the amount and distribution of annual rainfall is very essential. The amounts of moisture received in November, December and January are particularly important because these are periods of mounding and planting, activities that require adequate moisture in the soil.



**4.4.5 Mean Annual Maximum Temperature (°C) - 1989 to 2019**

One major driver of climate variability and change is temperature change. Using the IPCC scenarios, Kumar, Gaiser, Paeth, & Ewert (2012) predicted that global warming will induce temperature increases up to 8% by the year 2040. The rise in global temperatures will have dire consequences for yam whose temperature requirement for growth, according to Kumar et al. (2012), is between 25$^{o}$C and 30 $^{o}$C .

Figure 4.18 depicts the three-year annual average maximum temperatures recorded at the Yendi station spanning the year 1989 to 2019. It is evident from the figure that the maximum temperature levels have been fluctuating during the last three decades. The highest mean maximum temperature of 34.9$^{o}$C was recorded 1998. The lowest annual mean maximum temperature (31.1$^{o}$C) for the period was recorded in 1992. From 34.9$^{o}$C in 1998, temperature levels have declined to 33.8$^{o}$C in 2004, increased to 34.3$^{o}$C in 2010 and later declined to 33.8$^{o}$C in 2013.

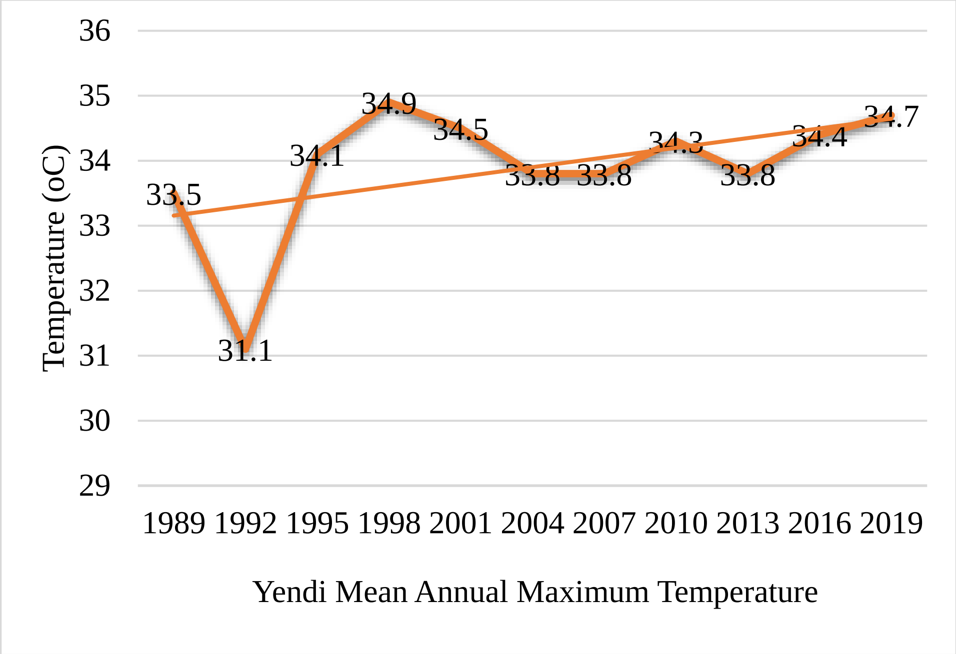



**Figure 4.18: 3-Year Mean Annual Maximum Temperature for Yendi –1989- 2019**

Source: Meteorological Services Department, Northern Regional Office, Tamale.

Evidence from Figure 4.18 indicates that since 2013, maximum annual average temperatures have been increasing, moving above the trend line with the 2019 recording as high as 34.7°C, second to the 1998 record. The trend line clearly shows an increase in mean annual maximum temperature for the area between 1989 and 2019 from about 33.1$^{o}$C in 1989 to 34.7$^{o}$C in 2019. This shows an increase of about 1.6$^{o}$C.

### 4.4.6 Mean Annual Minimum Temperature (°C) - 1989 to 2019

Figure 4.19 shows the average annual minimum temperature recorded at the Yendi Meteorological station over the last three decades. The figure shows clearly that there is a consistent rise in the average annual minimum temperature levels in the area as depicted by the trend line. The trend line shows a gradual increase from 21.8°C to about 23.2°C, a difference of about 1.4°C.

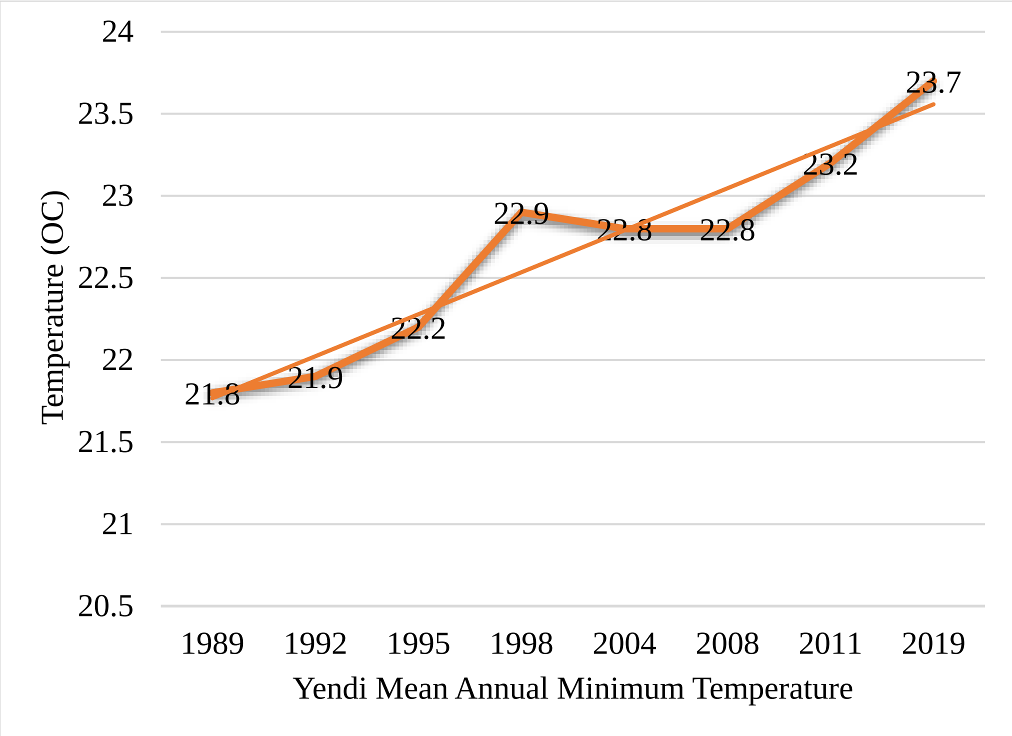



**Figure 4.19: Yendi Mean Annual Minimum Temperature ($^{O}$C)**

Source: Meteorological Services Department, Northern Regional Office, Tamale.

From the lowest of 21.8$^{o}$C in 1989, it increased consistently to 21.9$^{o}$C in 1992, 22.2$^{o}$C in 1995 and 22.9$^{o}$C, moving above the trend line in 1998. Thereafter, the annual average minimum temperatures declined to 22.8$^{o}$C in both 2004 and 2008. Since 2008, the average annual minimum temperature levels have been increasing steadily by rising to 23.2$^{o}$C in 2011 and 23.7$^{o}$C crossing the trend line for the second time in 2019.

### 4.4.7 Mean Annual Total Temperature (°C) - 1989 to 2019

Figure 4.20 shows average annual total temperature for Yendi. The data shows a clear variability in the average annual total temperatures. From an average of 27.7$^{o}$C in 1989, annual temperatures decreased to 26.5$^{o}$C in 1991 and thereafter, increased continuously to 28.2$^{o}$C in 1995 and 29$^{o}$C in 1998.

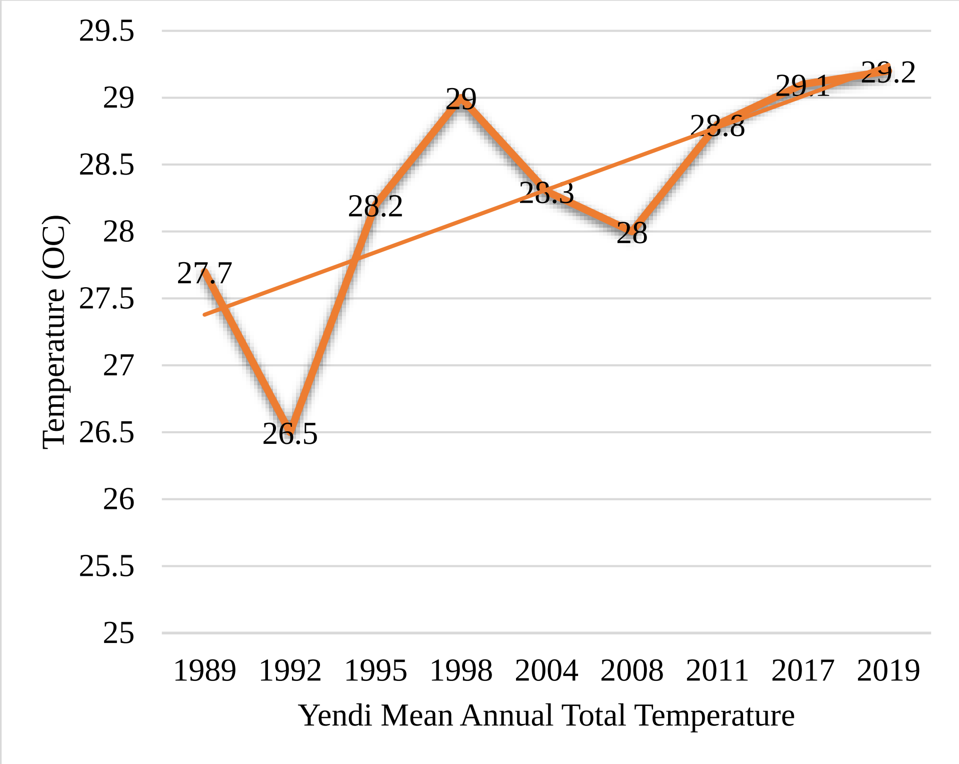



**Figure 4.40: Yendi Mean Annual Total Temperature (ºC)**

Source: Source: Meteorological Services Department, Northern Regional Office, Tamale.

It again decreased to 28.3ºC in 2004 and 28ºC in 2008. Since 2008 the average annual total temperatures have been on the ascendency. From 28ºC, it increased to 28.8ºC in 2011, 29.1ºC, moving above the trend line in 2017 and reaching 29.2ºC 2019.

The results in figures 4.18, 4.19 and 4.20 indicate a clear sense of temperature variability in the study area. It also shows a changing trend in temperature levels with the last ten years witnessing a gradual rise in both maximum and minimum annual mean temperatures. Rising temperatures can have severe consequences for crop cultivation as it enhances the rate of evaporation, transpiration, and above all, the loss of soil moisture (Obeng, 2005). Kumar et al. (2012) stated that temperature is a the main cause of soil water loss and transpiration in crops and that temperature affects the availability of soil moisture and plant growth.



### 4.4.8 Conclusion

Analysis of the data above shows a clear variability in both the rainfall and temperature. This variability puts farmers at greater risk since success in yam farming largely depends on the accurate prediction and responds to climate variables. Beside the climate variability, the results also show a changing trend in both the rainfall and temperature patterns. There is a gradual and consistent decline in rainfall averages, especially for the months November, December and January which coincide with the period of mounding and yam planting. In addition to the declining rainfall, there is also a gradual increase in temperature levels which means that the little moisture derived from the decreasing rains is further drained from the soil.

## 4.5 Farmers' Perception of Climate Variability and Change

Awareness of climate variability and change is a key factor influencing the adoption of strategies to effectively minimise the effect of climate change.

The adoption of modern and improved technologies is also by farmer's knowledge and awareness of climate change. An understanding of farmers' knowledge on climate variability and change is therefore imperative in adaptation studies. This section examines yam farmers' perception of climate variability and climate change.



### 4.5.1 Knowledge of Climate Change

Knowledge is the first step towards the perception of climate variability and change. Prior to perceiving climate change or its variability, the farmer might have heard of it, seen its outcome or felt it. In this study, farmers were asked whether they have heard of climate change and the results are presented in Figure 4.21.

As indicated in Figure 4.21, majority (68%) of the respondents said they have not heard of climate change whilst only 32% have heard of the phenomenon. Comparing the two districts, it could be realised that a majority (54%) of yam farmers in the Nanumba South have heard of climate change compared to only 13% of their counterparts in the Yendi Municipality.

This implies that awareness of climate change is high among yam farmers in the Nanumba South and very low in the Yendi Municipality. This finding is consistent with that of Mngumi (2016) that farmers knowledge and perception of climate change vary depending on their locality.

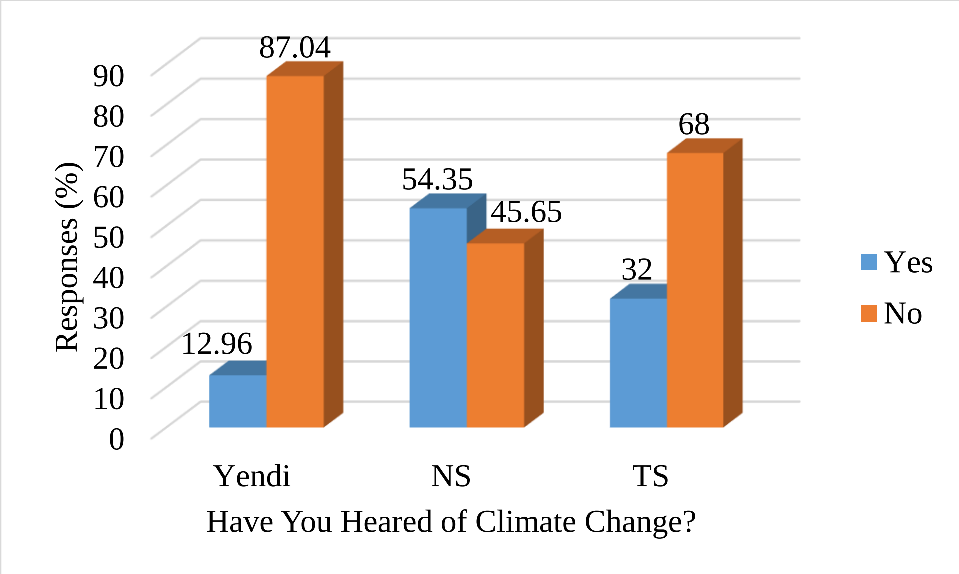



**Figure 4.21: Farmers Knowledge of Climate Variability and Change**

Source: Field Survey, 2020.

The low awareness of climate change among respondents in Yendi Municipality was corroborated by an extension agent in Yendi during an in-depth interview as follows;

> *Our people in the communities do not seem to be aware of the effects of climate change. They even seem not to know what climate change is all about but then we have started the awareness creation as to what climate change is and what it tends to do to us* (KI, Yendi, 2020).

It was expected that farmers in Yendi Municipality will be better exposed to climate change information than their counterparts in the Nanumba South due to their exposure to media outlets in the Region. An explanation to this could be insufficient number of extension agents. Both Yendi Municipality and the Nanumba South have equal number of extension agents (4 each), meanwhile the Yendi Municipality is about twice the size of the Nanumba South in terms of land size. Commenting on the insufficiency of extension agents, the Yendi Municipal Director of Agriculture had this to say;

> *One of the challenges we face here is inadequate staff, but I will blame it on inequitable distribution. For example, Nanton, a newly created district and about one-third the size of our Municipality has twice the number of extension agents that we have. The fewer number of extension agents has significantly impacted negatively on extension-farmer contact in the Municipality.* (KI Yendi, August, 2020).

Farmers poor access to extension contact is likely to affect their knowledge and perception of climate variability and climate change. Adusei (2016) noted that access to extension contact is an important factor that affects farmers' perception of climate change.

The implication of poor awareness of climate change especially among respondents in the Yendi Municipality is that farmers are less likely to take adaptation measures and this could affect yam production.

### 4.5.2 Source of Climate Change Information

Getting information on climate is very crucial for being aware of the changes in the climatic condition of an area. Similarly, farmers source of climate change information is critical in determining the relevance of the information relative to the farmers' context. Sources such as local radio stations, district agricultural officers as well as friends and relatives are more likely to present information that is locally specific and contextually relevant to the needs of the receiver than a national television or radio that presents a more general information.

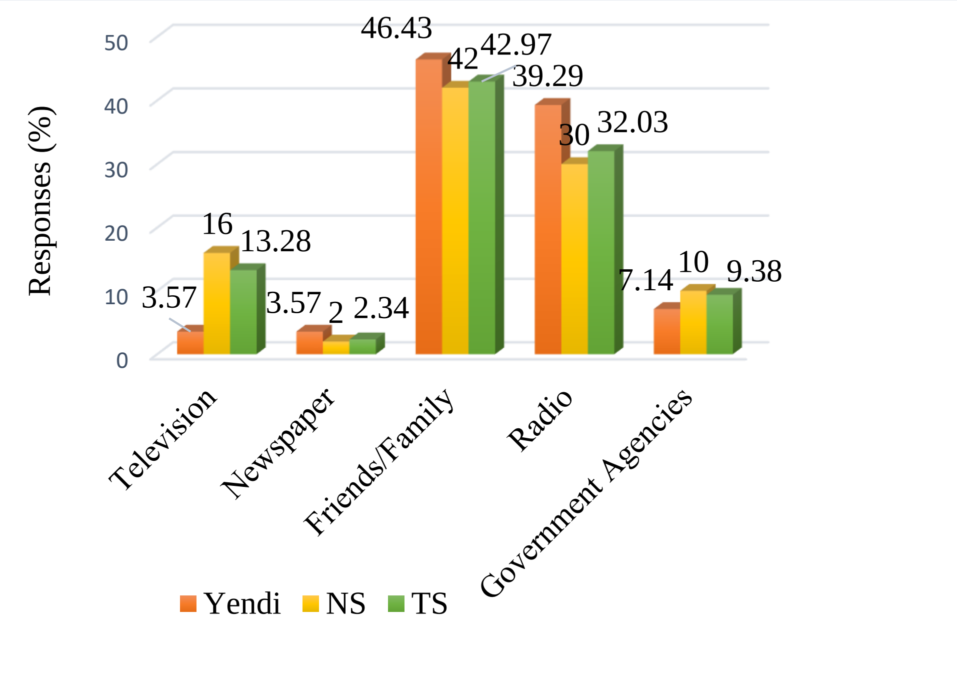



**Figure 4.5: Respondent's Source of Climate Change Information**

Source: Field Survey, 2020

Respondents were asked to indicate their sources of climate change information; that is, television, newspaper, radio, government agencies or friends and family members. The results have been presented in Figure 4.22.

From Figure 4.22, 42.97% of the total respondents get their climate information from their friends and family members. The second major source is the radio. Thirty-two percent (32.03%) of the total respondents, listen to radio as a source of climate information. Television ranks third with 13.28% of the total respondents relying on that source for climate and weather information. Only 9.38% and 2.34% of the respondents get their climate related and weather information from government agencies and newspapers respectively.

The implications of this finding are that policies aimed at creating climate change awareness will get wider coverage if directed through radio programmes and probably community fora rather than through television and newspapers. It also implies that government institutions especially, the Ministry of Food and Agriculture have not been active in promoting climate change awareness among farmers. This is consistent with Adusei (2016) that 73.6% of farmers interviewed mentioned the radio as their main source of information on climate change.

The poor reliance on newspapers as sources of information on weather and climate could be attributed to the cost of newspapers which cannot be easily afforded by ordinary farmers (Müller-Kuckelberg, 2012) as well as high illiteracy rates in the two districts. As indicated in Table 1 of section 4.1, over 62% of the total respondents have not had formal education.

### 4.5.3 Belief in Climate Change

Belief in climate change has popularly been demonstrated as one cognitive factor contributing to adaptation intention. Often times perceptive behaviours are driven by personal beliefs on the truth or otherwise of a given phenomenon.

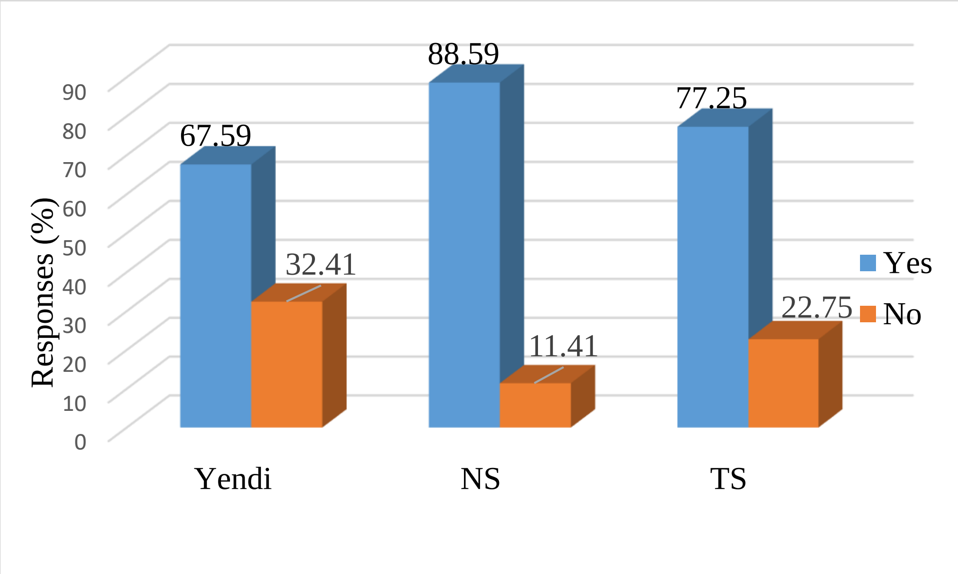



**Figure 4.23: Respondent's Belief in the Reality of Climate Change**

Source: Field Survey, 2020

The strength of belief in climate change has empirically been justified to significantly influence the adaptive behaviour of smallholder farmers (Uddin et al. 2017). Respondents were asked whether they believe that climate change is a reality. Their responses are presented in Figure. 4.23.

It can be seen in Figure 4.23 that majority (77%) of respondents believe that climate change is a reality. Only 23% of the respondents were of the view that climate change is not real. Comparatively, the belief in the reality of climate change is stronger among respondents in Nanumba south than those of the Yendi Municipality.

Almost 89% of respondents in Nanumba South as against 68% in the Yendi Municipality believe that climate change is real. This is understandable because as stated earlier, as much as 87% of respondents in the Yendi Municipality compared to about 46% of their counterparts in the Nanumba South has never heard of climate change. It is therefore inferred that the belief in climate change is associated with the knowledge of climate change.



### 4.5.4 Perceived Drivers of Climate Variability and Change

Previous studies attributed common drivers of climate variability and change to natural processes such as the El Niño and La Niña events, volcanic eruptions and sunspots, human actions that contribute to the modification of the atmosphere or spiritual forces such as the will of God (Ume, Ezeano, et al. 2018). The aim of this study was to find out the extent to which respondents agree with the statements that human action, spiritual forces or natural forces are the drivers of climate variability and change.

**4.5.4.1 Human Action as a Driver of Climate Variability and Change**

In Table 4.6 A, a majority of respondents in Yendi Municipality (59.72%) and 58.15% in the Nanumba South strongly agreed that climate variability and change is caused by human activities. About 35.65% of respondents in Yendi Municipality and 24.46% of their counterparts in the Nanumba South agreed that climate variability and change is caused by human action. Only 9.3% and 3.7% of respondents in the Yendi Municipality disagreed and strongly disagreed whilst in the Nanumba South 7.61% and 9.24% also disagreed and strongly disagreed respectively that climate change is caused by human action.

This is what a key informant had to say about human action as a driver of climate variability and change;

> *The activities of our farmers also contribute to climate change. Some of the activities like charcoal burning, indiscriminate burning of bushes, indiscriminate harvesting of wood are the businesses of some people. They have to harvest the wood or burn the charcoal to get their livelihoods. And I have realized that even with that if you were to discourage them then you have to find an alternative to what their*

*livelihood has been. Otherwise, you can't do anything. You can't stop them.*

*Even the way we do our land preparation contributes to the negative effects of climate change. Some farmers ploughed not across the slopes but rather along the slopes. Tractor operators also cause problems because they do not do the proper land ploughing. They just do it anyhow and then you enter an arable crop field and then you see that there are a lot of gullies scattered. All these activities cause a lot of erosion when we have major rains resulting in nutrient depletion.* (KI Yendi, 2020).



The findings imply that respondents are aware that their activities also contributing to climate change. With this knowledge, farmers are likely to support local level actions that will mitigate the effect of climate change.

**4.5.4.2 Spiritual Forces as Drivers of Climate Variability and Change.**

Some smallholder farmers have attributed the causes of climate variability and change to spiritual forces. As can be seen in Table 4.6 A, most (33.33%) of the respondents in the Yendi Municipality and 35.87% in the Nanumba South agreed that climate change is caused by spiritual forces whilst 21.76 and 19.02% from the two districts respectively strongly agreed.

On the other hand, 28.70% and 0.93% of respondents in the Yendi Municipality disagreed or strongly disagreed that spiritual forces are the cause of climate variability and change respectively. Similarly, 25% and 17.93% of respondents in the Nanumba South disagreed and strongly disagreed respectively that spiritual forces are responsible for climate variability and change. From Yendi Municipality and Nanumba South 15.28% and 2.17% respectively were uncertain. From the total sample, a little over 50% of respondents at least agreed that spiritual forces are drivers of climate variability and change whilst a little over 40% either disagreed, strongly disagreed or uncertain.



According to Nyanga et al.et al. (2011) some farmers argue that non adherence to God's principles and disrespect of ancestral spirits and other customs are the causes climate change. This finding is also consistent with Kuruppu & Liverman (2011) but contradicted Nti (2012) that some farmers think that climate change has no spiritual inclination.

According to an informant;

> *We were told that the cutting of some old trees in the wild is what accounts for the changing and variable climate. Others say it is the work of God. For me some of the causes are by the act of God. Others too are by our own doing.* (KI, Nakpachie, 2020).

**Table 4.6 A: Perceived Drivers of Climate Variability and Change**

| Human Action | | SA | A | U | D | SD | T | Mn | RM |
|---|---|---|---|---|---|---|---|---|---|
| **Climate Change is Caused by Human Action** | | | | | | | | | |
| Yendi | Freq. | 129 | 77 | 0 | 2 | 8 | 216 | | |
| | % | 59.72 | 35.65 | 0 | 0.93 | 3.70 | 100 | | |
| NS | Freq. | 107 | 45 | 1 | 14 | 17 | 184 | | |
| | % | 58.15 | 24.46 | 0.54 | 7.61 | 9.24 | 100 | | |
| TS | Freq. | 236 | 122 | 1 | 16 | 25 | 400 | 2 | A |
| | % | 59.00 | 30.50 | 0.25 | 4.00 | 0.25 | 100 | | |
| **Climate Change is Caused Spiritual Forces** | | | | | | | | | |
| Yendi | Freq. | 47 | 72 | 33 | 62 | 2 | 216 | | |
| | % | 21.76 | 33.33 | 15.28 | 28.70 | 0.93 | 100 | | |
| NS | Freq. | 35 | 66 | 4 | 46 | 33 | 184 | | |
| | % | 19.03 | 35.87 | 2.17 | 25.00 | 17.93 | 100 | | |
| TS | Freq. | 82 | 138 | 37 | 108 | 35 | 400 | 3 | U |
| | % | 20.50 | 34.50 | 9.25 | 27.00 | 8.75 | 100 | | |
| **Climate Change is Natural and Normal Phenomenon** | | | | | | | | | |
| Yendi | Freq. | 111 | 89 | 14 | 0 | 2 | 216 | | |
| | % | 51.39 | 41.20 | 6.48 | 0 | 0.93 | 100 | | |
| NS | Freq. | 118 | 58 | 0 | 4 | 4 | 184 | | |
| | % | 64.13 | 31.52 | 0 | 2.17 | 2.17 | 100 | | |
| TS | Freq. | 229 | 147 | 14 | 4 | 6 | 400 | 2 | A |
| | % | 57.25 | 36.75 | 3.50 | 1.00 | 1.50 | 100 | | |

SA- Strongly Agree=1, A- Agree=2, U- Uncertain=3, D- Disagree=4, SD- Strongly Disagree=5, T- Total, Mn- Mean, Yendi-Yendi Municipality, NS- Nanumba South District, TS- Total Sample, RM.' Remarks

Source: Field Survey, 2020

#### 4.5.4.3 Climate Variability and Change as Natural and Normal Phenomenon

Whilst many believe that climate variability and change is driven by either spiritual forces, human activities or both, a section of farmers think that climate variability and change is just a normal and natural process that is bound to happen irrespective of human or spiritual intervention (Nyanga et al. 2011). That being said, participants were asked to indicate the extent to which they agree with the notion that climate change is natural and normal process. Their views are presented in Table 4.6.

From Table 4.6 A, it can be noticed that a majority of respondents (51.39%) in Yendi Municipality and 64.13% in the Nanumba South District strongly agreed that climate variability and change is a normal and natural phenomenon. In addition, 41.20% and 31.52% in the Yendi Municipality and Nanumba South respectively, agreed with the assertion. Less than 8% of respondents in the Yendi and less than 6% of respondents in the Nanumba South either disagreed, strongly disagreed or were not certain that climate change is just a normal and natural phenomenon.

Generally, overwhelming majority (94%) of the total sample at least agreed that climate change is a normal and natural phenomenon. Based on these findings, it can be concluded that farmers in the two districts believe that climate variability and change is partly driven by human actions, spiritual forces and partly as a natural phenomenon.



#### 4.5.4.4: One Sample t – test for Drivers of Climate Variability and Change

To ascertain that the sample mean scores are representative of the population means, one sample t-test was conducted and the results are presented in Table 4.6 B. It can be seen from the table that the mean score for human action as a driver of climate change is 1.64 (std. 1.013) with a t-value of 32.384 and a significant p-value of 0.000. The significant p-value is indicative of the fact that the sample mean is not different from the population mean, which means that respondents generally agree that human action is a driver of climate.

**Table 4.6 B: One Sample t – test for Drivers of Climate Variability and Change**

| Statement | Mean | Std. Deviation | T | df | P<0.05 |
|---|---|---|---|---|---|
| Human action | 1.64 | 1.013 | 32.384 | 400 | .000 |
| Spiritual | 2.69 | 1.300 | 41.409 | 400 | .000 |
| Natural | 1.53 | .748 | 40.842 | 400 | .000 |

1 = SA; 2 = A; 3= U; 4 = DA; 5 = SDA

Source: Field Work, 2020.

Similarly, the mean score for the statement 'climate variability and change are caused by natural and normal phenomena' is 1.53 and rounds off to 2 (std. 0.748 with a t-value of 40.842 and a significant p-value of 0.000. This implies the sample mean is representative of the population mean and that generally, the respondents agree that climate variability and change is a natural and normal phenomenon.

The statement that climate variability and change is caused by spiritual forces had a mean score of 2.69 rounded up to 3 (std. 1.300) with a t-value of 41.409 and a significant p-value of 0.000. This implies that the sample mean is representative of the population mean and that respondents were generally not certain that climate variability and change is caused by spiritual forces.



### 4.5.5 Human Actions that Contribute to Climate Variability and Change

Previous studies have elaborated on the contribution of human activities to climate variability and change. Whist the UNFCCC has attributed climate variability and change to the consequences of direct and indirect human activities (Sadiq, 2013), the Australian government blames climate change on human induced greenhouse gases (Rahman, 2013). Both the Yendi Municipal and the Nanumba South District Assemblies have attributed climate related challenges to indiscriminate bush burning, over exploitation of forest resources and overgrazing (Yendi Municipal Assembly, 2013; Nanumba South District Assembly, 2015). Respondents of the study were therefore asked to indicate their agreement or disagreement on whether indiscriminate bush burning, deforestation, overgrazing, over exploitation of fuelwood, and wrongful use of agrochemicals contribute to climate variability and change. The results have been presented in Table 4.7 A.

**4.5.5.1 Indiscriminate Bush Burning Contributes to Climate Change**

In Table 4.7 A, respondents were asked whether they agree that indiscriminate bush burning contributes to climate change. It can be seen from the Table that a majority of respondents (54.63% and 61.41%) in the Yendi Municipality and the Nanumba South respectively strongly agreed that indiscriminate bush burning contributes to climate change. This was followed by 40.74% and 27.72% of respondents from the Yendi and Nanumba South respectively who agreed to the statement. Less than 1% of respondents in the Yendi Municipality and about 10% of their counterparts in the Nanumba South either disagreed or strongly disagreed that bush burning contributes to climate change. About 4% (3.70%) and 0.54% of respondents from Yendi and Nanumba South respectively, were uncertain as to whether bush burning contributes to climate change. This means that the awareness that indiscriminate bush burning contributes to climate change is very high among yam farmers in the two districts since 95.37%

and 89.13% of respondents of the two districts at least agreed with the statement.

The findings fall in line with Mngumi (2016) in his study in Tanzania that;

> *forest fires have reduced the density of the Kindoroko Forest Reserve, hence exposing the water catchment to direct sunlight leading to increased evaporation. This has resulted in a decline in the volume of running water in many of the springs and streams that originate from this forest.*

**4.5.5.2 Deforestation Causes Climate variability and change**

Elijah, et al. (2018) and Ume, et al. (2018) identified deforestation as one of the activities that accelerates climate change. Tesfahunegn, et al. (2016), noted that deforestation is perceived by farmers as the number one cause of climate change. It was based on these statements that this present study was set out to find out the level of agreement by smallholder yam farmers that deforestation causes climate variability and change.

As can be seen in Table 4.7 A, a majority (51.25%) of respondents strongly agreed that deforestation has resulted in climate variability and climate change in their areas. This was followed by 44.75% who agreed with that assertion. Only a small minority of the respondents (0.50% and 2.00%)

disagreed and strongly disagreed that deforestation causes climate change whilst 1.50% were not certain on the consequences of deforestation on climate change.

There are no major differences on the perceived role of deforestation as driver or enhancer of climate variability and climate change. For instance, 96.76% and 95.11% of respondents in the Yendi and Nanumba South respectively agreed that deforestation causes climate variability and change.

A key informant explained the situation in the narration below;

*We are aware that the cutting down of trees is what accounts for the changing and variable climate. So instead of cutting down trees we have been advised to rather plant trees.* (KII, Nakpachie, 2020).

The implication drawn from indiscriminate bush burning also applies here. These findings confirm Elijah et al. (2018) and Abdoulaye (2017) that deforestation is one of the major perceived causes of the variable and changing climatic conditions.

**Table 4.7A: Human Actions that Contribute to Climate Variability and Change**

| | | SA | A | U | D | SD | T | Mn | RM |
|---|---|---|---|---|---|---|---|---|---|
| **Bush Burning Contributes to Climate Change** | | | | | | | | | |
| Yendi | Freq. | 118 | 88 | 8 | 1 | 1 | 216 | | |
| | % | 54.63 | 40.74 | 3.70 | 0.46 | 0.46 | 100 | | |
| NS | Freq. | 113 | 51 | 1 | 7 | 12 | 184 | | |
| | % | 61.41 | 27.72 | 0.54 | 3.80 | 6.52 | 100 | | |
| TS | Freq. | 231 | 139 | 9 | 8 | 13 | 400 | 2 | A |
| | % | 57.75 | 34.75 | 2.25 | 2 | 3.25 | 100 | | |
| **Deforestation Contributes to Climate Change** | | | | | | | | | |
| Yendi | Freq. | 99 | 110 | 6 | 0 | 1 | 216 | | |
| | % | 45.83 | 50.93 | 2.78 | 0 | 0.46 | 100 | | |
| NS | Freq. | 106 | 69 | 0 | 2 | 7 | 184 | | |
| | % | 57.61 | 37.50 | 0 | 1.09 | 3.80 | 100 | | |
| TS | Freq. | 205 | 179 | 6 | 2 | 8 | 400 | 2 | A |
| | % | 51.25 | 44.75 | 1.5 | 0.5 | 2.00 | 100 | | |
| **Overgrazing Contributes to Climate Change** | | | | | | | | | |
| Yendi | Freq. | 89 | 87 | 5 | 12 | 23 | 216 | | |
| | % | 41.20 | 40.28 | 2.31 | 5.56 | 10.65 | 100 | | |
| NS | Freq. | 71 | 74 | 0 | 24 | 15 | 184 | | |
| | % | 38.59 | 40.23 | 0 | 13.04 | 8.14 | 100 | | |
| TS | Freq. | 160 | 161 | 5 | 36 | 38 | 400 | 2 | A |
| | % | 40.00 | 40.25 | 1.25 | 9.00 | 9.50 | 100 | | |
| **Fuelwood Harvesting Contributes to Climate Change** | | | | | | | | | |
| Yendi | Freq. | 107 | 97 | 10 | 2 | 0 | 216 | | |
| | % | 49.54 | 4.91 | 4.63 | 0.93 | 0.00 | 100 | | |
| NS | Freq. | 83 | 58 | 14 | 17 | 12 | 184 | | |
| | % | 45.11 | 31.52 | 7.61 | 9.24 | 6.52 | 100 | | |
| TS | Freq. | 190 | 155 | 24 | 19 | 12 | 400 | 2 | A |
| | % | 47.50 | 38.75 | 6.00 | 4.75 | 3.00 | 100 | | |
| **Application of Agrochemicals Contributes to Climate Change** | | | | | | | | | |
| Yendi | Freq. | 101 | 100 | 11 | 1 | 3 | 216 | | |
| | % | 46.76 | 46.30 | 5.09 | 0.46 | 1.39 | 100 | | |
| NS | Freq. | 40 | 65 | 14 | 43 | 22 | 184 | | |
| | % | 21.74 | 35.33 | 7.60 | 23.37 | 11.96 | 100 | | |
| TS | Freq. | 141 | 165 | 25 | 44 | 25 | 400 | 2.05 | A |
| | % | 35.25 | 41.25 | 6.25 | 11.00 | 6.25 | 100 | | |

Source: Field Survey, 2020

#### 4.5.5.3 Overgrazing as Driver of Climate Change

Reports from the Ministry of Food and Agriculture (MoFA, 2017) show that the number of animals in Ghana is increasing. Cattle, sheep and goats for instance, have increased significantly over the years and this has put pressure on the available grazing space. Ghana has over 13.5 million hectares of agricultural land, 58% of which is currently under cultivation (MoFA, 2017). The remaining 42% is has become pasture land for large ruminants. Large animals, especially cattle serve as sources of methane gas emission (Ministry of Environment, Science, Technology and Innovation, 2015). The dry conditions of northern Ghana coupled with overgrazing by livestock has exposed the environment to adverse effects of climate change (Kuivanen et al. 2016). In view of this the study sought to find out the views of respondents about overgrazing as a driver of climate change.

In Table 4.7 A, it can be seen that a little over 80% of the total respondents at least agreed that overgrazing is one of the drivers of climate change. Nine percent (9.00%) and 9.50% disagreed and strongly disagreed with the assertion whilst 1.25% were not certain. The finding in both districts follow a similar trend with significant majority (81.48%) of respondents in the Yendi Municipality and 78.81% in the Nanumba South are either in strong agreement or at least agreed that climate change is partly caused by overgrazing. On the other hand, only 16.21% and 21.19% of respondents in the Yendi and Nanumba South respectively disagreed and strongly disagreed that overgrazing causes climate change.

This is what participants at a focus group discussion said about overgrazing as driver of climate change;

> *In the past we did not have so many animals in this area, the environment was very grassy, there were lots of trees and our water bodies were very clean. With the influx of Fulani people and their animals the story has changed. They have overgrazed the land to the extent that it is almost bare. They cut down branches of trees for their animals and they leave those branches around so in the dry season the affected trees get burnt by bush fires. Because of these activities there is an increase in heat especially during the warm season making life unbearable for people.* (FGD, Montanaya, 2020).

This finding falls in line with that of Teye,et al.et al. (2015) that

> *…….in most cases, the behaviour identified as a root cause of declining rainfall and rising temperatures was of a general nature, such as overgrazing and harvesting trees for firewood. While some of the farmers rightly identified economic activities such as overgrazing and wood harvesting, as the factors responsible for climate change in the area.*

#### 4.5.5.4 Fuelwood Harvesting as a Driver of Climate Variability and Change

The present study sought to find out the extent to which yam farmers in the study area agree with the statement that fuelwood harvesting contributes to climate change.

In Table 4.7 A, respondents were asked to indicate their level of agreement with the statement that fuelwood harvesting contributes to climate change. From the Table, 49.54% and 44.91% of respondents in the Yendi Municipality strongly agreed and agreed that fuel harvesting contributes to climate change. In the same way 45.11% and 31.52% of respondents in the Nanumba South strongly agreed and agreed that fuelwood harvesting contributes to climate change. About 1% and 9.24% of the respondents in the Yendi Municipality and Nanumba South respectively disagreed with the assertion. About 6.52% of the respondents in the Nanumba South strongly disagreed whilst 7.61% in same district and 4.63% in Yendi were not certain. High levels of illiteracy coupled with endemic poverty have made it difficult for the people to explore alternative sources of energy. Overwhelming majority therefore rely on firewood and charcoal as the only available and affordable sources of energy. Cooking, both for domestic and commercial purposes is done with sole reliance on firewood and charcoal. As a result, charcoal burning and cutting of firewood has become very lucrative business activities where several truckloads of fire wood and or charcoal could be seen heading to the major towns and cities both within and outside the districts.

These findings imply that by trying to meet their livelihood needs the activities of the farmers are also accelerating climate change and this is consistent with previous studies which highlighted the contribution of fuelwood harvesting to climate change. In a study on “farmer perceptions and climate change adaptation in the West Africa Sudan savannah”, Callo-concha (2018) found that most of the respondents (83%) were of the view that cutting of trees contribute significantly to climate change. In a similar study, temperature increases and diminishing rainfall were attributed to the commercialization of firewood industry (Teye, et al.et al. 2015).

#### 4.5.5.5 Excessive Application of Agrochemicals as a Cause of Climate Change

The use of agrochemicals by farmers is not a new thing. Many farmers in the past used chemicals either to enhance yield or to control pest and rodent attacks on their crops. Some of these chemicals that were found to be detrimental to the environment were later prohibited or banned. In recent times, farmers are subscribing to the use of agrochemicals not just as pesticides but for weed control and also to hasten the maturity of crops. The harmful effects of these chemicals have been widely publicised and many farmers are well aware of their side effects both to human health and to the environment. According to Tesfahunegn, et al. (2016), a lot of farmers in Ethiopia are aware that the use of excess agrochemicals on farmlands contributes to climate change. Dimmie (2016) observed that the use and misuse of agrochemicals has a long-term negative effect on the climate. These studies have highlighted the adverse effect of agro-chemicals on local climates.

When participants were asked the extent to which they agree with the statement that the use of agrochemicals contributes to climate change, most of the respondents (46.76% and 46.30%) in the Yendi Municipality as shown in Table 4.7 A strongly agreed and agreed respectively, that the application of agrochemicals causes climate change. Similarly, 21.74% and 35.33% in the Nanumba South at least agreed that the application of agrochemicals causes climate change. Only 1.85% of respondent yam farmers in the Yendi Municipality as against 35.33% of their counterparts in the Nanumba South either disagreed or strongly disagreed that agrochemical application causes climate change. In both the Yendi Municipality and the Nanumba South districts respectively, 5.09% and 7.61% of respondents were uncertain as to whether the application of agrochemicals causes climate change.

The excessive use of agrochemicals by farmers has been confirmed by one of the AEAs as follows;

> *The farmers are overusing the agrochemicals and it is affecting the soil. Though they have been warned, the problem is that they have difficulties getting labour. He doesn't have labour to weed the whole place so he just uses the chemicals anyhow. You see somebody using the chemicals this week, the following week or just two weeks he uses the same chemicals on that same plot again*. (KI Yendi, 2020).

It can be deduced from the analysis that the perceived effects of agrochemicals on climate change is higher among yam farmers in the Yendi Municipality than that of the Nanumba South. Several factors have accounted for the different levels of perception among the two districts. The first is accessibility. Agrochemicals, be it weedicides, pesticides or insecticides are more readily accessible to farmers in the Yendi Municipality than their counterparts in the Nanumba South. The major chemical companies like Garnorma, Wumpini Agrochemicals, Masara N' Ariziki, and Iddisal in Tamale are approximately 96 km away from the Yendi Municipal capital and have several distribution outlets both in the Yendi township and many other areas in the Municipality. Wulensi, the Nanumba South District capital on the other hand is approximately 187 km away from these chemical companies and much fewer distribution outlets than that of Yendi.

The proximity to chemical sellers and distributors will definitely impact on cost as transport which is likely to be passed on to the consumer and will be lower for farmers in Yendi Municipality than those in Nanumba South. That being the case, cost of agrochemicals will be lower in Yendi Municipality, more affordable and hence more likely to be overused than in the case of the Nanumba South. Given this scenario, the impact of excessive use of agrochemical would be felt much more in the Yendi Municipality than the Nanumba South District.

Another possible reason for the different levels of perception among the two districts is environmental in nature. The climatic conditions in the Municipality are much drier and more fragile with mean annual rainfall of 1125mm and temperature range of 15$^{o}$C. The Nanumba South District on the other hand, has a mean annual rainfall of 1200mm with a temperature range of 12$^{o}$C. This means that Yendi Municipality is more prone to climate change than the Nanumba South District (YMA, 2013; NSDA, 2015). That could explain why soils in the Municipality are unable to tolerate high doses of agrochemicals as perceived by the respondent yam farmers.

#### 4.5.5.6 One Sample t – test for Human Activities that Contribute to Climate Variability and Change

The results of one-sample t-test for human activities that contribute to climate variability and change are presented in Table 4.7 B. The results indicate that bush burning as a contributor to climate variability and change has a mean score 1.58 which rounds off to 2 (std. 0.894) with a t-value of 35.48 and a significant p-value of 0.000. This implies that the sample mean score is representative of the population mean and that respondents generally agree that bush burning is a driver of climate variability and change.

**Table 4.7 B: One Sample t – test for Human Activities that Contribute to Climate Variability and Change**

| Statements | Mean | Std. Deviation | t | df | P<0.05 |
|---|---|---|---|---|---|
| Bush burning | 1.58 | .894 | 35.48 | 400 | .000 |
| Deforestation | 1.57 | .739 | 42.59 | 400 | .000 |
| Overgrazing | 2.08 | 1.273 | 32.66 | 400 | .000 |
| Fuel wood harvesting | 1.77 | .971 | 36.44 | 400 | .000 |
| Application of agro-chemicals | 2.12 | 1.185 | 35.78 | 400 | .000 |

1 = SA; 2 = A; 3= U; 4 = DA; 5 = SDA

Source: Field Work, 2020

Similarly, deforestation with the mean score 1.57 and rounded off to 2 (std. 0.739) with a t-value of 42.59 and a significant p-value of 0.000, overgrazing with the mean score of 2.08 and rounded off to 2 (std. 1.273) with a t-value of 32.66 and a significant p-value of 0.000, application of agro-chemicals with the mean score of 2.12 and rounded off to 2 (std. 1.185) with a t-value of 35.78 and a significant p-value of 0.000 as well as fuelwood harvesting with mean score of 1.77 and rounded to 2 (std. 0.971) with a t-value of 36.44 and a significant p-value of 0.000 are all representative of the population means and indicate that respondents generally agree that these human activities contribute to climate variability and change.



### 4.5.6 Perceived Indicators of Climate Change

The respondent farmers were asked to agree or disagree with the statements that decreasing rainfall, increasing temperature levels, recurrent violent storms increased incidents of floods and droughts are indications of the changing and variable climate. The outcome of the responses is captured the following presentation.

#### 4.5.6.1 Decreasing Rainfall is an Indicator of Climate Change

This study sought to find out the extent to which respondents agree with statements that decreasing rainfall, increase in temperature, frequent violent winds, increased incidence of floods and droughts are indicators of climate variability and change.

In Table 4.8 A, most (47. 50%) of the respondents in the total sample strongly agreed that decreasing trend of rainfall is one of the indicators of a changing climate. About forty-four percent (44.75%) agreed, 1.5%, 0.75% and 5.50% respectively disagreed, strongly disagreed or were uncertain as to whether decreasing trend of rainfall is an indicator of climate change. The perception that rainfall pattern has shown a decreasing trend is stronger among farmers in the Nanumba South than that of the Yendi Municipality. About 57% of respondents in the Nanumba South as against 39% in the Yendi Municipality strongly agreed to the assertion.

The notion that rainfall pattern has assumed a decreasing trend was supported by members during a focus group discussion in the following narration;

> *These days the rain starts late and ends early, and even when it rains and we plant, those of us who plant early, the time the crops need moisture it won't rain and the crops may fail. For example, for a long time it has not rained in this community. It was only three days ago that we had some rains* (FGD, Gbungbaliga, 2020).

The perception that rainfall has been decreasing is supported by meteorological data which shows a consistent decline in annual distribution over the last three decades with January, November and December becoming dry consistently over the past three decades (see figures 4.14, 4.15, 4.16 and 4.17). This findings confirm similar findings by Mngumi (2016:111) where 74% of farmers interviewed in Tanzania identified the declined in rainfall as an indicator of climate change.



**4.5.6.2 Increase in Temperature Levels is an indicator of Climate Change**

One of the most important indicators of climate change is temperature change. Most authors (Morton, 2007; Treut et al. 2007; Johnston, Hoanh, Lacombe, Noble, Smakhtin, Suhardiman, Kam Suan Pheng, and Sze, 2010) have confirmed a gradual and systematic rise in global temperature resulting in global warming. At the local level farmers' observation on the rising heat and the extension of the duration of the warm season goes to confirm an increase in temperature.

As is indicated in Table 4.8 A, 53.8% and 42.93% of respondents in the Nanumba South strongly agreed and agreed respectively that temperature levels have increased. This represents about 96.7% of total respondents in the district. In the Yendi Municipality, 35.19% and 26.85% respectively strongly agreed and agreed that temperature level increases are indicators of climate change.

Thirty-six point five-seven percent (36.57%) and 1.63% of respondents in the Yendi and Nanumba South respectively were not certain. These results suggest that temperature rise is more felt by respondents in the Nanumba South as compared to respondents in the Yendi Municipality. This could probably be due to the fact that being traditionally part of the transition zone, climate change impact is now gradually being felt by residents in the Nanumba South District. With the mean score of 2.41, increase temperature levels have been agreed on by respondents as an indicator of climate change.

The view that temperature levels are on the rise was shared by the Nanumba South District Director of Agriculture as follows;

*Though I have not stayed here for long, what I have learnt is that this used to be a transitional zone where temperatures were not high as other places in the North but now the temperature is high as any other place in the north.* (KI, Wulensi, 2020).

Farmers feeling that there is increasing levels of heat is supported by temperature values in figures 4.18, 4.19 and 4.20. which show that both the maximum and minimum as well as the average temperature levels have been rising since the beginning of the last decade.

**Table 4.8 A: Indicators of Climate variability and change**

| | | SA | A | U | D | SD | T | Mn | RM. |
|---|---|---|---|---|---|---|---|---|---|
| **Decrease in rainfall is an indicator of Climate Change** | | | | | | | | | |
| Yendi | Freq. | 85 | 108 | 20 | 2 | 1 | 216 | | |
| | % | 39.35 | 50.00 | 9.26 | 0.93 | 0.46 | 100 | | |
| NS | Freq. | 105 | 71 | 2 | 4 | 2 | 184 | | |
| | % | 57.06 | 38.59 | 1.09 | 2.17 | 1.09 | 100 | | |
| TS | Freq. | 190 | 179 | 22 | 6 | 3 | 400 | 2 | A |
| | % | 47.50 | 44.75 | 5.50 | 1.50 | 0.75 | 100 | | |
| **Increase in temperature levels is an indicator of Climate Change** | | | | | | | | | |
| Yendi | Freq. | 76 | 58 | 79 | 3 | 0 | 216 | | |
| | % | 35.19 | 26.85 | 36.5 | 1.39 | 0 | 100 | | |
| NS | Freq. | 99 | 79 | 3 | 2 | 1 | 184 | | |
| | % | 53.81 | 42.93 | 1.63 | 1.09 | 0.54 | 100 | | |
| TS | Freq. | 175 | 137 | 82 | 5 | 1 | 400 | 2 | A |
| | % | 43.5 | 34.25 | 20.50 | 1.25 | 0.25 | 100 | | |
| **Frequent Violent Strong Winds is an indicator of Climate Change** | | | | | | | | | |
| Yendi | Freq. | 81 | 48 | 85 | 0 | 2 | 216 | | |
| | % | 37.50 | 22.22 | 39.35 | 0 | 0.93 | 100 | | |
| NS | Freq. | 88 | 65 | 10 | 20 | 1 | 184 | | |
| | % | 47.83 | 35.33 | 5.43 | 10.87 | 0.54 | 100 | | |
| TS | Freq. | 169 | 113 | 95 | 20 | 3 | 400 | 2 | A |
| | % | 42.25 | 28.25 | 23.75 | 5.00 | 0.75 | 100 | | |
| **Increased Incidence of Floods is an indicator of Climate Change** | | | | | | | | | |
| Yendi | Freq. | 58 | 60 | 90 | 7 | 1 | 216 | | |
| | % | 26.85 | 27.78 | 41.67 | 3.24 | 0.46 | 100 | | |
| NS | Freq. | 66 | 74 | 13 | 24 | 7 | 184 | | |
| | % | 35.87 | 40.22 | 7.07 | 13.04 | 3.80 | 100 | | |
| TS | Freq. | 124 | 134 | 103 | 31 | 8 | 400 | 2 | A |
| | % | 31.00 | 33.50 | 25.75 | 7.75 | 2.00 | 100 | | |
| **Increased Incidence of Droughts is an indicator of Climate Change** | | | | | | | | | |
| Yendi | Freq. | 68 | 48 | 97 | 3 | 0 | 216 | | |
| | % | 31.48 | 22.22 | 44.91 | 1.39 | 0 | 100 | | |
| NS | Freq. | 99 | 75 | 5 | 3 | 2 | 184 | | |
| | % | 53.80 | 40.76 | 2.72 | 1.63 | 1.09 | 100 | | |
| TS | Freq. | 167 | 123 | 102 | 6 | 2 | 400 | 2 | A |
| | % | 41.75 | 30.75 | 25.50 | 1.50 | 0.50 | 100 | | |

Source: Field Survey, 2020.

The findings are consistent with Teye, et al. (2015) where 84.2% of farmers interviewed in the northern region of Ghana noted an increase in temperature levels; Tripathi & Mishra (2017) where most of the Indian farmers who participated in the FGDs reported a gradual increase in warming. It however, contradicted that of (Donkoh and Amikuzuno, 2012) which shows no perceived significant change in temperature.



#### 4.5.6.3 Increased Frequency of Violent and Strong Winds is an Indicator of Climate Change

Respondent were asked to state the extent to which they agreed with the statement that increased frequency of violent storms is an indicator of climate change.

As indicated in Table 4.8 A, 37.50% and 47.83% of respondents in the Yendi Municipality and the Nanumba South respectfully strongly agreed that one of the indicators of climate change is an increase in frequency of violent winds. In Nanumba South, 35.33% as against 22.22% of respondents in the Yendi Municipality agreed that an increase in the frequency of strong and violent winds is an indication of a changing climate. As high as 39.35% of respondents in Yendi Municipality as against only 5.43% in Nanumba South were not sure whether increased frequency of strong winds is an indicator of climate change. From Table 4. 8, it can be deduced that the impact of strong winds is much felt in the Nanumba South as compared to the Yendi Municipality.

Residents at Kpanso No. 1, a community in the Nanumba South District had this to say in relation to the effects of violent winds;

> *This community had a lot of trees when we were young but most of them have been uprooted by strong winds. There was one particular storm that toppled over forty big trees and destroyed over twenty houses in the community. Today you can see that most of the houses have no trees to provide shade so most of the people stay in their rooms in the afternoon during the dry season. If there were trees as was the case in the past by now you will see a lot of young people playing and chatting under them* (FGD, Kpanso No.1, 2020).

Trees form part of critical assets in every community. Apart from providing shade for residents against the scorching sun, they also serve as rallying points where meetings are held to share experiences and ideas after a hard day's work. Some farmers hang their seeds meant for the following seasons on the trees to avoid rodent attacks.

**4.5.6.4 Increased Incidence of Floods is an Indicator of Climate Change**

In rural areas, floods are generally caused by prolonged rainfall, high intensity of short heavy rains or a diversion of water ways. Studies show that climate change is likely to increase flood risk in certain parts of the world (Rosenstock & Nowak, 2019). For example, studies in southern Nigeria have identified flooding as a major outcome of climate change (Chukwuone, 2015). Floods are also counted as one of the major causes of crop loses (Alpuche, 2015).

In Table 4.8 A, respondents were asked to indicate whether increasing incidence of floods is one of the indicators of climate change. From the Table it can be seen that a majority of the respondents (40.22%) in Nanumba South agreed that increasing incidence of floods is an indicator of climate change. On the contrary a majority of respondents in the Yendi Municipality were not certain whether increased incidence of floods is an indicator of climate change.

It can be seen from the Table that as high as 76.09% of respondents in the Nanumba South at least agreed that increased incidence of floods is an indicator of climate change compared to the Yendi Municipality, where 54.63% of the respondents at least agreed with the statement.

It can be concluded from the findings that the issue of flooding is of serious concern to residents in the Nanumba South than their counterparts in the Yendi Municipality. The explanation to this could be linked to the geography of the two districts. Unlike Yendi which is drained by only the river Dakar, the Nanumba South is drained by both the Dakar and Oti rivers. These two rivers together with their tributaries could be the contributory factor to the flood perception among residents in the Nanumba South District. This is what a key informant in Sakpegu said about floods:

> *Floods now frequently destroy our farms. This year my yam farm was destroyed by floods. There were three heavy rains that we had continuously for three days and my yam farm was completely submerged* (KI, Sakpegu, 2020).

This implies that in spite of the perceived decrease in rainfall, farmers still see floods as an obstacle to yam production. This is probably due to the intensity of major rains.

#### 4.5.6.5 Increased Incidence of Droughts is an Indicator of Climate Change

Droughts, which are symptoms of prolonged periods of moisture deficit have been associated with both climate change and climate variability. With respect to climate change, some farmers feel that the frequency of drought have increased over the years (Ume, et al. 2018). In respect of climate variability many farmers felt that droughts have become too unpredictable. A majority (53.80%) of respondents in Nanumba South strongly agreed that increased incidence of drought constitute one of the important trademarks of climate change, whilst 40.76% agreed with the assertion. In the Yendi

Municipality, however, 31.48% and 22.22% respectively strongly agreed and agreed that increased frequency of drought is an indicator of climate change. Here again it can be seen that the perception of increased incidence of drought is higher among respondents in the Nanumba South than that of the Yendi Municipality. As much as 44.91% as compared to 2.72% in the Nanumba South were uncertain about whether indeed increased incidence of drought is an indicator of climate change. The following statement by a key informant confirms the perceived increase of drought incidence among respondents;

> *Droughts are more frequent now than previously. In the past the amount of rainfall was sufficient enough for us but currently the time you least expect that there will be drought, that is the time you experience drought. In the past the rain could exceed the expected duration. Now the rain doesn't start early. Even sometimes our crops get short of moisture* (KI Sakpegu, 2020).

From the analysis it could be seen that farmer's perception of increased drought incidence as a climate change indicator is higher among respondents in Nanumba South than their counterparts in Yendi Municipality. This is in spite of the fact that the Nanumba South has a more favourable climate for yam cultivation compared to the Yendi Municipality. One sure explanation is probably the fact that the effect of climate change on the lives of farmers could be more pronounced in Nanumba South given the fact this area used to enjoy a more favourable transitional zone which is now being replaced by a drier guinea savannah form of climate.

#### 4.5.6.6: One Sample t – test for Indicators of Climate Variability and Change

Table 4.8 B shows the results of one-sample t-test for the indicators of climate variability and change as presented in Table 4.8A. It can be seen in Table 4.8 B that the mean score for decrease in rainfall as an indicator for climate variability and change is 1.63 which rounds off to 2 (std. 0.723) with a t-value of 45.259 and a significant p-value of 0.000. The significant p-value implies that the sample mean is not at variance with the population mean and that respondents generally agree that decrease in rainfall is an indicator for climate variability and change.



**Table 4.8 B: One Sample t – test for Indicators of Climate Variability and Change**

| Statements | Mean | Std. Deviation | t | df | P<0.05 |
|---|---|---|---|---|---|
| Decrease in rainfall | 1.63 | .723 | 45.239 | 400 | .000 |
| Increase in tempt. level | 1.80 | .823 | 43.772 | 400 | .000 |
| Freq. Strong winds | 1.94 | .961 | 40.374 | 400 | .000 |
| Increase in floods | 2.16 | 1.017 | 42.519 | 400 | .000 |
| Increase drought | 1.88 | .874 | 43.143 | 400 | .000 |

1 = SA; 2 = A; 3= U; 4 = DA; 5 = SDA

Source: Field Work, 2020

Similarly, all the other indicators that is, increase in temperature whose mean score is 1.80 and rounded off to 2 (std. 0.823) with t-value of 43.772 and a significant p-value of 0.000, frequency of strong winds with the mean score of 1.94 and rounded off to 2 (std. 0.961) with a t-value of 40.374 and a significant p-value of 0.000, increase incidence of floods with the mean score of 2.16 and rounded off to 2 (std. 1.017) with a t-value of 42.519 and a significant p-value of 0.000 as well as increase incidence of droughts with mean score of 1.88 and rounded to 2 (std. 0.874) with a t-value of 43.143 and a significant p-value of 0.000 are all representative of the population and indicate that respondents generally agree that these phenomena are indicators of climate variability and change.



### 4.6 Perceived Effects of Climate Variability and Change

In section 4.5, the perception of climate variability and change was discussed and it was revealed that the major perceived drivers of climate variability and change were human action, spiritual intervention and natural environmental processes. It was also established that deforestation, overgrazing, bush burning, fuelwood harvesting and the use of agro chemicals are the major human activities that trigger climate change. Finally, a decrease in rainfall, increase in temperature, increased frequency of violent strong winds and increased frequency of drought and flood were identified as the main indicators of climate change. This current section discusses the perceived effects of climate variability and change on yam production. Issues discussed include changes in the land cover, changes in land clearance, effects on mounding, planting, mulching, staking, weed control, harvesting and storage.

### 4.6.1 Effects on Vegetation, Soils and Water Bodies

To appreciate the effect of climate variability and change on yam farming, it is imperative that we understand the changes in the land and vegetational cover of the localities in which the yam farming takes place. This is because unlike other crops, yam farming as indigenous activity, relies largely on the resources found in the local environment. The grasses to be cleared, the stakes and shrubs for mulching among others are all land cover resources whose presence or otherwise directly impact yam farming activities.

#### 4.6.1.1 Disappearance of Some Plant and Animal Species

Respondents were asked to identify land cover changes that have occurred in their localities. In Table 4.9, 83.80% of respondents in the Yendi Municipality as against 60.87% of their counterparts in the Nanumba South said some of the plants and animals that were very common in the past have either disappeared or are hard to see these days. They cited grass cutters, antelopes, squirrels as animals you will hardly see in the localities currently. This was corroborated by members at a focus group discussion as follows;

> *The number of wild animal species has dwindled. In the past you will encounter a lot of animals on your way to and from the farm but hardly will you encounter even one today*. (FGD, Montanaya, 2020).

In a related focus group discussion, participants expressed the following view;

> *The vegetation has been depleted due to population expansion. We used to have elephant grasses all over but of late most of them have disappeared. All you see now are short, tiny grasses that are densely packed together*. (FGD, Nasamba, 2020).

Whilst some of the respondents blamed the situation on the changing and variable climate, others thought it is as a result of population growth and reduction of fallow periods. A personal observation suggests that the invasion of cattle herdsmen in the area has contributed to the disappearance of most of the plant and animal species. The findings on the loss of vegetation confirms that of Obeng (2005) that the grass species that used to be so common have reduced drastically in numbers and in their places other species have emerged.

**Table 4.9: Land Cover Change (Multiple Responses)**

| Effects of CV & C | Yendi | | NS | | TS | |
|---|---|---|---|---|---|---|
| Variable | Freq. | % | Freq. | % | Freq. | % |
| Disappearance of some plant and animal species | 181 | 83.80 | 112 | 60.87 | 293 | 73.25 |
| Snails are no longer as common as they were years ago | 124 | 57.41 | 99 | 53.80 | 223 | 55.75 |
| Earthworms are no longer common as they were 20years ago | 138 | 63.89 | 136 | 73.91 | 274 | 68.50 |
| Decline of soil productivity/fertility | 177 | 81.94 | 135 | 73.37 | 312 | 78.00 |
| Drying up of water bodies | 180 | 83.33 | 116 | 63.04 | 296 | 74.00 |
| | | | Mean = 2.03 | | SD – 1.142 | |

Source: Field Survey, 2020

Footnote: CV & C - Climate Variability and Change

Unlike the local herders who graze their animals only during the day time, the Fulani herdsmen graze theirs both day and night. This intense grazing depletes the vegetation and disturbs the habitats of the animals forcing most of them to relocate. Those who may not be able to relocate easily fall prey to hunters and other predatory animals.

Some local farmers rely on native plants and animals for useful weather information (Ashish 2014). The disappearance of these plants and animals implies that farmers' ability to adjust to the changing weather conditions is hampered and that could affect productivity.



#### 4.6.1.2 Snails and Earthworms are no Longer Common as They Were 20 Years Ago

A majority of the respondents were also of the view that these day's snails and earthworms are not very common as they were in the past. Snails and earthworms thrive in moist humid areas. The drier an area becomes chances are that these creatures are likely to disappear. From Table 4.9, 57.41% and 63.89% of respondents in the Yendi Municipality held the view that snails and earthworms respectively are not easily found within their localities. In the Nanumba South, 60.87% and 53.80 were of the view that snails and earthworms respectively are not easily found in their communities as compared the situation 20 years ago. This finding is consistent with Mngumi (2016) that local farmers in Tanzania noted the disappearance of ground hornbill as one of the effects of climate change.

#### 4.6.1.3 Decline of Soil Productivity/Fertility

A significant majority (81.94%) of respondents in the Yendi Municipality and 73.37% in the Nanumba South thought that the soil fertility level and by extension the productivity of the soil has declined over the years as a result of climate change. Some were of the view that the excessive heat experienced these days has led to the death of some micro-organisms in the soils thus rendering it infertile and unproductive. Participants at a focus group discussion had this to say on soil fertility and productivity.

> *Before our meeting we had discussed among ourselves the decline in yam yield in this community. The soil fertility has gone down. Harvests are now lower than before. In the past the land could produce tubers that were so big that two or one and half of it could feed a household of ten to twenty-five people. Today you will use ten tubers but it cannot feed the same number of household members.* (FGD, Nasamba, 2020).

Personal observation in the study districts shows that there is general decline in soil suitable for yam cultivation. As a result of the recurrent droughts and early cessation of rainfall most yam farms have been relocated to lower grounds and more humid environments and since this type of lands are limited in supply, farmers are compelled to cultivate them over and over again leading to soil nutrient depletion. According to focus group participants;

> *In the past you could allow your land to fallow for several years before you return to it. But now because of the shortage of land suitable for yam farming, a family will often divide one piece of land among*

*themselves with each person getting one-acre. So, for every year you will be using the same piece of land allocated to you. That is why the land has lost its fertility*. (FGD, Gbungbaliga, 2020).

The declining fertility of the soils will definitely impact on yam output with direct consequences on the farmers whose livelihoods depend of yam farming. The findings confirm that of Dimmie (2016) that the continuous cultivation and declining rainfall has led to the loss of soil fertility.

#### 4.6.1.4 Drying Up of Water Bodies

Studies by Amadou, et al. (2015), Kumar et al. (2012) and Abdoulaye, et al. (2017) show that climate change has led to a gradual decline in precipitation levels with corresponding increase in desiccation throughout the Northern region. The phenomenon has resulted in an increase in the rate of evaporation and transpiration leading to drying up of water bodies and creating acute water shortages (Kumar et al. 2012; Obeng, 2005). In Table 4.9, 83.33% of respondents in the Yendi Municipality observed that climate change has led to the drying up of water bodies in their communities whilst in the Nanumba South District 63.04% of the respondents held the same view.

This is what an informant had to say on the drying up of water bodies;

> *Most of our water bodies have dried up because of the reduction of rainfall amounts. All the water holes in this community apart from 'Wobnapong' (elephant footprint) have disappeared. The amount of rainfall has reduced so the water holes do not collect water again. As for 'Wobnapong', it has water always.* (KI, Gbungaliga, 2020).

A similar sentiment was expressed by a focus discussion group at Montanaya as follows;

> *We have a number of wells but they don't yield water any longer. There is a pond we use but that one too the water level has reduced. There is also a stream which used not to dry but now it dries up during the dry season.* (FGD, Montanaya, 2020).

The drying up of water bodies in the district has resulted in acute water shortage with direct consequences on productivity. Some of the communities rely on streams, wells, ponds and springs for their water needs. As a result of the sustained desiccation most of the water sources are no longer productive.

The declining water levels and consequent reduction in moisture levels implies that the soil's ability to support the growth of yam is also being affected since yam is one the crops whose moisture requirements is high. The findings are consistent with the IPCC projection that 75 to 250 million people will be exposed to climate change related water stress by 2020 with yields of rain-fed agriculture reducing by up to 50% (Sadiq, 2013).

### 4.6.2 Community Resource Maps Depicting the Effect of Climate Change on Vegetation and Water Resources

Figures 4.24 and 4.25 represent community resource maps for Tusani in the Yendi Municipality and Kpanso in the Nanumba South District. In the figures, each of the communities is represented by two maps. Fig. 4.24a and 4.25a reflect how members saw their communities about twenty to thirty years ago. Figure 4.24b and 4.25b represent the current states of the community resources as seen by community members. Each of the maps has a key, title, cardinal directional indicator and a boundary.

According to the map key, objects shown on the maps could be classified into three, namely, vegetation, water bodies and man-made objects. The vegetation includes medium to large size trees, young trees and shrubs. The water bodies are streams and ponds. The man-made features are the dwelling compounds, wells, boreholes, schools, religious structures, roads, footpaths, farm tracks and farms. The interest for the present study, however, are the vegetation, the water bodies and the farms.

#### 4.6.2.1 Vegetation

It can be seen from figure 24 that Kpanso No. 1 community (figure 24a) has highly dense vegetation made up of large to medium size trees (prominent trees) both within and at the outskirts of the community. A forest comprising of highly dense population of young trees can also be found at the outskirts of the community and along the stream to the southeast of the community.

In Figure 4.24b, the forest cover has significantly reduced. The large to medium size trees are now widely spaced apart whilst young tree and twig numbers have significantly declined to the extent that they could not be represented on the map.

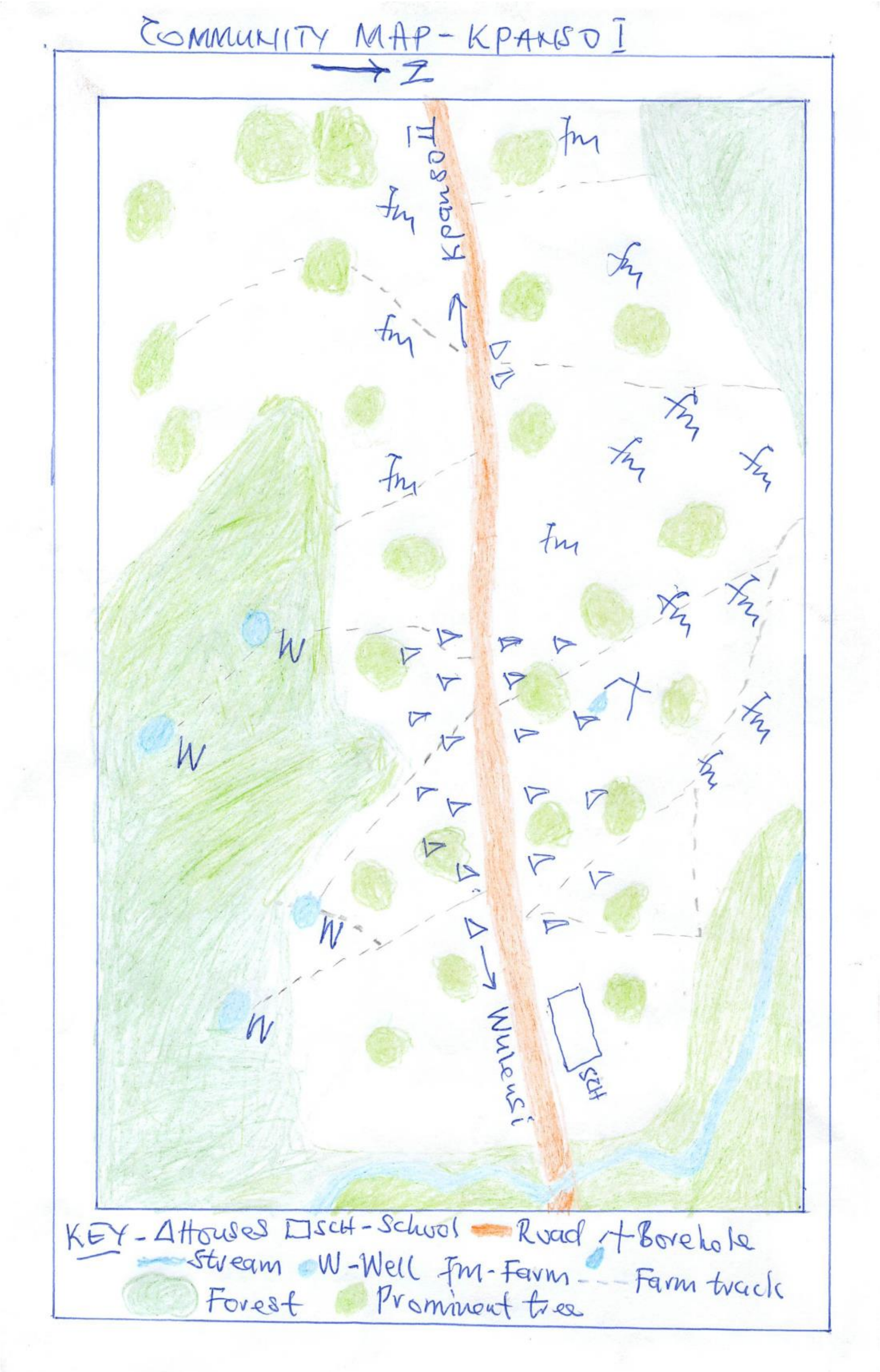



**Figure 4.6a: Kpanso Community Resource Map (20 – 30 years ago)**

Source: Field Work, 2020

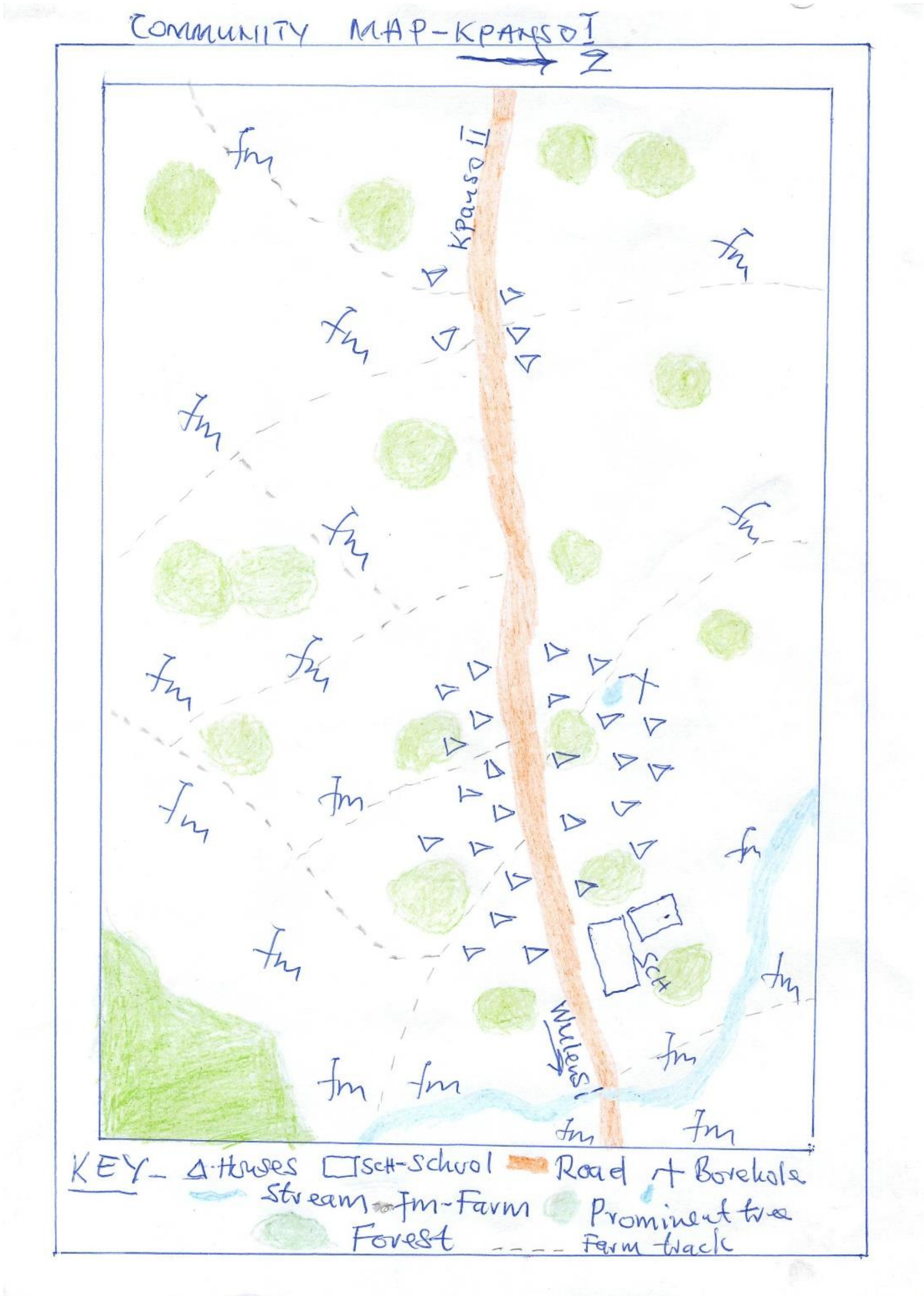



**Figure 4.24b: Current Kpanso Community Resource Map**

Source: Field Survey, 2020

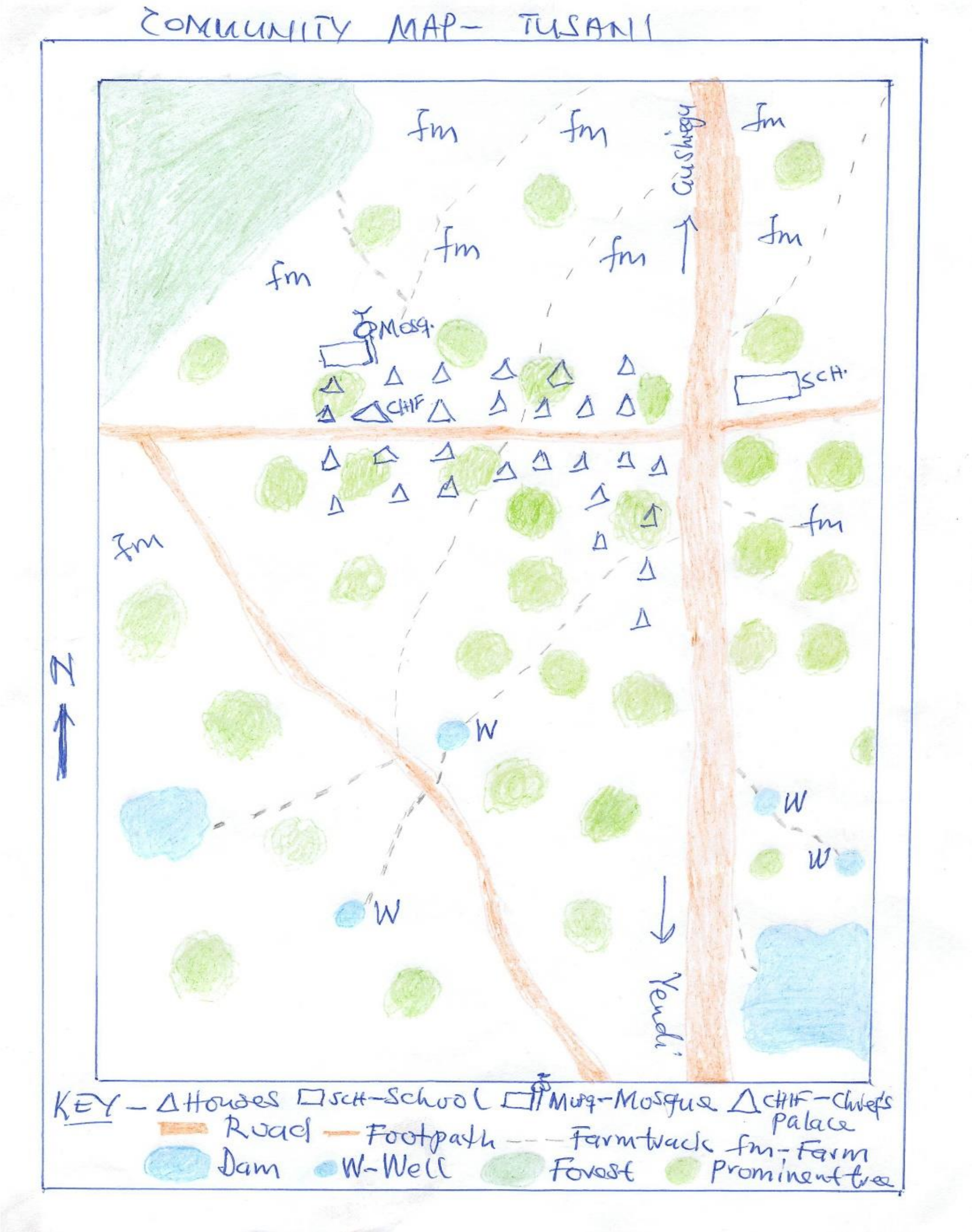



**Figure 4.7a: Tusani Community Resource Map (20 – 30) years ago**

Source: Field Work, 2020

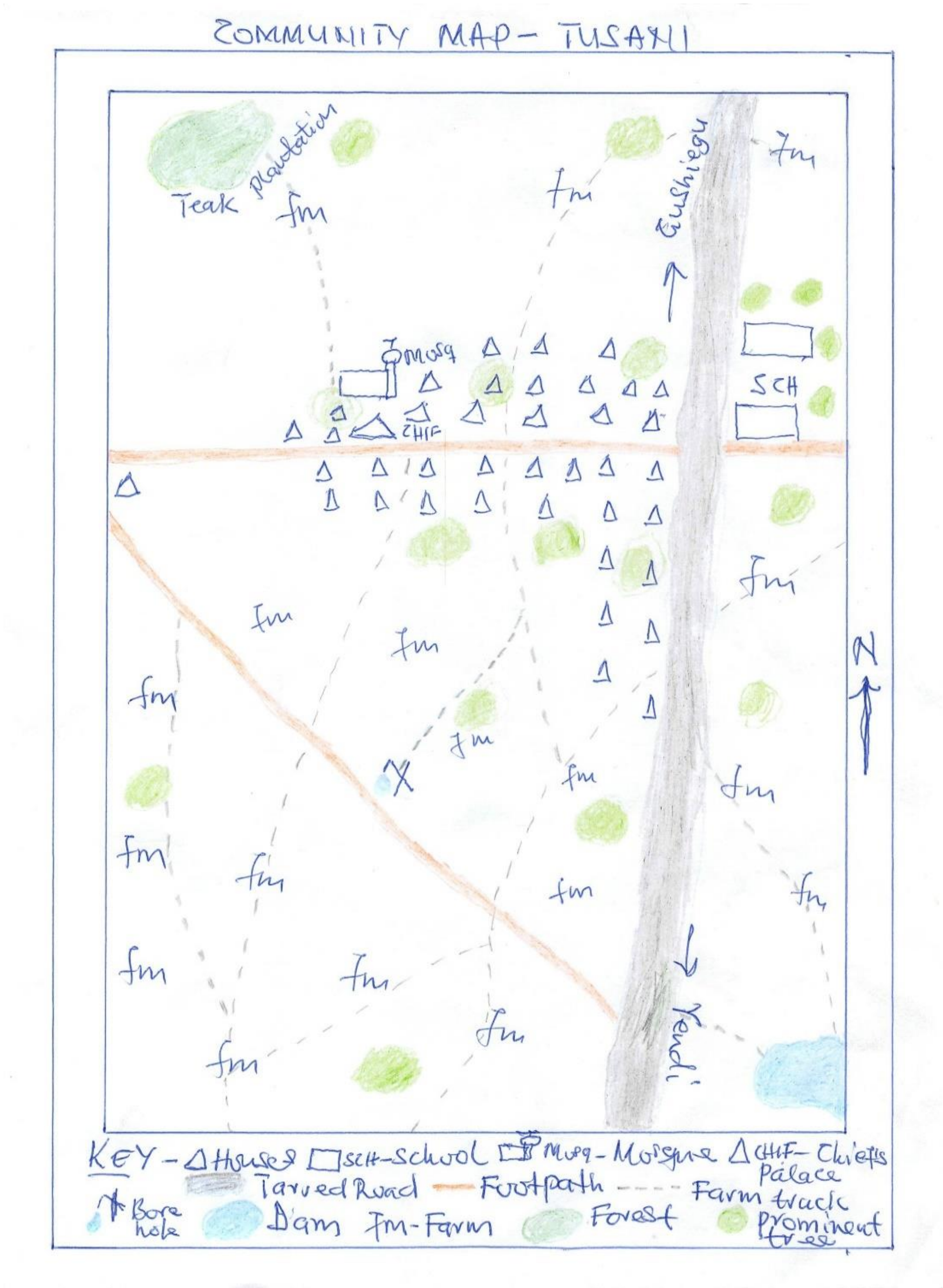



**Figure 4.25b: Current Tusani Community Resource Map**

Source: Field Survey, 2020

A similar situation exists in Tusani community of the Yendi Municipality where the vegetation in Figure 25a is moderately dense with large to medium size trees found within and at the outskirts of the community with a forest of young trees and shrubs located at the outskirts. Just as in Kpanso, the vegetation of Tusani has declined significantly in Figure 4.25b.

Several factors accounted for the decline in vegetation cover. Strong winds, increased desiccation, extension of farmlands and the activities of herdsmen are some few. This is what a member of a focus group discussion said about tress in Kpanso No. 1;

> *These days the wind is too strong. There used to be a lot of trees in this community but most of them have been toppled by the strong winds. Last year alone about four trees were uprooted by the wind. One of them was so old that even our grandfathers told us they came to meet it as a fully grown tree.* (FGD, Kpanso No.1, 2020).

Another member of a focus group discussion at Tusani said the following;

> *When we were still young the outskirts of this community were made up of a very thick forest. There were a lot of wild animals in that forest but because of how thick the forest was nobody could hunt them. However, because the rainfall has reduced, the place has become so dry that most of the forest have been destroyed by wild fires. For instance, five years ago there was a very severe drought that lasted for*

*two months. During the drought most of the plants died and were completely burnt during the dry season.* (FGD, Tusani, 2020).

There are other indirect effects of climate change on vegetation that have been explained by respondents. Under the fallow system or even the system of shifting cultivation, the land is allowed to rest for a certain number of years during which it is able to rejuvenate. This system allowed the vegetation to grow to their natural status. However, because of climate change, much of the land has been rendered unproductive, especially for yam. This resulted in shortage of land suitable for yam farming. Farmers were therefore compelled to continuously cultivate the remaining land and this contributed to the degradation and changes in vegetative cover in yam producing areas. A similar study by Chidumayo, Okali, Kowero, & Larwanou (2011) revealed that climate change has resulted in loss of forest cover of up to 57% in Juude Waalo and 40% in Aten, Mauritania and 41% in Banizumbi Niger.

Available data indicates that From 1975 to 2000, Ghana's agricultural lands have expanded from 13 percent in 1975 to 28 percent in 2000 and to 32 percent in 2013 (MoFA, 2017). The continued expansion of agricultural land has had adverse consequences on the natural vegetation cover.

A key informant at Nakpachie commented on change of vegetation cover in the following narration;

> *The vegetation cover has drastically reduced as a result of extension of farmlands. Wild animal species are also no longer common because their habitats have been taken over by farmlands*. (KI, Nakpachie, 2020).



#### 4.6.2.2 Water Bodies

The presence and quantum of water bodies in an area is determined by the amount of precipitation received and the level of temperature. Where precipitation levels are high, chances are that the amount of surface water is also likely to be high provided run off and evapotranspiration levels are held constant. Temperature levels directly affect the rate of evapotranspiration which in turn influences the water retention capacity of any given area (Obeng, 2005).

Topography of the land influences run off which in turn determines the amount of water that could be retained after precipitation. Both Tusani and Kpanso No. 1 are situated on generally low-lying grounds sloping gently towards the south in the case of Tusani and toward the east and south east at Kpanso No. 1. The water bodies for both communities, apart from the borehole in Kpanso No. 1, are all located at the lower parts of the slopes.

In figures 4.24 and 4.25 the water bodies of the two communities are highlighted clearly. A number of water bodies can be identified in Figure 4.24a for Kpanso community. Four hand dug wells can be sighted in the southern part of the map. There is a stream to the south east that crosses the Kpanso No. 1 – Wulensi road. There is also a borehole at the centre of the community which, together with the stream and wells, serve as sources of water for members of the community. Figure 4.24b community depicts the current state of the Kpanso No. 1 community, the four wells have completely disappeared. The stream and the borehole are what constitute the current sources of water in the community.

In Figure 4.25a of Tusani community, there are two wells and a mini dam in the south west as well as two wells and a dam in the south east. The whole of the southern part of the map is a lowland that is subjected to periodic flooding. In Figure 4.25b, however, the wells in the south west as well as those in the south east have all disappeared. Though the dam in the south east is captured in the current map the size appears to have shrunk.

Regarding changes in the distribution of water bodies in the community a member at a community forum in Kpanso said the following;

> *Until the borehole was constructed, we used to rely on the wells and the stream for our water needs. When we realized that the wells were*

*no longer providing sufficient water, we appealed for support to construct the borehole. Though the wells still provided water for some people, the amount of water they contain continued to dwindle. Now all of them have dried and silted up.* (FGD, Kpanso, 2020).

A similar statement was made by members of a focus group discussion in Tusani as follows;

*We used to drink from the wells until we were able dig a dugout that supplemented the wells. Later, government gave us a dam and we thought the water scarcity in the community had been resolved. Suddenly the wells started drying up and now all of them have been closed down. In placed of the wells the Municipal Assembly drilled a borehole around where the wells were.* (FGD, Tusani, 2020).

According to members of Tusani community, their main sources of water have remained the dam and the borehole.

The implications drawn from the drying up of water bodies in subsection 4.6.1.4 also applies here and confirms CEC (2009) prediction that climate change will cause significant changes in the quality and availability of water resources, affecting many sectors including food production, where water plays a crucial role.

The IPCC projects that several West African countries will move from being water surplus to a water deficit state by 2025 and that per capita availability of water is expected to decline by 60%.

#### 4.6.2.3 Farmlands

The drying up of the land and water bodies, as well as the decline of the vegetation cover have a lot of implications on yam farming activities. It has implications for the availability of yam sticks, shrubs for capping mounds, materials for storage and moisture availability for mounding.

Comparing Figures 4.24a and 4.25a for both communities, it could be seen that farmers initially cultivated on the high grounds, that is, the northern and western part of Kpanso No. 1 as well as the north east, northern and north western part of Tusani. In Figures 24b and 25b, it is noticed that the farms, most of which are yam farms, have been relocated to the eastern part of Kpanso No. 1 and in the case of Tusani, to the southern section of the community which are low lying areas. This is probably to take advantage of the declining moisture levels.

### 4.6.3 The Effect of Climate Variability and Change on Seasonal and Yam Cropping Calendar

As an indigenous African crop, yam production is generally tied to African traditional knowledge and practices handed from generation to generation. One of this is the well calculated seasonal calendar among the Dagomba ethnic group in the Northern region which has been widely accepted and used by yam farmers in the Yendi Municipality and the Nanumba South District albeit with some few modifications. Information received from key informants and a series of focus group discussions on the seasons have been put together in figure 4.26 as an annual yam growing calendar for the study area. The seasonal calendar has divided the year into ten seasons that are distinguished from one another by their characteristics. The seasons are the Gbanzhegu, Kabing, Bintra wolugu, Kikaa, Movilla Saa, Gungunlelgu, Woligu Saha, Salanga, Sigli and Sheg' ni. Among yam farmers, each season has its own peculiar farming and cropping activities.

The use of traditional cropping calendar in analysis of farmers' experience and adaptation to climate change is not new. Studying small scale farmers in northern Tanzania, Mngumi (2016) relied on the local cropping calendar to understand how farmers plan their farming activities. Similarly, Gay (2006) used seasonal calendars extensively in his study; "Vulnerability and Adaptation to climate variability and change" by farmers in Mexico and Argentina. Callo-concha (2018) and Tiyumtaba et al (2016) also made references to the use of seasonal calendars by small holder farmers in Burkina Faso and Ghana respectively. This study examined the effect of climate variability and change on the traditional yam farming system and the modifications farmers have made to enable them withstand the menace of climate variability and change. It further examined the extent to which climate change has affected the timing and consistency of the cropping calendar. Fig. 26 is the seasonal calendar for yam cultivation in the Northern Region of Ghana. Detail description of the seasons as indicated in the figure is captured in ensuing subsections.



#### 4.6.3.1 Gbanzhegu (Period during the rainy season when the grass is fully grown)

In focus group discussions at Nasamba, participants disclosed that the annual yam production cycle starts at "Gbanzhegu", that is from September to October. A description of the season is captured in the following narration;

> *The Gbanzhegu comes at the tail end of the rainy season and is characterised by intermittent rains with bright sunshine and high temperatures. The rains are accompanied by windstorms. By this time the grass, which used to be elephant grass type ("Gbangu"), was fully grown in height and usually bent towards the direction of the prevailing windstorm. Hence the name "Villigbang saa or*

*Gbangvillima saa (Rainstorm that flattens the otherwise upright grass).* (FGD, Nasamba, 2020).

| **Season** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gbanzhegu | | | | | | | | | | | | |
| Kabing | | | | | | | | | | | | |
| Bintra wolugu | | | | | | | | | | | | |
| Kikaa | | | | | | | | | | | | |
| Movilla Saa | | | | | | | | | | | | |
| Gungunlelgu | | | | | | | | | | | | |
| Woligu Saha | | | | | | | | | | | | |
| Salanga | | | | | | | | | | | | |
| Sigli | | | | | | | | | | | | |
| Sheg' ni | | | | | | | | | | | | |

**Figure 4.26: Seasonal Calendar for Yam Farming Activities in Northern Region**

Source: Field Survey, 2020

A key informant at Sakpegu corroborated this statement and added that this type of rain is quickly replaced by "Kapuya saa". According to him;

*The "Kapuya saa" is characterized by pronounced thunder and lightning. "Kapuya" is the stage of millet growth when the panicle* *is enclosed in the sheath of the flag leaf whilst "saa" means rain. The thunder and lightning, it is said, triggers the millet to release the panicle.* (KI, Sakpegu, 2020).

A Municipal Chief Yam Farmer for Yendi (2019) explained this in the following narration;

*There are certain yellow and black spotted beetles known locally as "sakaricheensi" that you will see in the bush around this time to indicate that it is time for land clearance.* (KI, Nakpachie, 2020).

In clearing their lands farmers made sure that the grass was evenly spread to cover the soil. The aim was to preserve moisture and protect the land from the scorching sun. As a result of changing and variable climate, it is now difficult for farmers to determine the timing and duration of "Gbanzhehu".

In a focus group discussion at Kabreya participants were of the opinion that:

*Sometimes the rains stop abruptly. Now we hardly even get the 'Kapuya saa'. When the Gbanzhegu is cut short like that you will see that the land easily gets dry making land clearing difficult. Most of us are not able to clear our lands now because the land easily dries up.* (FGD, Kabreya, 2020).

The abrupt ending of the Gbanzghegu implies that farmers do not get moisture to raise yam mounds and this could push back the period of mounding. The delay in mounding affects plating time and all other yam cultivation processes.



#### 4.6.3.2 Kabing (A short period of intense cold weather that follows the end of the rainy season)

The "gbanzhehu" is followed by "Kabing". This is characterized by intense chilly weather which lasts between two to three weeks. The Kabin falls within the milking stage of millet, that is when the panicle has just emerged from the sheath. According to a focus group discussion at Gbungbaliga;

> *The chilly weather ('Kabin ware') is meant to help the millet to form seeds. This period is used to prepare yam mounds. Farmers will initially burn the trash on the land through a process called controlled burning. By controlled burning farmers will estimate the size they can cultivate within a few days, three, four or five days. They then create a fire belt around it and burn. As and when they finish cultivating that piece, they burn another portion. The process continues until they finish mounding the whole field* (KI, Yendi, 2020).

A member of a focus group at Nasamba, described the period as follows;

*I remember by dawn we were already on the farm and the weather was so chilly that you will see everybody shivering from the cold weather. Immediately you start working you will not feel the cold again. By 11 am everybody would have raised about two to three hundred mounds and then close for the day.* (FGD Nasamba, 2020).

These days because of climate change the occurrence of "Kabin woare" has become unpredictable. In certain years, farmers do not even experience it at all. Other times it lasts for a very short time. An extension officer in Nanumba South observed that;

*These days the Gbanzhegu is mostly followed by a period of intense heat that lasts for a very long time and that when it happens this way farmers are not able to raise their mounds.* (KI, Wulensi, 2020).

The implication drawn under Gbanzhegu also applies here.



#### 4.6.3.3 Bintra Wolgu (A period of intense warm weather that precedes the Harmattan season)

The "Kabing woare" is followed by an intense warm and sunny period which lasts for two to three weeks. Local farmers call this period "*Bintra wolgu*". A key informant at Jagando described this period as follows;

*This is the season during which most plants develop flowers and the warm season is meant to help the plants transform the flowers into* *fruits. This period is used for the harvest of late yam and yam setts from the previous harvest. This period lasts within two weeks and is followed by the harmattan period (Kikaa saha).* (KI, Jagando, 2020).

**4.6.3.4 Kikaa Saha (The Harmattan Period)**

The harmattan is a period in which the dry North Easterly Winds prevail over most parts of West Africa. Cold and dry, the harmattan ("Kikaa") lasts for a period of three months. A key informant at Kabreya shared his experience as follows:

*farmers, most especially those who were able to prepare their mounds in the previous season use the period for planting their yams. At the same time of planting, farmers also cap their mounds with grass straw or shrubs to prevent moisture loss. Farmers who could not harvest their yams also continue to do so during the harmattan period. One advantage of planting in the harmattan as was done in the past is that when you keep the setts in barns for a long time by the time you plant in the next season the number of setts that will die in storage is usually more than the number that die in mounds. In recent times, because of the changes in the weather, some farmers are not able to prepare their mounds before the onset* *of the harmattan ("Kikaa") and so are unable to plant as well.* (KI, Nakpachie, 2020).

The effect of the changing and variability of the climate on the previous season ("Bintra Wolgu") also affect activities during harmattan. Farmers who could not plough their fields previously will certainly not be able to plant during this season.

#### 4.6.3.5 Movilla Saa (An isolated rain that occurs shortly after the annual bushfires)

Respondents believe that there is an isolated rain that falls immediately after the harmattan and known as Movilla saa. A full description of this rain is encapsulated in the following narrations;

> *This is usually the first rain after the annual bush fires and because the rain washes away the ashes of the burnt grass ("movilla"), it is normally referred to as "Movilla saa". The rain provides opportunity for farmers who could not raise their mounds in the previous seasons to do so. However, because of the changing weather, this rain has become irregular and unpredictable.* (KI, Tusani, 2020).

> *In recent times the "Movilla Saa" has not been regular. Sometimes for several years the "Movilla Saa" will not rain so even if it*

*eventually comes, we are caught unprepared and are unable to take advantage of it*. (KI, Kanjo East, 2020).

The implications for missing the "*Movilla saa"* could have dire consequences for farmers. The rains always present the last chance for farmers to plant before the beginning of the ensuing rainy season. When missed the opportunity to plant or even mound at this time, farmers have to wait till the beginning of the rainy season by which time the crops of those who planted early would have sprouted and started developing foliage. Late planting affects maturity and timing of harvest, development of setts and overall tuber quality.

#### 4.6.3.6 Gungunlelgu (A period of dry and dusty harmattan winds lasting at least a month)

This is a period of dry and dusty winds that blows across the northern part of Ghana. According to a key informant at Adibo, because the wind is dry, their onset facilitates the drying of silk cotton fruits ("gunguma") hence the name. Participants at focus group discussion in Kpanso 1 described the period in the following narration;

*This period is so dry and windy and this facilitate the burning of crop residues and any other unwanted material on the farm. As yam farmers we use this period to clear the previous year's yam fields*

> *known as "batandali" and later use those fields to plant cereals or legumes when rain starts. Some farmers also use the period to cut sticks to be used later on for sticking yam vines. If there are trees on the newly cleared field this is the time to burn some of them to reduce the amount of shade on the farm. The burnt trees are subsequently used to carry yam vines.* (FGD, Kpanso 1, 2020).

The implication drawn under the harmattan also applies to this season.

**4.6.3.7 Woligu Saha (Warm Season)**

Participants at a focus group discussion in Tusani described the "Woligu" in the following narration;

> *This period is characterised by intense heat with days and nights becoming warmer than before. We use this period to attend to our yam setts in storage. Whist in storage, the setts germinate and grow and if not attended to the growing seedlings gradually drain the seed of its water content and it dies eventually. When allowed to grow too long the vines get entangled with one another and it becomes difficult to sort out setts during the planting period. To prevent this, farmers constantly have to trim the vines in storage. We also inspect the barns to remove dead or rotten setts and tubers. In recent times the warm season seems to have extended beyond its normal period* (FGD, Montanaya, 2020).

The extension of the "*woligu saha*" (the warm season) implies that setts in storage are going to experience an extended shelf life which further expose them to the attacks of rodents, pest and diseases. Most of the setts are likely to rot due the heat. The extension of the heat period would also affect planted setts most of which will die in the mounds.



**4.6.3.8 Salagna (Early rain)**

Prior to the onset of the raining season, there is an isolated rain that usually prompts farmers that the raining season is eminent and that they need to start preparation for intense farming activities. Respondents called this rain "Salang saa", The description and significance of this period is encapsulated in the following narration;

> *The "Salang saa" facilitates the regeneration of vegetation after the long dry season. Shrubs grow and blossom. Often, we have to clear our fields of overgrown shrubs. The shrubs provide material for capping of mounds in case of farmers who are now planting their fields. Farmers who have not yet planted take advantage the rain to plant their setts or the case of those who could not raise their mounds to mound.* (FGD, Sakpegu, 2020).

Respondents noted that the "Salang saa" does not come regularly as it did in the past and that has negatively affected the yam calendar. According participants at a focus group discussion in Bago;

> *These days the "salang saa" is not reliable at all. At the time we expect it, it will not come at all. All that we see is clouds gathering and disappearing. Sometimes the clouds gather and instead of rain they rather produce wind to destroy our property. Whenever the "Salang saa" is skipped, the activities that were expected to be done at that time are carried over to "Sigli saha" putting pressure on us.* (FGD, Bago, 2020).

As indicated earlier, the "salagna" is the period that farmers who did not have the opportunity to either mound or plant to do so. When farmers miss the period, the activities of mounding are pushed to the next season, that is the "sigli saha". Apart from having to compete with other farming activities like the ploughing and planting of cereals, yams planted late mature late. Late maturity of yam has several effects. Farmers who harvest early get the highest market value for their produce than those who harvest at later times when there is a glut. The late maturity of earl yam, especially affects the development of yam setts.

**4.6.3.9 Sigli Saha (The onset of the rainy season)**

Participants at a focus group discussion in Kpanso 1 described "sigli saha" as follows;

> *"Sigli" signals the onset of the rainy season. Any rain that we have at this period is a known as "sigli saa". This is the time we clear the weeds and shrubs on the yam field. During weeding the mulching materials are remove from the mounds to ensure free flow of air into the mound and also to deprive dangerous reptiles and scorpions from using them as hiding places. In recent times mounding and planting is now done by some farmers during this period because the time you are expected to mound or even plant there will be no moisture.* (FGD, Kpanso, 2020).

In normal times farmers use the period to weed through their farms and attend to yam vines. Farmers who now plant at this time because they could plant at the earlier period suffer the same fate as stated under the "salagna saha" above.

**4.6.3.10 Sheg'ni (The peak of the rainy season)**

"Sheg'ni" is the peak of the raining season which lasts for three months approximately. It can also be described as the peak of the yam farming season because it is the period the vines blossom. Early yams are also harvested during this period. The major cultural practices undertaken by farmers during the period are described by focus group participants in the following narration;

> *After the first weeding in "sigli saha", the second and possibly the third weeding is done in "Sheg'ni". The early yam like the "laabako" and "kpuna" are harvested during this period. "Milking" the practice of harvesting yam early to pave way for the development of yam setts is also done during "sheg'ni". This season used to start as early as the sixth month after Christmas (June)and so there was always new yam in the market at this time. These days we can't even predict the time of the season. In certain years it comes in between July and August and other times between August and September.* (FGD Kabreya, 2020).

The late start of the rainy season affects the development and maturity of early yam and delays the harvest of new yam. Since yam is the staple food of the people in the study area, a delay in harvest affects food security and the overall livelihoods outcomes of farmers.

### 4.6.4 Effects of Climate Variability and Change on Yam Cultivation

Section 4.6.4 discusses the effects of climate variability and change on yam cultivation with reference to changing cropping calendar, issues associated with land clearance, mounding, planting, weed control and pest and disease management.

#### 4.6.4.1 Land Clearance

Table 4.10 indicates the effect of climate variability and change on yam farming activities. As shown in the Table, a majority of respondents in both the Yendi Municipality (97.22%) and the Nanumba South (86.96%) were of the view that land clearance for yam cultivation has become difficult in recent times than it was in the past. Respondents were of the view that climate change has led to the proliferation of weeds that were previously not known in the area and that unlike the native weeds, these alien weeds are difficult to clear manually. Previously farmers cleared their fields using the hoe and cutlass. The type of weed was elephant grass that grew tall and wide. This type of grass has been replaced with short and tiny bushes that are closely knit together making manual clearing very tedious. This view is encapsulated in the following narration;

> *Land preparation is now done by tractors. Those days we did it manually, we used a stick ('Fun dogu'). We used the stick to push down the grass before clearing. Because of the size of the grass if you were not very strong you will not be able to bend a stock of grass using the stick. But today the grass is so stunted that you cannot hold it and uproot it with a hoe so you have no option than to rely on a tractor to*

*plough the land for you. But the manual clearing was more beneficial than the mechanized clearing because those days the land was very productive and a small piece of land could yield a lot of tubers. Currently you will be lucky to harvest a thousand tubers from two thousand mounds.* (FGD, Gbungbaliga, 2020).

Another factor related to climate change is the reduction of fallow periods owing to the decline of lands suitable for yam production. The reduction fallow periods mean the grass is not allowed to regrow to its previous form. Consequently, some farmers have resorted to crop rotation where yam is rotated with legumes or cereals. In this case there is no need for land clearance. Farmers just plough the previous crop field. Other farmers have resorted to the use of weedicides.

A respondent has expressed this in the following narration;

*These days because of the effects of the climate change we hardly have such fallow lands where clearing have to be done before ploughing. They keep on rotating the lands that have been used already for, may be groundnuts or maize previously. And another thing is because of this lack of shrubs farmers easily use glyphosates to spray their yam fields these days before even ploughing. Some have decided to just spray when it is getting close to the farming season. When the rains* *start and the soils are moist, they just raise their mounds without necessarily using the tractor to plough*. (KI, Yendi, 2020).

Tractors are not very effective in a woody environment and as a result most of the trees are cleared to pave way for their operation. Farmers relying on tractors to clear their fields are therefore deprived of yam sticks that would have had if there were doing manual clearing. The loss of sticks affects yield since staked yams are found to produce better yields than the non-staked yams (Ennin, Issaka, Acheampong, Numafo, & Danquah, 2014).

#### 4.6.4.2 Delay in Raising Mounds Due to Early Cessation of Rains

One major perceived effect of climate variability and change is the shortened duration of the raining season. Many farmers have complained that the rains now stop earlier than normal and that affects late maturing yams. In Table 4.10, 83.33% of respondents in the Yendi Municipality as against 56.52% of their counterparts in the Nanumba South District have noted that the changing and variable climate has led to the delay in the raising of their yam mounds.

**Table 4.2: Effects of Climate Variability and Change on Yam Cultivation**

| Effects CV & C on Yam Production | Yendi | | NS | | TS | |
|---|---|---|---|---|---|---|
| Variable | Freq. | % | Freq. | % | Freq. | % |
| Difficulty in clearing new fields | 210 | 97.22 | 160 | 86.96 | 370 | 92.50 |
| Delay in raising mounds | 180 | 83.33 | 104 | 56.52 | 284 | 71.00 |
| Late start of rains | 204 | 94.44 | 153 | 83.15 | 357 | 89.25 |
| Proliferation of new weeds | 170 | 78.70 | 112 | 60.87 | 282 | 70.50 |
| Quality of seed is affected | 153 | 70.83 | 113 | 61.41 | 266 | 66.50 |
| Loss of crops due to droughts | 117 | 54.17 | 104 | 56.52 | 221 | 55.25 |
| Rotting of planted seeds | 216 | 100.00 | 134 | 72.83 | 350 | 87.50 |
| High storage loses | 216 | 100.00 | 148 | 80.43 | 364 | 91.00 |
| Wilting and drying of yam vines | 149 | 68.98 | 129 | 70.11 | 278 | 69.50 |
| Shortage of shrubs | 141 | 65.28 | 89 | 48.37 | 230 | 57.50 |
| Shortage of yam sticks | 137 | 63.43 | 70 | 38.04 | 207 | 51.75 |
| Late maturity of early yam | 210 | 97.22 | 149 | 80.98 | 359 | 89.75 |
| Shortage of suitable land | 89 | 48.37 | 161 | 74.54 | 250 | 62.50 |

Source: Field Data 2020 Multiple Responses

Judging from the seasonal calendar in figure 4.26, it can be realized that farmers usually raise their mounds between October and November during the “Kabin ware”. Due to climate change and climate variability the “Kabin” has become irregular and transient. As a result, the land easily dries up rendering mound making difficult. Some farmers disclosed that these days the rains sometimes cease as early as the “Gbanzhegu”. When that happens, most farmers are unable to clear their lands and raise their yam mounds.

Farmers who missed the “Kabin” usually take advantage of the isolated rain (Movilla saa) that comes around January to raise their mounds. The “Movilla saa” too has become very irregular and so most farmers now raise their mounds during the “Salang saa” (May), that is, if they are lucky to have that or during the “Sigli saa” (the beginning of the raining season in June).

The delay in raising mounds has direct effect on planting time which also has several consequences as noted by focus group participants;

> *We know that even if you store your yam in the house or in the barn in the dry season time, it germinates and it loses the moisture in it. So, when you plough very early and there is moisture in the soil and you plant, you will have your yam growing faster than those who will come*

*late to plant. So, your yield could be better. For example, if you were supposed to sow around February/March and as a result of the drought, you move the sowing to somewhere May, as it happened especially this year when some sowed around May. So, when you move sowing to May instead of around February/March, you are likely not to get your yam setts again for the following season. More so the more you delay sowing your yam setts, the more most of it will rot.* (FGD, Wulensi, 2020).

The delay in mounding and early cessation of rains and consequently late planting affect the maturity and development of tubers and setts. Consequently, it affects yields and livelihoods of farmers. The finding is consistent with Kumar et al. (2012) that beside water stress, the indirect effect of reduced rainfall on the release of nitrogen from soil organic matter and hence nitrogen deficiency in the yam crop was the major constraint to farmers.

**4.6.4.3 The Effect of Late Start of the Rains**

Yam is a crop species that does not do well in dry environments. In order to be successful, yams require moisture amounts that are adequate in quantity, reliable in supply and timely. Most farmers are of the view that climate change has affected the timeliness and reliability of the rainfall pattern.

In Table 4.10, majority of respondents (94.44%) in Yendi Municipality and 83.15% in the Nanumba South District have noted that the rains now start later than expected. According to the seasonal calendar on figure 4.26, the early rains known locally as "Salang saa" is usually expected in April whilst the main raining seasons is expected to begin in May. Climate variability and change has not only changed the trend of the rainfall pattern, it has also made it very unpredictable. Often times the rains do not come as expected or when they do they come very little.

The late start of the rains has an effect on the timing of harvest, development of tubers and yam setts and this view has been expressed by members of a focus group discussion as follows;

> *Rainfall pattern has changed. In the past after bush burning, there was rain after which we farm. That was "Movillah saa". We mound and plant. Thereafter another rain falls on the planted field. That time we level the previous year's yam mounds and plant corn. This time it doesn't rain that way. After ploughing the "Batandali", that is, the previous year's yam field,* we *return to the current planted field to clear shrubs to pave the way for the yam seedlings to sprout. We used to harvest yams much earlier than now. Those days when we harvest early yam (*milked) the setts developed very well but these days the setts don't develop that much*. (FGD, Kpanso No. 1).

*Milking is the practice of harvesting yams early, especially during the peak of the rainy season so that the plant can produce another set of tubers or tuber which is used as setts for subsequent planting. This practice applies to early yams like the *laabako, Puna and Nyame Nti.*

The implication drawn from this is that the late start of the rains affects the timing of harvesting early yam, the development of yam setts and consequently the cost and availability of setts in the following season.

The finding is consistent with Kumar et al. (2012) that;

> *yam yields in West Africa have generally declined due to delay in the onset of rains. It has however contradicted Elijah et al. (2018) that climate variability and change has no significant effect on the production of root crops.*



#### 4.6.4.4 Proliferation of Previously Unknown Weeds

One of the effects of climate variability and change is the invasion of alien weeds in the yam growing communities. Most farmers expressed concern about the proliferation of the new weeds since it has a negative effect on production. In Table 4.10 it can be seen that a majority (70.50%) of respondents in both study districts were of the view that climate change has led to appearance of previously unknown weeds. Whilst as many as 78.70% of respondents in the Yendi Municipality has noted the increasing proliferation of the alien weeds, 60.87% of their counterparts in Nanumba South have also observed a similar trend. Participants at focus group discussion have listed a number of these alien weeds as follows;

> *These days there are all kinds of weeds that that are alien to this area. For example, we have weeds like the "Gbaringbata, Kpaanfoe, 50/50, Condemn shiwaka, Naa ningbrin, Banyoli paana, paantulim, Baamogu, Kpunkpangon, Pehinyemari". Controlling these weeds is a very tedious exercise.* (FGD, Nasamba, 2020).

The names of some these weeds explain their nature and timing of their initial appearance. With respect to the weed called *50/50*, for instance, participants explained that;

> *this type of weed spreads its roots around the yam mount. If you try uprooting it by hand it cuts into two halves. If you insist on removing the remaining half, the roots will fetch almost half of the mound soil, hence the name 50/50. As for Banyoli paana, the name simply means the new comers in Nanumba language. This implies that the weed is new in the area.* (FGD, Nasamba, 2020).

The proliferation of weeds affects production in several ways. It increases the number of times farmers have to weed their farms; it affects the development of tubers as well as the cost of farm labour. This is what a member at focus group discussion had to say about the proliferation of weeds;

> *As for new weeds they are many. There are even some types of weeds we have never seen. When we used to weed manually, when you weed once by the time you weed for the second time the yams will be readying for harvest. But because the soil is almost dead, these days if you don't use weedicides, you may weed it three times and the yam may not be ready for harvesting or the weeds may completely take over the farm. For instance, on my second yam farm I had to level the mounds and convert it to soya bean farm and even so I had to push down the grass before I covered them with soil* (FGD, Gbungbaliga, 2020).

The emergence of these weeds has affected labour cost as is evident in the following narration;

> *When it comes to the time of weed control, cost of labour goes up because labourers always try to take advantage of the scarcity of labour to increase the cost of weeding* (KI, Yendi, 2020).

The implication drawn from this is that the proliferation of the new weeds has had an effect on the growth and development of tubers, cost of labour and an overall cost of production. The finding is in line with Obeng (2005) that the original vegetation has been taken over by weed species that are associated with degraded lands.

#### 4.6.4.5 Early Cessation of Rains and Its Effects Quality of Setts

Farmers generally cultivate two main types of yams, the early yam and the late yam. The early yam like the “Laabako”, “Juna Sheini” and “Onyame Nti” are harvested twice in a year, first by milking to allow the plant to produce setts for the next planting. The second harvest is done during the dry season when both the setts of the early yam and tubers of the late yam (“Afe Batua” and Water yams) are harvested. To get quality setts, two conditions must be met. First the yam must be harvested early enough so that the plant can get enough moisture to produce the setts. Secondly the duration of the raining season must be long enough to enable the setts to develop.

Of late many farmers have been complaining that the raining season is getting shorter and that their yams do not get enough moisture to mature effectively. For example, a majority (70.83%) of respondents in the Yendi Municipality were of the view that the early cessation of the rains has an effect on the quality of yam setts. Similarly, 61.41% of their counterparts in the Nanumba South District held the same view. A farmer explained that;

> *A sett that develops under good condition normally should be big enough to split into two or three and planted to a mound each. Of late because of the poor rains some of the setts are two small that you have to combine two or three setts to plant in one mound.* (KI, Kabreya, 2020).

The early cessation of the rains has an effect on the development of setts and tubers of late yam. Poorly developed setts imply low quality seed yam for the ensuing season which eventually affects the overall growth and development of the yam sector since quality of tubers is influenced by the quality of setts used for planting. The early cessation of the rains also affect planting since most farmers are not able to raise mounds. The development compels farmers to shift planting to the following season. Consistent with Cornet, Sierra, & Tournebize (2014) that;

> *plants which emerged early initiated their tuberization earlier in the growing season and reached higher maximum yield than those planted late*.

**4.6.4.6 Loss of Crops Due to Droughts**

One of the features of climate variability and change in African countries is recurrent droughts (Obinna, Thomas, Jenkins, Phillips, & Kantamaneni, 2017 & Jarawura, 2014). Droughts have become a major source of worry to yam farmers as they have become more frequent and unpredictable (Kumar et al. 2012) .

As can be seen from Table 4.10, 56.52% and 54.17% of respondents from the Nanumba South and the Yendi Municipality respectively, said they have experienced crop losses as a result of droughts. This was corroborated by a key informant at Yendi as follows;

> *Yam production has seriously dropped compared to previous times. I will recall about 5 or 6 years ago the rainfall that we received around here was so scanty and that resulted in most yam farmers losing their yam crops. Production wasn't good as the rains were not good. Most yam farms almost died out. From then to now production has seriously or drastically reduced. People had larger farms of about ten acres but because of the negative weather that we experienced they lost about half of their crops. Some even completely lost their yam farms. Some have tried to revive their fields but it has not been that easy because yam setts have become so scarce that they can't easily get the setts to start again. As a result of the scarcity of the yam setts, the cost of yam setts has risen so high. So, over all climate change has brought about a drastic reduction in yam production in the Yendi Municipality.* (KI, Yendi, 2020).

These findings imply that droughts pose a major threat to the yam farming sector and is consistent with Sagoe (2006) that prolonged drought increases the population of pests which destroy food crops in Ghana and Mngumi (2016) that Tanzanian farmers cultivating beans, sugarcane and bananas were badly affected by droughts.

**4.6.4.7 Rotting of Planted Setts Due to Excessive Heat (High Temperature)**

Studies show that climate change has induced temperature level increases especially in the tropics (Larminat, 2016). Temperature figures taken from the Yendi Office of the Meteorological Services Department (MSD) show that temperature levels in the study area have been rising (see figures 4.18 to 4.20). High temperatures correspond with increased levels of evapotranspiration that has significant impact of crop cultivation. Depending on the species, temperature levels between 25°C and 30°C are ideal for the growth of yam (Kumar, et al., 2012). High temperatures are detrimental to yam production especially the planted setts. Table 4.10 clearly demonstrate the perceived impact of high temperatures on planted yam setts. From the Table it could be seen that all the respondents in the Yendi Municipality were of the view that high temperatures have resulted in the rotting of their planted yam setts. A majority (72.83%) of respondents in the Nanumba South District also expressed a similar view. This view was supported by members at focus group discussion as follows;

> *It is the heat that is killing our yams. It does not have to take a long time to do this. Mostly the droughts take about 15 days but yam cannot tolerate that. Within the fifteen days the yam has already started forming roots and the drought sets in. In this case once there is shortage of moisture even if it takes less than ten days by the time it rains all the setts will have died. Most of us have lost our yams setts*

*this year because of the heat. Some even germinated and died with the seedlings.* (FGD, Gbungbaliga, 2020).

A member of focus group discussion at Wulensi had this to say

*Yams generally do not tolerate too much heat and even when you plant and there is too much heat in the mound it affects the setts. Most of them will die.* (FGD, Wulensi, 2020).

The implication drawn from the above finding is that setts that are even planted early are prone to high temperatures. The extended warm season and rising temperatures are detrimental to the survival of the yam sector.



**4.6.4.8 High Storage Losses**

Yams in storage are subjected to several factors, namely, heat wave, pest and rodent attacks and even theft. Climate variability and change has exacerbated these by increasing temperatures beyond the tolerant level of yams and extending the duration of the dry season. Due to the early cessation of the rains most farmers are unable to plant their yam setts and have to store until moisture is available. Most often the rains no longer come at the expected time. Most farmers are of the opinion that the dry season is now longer than it used to be.

Yams in storage, as stated earlier, are subjected to the menace of rodents, pest and even theft. The longer the dry season, the longer the yams remain in storage and are dissipated by the menace. Like the rotting of planted setts, the high storage losses are major source of concern to farmers. All (100%) respondents in the Yendi Municipality indicated that they have lost their stored yams to excessive heat and the extended dry season whilst 80.43% of their counterparts in Nanumba South also expressed a similar view. A member at focus group discussion in Wulensi had this to say;

> *You know, for yam in storage, it actually needs a very conducive atmosphere, especially when there is too much heat yam setts get rotten. So, when you store and there is no rain or moisture or even too much heat it affects the yam setts in the barn. In the past you could store yam setts in a barn for a number of months and at the end only very small percentage will get rotten. But now that we are experiencing this climate change when you store, there is too much heat, and this definitely affects the setts.* (FGD, Wulensi), 2020).

This implies that long period of storage and high temperatures affect the health of yam tubers and setts and confirms the finding of Mbabu (2015) & Aighewi, Maroya, & Robert (2014) that prolonged storage of tubers exposes them to pilfering, pests and rodent attacks and rot. Yam diseases and pest infestation emanating from storage result in poor quality planting materials leading to low tuber yields and poor shelf life.

#### 4.6.4.9 Wilting and Drying of Yam Vines Due to Excessive Heat

Yam vines are very delicate and easily get destroyed when exposed to heat, strong winds and even insect pest. When yam vines are exposed to soil heat, they lose their moisture content and dry up. During periods of pronounced drought yam vines lose their moisture through transpiration, the leaves curl out and eventually the whole vine dies.

A majority (70.11%) of respondents in the Nanumba South District noted that climate change and its associated heat stress is causing their yam vines to wilt or dry. Similarly, 68.98% of the respondents in the Yendi Municipality also held the view that their yam vines have wilted or dried because of climate change related heat stress. These views conform to that of key informant who stated that;

> *Because of heat if you do not stake your vines, they will lose their sprouts when they are in contact with the warm soil.* (KI, Nakpachie, 2020).

This implies that the wilting of vines is considered by farmers as one of the effects of climate change. The increase in heat and scarcity of sticks constitute an important threat to growth of vines and consequently affects tuber yield. The finding is in line with Owusu, Asare-Baffour & Obour (2015) that farmers stressed on excessive heat and dryness as the main climatic changes and variations that lead to wilting of crops.

#### 4.6.4.10 Shortage of Land Suitable for Yam Production

Land for yam production is currently in short supply in the Yendi Municipality and the Nanumba South District. Apart from population growth and extension of farm lands, climate change has played a crucial role in the reduction of lands that are suitable for yam production.

The moisture requirements for yam are higher than most of the crops. Therefore, the reduction in the rainfall amounts and the temperature rises have affected the moisture holding capacity of lands that are on higher grounds.

In Table 4.10, 74.54% of farmers in the Nanumba South District thought that lands suitable for yam production is currently in short supply. In the Yendi Municipality only 48.37% of the respondents thought that there is a reduction in lands that are suitable for yam production. It can be seen from the Table that land shortage is a major concern to farmers in Nanumba South than their counterparts in Yendi. Being part of the transition zone in Ghana, the Nanumba South is more humid than the Yendi Municipality. One would have thought that land shortage related to climate change would not be more serious in the Nanumba South District compared to the Yendi Municipality. The Nanumba District Director of Agriculture, however, explained the causes of land shortage as follows;

> *One of the effects of climate change is an increase in yam pest. There are areas that when you grow yam you will not harvest anything*

> *because of yam Beetles and storage issues. These areas are now common than previously. I remember last week I was in about three communities and they showed me some areas which are heavily infested by yam beetles*. (KI, Wulensi, 2020).

The shortage of land has led to a reduction of fallow periods and over cultivation resulting in low yield. Members of a focus group discussion in Gbungbaliga had this to say about the effect of land shortage on yam production:

> *In the past, you could allow a piece land to fallow for several years before you return to it. But now because of the shortage of land suitable for yam farming, often a family divides one piece of land among themselves with each person getting one-acre. So, for every year you will be using the same piece of land allocated to you. That is why the land has lost its fertility*. (FGD, Gbungbaliga, 2020).

The implication drawn from this is that climate change menace is also leading to the decline in productive land and if this continues areas known as yam zones will eventually lose their status leading to a decline in national output. The findings corroborate with Mngumi (2016) where 67% of the respondents associated climate change with the increase of pests, crop diseases and insects and Bergh et al. (2012) that yam pests, particularly insects constitute a major production constraint to farmers.

#### 4.6.4.11 Shortage of Shrubs for Mulching

Mulching or capping of planted mounds is common among yam farmers in Ghana. The practice is to prevent heat from penetrating the mound and to conserve moisture for the planted sett. Materials mostly used for mulching include shrubs and grass. Climate change and related desiccation has led to the scarcity of shrubs and grass, materials used for mulching. Evidence in figures 24 and 25 clearly shows the impact of climate change on the vegetation in some selected communities in the study area.

In Table 4.10, 65.28% of respondents in the Yendi Municipality and 48.37% of their counterparts in Nanumba South think that the material for mulching is currently in short supply. In the past farmers cleared shrubs that have grown after the mounds were raised and them for mulching. They complemented the shrubs with the partially burnt grass. As a result of climate change and continues cultivation, the shrubs have disappeared and at the same time the grass is no longer stalky enough to be used for mulching. According to the Yendi Municipal Best Yam farmer in 2019, materials for mulching of planted mounds is now scarce except for those who are able to plough early whose farms may grow some shrubs to be harvested for mulching.

Members at focus group discussion in Nasamba stated the following:

*In the past because we used to have elephant grass that were very stalky, when you burn, it was not all the grasses that would burn. The unburnt remains were collected in between mounds during mounding and later used as mulching material to cap the mounds. There were also shrubs that shoot up after mounding which were later harvested and used as mulch. These days we don't have elephant grass and because of the use of tractors the shrubs too are no longer available so we have to travel long distances to look for materials for mulching.* (FGD, Nasamba, 2020).

In another focus group discussion at Kpanso 1, members stated the following;

*We still cap the mounds but the way we used to do it has changed. Those days when you mound by the time you plant lots of shrubs would have grown on the farm so you harvest and use them as mulch. Now the shrubs are no longer available, so we use grass and even the grass is in short supply.* (FGD Kpanso 1. 2020).

The shortage of capping materials implies that farmers may not be able cap their planted mounds especially if the situation continues. Planted mounds exposed to scorching heat will lead to death of most planted setts. This is consistent with the findings of Ishaya & Abaje (2008) that only

2.36% of farmers in Kaduna State of Nigeria cap their mounds to reduce the loss of soil moisture.

**4.6.4.12 Shortage of Sticks**

In Table 4.10, a majority (63.43%) of respondents in the Yendi Municipality expressed the view that there is shortage of sticks for staking of yam vines. This compares with 38.04% of respondents in Nanumba South. This is not surprising because Nanumba South is more woody than the Yendi Municipality.

The following is what a key informant had to say about the shortage of sticks;

> *Now it is difficult to get sticks for staking purposes and because most of the trees have also died, some farmers don't stake their farms whiles others also try to stake part of the farm. I have two farms; one of them have been staked half way, the other has not been staked at all.* (KI, Nakpachie, 2020).

In a separate focus group discussion, members also said this;

> *Those days because there were lots of trees on the farms, we did not cut sticks for staking. The vines used to climb the trees around. Now there are fewer trees so we cut and convey sticks to the farms to do staking. Even these days it is not easy to get the sticks to cut.* FGD, Kpanso, 2020.

Staking is one of the cultural practices carried out by yam farmers in growing areas. Different staking options are used by farmers in yam growing areas. If there are trees on the farm, farmers burn them during the dry season and guide the yam vines to climb them. The practice is known as pyramidal staking because vines of mounds surrounding the tree are all guided onto the tree in a pyramidal manner (Ennin et al. 2014). Another form of staking is where the farmers plant a stake to each mound and guide the vine of that particular mound onto the stick.

The shortage of sticks implies that most farmers are likely not to stake their yams and this could expose the vines to the soil heat leading to the destruction of vines and reduction in yield. Ennin, Issaka, Acheampong, Numafo, & Danquah (2014) noted that staking helps yams to produce better quality tubers, protects the vines from soil heat and crawling pest which damages yam vines.



#### 4.6.4.13 Late Maturity of Early Yam

Yam farmers do multiple harvesting. The early yam is harvested between August and September whilst the late yam is harvested between December and January. The early yam is usually harvested to pave way for the plant to produce setts. As a result, farmers are always careful not the cut the roots during harvesting. After harvesting, the roots of the vine are carefully covered. The early harvesting (milking) is done when the farmer needs setts for the following year. During the late harvest tubers of the late yam and setts for the early are harvested.

Climate variability and change has affected plating time which in turn has affected maturity and timing of harvest. When the harvest is delayed, it affects the formation of quality setts which again affects planting material.

In Table 4.10, it can be seen that a majority (97.22% and 88.98%) of respondents in Yendi Municipality and Nanumba South respectively, held the view that climate change has affected the timing of harvest and that yams are now harvested later than previously. They noted that the late start of the raining season is responsible for late harvest.

> *Climate change as evidenced in late start of the rain's delays planting, delays growth and development of the plant, delays maturity of yam, and overall, it delays harvesting greatly.* **(**FGD, Wulensi, 2020).

The implication drawn for this finding is that farmers are likely to experience a decline in the production of setts for early yam since yams produce better setts if they are harvested early enough.

#### 4.6.4.14 Loss of Some Yam Species

Climate variability and change has led to the loss of some yam varieties, especially those that are not able to tolerate extreme heat and moisture deficit. As the weather pattern changes, farmers drop varieties that are not compatible with the changing trend and adopt new varieties. According to members at focus group discussion in Kpanso 1;

> *Most of the yam varieties we used to grow do not exist again. We changed them because if you continue to use the old variety you will not get anything because the land is no longer good for them.* (FGD, Kpanso No. 1, 2020).

In another a separate focus group discussion at Nasamba, members noted the following;

> *Some of the varieties we knew have become extinct. We are older than all the current yam varieties. All the yam varieties we came to meet do not exist today apart from Laabako and Kprinsi. Even laabako has also changed because we used to have laabako nyan (female laabako) and laabako laa (male laabako) which are no longer in existence. All the current varieties are new and even the yield is lower than the previous varieties. In the past there were certain tubers that were big enough to provide a meal for a whole family.* (FGD, Nasamba, 2020).

In a series of focus group discussions in the Yendi Municipality and Nanumba South District, farmers identified over seventy yam varieties that have become extinct because of the changing and variable climate. Most of these varieties are late maturing and because of the short duration of the raining season these days, they can no longer be grown successfully, hence the adoption of new and early maturing varieties. Table 4.11 is a list of yam varieties that are almost extinct. The table was generated through focus group discussions with members at Nasamba, Sakpegu, Gbungbaliga and Kpanso.

The implication drawn from the above is that a lot of the local varieties are being lost to climate change and this is significant because apart from being a staple food for most people, yam is one of the few indigenous crops in West Africa that does not have a close foreign substitute. The collapse of the yam sector could worsen the food security situation in the sub region and deprive producing countries of the much-needed foreign exchange.

**Table 4.3: Yam Species that are Extinct or are Near Extinction**

| | | | | | |
|---|---|---|---|---|---|
| Abinnyala | Bombe Tinga | Gungung Kpilli | Kprunkpula | Mpoanu | Tindang |
| Abochi Nya Ala | Chamba | Gungung Salli | Kpun mangli | Nawazegu | Tori |
| Abujasei | Chanchito | Jalikpiring | nyu pielli | Wulando | Yire |
| Abuyaso | Chimo | Jangjema | Kulkulsi, | Nyumangli | Zeglangbo |
| Afia | Chulungba | Jarigu Nyubiegu | Kulunku | Nyusabinli | |
| Afibatuya | Dakorba | Jetiba | Kunkon | Onimo | |
| Akaba | Dangba, | Kangbaringa | Kwametiso | Pag'soshe | |
| Ali | Deha | Keke | Laabako nyan | Zong | |
| Alodo | Dide | Kpagohi, | Lakon /Ponna | Pun nyan | |
| Amonia | Firinkpilli | Kpanjoli | Liilii | Saa | |
| Baafose | Fugla | Kpirinjo | Like | Tiilakeke | |
| Baafugu | Fushein Bila | Ggungung Kpilli | Limo | Tikolikobli | |
| Baayire | Gbedobiga | Kpirinsi | Mogini Nyuya | Tila | |

Source: Field Survey, 2020

**4.6.5 Perceived Severity of the effects of Climate Variability and Change on Yam Production**

According to the Protection Motivation Theory – PMT (Osberghaus, et al. 2010), farmer's assessment of the risks associated with climate variability and change influences their response in coping, adaptation and resilient choices. The way farmers manage the impact of climatic variability and change is influenced by the magnitude of the perceived impact. Based on this statement, farmers in the study area were asked to rate the effect of climate variability and change on yam production in terms of level of severity.

As seen in Table 4.12, 32.75% of farmers in the total sample thought the effect of climate variability and change on yam production is very severe, 51.00% thought it is severe whilst 16.25% think the impact is not severe. At the district level 47.22% and 15.76% of respondents in the Yendi Municipality and the Nanumba South respectively think that the impact of climate variability and change on yam production is very severe. A majority (50.93% in Yendi and 51.09% in Nanumba South) view the impact of climate variability and change as severe whilst only 1.85% of respondents in the Yendi Municipality and 33.15% of their counterparts in the Nanumba South see the impact of climate change not to be severe.

From the Table it could be seen that the perceived severity of climate change impact is higher among respondents of the Yendi Municipality than those of the Nanumba South District. As high as 98.15% of respondents in the Yendi Municipality as against 66.85% of their counterparts in Nanumba

South perceived the impact of climate variability and change to be at least severe.

**Table 4.4: Perceived Severity of Climate Variability and Change Effect on Yam Production**

| **Perceived Impact of CV & C** | **Yendi** | | **NS** | | **TS** | |
|---|---|---|---|---|---|---|
| Variable | Freq. | % | Freq. | % | Freq. | % |
| Very severe | 102 | 47.22 | 29 | 15.76 | 131 | 32.75 |
| Severe | 110 | 50.93 | 94 | 51.09 | 204 | 51.00 |
| Not severe | 4 | 1.85 | 61 | 33.15 | 65 | 16.25 |
| **Total** | **216** | **100.00** | **184** | **100.00** | **400** | **100.00** |

Source: Field Survey, 2020.

These findings are not surprising giving the fact the unlike the Nanumba South District which is located within the transition zone and enjoys a relatively higher amounts of rainfall and moderate temperature ranges, the Yendi Municipality is in the interior savannah and experiences rainfall as low as 500mm to 600mm with a temperature range of 21$^{o}$C - 36$^{o}$C. Given the high temperature ranges and moisture deficits, it is obvious that the impact of climate change in the Yendi Municipality would be higher and more severe on farmers.

### 4.7 Farmer Adaptation to Climate Variability and Change

In section 4.6 the perception of smallholder yam farmers on the effects of climate variability and change was discussed. It was realised that climate change has affected all aspects of yam production including land preparation, planting, weed control, harvesting and storage. This section seeks to explore the extent to which farmers have responded to the negative effects of climate variability and change. It also identifies measures that farmers have undertaken in the face of the variable and changing climate.

#### 4.7.1 Climate Variability and Change Adaptation Measures

Table 4.13 indicates the number of respondents who have taken up adaptation measures to cushion themselves against the effects of climate variability and climate change. It also includes those who have not taken up any adaptation at all, From the Table it can be seen that a majority of respondents (66.50%) from the total sample have not taken any adaptation measures against climate variability and change. In the Yendi Municipality, 48.15% of respondents have taken adaptation measures whilst only 16.30% of their counterparts in the Nanumba South District have also taken at least one adaptation measure against climate variability and change.

From Table 4.13, it can be seen that only 134 farmers representing 33.50% of respondents from the study areas have taken up at least one adaptation measure. All subsequent discussions on adaptation measure will be based on the 33.50% of farmers who have taken up adaptive measures.

**Table 4.13: Have You Adopted Climate Variability and Change Adaptation Measure?**

| | Yendi | | NS | | TS | |
|---|---|---|---|---|---|---|
| Variable | Freq. | % | Freq. | % | Freq. | % |
| No | 112 | 51.85 | 154 | 83.70 | 266 | 66.50 |
| Yes | 104 | 48.15 | 30 | 16.30 | 134 | 33.50 |
| **Total** | **216** | **100.00** | **184** | **100.00** | **400** | **100.00** |

Source: Field Survey, 2020

Farmers who did not take up adaptation measures cited lack of knowledge as one of the reasons why they have not been able to take up Adaptation measures. Others said they do not have money to take up any recommended action against the effects of climate variability and change. Members at a focus group discussion in Nasamba for instance had this to say;

> *What measure can we take? There is no support. We are still following our old ways of doing things. Whether the yield is good or bad you have to farm because there is no alternative. Agricultural officers from time to time come to teach us new ways of doing things but they are not regular. It sometimes takes 2 to 3 years before we have a visit.*

*However, change happens every day so we are now working in the name of God (Onyame Nti).* (FGD, Nasamba, 2020).

It can be seen from the finding that the rate of adaptation is high among respondents in the Yendi Municipality (48.15%) than those in the Nanumba South (16.30%). This implies that the perceived effect of climate variability and change is higher in Yendi than in the Nanumba South.

These findings also confirm the Protection Motivation Theory (explained in chapter two) that “farmer’s ability to take up climate change adaptation is influenced by the cost of adaptation and farmers access to information.



### 4.7.2 Land Management Practices as a Climate Change Adaptation Measure

Farmers were asked to indicate whether they have adopted any of the following land management practices; land rotation, increase in farm size and relocation of farms as adaptation measures against climate variability and change.

#### 4.7.2.1 Land Rotation

It can be seen from Table 4.14 that a significant majority (97.01%) of the respondents have adopted land rotation as an adaptation measure. From the Table it could be seen that 98.08% and 93.33% of respondents in the Yendi Municipality and Nanumba South District respectively, have taken up land rotation. According to the respondents, lands suitable for yam production is declining. Families now have fixed lands that they use for crop cultivation. To ensure that the land remains productive, farmers divide their fields meant for yam production into five years to seven-year production cycles.

After cultivating a particular piece of land, that piece is reserved for subsequent years whilst another piece of land is brought under cultivation. The farmers continue to move onto a new land until the entire land area has been brought under cultivation when he then moves back to the originally cultivated plot. This method allows the land to rest and regain its fertility.

It also allows the regrowth of shrubs and sticks which are harvested and used as mulching and staking materials.

> *What some of us have done is that we have reserved portions of our fields we think are good for yam cultivation into three - years, four – year or five-year production cycles. After planting yams on the fields for the first year, the filed is planted with cereals or legumes in the following year. In the third, fourth and possibly fifth year, the land is*

*allowed to rest. This allows the land to regain its fertility and shrubs to regrow.* (FGD, Kpanso, 2020).

This implies that land rotation is an important adaptation measure among farmers in the study area. It however contradicts that of Sadiq, Kuwornu, & Al-hassan (2019) and Elijah et al. (2018) where majority of respondents practiced continuous cropping because they had no extra land to do land rotation.



**4.7.2.2 Decrease in Farm Size**

As discussed in chapter 4.6, climate change has affected the availability and cost of yam setts, cost of labour among others. Farmers are finding it difficult to obtain setts for planting. When they have the setts, getting labour to raise the mounds or weed the farm is another challenge. These have compelled some farmers (98.51%) to reduce the size of their yam farms to levels they can easily manage.

In Table 4.14, an overwhelming majority (100.00%) of respondents in the Nanumba South said they have reduced their farm sizes. Similarly, 98.08% of respondents in the Yendi Municipality have reduced their farm sizes.

**Table 4.14: Land Management Practices**

| **Adaptation Option to CV& C** | **Yendi** | | **NS** | | **TS** | |
|---|---|---|---|---|---|---|
| Land Management Practices | Freq. | Percent | Freq. | Percent | Freq. | Percent |
| Adopted land rotation | 102 | 98.51 | 28 | 93.33 | 130 | 97.01 |
| Decreased farm size | 102 | 98.08 | 30 | 100.00 | 132 | 98.51 |
| Relocating farms into valleys and humid areas. | 101 | 97.12 | 27 | 90.00 | 128 | 95.52 |

Source: Field Survey, 202 Multiple Responses

The following is what an Agricultural Extension Agent in Yendi had to say about the reduction of yam farm sizes.

> *Bad weather conditions associated with climate change in the past years has led to a drastic reduction of yam output in this area. People had larger farms of about ten acres but because of the negative weather that we experienced they lost about half of their crops. Some even completely lost their yam farms. Some have tried to revive their fields but it has not been that easy because yam setts have become so scarce that they can't easily get the setts to start again* (KI, Yendi, 2020).

This implies that a reduction of farm size is a major component among the adaptation measures taken by farmers in the study area. This is probably due to shortage and high cost of yam setts.



**4.7.2.3 Relocating Farms into Valleys and Humid Areas.**

One feature of climate change is the reduction of rainfall and increases in temperatures. This has resulted in increased desiccation and loss of soil moisture. Yam production is greatly affected because the crop has a higher requirement of moisture. Some yam farmers have now resorted to cultivation in valleys and other low-lying areas where moisture retention rate is higher than that of the upland environments.

As indicated in Table 4.14, a significant majority (97.12%) of respondents in the Yendi Municipality said they have moved their fields into valleys and low-lying areas. In the same way, 90% of respondents in the Nanumba south have equally moved their farms into valleys and low-lying areas. According to the Nanumba South District Agricultural Officer;

> *The rainfall requirements for yam are generally higher than most of our staple crops like maize, groundnuts. Because of that most of the farmers are now resorting to going closer to valleys to grow their yams where they can have longer duration of moisture*. (KI, Wulensi, 2020).

This implies in the that face of dwindling amount of moisture, valleys and low-lying areas are becoming more attractive as sites suitable for yam farming. This is consistent with the findings of Mngumi (2016) that Mimbres people of Asia are adapting to drought conditions by settling along valleys . Farming in valleys can however be risky especially during floods.

### 4.7.3 Soil Management Practices

Soil management is key to successful yam cultivation and farmers both in the past and present have always taken steps to ensure soils are protected against runoff and compaction. Soil management as used in this study refers soil moisture conservation and using tractors to loosened hard and compacted soils. Soil moisture conservation is done in two stages, first by spreading stalks of grass during land clearance to cover the field to protect it against the direct sunlight. The second stage is when farmers use shrubs or straw to cap the mounds. The former is no longer common in most parts of the yam growing areas. As explained under Land Clearance in subsection 4.6.4.1 the grass that used to cover the land has been replaced by new ones that are too short and tiny and cannot be used as a mulching material.

#### 4.7.3.1 Mulching (Capping of Mounds)

Capping the mounds is still done as is shown in Table 4.15. From the Table it can be seen that 95.52% of respondents from both study districts cap their mounds. An overwhelming majority (97.12%) of respondents in the Yendi

Municipality and 90.00% of their counterparts in the Nanumba South cap their yam mounds.

Farmers now use unconventional methods to cap their yam mounds. With the shortage of shrubs and grass, farmers have resorted to alternative mulching materials like rice and soya bean straw.

According a member of focus group discussion;

> *We still cap the mounds but the way we used to do it has changed. Those days when you mound, by the time you plant lots of shrubs would have developed on the farm so you harvest them for the mulch. Now the shrubs are not available, so we use grass and even the grass is in short supply. In place of that we use rice straw obtained after thrashing of rice*. (FGD, Kpanso No. 1).



**Table 4.15: Soil Management Practices**

| **Adaption Option to CV & C** | **Yendi** | | **NS** | | **TS** | |
|---|---|---|---|---|---|---|
| Soil Management Practices | Freq. | % | Freq. | % | Freq. | % |
| Mulching (capping mounds to prevent moisture loss during planting season | 101 | 97.12 | 27 | 90.00 | 128 | 95.52 |
| Using tractor to plough before raising mounds | 104 | 100.00 | 26 | 86.67 | 130 | 97.01 |

Source: Field Survey, 2020. Multiple Responses

This information was corroborated by a key informant as follows;

> *Now there are no shrubs to be used for mulching so we have resorted to the use of soya bean straw. After harvest we collect the straw of the soya beans and use them to cap the yam mounds.* (KI, Sakpegu, 2020).

The findings imply that in spite of the shortage of capping materials, farmers are finding an innovative means of capping their mounds to protect their setts against rising temperatures. Apart from the rice and soya beans straw, some farmers harvest shrubs in the wild and convey them to their farms to be used as mulch. The results underscore how important capping mounds is to farmers.

**4.7.3.2 Using Tractors to Plough before Raising Mounds**

Due to early cessation of rains, the land easily dries up and become too hard for farmers to be able to make their yam mounds. In order to circumvent this, farmers now use tractors to plough so that the soil will become loose to enable them make their mounds. All the farmers in Yendi Municipality who have taken up adaptation measures also use tractors to plough their fields. A majority (86.67%) of their counterparts in the Nanumba South indicated that they use tractors to plough before mounding. As indicated earlier in the study, the climate of the Yendi Municipality is drier than that of Nanumba South. It is therefore not surprising that most farmers in the former rely on tractors to loosen the soil before mounding. Participants at a focus group discussion said this about ploughing with tractors;

> *We no longer do the manual clearing. Most farmers now use tractors to plough their fields. These days because the land is no longer fertile, if you do manual clearing and someone also ploughs with a tractor, the one who plough will get better yield than you.* (FGD, Nasamba, 2020).

The implication drawn from the findings is that the use of tractors for land clearance is fast replacing manual clearing. Many reasons have been adduced for this. First farmers said the current grass can no longer be cleared manually. Secondly the land has become harder and is difficult to mound if manually cleared and worst still labour for manual clearing is virtually non-existence. The use of tractors also means that sticks meant for yam staking will finally disappear since tractor usage leads to the clearing of trees.



**4.7.4 Crop Management Practices**

Crop management practices as used in this study refers to the adoption of high yielding varieties, using multiple yam types, planting early maturing varieties, changing planting dates and using drought resistant varieties.

### 4.7.4.1 Planting High Yielding Varieties

One of the effects of climate variability and change is the decline in yam yield or crop failure resulting in famine and destitution among farmers. One way of minimising the effects of low yield is the introduction of high yielding yam varieties

**Table 4.16: Crop Management Practices**

| **Adaptation Option to CV & C** | **Yendi** | | **NS** | | **TS** | |
|---|---|---|---|---|---|---|
| Crop Management Practices | Freq. | % | Freq. | % | Freq. | % |
| Planting high yielding varieties | 101 | 97.12 | 29 | 96.67 | 130 | 97.01 |
| Adopted multiple yam varieties | 101 | 97.12 | 29 | 96.67 | 130 | 97.01 |
| Planting early maturing varieties | 101 | 97.12 | 29 | 96.67 | 130 | 97.01 |
| Change in planting dates | 102 | 98.08 | 28 | 93.33 | 130 | 97.01 |
| Planting heat tolerant varieties | 100 | 96.15 | 27 | 90.00 | 127 | 94.78 |
| Planting drought resistance yam varieties | 100 | 96.15 | 26 | 86.67 | 126 | 94.02 |

Source: Field Survey, 2020 Multiple Responses

According to farmers interviewed, when you are using high yielding varieties like the *Olodo and Nyame Nti*, you are able to get good harvest especially when the weather is good. With the good harvest you are able to save money so that in bad times you can always purchase seeds to save your farm from collapsing.



As can be seen in Table 4.16, an Overwhelming majority (97.01%) of respondents are planting high yielding yam varieties.

The proportion of respondents for both study districts are almost the same, that is, 97.12% for the Yendi Municipality and 96.67% for the Nanumba South District. The reasons why participants have adopted high yielding varieties are in encapsulated in the following narration;

> *We used to grow varieties like the "Moani nyuya (wild yam), Mpoanu, Kpurinjo and Akaba" but yield was low so we adopted new and high yielding varieties like the* **"***Olodo, Gbundri, Koliko and Nyame Nti".* (FGD, Nasamba, 2020).

**4.7.4.2 Using Multiple Yam Varieties**

Growing multiple yam varieties by farmers serves as a form of insurance against climate shocks. It is rare for farmer to produce just a single yam variety. Often times they cultivate as many as ten to twenty different varieties in a single farm (Observation).

In Table 4.16, respondents who use multiple yam varieties constitute 97.12% and 96.67% in the Yendi Municipality and the Nanumba South District respectively.

According to members at focus group discussion at Sakpegu;

> *Growing multiple yam varieties have two benefits; When the rains stop early, it will only affect the late yam but the early yam will not be affected. However, when the rains do not start early enough, the development of the early yam will be affected but you will still be able to have your late yam. The second thing is that when you grow different yam varieties all maturing at different times, you tend to have access to yams at all times compared to the one who grows only one variety.* (FGD, Sakpegu, 2020).



The implication drawn from this finding is that in order to avert crop loses, farmers are planting different yam varieties on their fields. In the event that one variety fails the farmer can still rely on other varieties.

#### 4.7.4.3 Planting Early Maturing Varieties

Climate change has led to reduction in the length of the raining season. This has affected the yield of late maturing yam varieties. Farmers have responded by adopting varieties that have shorter maturity periods. As is seen in Table 4.16, an overwhelming majority (97.12%) of respondents in the Yendi Municipality and 96.67% of their counterparts in the Nanumba South are planting early maturing varieties. Participants at focus group discussion corroborated this statement in the following narration;

> *We used to grow varieties like "Zogno, Chimo, Keke, Dangba, Nyu pielli, Baayire and Pag'soshe". These varieties take too long a time to mature and because of changes in the weather these days those who continue to grow those varieties do not get good harvest. Most farmers have now replaced them with the early maturing types like "Nyame Nti, Olodo, Kpurinjo and Gbunduli"* (FGD, Kpanso 1., 2020).

The wide adoption of early maturing verities among the respondents is understandable as yam is an important food crop in reducing hunger among poor rural farmers in West Africa. The months of May, June and July are regarded as a period in Northern Ghana when food shortages are common in most of the households (Sadiq, 2013; Sam and Dapaah, 2016). The maturity of yam during this period provides great relieve to the affected farming households as it provides food security and income for members. Yam is used to prepare many dishes like fufu, boiled yam (ampesi?), yam porridge, fried yam among others. The early yam also attracts good sales and income and could be used for other food items. Varieties like the "Puna" and "Laabako" taste good and are early maturing and are therefore the most popular varieties of white yam grown in Ghana.

#### 4.7.4.4 Change in planting dates

Yam farmers in the past used to plant their setts during the harmattan when temperature levels are lower. However, climate change and associated temperature changes have compelled most farmers to change the time of planting. Farmers who plant early now stand the risk of losing their setts when temperature rises beyond the expected levels. In Table 4.16 for instance, all respondents (100%) in the Yendi Municipality have changed their planting time. In the Nanumba South District, 93.33% of the respondents have also changed their planting time. This means that an overwhelming majority (98.51%) of the respondents who have taken up adaptation measures have changed their planting time.

According members of a focus group discussion at Kabreya, they used to plant as early as January/February because the isolated rain (Movilla saa, see figure 4.26) used to be regular but now they hardly get this rain and planting sometimes delays up the beginning of the rainy season in May.

This is what an agricultural extension agent had to say on the change of planting dates;

> *Planting too, I think these days everything is changing. Those days they used to plant somewhere around January to February but these days some plant even very late, around March or April when there is moisture in the soil as a result of the weather changes. Those who plant*

*earlier than this time to take advantage of the previous rains are sometimes affected because when temperatures rise, they lose a lot of their setts as a result of heat.* (KI, Yendi, 2020).

Though it has its advantages, the late planting also has challenges. These challenges were elaborated by the Yendi Municipal Best Yam Farmer for 2019 as follows;

*Some people still plant as early as they used to do but others wait and plant when the next rains set in. Planting in the harmattan as was done in the past is more beneficial because when you keep the setts in barns for a long time before planting in the next season the number of setts that will die in storage is usually more than the number that die in mounds.* (KI, Nakpachie, 2020).

The implication drawn from this study is that because of the changes in rainfall pattern, farmers taking up adaptation measures have also changed the dates of planting in order to meet the moisture and temperature requirements for the growth of yam. This is consistent with (Alhassan, et al. 2019) that 20% of farmers have adopted a change in planting date as a climate change adaptation strategy.

#### 4.7.4.5 Planting Heat Tolerant Varieties

The heat wave associated with climate change has profound effect on yam production especially in northern Ghana where temperature levels are high for most part of the year. To be able to withstand the changing climate, farmers need to formulate adaptive strategies that can endure the rising temperature levels. Studies by Lemma (2016) show that following the rising temperature and increasing heat, farmers have fashioned out strategies that are inclined towards more heat-tolerant crops. This shift towards heat tolerant varieties is evident in Table 4.16. It can be seen from the Table that a significant majority (94.78%) of the total respondents have adopted heat tolerant yam varieties. Ninety percent (90.00%) of respondents in the Nanumba South District and 96% percent of their counterparts in the Yendi Municipality plant heat tolerant yam varieties.

A District extension officer described the heat tolerant varieties in the following narration;

> *Some of the heat tolerant varieties identified and used by farmers include the "Ziglangbo" and "Sanyaka" both of which could be stored for a longer period of time and will therefore be available when other varieties are not in season. We also have Sanyaka, a variety that could be stored for one full year and even drain all its water content and turn into something like a stick but it will not get rotten.* (KI, Wulensi).

This implies that heat tolerant varieties as climate change adaptation measure could help reduce storage losses and enhance productivity.

**4.7.4.6 Planting Drought Resistance Yam Varieties**

One of the direct impacts of climate variability and change is the recurrent droughts within the dry regions of the tropics (Rosenstock & Nowak, 2019). Yam production is highly sensitive to climate change and weather extremes such as droughts, which have a drastic impact on output in growing areas. One sure way of sustaining yam production in the face of recurring droughts is the adoption of drought resistant varieties.

As can be seen from Table 4.16, a significant majority (94.03%) of all respondents have planted drought resistant varieties. In the Yendi Municipality, 96.15% of the respondents have planted drought resistant yam varieties. Similarly, 86.67% of the respondents in the Nanumba South District have embraced drought resistant yam varieties.

The implication drawn from the above finding is that farmers willingness to adopt drought resistant varieties is depended on their geographical location. The climate of the Yendi Municipality is drier than the more humid and woodier Nanumba South. Droughts in the Yendi Municipality are therefore more likely to be hasher and pronounced than that of the Nanumba south hence the higher proportion of respondents in the Yendi Municipality adopting drought resistant varieties as compare to those in the Nanumba South.

### 4.7.5 Diseases and Pest Management Practices

Diseases and pests are major causes of crop losses (Thiele et al. 2017; Mngumi, 2016). Yam pests, particularly insects, are one of the major production constraints confronting yield improvement and produce quality. The phenomenon of global climate change is exacerbating the incidence of diseases and pest by modifying growing environments and adding new stress factors (Mngumi, 2016).

In order to minimise the impact of pest and diseases on yield, farmers in the Yendi Municipality and the Nanumba South District are embarking on a number of pest and disease management practices ranging from planting pest and disease resistant varieties, application of insecticides to the spraying of yam barns with pesticides. Respondents mentioned *Jarigu Nyubiegu* as one the species most farmers now grow because they don't easily get infected by pest or diseases.

#### 4.7.5.1 Planting Pest and Disease Resistance Varieties

As Table 4.17 demonstrates, an overwhelming majority (93,28%) of the respondents planted pest and disease resistant yam varieties. About ninety-six percent (96.15%) representing an overwhelming majority of the respondents in the Yendi Municipality as compared to 83.33% in the Nanumba South have planted pest and disease resistant varieties. Giving the high cost of pesticides, the use of pest's resistance is probably the most viable adaptation option if those varieties are easily available.

#### 4.7.5.2 Spraying the Barns with Pesticides

As can be seen in Table 4.17 a majority of respondents from both Districts spray their barns with pesticides to prevent pest and insect attack. However, contrary to the Yendi Municipality where an overwhelming majority of the respondents (94.23%) indicated that they sprayed their barns, only 63.33% of their counterparts in the Nanumba South did same. These findings show that the act of barn spraying is more popular in the Yendi Municipality than the Nanumba South.

> *After harvesting we store in barns. The barns are made with poles and zana mat on a raised platform. Before you place the yam in the barn, you have to spray the floor, the roof and the side walls with pesticides. Also, during storage, you continue to spray the outer walls of the barn to prevent pest from getting access to your yam.* (KII, Nakpachie,

2020).

The implication drawn from this is that farmers quest to improve the shelf life of yams in wake increasing pests and diseases are now relying on pesticides to ward off pests and rodents. This means additional production cost to farmers since most of these chemicals can be very expensive. Bergh et al. (2012) observed that one of the major production challenges faced by farmers is pest infestation. They however added that of the 90% of farmers in who reported pest problems, only 3% used of pest control measures.

#### 4.7.5.3 Application of Insecticides

Insects such as termites contribute significantly to crop losses, especially, planted setts. To minimise the effects of termites, farmers dip their setts into insecticides before planting. In Table 4.17, an overwhelming majority (93.28) of respondents apply insecticides. In the Yendi Municipality 99.04% of the respondents apply insecticides on their farms. This compares with 73.33% of their counterparts in the Nanumba South. Like the spraying of barns, the use of insecticides is more popular among respondents in the Yendi Municipality than those of the Nanumba South District.

**Table 4.17: Diseases and Pest Management Practices**

| | Yendi | | NS | | TS | |
|---|---|---|---|---|---|---|
| Diseases and Pest Management Practices | Freq. | % | Freq. | % | Freq. | % |
| Planting pest and disease resistance varieties | 100 | 96.15 | 25 | 83.33 | 125 | 93.28 |
| Spraying the barns with pesticides | 98 | 94.23 | 19 | 63.33 | 117 | 87.31 |
| Application of insecticides | 103 | 99.04 | 22 | 73.33 | 125 | 93.28 |

Source: Field Survey, 2020

Over all the practice of diseases and pest management is higher among respondents in the Yendi Municipality than their counterparts in the Nanumba South. This is not surprising because the incidence of yam losses in storage and in planted mounds is higher in the Yendi Municipality than that of the Nanumba South District (see section 46).

The implications on the use of insecticides drawn under the spraying of barns also apply in this particular instance.

### 4.7.6 Vine Protection and Management

Yam vines are very delicate and requires deliberate action by farmers to protect them against soil heat, insect attack and being trampled upon by humans and strayed animals. Historically, farmers protected yam vines by curling them around sticks or guiding them to climb trees. With shortage of trees and sticks farmers have resorted to partial, where only a section of the farm is staked and zero staking, where none of the mounds is staked. Plate 1 captures part of a partial staked farm. From the plate it can be noticed that all the vines in the foreground are raised on vertical sticks whilst in the background looks rather flat, indicating that the vines are lying on the ground or on the mounds. On plate 2 which represents a zero staked or non-staked farm, it is noticed that all the vines are on the floor or on the mounds.

#### 4.7.6.1 Partial/Selective staking

In Table 4.18, it can be seen that a significant number (93.28%) of the total respondents practice partial or selective staking. It can also be seen that whilst an overwhelming majority (99.04%) of respondents in the Yendi Municipality practice partial and selective staking, 73.33% percent of their counterparts in the Nanumba South practice same.

#### 4.7.6 .2 Zero Staking

It can also be seen from Table 4.18 that 79.10% of the total respondents practice zero staking or no staking at all. Similarly, 98.08% of respondents in the Yendi Municipality as against 13.33% of their counterparts in the Nanumba South practice zero staking or do not stake their yams at all. Judging from the data on Table 4.18, the practice of partial and zero staking are popular in the Yendi Municipality than the Nanumba South. Zero staking is not popular in the Nanumba South since only 13.33% of the respondents practice it.

It has already been stated in the study that the Nanumba South is woodier than the Yendi Municipality hence access to sticks may not constitute a major challenge as it is in the Yendi Municipality.

**Table 4.18: Vine Management Practices**

| | Yendi | | NS | | TS | |
|---|---|---|---|---|---|---|
| Vine Management Practices | Freq. | % | Freq. | % | Freq. | % |
| Partial/Selective staking | 103 | 99.04 | 22 | 73.33 | 125 | 93.28 |
| Zero Staking | 102 | 98.08 | 4 | 13.33 | 106 | 79.10 |

Source: Field Survey, 2020

**Plate 1: A Partially Staked Farm**

Source: Field Survey, 2020.

This is what the District Best Yam Farmer for 2019 had to say about vine staking:

> *Now it is difficult to get sticks for staking purposes and because most of the trees have also died, some farmers don't stake their farms others too try to stake part of their farms. I have two farms; one of them has been staked half way, the other has not been staked at all. Because of the shortage of sticks we are selective in terms of yams we stake. We*

> *normally stake Laabako first because of its early maturing nature. The tuber of a staked Laabako does not grow as big as the non-staked one but the tuber usually grows long and beautiful and when you harvest early it develops larger setts. 'Puna' is next yam to be staked after 'Laabako'. Water yams are usually not staked these days*. (KI, Nakpachie, 2020).

This statement is consistent with Ennin, Issaka, Acheampong, Numafo, & Danquah (2014) that yields of staked yams are higher than the non-staked yams. The claim was also confirmed by members at a focus group discussion as follows;

> *The sticks are difficult to get. You have to climb a tree to trim its branches to be used as yam stakes and even so the trees are not readily available. Some of us have even stopped staking. Those who have the means travel with their families to far way places to cut sticks and then convey them by tricycles to their farms.* (FGD, Nasamba, 2020).

Whilst farmers are conscious of the ramifications of not staking their yams, many are compelled to adopt the partial and zero staking in the face of dwindling nature of staking materials. Farmers at a focus group discussion expressed the following sentiments;

*We used to stake our yam vines because of heat. If you did not stake your vines, they will lose their sprouts when they come in contact with the warm soil. We do not stake any longer because the sticks are not available. For now, the vines are exposed to the soil heat.* (FGD, Sakpegu, 2020).

**Plate 2: The Practice of Zero Staking**

Source: Field Survey, 2020**.**

### 4.7.7 Off-farm Adaptation Strategies

Climate variability and change invariably affects productivity and livelihoods compelling farmers to adopt off-farm activities such as migration (Obeng, 2005), and trading (Tiyumtaba, 2016). This is likely to affect yam output in growing areas. Many farmers have turned their attention to off farm livelihood activities. Others have managed to avoid storage losses by disposing off produce immediately after harvest.

#### 4.7.7.1 Sell Off-farm Produce Immediately after Harvest

In the past, farmers stored their yams for a very long time and sold them in the lean season when prices were high. However, in the face of mounting storage losses, some farmers now prefer to sell their produce shortly after harvest. In Table 4.19, it can be seen that a significant majority (94.23%) of the respondents in the Yendi Municipality sold their produce shortly after harvest. This compares with 50% of their counterparts in the Nanumba South. This indicates that the need to sell yam early is higher in the Yendi Municipality than in the Nanumba South district. This is because the incidence of storage losses is higher in the Yendi Municipality than that of the Nanumba South District (see section 4.6.4.8).

The following sentiments were expressed by members at a focus group discussion concerning the need to sell yams early to avoid losses;

> *In the past yams could be stored in barns for a long time without getting spoiled but these days, yams spoil early in barns. Even now the incidence of theft is rising. For now, when you harvest your yam and*

*fail to sell it immediately, you are likely to lose everything.* (FGD, Nasamba, 2020).

The immediate sale of yams after harvest is not a viable option since yam prices at the time of harvest is always low because of a glut in the market. This implies that farmers selling during this period are obtaining lower returns on their produce than those who will sell later. This has the potential to discourage people from undertaking yam farming as a business.

**Table 4.19: Off-farm Adaptation Options**

| **Adaptation Option to CV & C** | **Yendi** | | **NS** | | **TS** | |
|---|---|---|---|---|---|---|
| Off-farm adaptation Options | Freq. | % | Freq. | % | Freq. | % |
| Sell off-farm produce immediately after harvest | 98 | 94.23 | 15 | 50.00 | 113 | 84.33 |
| Engage in off-farm employment | 103 | 99.04 | 27 | 90.00 | 130 | 97.02 |

Source: Field Survey, 2020. Multiple Responses

#### 4.7.7.2 Off-Farm Employment

Just like elsewhere in Africa, yam farmers in the Yendi Municipality and Nanumba South District have responded to climate change and declining yield by raising livestock, selling charcoal and participating in petty trading to supplement their household cash flow.

Evidence from Table 4.19 shows that an overwhelming majority (97.02%) of respondents in the study areas are engaged in off-farm activities. An overwhelming majority (99.04%) of the respondents in the Yendi Municipality as against 90.00% of their counterparts in the Nanumba South are into off-farm ventures. This implies that livelihood diversification is popular among yam farmers in the Yendi Municipality compared to that of the Nanumba South. This is not surprising because being a Municipal area and closer to the Tamale Metropolis (the Regional Capital), the Yendi Municipality definitely offers more opportunities for off-farm employment than that of more rural Nanumba South District.

This finding is consistent with Herrero, Ringler, Steeg, Koo, & Notenbaert (2010), that;

> *For those that are relatively close to large human settlements, for example, there may be options for off-farm employment opportunities. For transition zones that are more remote, on the other hand, both*

*market and off-farm employment opportunities may be much more limited.*

These results highlight the importance of off-farm activities as alternative adaptation strategies to cushion farmers against the effect of climate variability and change and is consistent with Abdoulaye et al. (2017), Tripathi & Mishra (2017) and Mertz et al. (2011) that in the face of the changing and variable climate smallholder and poor farmers and tenants have been surviving on off-farm work.

**4.7.8 Relationship Between the Belief in the Reality of Climate Variability and Change and the Adoption of Adaptation Measure.**

To determine the applicability of the protection motivation theory in this study, a comparison was made between farmers' belief in the reality of climate change or otherwise and their adaptive behaviour. From Table 4.20, it can be seen that out of the number of farmers who believe that climate change is a reality, 188 representing 72.03% have expressed their intention to adopt adaptation measures whilst 73, representing 28.00% do not intend to take up any adaptation measure. On the other hand, only 53, representing 38.13% of farmers who believe that climate change is not real do intend to take up adaptation measures whilst 86, representing 61.87% have no intention to take up any adaptation measure.

**Table 4.20: Belief in the Reality of Climate Variability and Change and its Influence on Adaptation Intention**

| | **Willingness to take Adaptation Measures** | |
|---|---|---|
| CC is a Reality | Yes | No |
| Yes | 188 (72%) | 73 (28%) |
| No | 53 (38%) | 86 (62%) |
| **Total** | 241 (60.25) | 159 (39.75) |

Source: Field Survey, 2020

The finding, which shows that there is a relationship between a farmers believe in climate change and climate change adaptation adoption intention is also consistent with the conceptual frame presented in chapter two of the thesis.

### 4.7.9 Relationship Between the Perceive Severity of Climate Variability and Change Impact and Climate Change Adaptation Adoption

In Table 4.21, only 13, representing 20%) of respondents who believe that the impact of climate change is not severe said they will take up adaptation as against 51 (70%) who do not intend taking up any adaptation measures at all. On other hand, 99 (48%) of the respondents who think that the effect of climate variability and change is severe do intend taking adaptation measures to minimise the effect. However, 106 (52%) respondents who think that the effect of climate variability and change is severe said they have no intention of taking up any adaptation measures. For those who think that the effect of climate variability and change is very severe, only 23 (18%) have expressed the desire to take up adaptation measures as against 108 (82%) who have no intention of taking up any adaptation measures. The reason why a majority of respondents who feel that the impact of climate change is very severe did not intend to take up adaptation measures is explained in the following narration;

> *What measure can we take? There is no support. We are still following our old ways of doing things. Whether the yield is good or bad you have to farm because there is no alternative.* (FGD, Sakpegu, 2020).

The results confirmed the Protection Motivation Theory (PMT) that farmer's willingness to adapt to climate change is influenced by their individual capacity to adopt adaptation measures (self-efficacy).

**Table 4.21: Relationship between the perceived severity of climate change and adaptation intension**

| | **Adoption of Adaptation Measures** | | **Pearson Chi-Square** | **Likelihood Ratio** |
|---|---|---|---|---|
| Severity of CV & C | **No** | **Yes** | | |
| Not severe | 51 (80%) | 13 (20%) | 40.297[a] | 41.581 |
| Severe | 106 (52%) | 99 (48%) | | |
| Very severe | 108 (82%) | 23 (18%) | | |
| **Total** | **265** | **135** | | |

Source: Field Survey, 2021

**4.80 Ranking of Adaptation Strategies by Respondents**

In Table 4.22, the dependent variables were ranked based on the number of respondents who responded yes to the question as to whether they have adopted the strategy. It can be seen from the Table 4.22 that out of 20 dependent variables, the decrease in farm size ranked first with 98.51% of respondents.

The use of tractors, change in planting dates, planting early maturing varieties and off farm activities each had 97.01 respondents and placed

**Table 4.22: Ranking of Adaptation Strategies by Respondents**

| Tabulation of Variables | No | Yes | Total | Percent of yes | Rank |
|---|---|---|---|---|---|
| Decrease in farm size | 2 | 132 | 134 | 98.51 | 1st |
| Use of tractors | 4 | 130 | 134 | 97.01 | 2nd |
| change in planting dates | 4 | 130 | 134 | 97.01 | 2nd |
| Planting early maturing varieties | 4 | 130 | 134 | 97.01 | 2nd |
| Engage in off-farm activities | 4 | 130 | 134 | 97.01 | 2nd |
| Mulching 2 | 6 | 128 | 134 | 95.52 | 3rd |
| Planting drought resistant varieties | 6 | 128 | 134 | 95.52 | 3rd |
| Planting heat tolerant varieties | 7 | 127 | 134 | 94.78 | 4th |
| Changing location yam farms | 8 | 126 | 134 | 94.03 | 5th |
| Adopted pyramidal staking | 9 | 125 | 134 | 93.28 | 6th |
| Growing disease resistance varieties | 9 | 125 | 134 | 93.28 | 6th |
| Mulching 1 | 9 | 125 | 134 | 93.28 | 6th |
| Application of insecticides | 9 | 125 | 134 | 93.28 | 6th |
| Adopted land rotation | 10 | 124 | 134 | 92.54 | 7th |
| Dropped some yam varieties | 10 | 124 | 134 | 92.54 | 7th |
| Planting high yielding varieties | 15 | 119 | 134 | 88.81 | 8th |
| Spraying barns with disinfectants | 17 | 117 | 134 | 87.31 | 9th |
| Selling produce immediately after harvest | 18 | 116 | 134 | 86.57 | 10th |
| Zero staking | 27 | 107 | 134 | 79.85 | 11th |
| Planting multiple yam varieties | 28 | 106 | 134 | 79.10 | 12th |

Source: Field Survey, 2020

second. At the third place is mulching 2 (capping of mounds) and planting drought resistant varieties with 95.52% respondents each.

Planting heat tolerant varieties and changing location yam farms placed 4th and 5th respectively whilst pyramidal staking, growing disease resistant varieties, mulching 1(spreading grass stocks on the ground to prevent soil moisture lost) and application of insecticides all placed 6th with 93.28% of respondents each.

Land rotation and dropping of some yam varieties placed 7th whilst planting high yielding varieties and the spraying of barns with disinfectants placed 8th and 9th positions respectively. Selling produce immediately after harvest, zero staking which represents no staking all and planting multiple yam varieties placed 10th 11th and 12th positions respectively. The first five variables have been chosen to run the multivariate probit analysis in section 4.8.

## 4.8 Factors Influencing the Choice of Climate Variability and Change Adaptation Strategies by Smallholder Yam Farmers

Section 4.7 discussed adaptation strategies undertaken by yam farmers in the Yendi Municipality and Nanumba South District. These strategies were categorized into land management, soil, crop, pests and diseases, and vine management strategies. This section examines the various factors that influence farmers' choice of adaptation options by first ranking all the adaptation strategies which constitute a set of dependent variables (Table 4.22). The first five rated adaptation options, that is, decrease in farm size, using tractors to plough before raising mounds, change in planting dates, planting early maturing varieties, and engagement in off-farm activities, have been selected and used to run the multivariate probit regression against some independent variables in Table 4.23.

### 4.8.1 Multivariate Probit Analysis of Factors that Influence Yam Farmers' Choice of Climate Variability and Change Adaptation Strategies

#### 4.8.1.1 Decrease in Farm Size

Findings from Table 4.23, indicate that the factors that influence farmers' decisions to decrease their farm sizes as an adaptation mechanism are age and the number of years of climate change awareness. The influence of age and the number of years of climate change awareness are significant at one percent. The farmer's age negatively affects the possibility of the farmer adopting a decrease in farm size. This implies that younger people are more likely to decrease their farm sizes as an adaptation strategy.

**Table 4.23: Results of Multivariate Probit Analysis of Determinants of Farmers' Choice of Adaptation**

| | Decrease in farm size 1 | Using tractors to plough before raising mounds. 2 | Change in planting dates 3 | Planting early maturing varieties 4 | Engage in off-farm activities 5 |
|---|---|---|---|---|---|
| Age | -0.035*** (0.008) | -0.032*** ( 0.009) | -0.033*** (0.009) | -0.039*** (0.008) | -0.029*** (0.008) |
| Educational level | 0.016 (0.017) | 0.027** (0.016) | 0.030** (0.015) | 0.029** (0.015) | 0.030** (0.017) |
| Marital status | 0.144 (0.459) | 0.541 (0.586) | 0.568 (0.607) | 0.753* (0.430) | 0.125 (0.447) |
| Years aware of CC | 0.075*** (0.007) | 0.079*** (0.008) | 0.075*** (0.008) | 0.071*** (0.007) | 0.068*** (0.007) |
| Access to Extension service | -0.071 (0.219) | 0.321 (0.202) | 0.237 (0.207) | -0.071 (0.188) | 0.032 (0.209) |
| Access to Institutional credit | -3.597 (102.367) | 0.503 (0.360) | -0.306 (0.367) | 0.546 (0.389) | 0.791 (0.552) |
| Access to market | -0.205 (0.356) | -0.306 (0.312) | 0.293 (0.252) | -0.485* (0.272) | -0.083 (0.310) |
| Membership of association | 0.188 (0.261) | 0.433* (0.233) | 0.036 (0.033) | 0.165 (0.246) | 0.305 (0.247) |
| Size of yam farm | 0.006 (0.036) | 0.000 (0.033) | 0.029 (0.031) | 0.047 (0.031) | -0.024 (0.042) |
| Farm distance | 0.043 (0.029) | 0.007 (0.031) | -0.061 (0.180) | -0.001 (0.028) | -0.139* (0.059) |
| Access to Radio | -0.008 (0.180) | -0.249 (0.175) | 0.711 (1.068) | -0.014 (0.165) | -0.197 (0.173) |
| _cons | 0.779 (0.889) | 0.832 (0.894) | -1.715 (1.170) | 1.235 (0.987) | 0.954 (0.829) |

Number of observation= 400
Wald chi2(59)= 259.84
Log likelihood= -326.44175
Prob > chi2= 0.0000
Notes: Base category: No adaptation. *, ** and *** indicates 10%, 5% and 1% levels of statistical significance respectively. p-values are in the parenthesis

Source: Field Survey, 2020

This finding is consistent with an a priori expectation that younger people are more likely to take up climate change adaptation since they are more energetic, have more access to information than the aged. Most older farmers stick to ancient conventional farming methods and hardly adjust to climate change adaptation measures. The study postulated that older farmers may neither have the information nor resources to adopt recommended climate change adaptation strategy.

The number of years of climate change awareness positively affects the likelihood that a farmer will decrease his farm size as an adaptation strategy against climate change. This implies that farmers with longer years of climate change awareness are more likely to reduce their farm sizes to adapt to the changing climate. The findings meet with an a priori expectation that farmers with previous awareness of climate change are expected to be risk-conscious and adopt appropriate measures, including decreasing their farm sizes to avoid future risks. The result is reflected in the conceptual framework, which links a farmer’s previous climate change awareness to adaptation behaviour. The finding is also consistent with Otitoju (2013) that the number of years of climate change awareness would lead to a 0.60% and 0.0087% in choosing and using various crop varieties and multiple planting dates, respectively.

#### 4.8.1.2 Using Tractors to Plough Before Raising Mounds

Factors that influence the decision to use tractors to plough before mounding are age, level of education, years of climate change awareness, and association membership, which are statistically significant at 1%, 5%, and 1% and 10% respectively. The age of a farmer has a negative effect on the possibility that the farmer will use tractors to plough before mounding, education level, years of climate change awareness, and membership of association have a positive effect. The influence of age on the possibility of using tractors to plough before mounding shows that younger people are more likely to use tractors than older farmers. The implications drawn under the decrease in farm size are applicable since younger farmers are more vibrant and can always manage to get tractors at a time when getting access to tractors is difficult.

The findings show that farmers who have had more years of formal education are more likely to adopt tractor use than those with fewer years of education. Consistent with an a priori expectation, education exposes farmers to information and innovation, which will automatically influence adaptive behaviour. This finding is in line with Alhassan et al. (2019) that a higher level of education of a farmer is likely to be associated with knowledge and information on climate variability and change , improved technologies and higher productivity and hence, appropriate adaptive methods would be preferred. It contradicts that of Adusei (2016) that a farmer being either a JHS or SHS leaver had a negative impact on a farmer's decision to adapt in the face of climate change. The influence of years of climate change awareness on the possibility of using tractors to plough before mounding shows that people with more years of climate change awareness are more likely to use tractors to plough as an adaptation strategy. This is in congruence with the a priori expectation that years of climate change awareness are expected to influence farmers' choice of adaptation positively.

Membership of an association positively influences the choice of using tractors to plough and was statistically significant at 10 percent. This implies a high possibility of using a tractor to plough by farmers who belong to associations than those who do not. This finding is consistent with the a priori expectation that membership of association will positively impact on members' choice of climate change adaptation. A farmer who belongs to an association is more likely to learn innovative farming methods and effective adaptation options from the other association members.

Extension service providers and other climate change adaptation promoters are more likely to prefer dealing with groups than individuals, thus giving group members more access to information and resources than people who do not belong to any group or association. Given the limited number of extension officers in the study districts, this is particularly so. This finding is consistent with Otitoju (2013) that social participation enhances farmers' production activities. Moreover, Tiyumtaba (2016) found that membership of an association comes with several benefits from having the chance to share information from one farmer to the other to receiving packages from Non-Governmental Organisations and other donors, which will help them (farmers) to increase their resilience to climatic change.



#### 4.8.1.3 Change in Planting Dates

Table 4.23 shows that the factors that significantly influence the choice of a change in planting dates as an adaptation strategy are age, education level, and years of climate change awareness. The influence of the age of a farmer on change in planting dates is negative and significant at one percent. This implies that younger farmers are more likely to adopt changes in planting dates.

The influence of age on the adoption of changing plantings dates as climate variability and change adaptation mechanism is in synchrony with the a priori expectation that older people are weak and lack the needed information on available adaptation choices. The finding contradicts Alhassan et al. (2019) that there is no link between a farmer's age and change in planting dates.

The influence of a farmer's education level and change in planting dates is positive and significant at 5%. This implies that higher levels of education influence the farmer's choice to change the planting dates of yam in response to climate change. In line with the a priori expectation, farmers with a higher level of education are more likely to adapt to climate variability and change by changing planting dates since educated farmers have more access to information on climate change and adaptation. This finding is consistent with Oo, Huylenbroeck, and Speelman (2017) that farmers with lower education levels are less likely to adapt to climate change than farmers with higher levels of education.

The influence of the number of years of climate change awareness on change in planting dates is positive and significant at 1%. This implies that several years of climate change awareness increases the probability of a farmer adopting a change in planting date as an adaptation strategy. The finding is congruent with an a priori expectation that farmers with previous awareness of climate change are sensitive to its effects and are likely to take the recommended measures to avert it. The implications drawn under the influence of years of climate change awareness on a decrease in farm size or using tractors to plough are applicable in this situation. This is in line with Tadesse et al. (2009a) that climate change awareness which represents information on temperature and rainfall, has a significant and positive impact on the likelihood of using different crop varieties.

#### 4.8.1.4 Planting Early Maturing Varieties

From Table 4.23, farmers' decision to adopt early maturing varieties as an adaptation strategy is influenced by age, education level, marital status, years of climate change awareness, and market access.

The influence of farmers' age on the adoption of early maturing varieties is negative and significant at 1%. The implication is drawn under the influence of age on the decrease in farm size, using tractors to plough, and change in planting dates also apply here. Planting early maturing varieties enables the farmer to escape an early cessation of rains which usually affects late-maturing crops.

Access to market influences the adoption of early maturing varieties negatively and statistically significance at a 10% level. This implies that farmers who have difficulty accessing markets are more likely to adopt early maturing varieties than farmers who have market access. Farmers who harvest their yams in the early part of the season often have better prices because demand at this is time is higher than supply. As a result of the excess demand, yam traders go to the farm level to purchase the product. During periods of glut, when most farmers have harvested, the demand falls. This time, producers have to cart their produce to the market before disposing of them. Depending on how long it takes them to sell their produce, farmers incur additional costs in securing security protection for their produce until they are sold. To avoid this, farmers living far away from market centres prefer to grow early maturity varieties that can be harvested and sold when there is a ready market. Besides, some yam-producing communities do not have access roads to market centres and are cut off by floods during the peak of the rainy season. Farmers in such communities will likely patronize yam varieties that could be harvested before the peak of the rainy season. This finding contradicted the conclusion drawn by Nhemachena, Hassan, and Chakwizira (2014) that access to markets for farm input and output can significantly impact farm-level adaptation.

Level of education of a farmer positively influences the planting of early maturing yam varieties and statistically significant at five percent. This means that farmers with higher levels of education are more likely to plant early maturing yam varieties than those with lower levels of education. This is consistent with an a priori expectation that formal education exposes farmers to information and innovation, which will positively impact adaptation strategy. According to Gbetibouo (2009), cited in Alhassan et al. (2019), formal education equips individuals with the ability and understanding of new varieties, which affects the adaptation decision making.

The influence of marital status on the planting of early maturing yam varieties is positive and statistically significant at 10%. This implies that married couples are more likely to plant early maturing crops and is consistent with a priori expectation that married couples pull their resources together and are better able to take up adaptation measures. It is also in congruent with Marie et al. (2020) that marital status had positively impacted the decision between early and late planting.



#### 4.8.1.5 Engagement in Off-farm Activities

Farmers' decision to engage in off-farm activities is influenced by age, education level, farm distance and years of climate change awareness.

The influence of age on the adoption of off-farm employment is negative and at a 1% statistically significant level. The results imply that younger people are more likely to engage in off-farm as an adaptation strategy than older people. This is consistent with an a priori expectation that as farmers grow older, they become weak in strength to engage in any climate change adaptation. Older people may not be able to effectively combine farming with other activities.

The influence of farm distance on off-farm activities as an adaptation strategy is negative and statistically significant at 10%. This implies that the probability of engaging in off-farm activities is higher for households with shorter distant farms. This is consistent with an a priori expectation that households who manage long distant farms spend much of their time traveling to and from their farms and may not have any spare time to engage in off-farm activities but contradicted Otitoju (2013) that average farm distance does not influence the adoption of off-farm activities.

The positive relationship between education level and the adoption of off-farm activities is consistent with an a priori expectation. It implies that people with higher education levels are more likely to engage in off-farm activity as an adaptation strategy. It, however, contradicts the findings of Otitoju (2013), which shows a negative relationship between the level of education and adoption of off-farm employment.

Table 4.23 illustrate that the relationship between years of climate change awareness and adoption of off-farm activities is positive at a 10% level of significance. This means that farmers with many years of climate change awareness have a higher possibility of adopting off-farm employment. Consistent with a priori expectation but contradicts the finding of Otitoju, (2013), which shows an inverse relationship between years of climate change awareness and involvement in off-farm activities.



### 4.8.2 Likelihood Ratio Test of the Farmer's Choice of Adaptation Strategies

A likelihood ratio test was conducted to understand the relationship between the dependent variables, that is, adaptation strategies. The test determines the influence of each explanatory variable on the original separate adaptation measures and whether farmers prefer specific adaptation strategies over the others and are therefore willing to substitute one for the other.

From Table 4.24, the test outcomes are positive. This implies that the adaptation strategies complement each other and that no farmer is willing to substitute one adaptation strategy for another.

**Table 4.24: Likelihood Ratio Test**

| **Adaption Strategies** | |
|---|---|
| Adaption strategy 2 & Adaption strategy 1 | 0.887*** (0.030) |
| Adaption strategy 3 & Adaption strategy 1 | 0.896*** (0.033) |
| Adaption strategy 4 & Adaption strategy 1 | 0.863*** (0.034) |
| Adaption strategy 5 & Adaption strategy 1 | 0.778*** (0.045) |
| Adaption strategy 3 & Adaption strategy 2 | 0.950*** (0.020) |
| Adaption strategy 4 & Adaption strategy 2 | 0.941*** (0.022) |
| Adaption strategy 5 & Adaption strategy 2 | 0.913*** (0.025) |
| Adaption strategy 4 & Adaption strategy 3 | 0.969*** (0.016) |
| Adaption strategy 5 & Adaption strategy 3 | 0.919*** (0.026) |
| Adaption strategy 5 & Adaption strategy 4 | 0.955*** (0.019) |

Source: Field Survey, 2020.

Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0

$chi^2(10) = 694.977$

Prob > $chi^2 = 0.0000$

**Foot notes**

Adaption strategy 1 = Decrease in farm size

Adaption strategy 2 = Using tractors to plough before raising mounds

Adaption strategy 3 = Change in planting dates

Adaption strategy 4 = Planting early maturing varieties

Adaption strategy 5 = Engage in off-farm activities

### 4.9 Chapter Conclusion

The findings from chapter 4 have demonstrated that yam farming is a male dominated activity and that a majority of the farmers are not formally educated. Fewer number of extension agents especially in Yendi Municipality has resulted in poor extension coverage. The poor coverage of extension service coupled with poor to institutional credit has resulted in low level of climate change awareness and adaptation. The major factors perceived to be driving climatic variability and change were Human, natural and spiritual forces while deforestation, fuelwood harvesting and overgrazing are the perceived human actions that contribute to climate variability and change.

The most perceived effects of climate variability and change on yam production were the depletion of vegetation which has affected land clearance and availability of sticks and shrubs, decline in soil moisture and fertility which affected mounding, planting and tuber quality.

Most farmers responded to the effects of the changing and variable climate by growing early maturing varieties, changing planting dates, land rotation or relocation of fields closer to valleys. The choice of adaptation strategy depended on a farmers age, education level, years of climate change awareness among others. A Likelihood Ratio Test, however, shows that all the adaptation choices are complementary.

# CHAPTER FIVE

# SUMMARY OF MAJOR FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

## 5.0 Introduction

This chapter presents the summary of the major findings of the study, conclusions, recommendations and suggested areas for further studies. The summary, conclusions and recommendations are presented in sections 5.2, 5.3 and 5.4 respectively. Whilst areas for further studies are presented in section 5.5.

## 5.1 Summary of Major Findings

The main objective of the study was to examine smallholder yam farmers' perception and response to climate variability and change. Specifically, the study sought to;

1. Examine the perception of climate variability and change among smallholder yam farmers in the Yendi Municipality and Nanumba South District.
2. Analyse the perceived effects of climate variability and change on yam production.
3. Identify adaptation strategies undertaken by smallholder yam farmers to mitigate the effects of climate variability and change.

4. Examine the factors that influence the choice of adaptation strategies by smallholder yam farmers.

The study adopted a mixed method research to examine the perception and response to climate variability and change by smallholder yam farmers in the Yendi Municipality and the Nanumba South District. Interviews and field survey started from July and ended in September, 2020. Questionnaire administration covered 400 small holder yam farmers across sixteen communities in the two districts. Key Informant Interviews were conducted using an interview guide and covered district directors of agriculture, district agricultural extension agents, district chief yam farmers as well as other experienced yam farmers. Focus group discussions were also held with farmer groups. A Likert-Type Rating Scale Technique was used to analyse farmer's perception on the causes and form of climate variability and change. Results were expressed in means, frequencies and percentages. The perceived effect of climate variability and change was also analysed in frequencies and percentages. Community resources maps and seasonal calendars as well as qualitative narratives were equally used to determine the perceived effect of climate change or its variability on yam farming. Farmers adaptation to climate variability and change was analysed using frequencies, percentages, Pearson's chi square statistical test, qualitative narratives and photographs. Finally, the Multivariate Probit Analysis was used to determine which demographic, institutional and farm level factors influence farmer's choice of adaptation strategies.

The salient points of the main findings of the study are presented below based on the study objectives.



### 5.1.1 Demographic, Institutional and Farm Level/Land Ownership Factors

The results of the study indicated that yam farming is a male dominated activity. An overwhelming majority (98%) of the respondents are males.

A majority (63.5%) of the respondents have had less than a year of formal education with only 4.5% attaining a minimum of thirteen years' formal education. This means that literacy rate among yam farmers is low.

Access to extension service is low (28%) in the study area and lower in the Yendi Municipality (11%). Forty-eight percent (48%) of respondents in Nanumba South have access to extension services.

Yam farmers in the study area do not have access to institutional credit facilities. Only 5% of respondents in Nanumba South had access to institutional credit. None of the respondents in the Yendi Municipality had access to institutional credit.

Most yam farmers in the study area, contrary to prior expectation, do not have problem accessing markets for their produce. Ninety-two percent (92%) of respondents from both districts have access to market.

Access to and control over land is not a major problem in the study area. Ninety-seven percent (97%) of respondents in the Yendi Municipality and 96% of their counterparts in Nanumba South own the lands they are currently cultivating. Overall, 85% of respondents think their current land holding is adequate for their needs.

Yam is a major crop cultivated in the area. Ninety-nine percent (99%) of respondents in Nanumba South as against 57% of their counterparts in the Yendi Municipality cultivate yam as their major crop.

Farms are generally closer to the homes of respondents in spite of the reported shortage of lands for yam cultivation. About 95% of the respondents have their farms less than 2 kilometres away from their homes.

### 5.1.2 Rainfall and Temperature Trends

Rainfall figures for the area show variability in annual totals and a slight decline since 1989. Monthly mean rainfall figures have also been declining since the last three decades with November, December and January showing consistent levels of decline.

Both the average minimum and maximum temperatures as well as the total averages show an annual variability with a steady rise in both the annual minimum and annual total temperatures since 2013.

### 5.1.3 Farmer Perception of Climate Variability and Change

Knowledge of climate change is very low among farmers in the Yendi Municipality with 87% of the respondents saying they have never heard of climate change.

Family/friends and radio are the two major sources of information on climate change among yam farmers in the study area, with 27% and 22% of respondents relying on the two sources for information on climate change.

According to majority of respondents, climate variability and change are natural and normal processes that will happen with or without the intervention of any external agent. About 97% of respondents either agreed or strongly agreed that climate variability and change is a natural phenomenon.

The second major driver of climate variability and change is human activities. About 90% of respondents either agreed or strongly agreed that human activities are the cause of climate variability and change.

The other perceived cause of climate variability and change is the one associated with spiritual intervention. Fifty-five percent of the respondents either agreed or strongly agreed that climate change is caused by spiritual forces.

Deforestation topped the list of perceived human causes of climate variability and change. Ninety-six percent (96%) of respondents either agreed or strongly agreed that the activity leads to climate variability and change. Next to deforestation is indiscriminate bush burning with 92.5%, fuelwood exploitation (86.25%) and overgrazing (80.25%). Excessive use of agrochemicals is the least perceived cause of climate variability and change with 76.5% rate of agreement or strong agreement.

Decrease in rainfall was the number one most perceived indicator of climate variability and change with 92.3% level of agreement and strong agreement followed by increase in temperature levels (78%), increased incidence of droughts (72.5%) increase frequency of violent strong winds (70.5%) and increase incidence of floods (64.5%).



### 5.1.4 Perceived Effects of Climate Variability and Change

Understanding the changes in the land and vegetation cover is relevant in the analysis of the effect of climate variability and change on yam farming since the activity relies largely on land cover resources. Seventy-eight percent (78%) of the respondents think that declining soil fertility and productivity is the number one effect of climate variability and change on the land cover resources. This is followed by the drying up of water bodies, 74%, disappearance of some plant and animal species, 73.3%, decline in number of earthworms, 68.5% as well as the decline in numbers of snails, 55.8%.

Climate change has led to a change in weather pattern that has altered the cropping calendar and affected the overall yam production system. A little over 92% of the respondents held the view that climate change has altered the vegetation pattern which has affected land clearance. Ninety-one percent (91%) noted increased storage losses due to increases in temperature, late maturity of early yam (89.8%) owing to late start of rains (89.3%). Rotting of planted setts due to excessive heat (87.5%), delay in raising mounds due to early cessation of rains (71%) and the proliferation of previously unknown weeds (70.5%). The findings indicate that climate change has led to the shortage of staking and mulching materials and strikingly to shortage of lands suitable for yam cultivation.

One interesting finding is the extinction of some yam species. About seventy (70) species of yam have either gone extinct or are on the verge of extinction due to the changing and variable climate.

### 5.1.5 Farmer Adaptation to Climate Variability and Change

Findings of the study indicate that majority of the respondents (66.5%) have not engaged in any adaptation measures. Only 34 representing 33.5% have adopted measures to combat the effect of climate variability and change.

Climate change adaptation measures undertaken by farmers in the present study have been grouped into land management practices under which 98% have reduced their farm sizes. Under soil management practices, 97% plough their fields before mounding whist under crop management practices, 97% either planted high yielding varieties, multiple yam varieties, early maturing varieties or changed planting dates. Under diseases and pest management practices, 93.3% either planted pest and disease resistant varieties or applied insecticides. About 93.3% practiced partial or selective staking under vine management practices whilst 92% engaged in off-farm employment under off-farm activities.

### 5.1.6 Factors Influencing the Choice of Climate Variability and Change Adaptation

A multivariate probit analysis of five adaptation strategies, namely, decrease in farm size, using tractors to plough before raising mounds, change in planting dates, planting early maturing varieties, engaging in off-farm activities indicate that a farmer's decision to decrease his farm size is significantly influenced by age and number of years of climate change awareness.

The decision to use tractors to plough before raising mounds is significantly influenced by age, level of education, years of climate change awareness and membership of association.

Decision to change planting dates is significantly influenced by age, level of education and years of climate change awareness whilst the choice of planting early maturing varieties is significantly influenced by age, years of climate change awareness and marital status.

Age, educational level, years of climate change awareness and farm distance are factors that significantly influence farmer's decision to engage in off-farm activities. Households headed by young people are more likely to adopt any of the adaptation strategies than households headed by older people, whereas households whose heads have had more years of education have higher possibility adopting all the adaptation strategies except decrease in farm size.



Having more years of climate change awareness increases the possibility of adopting all the adaption measures whilst being a member of an association significantly influence the possibility of using tractors to plough before raising mounds.

Whilst households whose heads are married are more likely to plant early maturing yam varieties, there is a high possibility for households without access to market to also plant early maturing yam varieties. Households with shorter distant farms are likely to engage in off-farm activities.

A Likelihood ratio test on the independence of the explanatory variables shows that the relationships between all the variables are positive, indicating that all the adaptation measures are complementary and that no farmer is ready to substitute one adaptation measure for another.

## 5.2 Conclusions

The findings indicated that climate variability and change have affected all the processes of yam cultivation right from land clearance, mounding, planting, capping of mounds, staking, weeding, harvesting and storage. The study further highlighted adaptation measures by farmers against the changing and variable climate. These include change in planting dates, using multiple yam varieties, ploughing with tractors before mounding, use of pesticides, adoption of off-farm activities and land rotation. This holistic view is a novelty and closes the gaps in knowledge created by previous studies which tackled only specific aspects of yam cultivation.

The study illustrated the importance of the community mapping in the analysis of climate change and adaptation strategies among small holder farmers. The present study stands out in its attempt to reconstruct the past vegetative, hydrological, human settlements and farming sites and then juxtapose same with current resource maps. An overlay of the maps provides a "birds' eye view" of the communities, showing a decline in both the vegetation cover and surface water bodies which had direct consequences on yam cultivation. The maps also showed that farmers have relocated their farmlands as part of adaptation measures against climate variability and change.

The study did an extensive analysis of the use of traditional yam cropping calendar by farmers in northern Ghana and concluded that climate variability and change have affected the operationalisation of the calendar. The present study is the first of its kind in this part of the world to do an in-depth analysis of the use of traditional cropping calendar in climate change studies. The changing and variability in the cropping calendar have affected the timing of mounding, planting and the overall yam production cycle. The findings therefore provided an additional knowledge on how farmers rely on local seasonal calendars to guide them in their farming activities and the extent to which this has been affected by climate change.

The study findings revealed that about seventy (70) different yam varieties have gone extinct or on the verge of extinction. This exposition is a significant contribution to knowledge on the effect of climate variability and change on yam production.

Findings from the study revealed that majority of the respondents who believed that climate change is real, indicated their intention to take up climate change adaptation measures. This indicates that there is a relationship between the believe in the reality of climate change and adaptation intention. This finding thus confirmed the protection motivation theory that the believe in climate change leads to adaptation intention.

On the contrary, a majority of respondents who believed that effect of climate change is severe did indicate that they did not intend taking up climate change adaptation measures. This indicates that there is no relationship between the perceived severity of climate change and adaptation intention and contradicts the protection motivation theory that perceived severity of climate change leads to adaptation intention.



## 5.3 Recommendations for policy

To improve the level of awareness and adaptation to climate variability and change, the following recommendations are made in order to enhance yam productivity.

- The Ministry of Food and Agriculture in collaboration with the Forestry Commission should assist farmers to plant trees in order to restore the vegetative cover of the environment. These trees can be harvested as yam sticks and shrubs for mulching purposes.

- In the face of scarcity of mulching materials, the Ministry of Food and Agriculture must encourage farmers to use rice and soya bean stocks in capping their mounds to protect their setts against direct heat from the sun.
- The Ministry of Food and Agriculture together with the Meteorological Services Department should provide consistent and reliable agro-meteorological information on timely bases to enable farmers plant at the right time.
- To avoid further extinction of yam species, it is recommended that the Root and Tuber Crop Division of the Ministry of Food and Agriculture in collaboration with the Savannah Agricultural Research Institute conduct further studies into yam varieties that are tolerant of the changing climate and encourage farmers to adopt varieties that can withstand heat and moisture stress
- It is recommended that farmers are supported by the Ministry of Food and Agriculture to construct barns that are rodent proof and can drastically reduce the amount of heat that gets in contact with yams in storage. Such an effort should be very participatory and involve the use of local resources.

### 5.4 Suggested Areas for Future Research

1. Changing location of farm sites and its implication on productivity. The findings revealed that as a result of increased dryness, farmers are now relocating to valleys and humid areas. Since these sites are also prone to floods, it will be interesting to understand how the relocation is affecting yam production.
2. Rapid extinction of yam species and its implication on sustainable production. The findings indicate that about seventy different varieties have gone to extinction. Most of the respondents witnessed the cultivation of these varieties. Though some new varieties are being introduced, it will be interesting to know how the rate of extinction is impacting of sustainable yam production.
3. Emerging weeds and cost implications for yam production. The findings indicate that new weeds, most of which are prolific, have emerged in the study area. Further studies will give indication as to how much cost is incurred by farmers in an attempt to control these alien weeds.

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**APPENDIX**

**FARMER PERCEPTION AND ADAPTATION TO CLIMATE VARIABILITY AND CHANGE: A STUDY OF SMALLHOLDER YAM FAMERS IN THE YENDI MUNICIPALITY AND THE NANUMBA SOUTH DISTRICT OF THE NORTHERN REGION**

**SURVEY QUESTIONNAIRE FOR YAM FARMING HOUSEHOLDS**

This questionnaire is prepared to collect data for the research proposal entitled **"Farmer Perception and Adaptation to Climate Variability and Change: A Study of Smallholder Yam Famers in the Yendi Municipality and the Nanumba South District of the Northern Region"**. The questionnaire is designed to generate data that will be used for academic purpose only. It complies with all research ethics, therefore, all information supplied by you will be strictly treated in confidence. Please feel free and share with us your rational views.

**Location**

1. Name of District …………………………………………………………

2. Community……………………………………………………………

3. Date of interview ………………………………………………………

**Part I: Demographic and socio-economic characteristics of the respondent household**

| | | |
|---|---|---|
| 4 | Household size | No. of people in household…………………… |

| | | |
|---|---|---|
| 5 | Gender of household head | Male (1) Female (0) |
| 6 | Age of household head | Age of hh head…………….……..years |
| 7 | Education level of household head | No. years of formal education……………………. years |
| 8 | How long have aware of climate change? | No. of years of CC awareness…………………………..years |
| 9 | Marital status | 1). Married 2) Single 3) Divorced 4) Widowed 5). Widower 6) Separated |
| 10 | What is your ethnicity? | 1) Dagomba 2) Konkomba 3) Nanumba 4) Other, specify………………… |
| 11 | Which religious denomination do you belong? | 1) Christian 2) Muslim 3) African traditionalist 4} Others (specify) …………………… |
| 12 | Are you a native of this community? | (1) yes (0 ) no |

**PART II. Institutional Factors**

| | | |
|---|---|---|
| 13 | Do you have access to extension service? | Yes 2) no |
| 14 | Do you have access to institutional credit? | (1) Yes (0) No |
| 15 | Which institution do you get credit from? | ………………………….. |
| 16 | Do you have access to market? | (1) yes (0) no |

| | | |
|---|---|---|
| 17 | How far is the nearest market from your location? | 1) Less than a kilometre 2) 2-3 kilometres, 3) 4-5 kilometres 5. Above 5 kilometres |
| 18 | Which of these information sources do you own? | (1) radio 2) TV set, 3) mobile phone 4) None (multiple answers are acceptable). |
| 19 | Do you belong to any association? | (1) yes (0) no |
| 20 | Which association do you belong? | …………………………………… |

21. How many people are currently working on your yam farm? ………………………….

22. How many of the workers are hired labour? ………………………

23. Are there roads that connect you with nearby towns or cities? 1. Yes; 0 No

24. Do you have access to improved production inputs and technologies?

1. Yes; 0 No (List those you have access to)

…………………………………………………………………………………

…………………………………………………………………………………

25. For each input indicate the source

1) government 2) NGOs 3) market partners 4) Don't know

26. Do you think the sources of inputs mentioned are reliable? 1) yes 0) no (give reason why reliable or unreliable) …………………………………………………………………………………

…………………………………………………………………………………

**Farm level and Land Ownership Factors**

| | | |
|---|---|---|
| 27 | What is the size of your total land holding? | less than 5acres (0) 2. more than 5acres (1) |
| 28 | Do you cultivate all of your land holding | (1). Yes (0). No |
| 29 | If no how do you benefit from the uncultivated land? | Share cropping 2. Rent it for money 3. Other ……… |
| 30 | Do you feel that your land holding is adequate to | (1). Yes (0). No |

| | | |
|---|---|---|
| | produce enough for your subsistence? | |
| 31 | If no how do you satisfy your land requirement | ……………………………………………………………… |
| 32 | What is the size of your yam farm? | ………………..(hectares) |
| 33 | How far is your farm from home? | ………………….(kilometres) |
| 34 | Do you think your land holding belongs to you | 1. yes 0. No |

| | | |
|---|---|---|
| | permanently? | |
| 35 | If you answered no in question 29 who controls ownership of your land holding? | ……………………… |
| 36 | What is your main cultivated crop? | 1.yam 2. Maize 3. Rice 4. Groundnuts 5. Other, specify…………………… |
| 37 | How long have you been producing yam? | ……………..(years) |

38. How do you satisfy your need for farm labour? 1 Hire 2. Family labour 3. Mutual exchange of labour with neighbours 4. Any other, specify (Tick as many as are applicable)

39. In which category do you classify your soil on basis of its fertility?

1. Low fertility 2. Medium fertility 3. Highly fertile

40. How productive is your land without fertilizer? 1. High 2. Medium 3. Low

41. How many tones of yam do you produce per hectare/year? ………………….(tones)

**PART III. Climate Change Perception Assessment**

42. Is today's weather the same as the weather conditions you experienced 20 to 30 years ago?

(1). Yes (0). No

43. If you answered no what is the difference in terms of rainfall? 1. The duration of rainy season has decreased 2. Number of heavy rains in a season has decreased 3. timing of the on start and cessation of the rainy season has become more unpredictable 4. Violent rainstorms are now common.

44. What has changed in terms of temperature? 1. The warm seasons are warmer than previously 2. There is an increase in the duration of the dry season 3. There is an increase in the number of drought spells

45. Have you heard of the word "climate change" before? (1). Yes (0). No

46. If yes when (year)……………………………………………………

47. From which source did you hear about climate change? 1.Television 2. Newspaper 3. Friends/families 4. Radio 5. Government agencies/information (Tick as many as are applicable)

48 Do you believe that climate change is a reality? (1) yes (0) no

49 To what extent will you agree that climate variability and change are caused by the following?

| No. | Cause of climate variability and change | Strongly Agree (1) | Agree (2) | Uncertain (3) | Disagree (4) | Strongly Disagree (5) |
|---|---|---|---|---|---|---|
| i | Human actions | | | | | |
| ii | Spiritual intervention | | | | | |
| iii | Natural and normal processes | | | | | |

50. Do you agree that climate change is associated with spiritual forces? 1. Yes. 0. No

51. If your answer in question 48 is yes, explain the reasons why God/gods or our ancestors will impose climate change/variability on us…………………………………………………………………………..

…………………………………………………………………………………

………………………………………………………………………………

52. To what extent will you agree that the following human activities are responsible for climate variability and change in your community?

| No. | | Strongly Agree (1) | Agree (2) | Uncertain (3) | Disagree (4) | Strongly Disagree (5) |
|---|---|---|---|---|---|---|
| i | Bush burning | | | | | |
| ii | Deforestation | | | | | |
| iii | Overgrazing | | | | | |
| iv | Fuel wood harvesting | | | | | |
| v | Application of agrochemicals | | | | | |

53. To what extent will you agree to the following as indicators of climate variability and change

| No. | Indicator | Strongly Agree (1) | Agree (2) | Uncertain (3) | Disagree (4) | Strongly Disagree (5) |
|---|---|---|---|---|---|---|
| i | Decreasing trend of rainfall | | | | | |
| ii | increasing trend of rainfall | | | | | |
| iii | increasing temperature levels | | | | | |
| iv | Increase frequency of violent | | | | | |

| | |
|---|---|
| | Strong winds |
| v | Decreasing incidence of dewfalls |
| vi | Increase in number of warm days in a year |
| vii | Duration of the dry season has extended |
| viii | Number of hailstorms per season are now fewer than before |
| ix | Increasing incidence of floods |
| x | Increased frequency of droughts |

54. Which of these local indicators do you use to evaluate today's climate trend? (Tick as many as applicable)

i. Disappearance of some plant and animal species

ii. Snails are no longer as common as they were 20 years ago

iii. Earthworms are no longer common as they were 20years ago

iv. Decline of soil productivity/fertility

v. Some bird species are no longer common

vi. drying up of water bodies

vii. Rivers/streams no longer produce as much fish as before

viii. Other (specify)

**Land Use /Land Cover Change Issues**

55. Is there any change in the forest land/wood land area in your locality?

(1). Yes (0). no

56. If there is change in the area of woodland is it decreasing or increasing in size? 1. Increasing 2. Decreasing 3. No change

57. If your answer in question 53 is that the woodland is decreasing, which of the following major reasons is/are responsible for the decreasing woodland? (Tick as many as applicable).

i. Expansion of farm lands

ii. Cutting of trees for fuel wood and charcoal

iii. Grazing encroachment/Overgrazing

iv. Bush fires

58. In your locality is there any indigenous tree species that are extinct or becoming extinct because of the changing trend of the climate? (1) Yes (0) no

59. If yes list the names of indigenous trees that are already extinct or becoming extinct in your locality:

……………………………………………………………………………………

**PART IV. Perceived Effects of Climate Variability/Change Assessment**

60. Which of the following moisture related challenges have you faced due to climatic change/variability? (Multiple responses are acceptable)

i. Delay in raising mounds due to early cessation of rains

ii. Late start of rains

iii. Shortage of moisture for main yam & seeds for early yam

iv. Quality of seed is affected by early cessation of rains

v. Loss of crops due to droughts

61. Which of the following temperature related challenges have you encountered in your yam farming activities?

i. Rotting of planted seeds due to excessive heat (high temperature)

ii. High storage loses due to excessive heat & extended dry season

iii. Wilting & Drying of yam vines due excessive heat

iv. Any other, specify……………………………………………………………………………

62. Which of the following weed control challenges do you face as a result of climate and variability?

i. Difficulty in clearing new areas due to invasion of alien weeds

ii. Proliferation of previously unknown weeds

iii. Any other,

specify……………………………………………………………………………

63. what challenges have you encountered as a result of excessive rains?

i. Flood inundation of farmlands

ii. Severe erosion on farm land

iii. Poor roads to markets due to floods/erosion

64. What other challenges have you faced as a result of climate variability and change? (tick as many as applicable)

i. Shortage of shrubs for mulching

ii. Shortage of tress/sticks for staking

iii. Emergence of new yam diseases and pest

iv. Late maturity of early yam

vi. Shortage of land suitable for yam production

vii. High storage loses due to the prevalence of previously unknown pest & diseases

viii. Distraction of vines by violent strong winds

ix. Late maturity of early yam

65. Will you say that today's rain fall pattern has led to a loss of some yam varieties? (1) yes (0) no

66. Mention some yam varieties that are no longer grown in your community…………………

67. What are the major challenges/problems that you face in your yam production? Please indicate them in order of importance

| No. | Challenge | Rank (1st-1 , 2nd-2 , 3rd -3 etc.) |
| --- | --- | --- |
| i | Moisture deficiency | |
| ii | Heat stress | |
| iii | Declining Soil fertility, | |
| iv | Insect pest | |
| v | Weeds | |
| vi | land shortage | |
| vii | Shortage of yam stakes | |

68. How do you describe the effect of climate variability/change in the last ten years?

Not severe (1) Severe (2) Very severe (2)

**PART V Assessment of Adaptation option to climate variability/change**

69. Is your annual production adequate to meet your food requirements?

(1) yes (0) no

70. If no how do you satisfy your food needs? a. Purchase by selling livestock or other products

b. Sell labour to generate income c. Practice small-scale trade d) burn charcoal for sale e) Other, specify…………………………………………….

71. Have you taken any action to mitigate the effects of climate variability/change on you? 1. Yes 2. No

72. If you answered yes in question 71, which of these adaptation measures have taken?

| No | Adaptation strategy | Yes (1) | No (0) |
|---|---|---|---|
| i | Decrease in farm size | | |
| ii | Change in location of yam farmlands/plots/ relocating farms along valley and humid areas. | | |
| iii | Adopted land rotation measures | | |
| | Crop management practices | | |
| iv | Using different or multiple yam varieties | | |
| v | Change in planting dates (i.e. multiple planting dates) | | |
| vi | Dropping yam varieties that are not tolerant to extreme weather/planting new/improved yam varieties | | |
| vii | Planting high yielding varieties | | |
| viii | Adopt the pyramidal staking option (tying vines from several mounds to one tree) | | |
| ix | No staking | | |
| x | Planting pest and disease resistance varieties | | |
| xi | Planting early maturing yam varieties | | |
| xii | Planting drought resistance yam varieties | | |
| xiii | Planting heat tolerant varieties | | |
| xiv | Mulching I (cover cleared fields with grass straw during the long dry season) | | |

xv Mulching II (cape mounds with straw to prevent moisture loss during planting season

xvi Using tractors to plough before raising mounds

vvii Engage in off-farm employment

xviii Application of insecticides

xix Spraying the barns with disinfectants on regular basis to minimise storage losses.

xx Sell produce immediately after harvest to avoid post-harvest losses

73. Do you think the adaptive mechanism(s) you employed is the best and viable one in current and future climate variability and change? (1) Yes (0) No. Give reasons for your answer………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

74. In your opinion, what is the best way to deal with the climate variability issues affecting yam production?.........................................................................................

**CHECK LIST FOR FOCUS GROUP DISCUSSIONS (FGD)**

**YAM FARMERS**

Name of Community: ……………………………………………….

Focus group size: ……………………………………………………

Focus group composition:

Male……………….............................................................................

Female…………………………………..............................................

1. What visible changes have you observed about the weather in your community over the last 10-20 years (rain fall pattern, temperature, soil fertility, forest vegetation, wildlife, crop productivity, livestock productivity, flow of streams, occurrence of big floods, incidence of drought, forest vegetation cover, river/stream flow etc.)

2. What do know about "climate change" and from which source did you first heard of the term "climate change"?

3. How do you adapt/cope with climatic variability?

4. What changes have occurred in the types of yams you cultivate over the past 20-30 years. (Probe: variations in variety, reasons for the changes, etc)

5. What effect has climate change inflicted on the livelihood of the local people? (Probe: food shortage, poor output, etc.)

6. How can the negative effects of the climate change be mitigated?

7. What development interventions are carried out in the village to avert the impact of climate change? (Probe: afforestation, water harvesting, irrigation, soil and water conservation, off farm employment, etc.)

8. Do you think the government is doing enough in support of yam farmers against the negative effects of climate change?

9. How has climate variability and change affected yam management activities? (Probe: i. Yam storage and preservation ii. Clearing of new sites for yam farms iii. Raising of yam mound iv. Sowing of yam seeds v. Mulching of yam mounds. Vi. Staking of yam vines. Vii weed control)

9. What adaptation measures have been adopted by to mitigate the effect of climate variability and change? (Probe: i. Yam storage and preservation ii. Clearing of new sites for yam farms iii. Raising of yam mound iv. Sowing of yam seeds v. Mulching of yam mounds. Vi. Staking of yam vines. Vii weed control- type of strategy, reasons for choosing a particular strategy)

10. How do you evaluate the role of agricultural extension agents in mitigating the negative effects of climate variability and changes?

11. What agricultural technology and meteorological information/early warning are provided to farmers to avert climate shocks? (Probe: type, institution providing, etc.)

12. What success stories have you observed in relation to coping and adaptation strategies for yam farmers in the face of climatic variability?

**CHECKLIST FOR KEY INFORMANTS**

**(Community leaders, FBO leaders, etc.)**

Name of Community: ……………………………………………..

Sex of Respondent……………………………………………………

1. What visible changes have you observed as related to the following: rain fall, temperature, soil fertility, forest vegetation, wildlife, crop productivity, livestock productivity, flow of streams, occurrence of big floods, incidence of drought, etc. during your life time in this village?

2. What changes have you observed in respect of land suitable for yam cultivation.

3. What changes have you observed in terms of timing and ease of carrying out the following yam cultivation activities (land clearing, making of mounds, sowing, mulching, staking, weed control, harvesting and storage, yam quality, pest and diseases)? What new challenges have you noticed?

4. What effect has climate change inflicted on the livelihood of the people in your community?

5. What coping and adaptation strategies have you crafted to alleviate problems arising from climatic variability/change? (Strategies, reasons for choosing a particular set of strategies, challenges encountered etc.)

6. How do you evaluate the role of agricultural extension agents in mitigating the negative effects of climate variability and changes? (Training, education, input support, number of visits/year)

7. What agricultural technology and meteorology information system do you access regularly and during climatic extremes?

8. How can the negative effects of the climate change be mitigated?

9. What are the success stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?

10. What do you think is responsible for climate variability/change? (human/natural/spiritual forces)



**CHECKLIST FOR STAFF OF DISTRICT/REGIONAL AGRICULTURAL OFFICES**

Name of District: ……………………………………………………

Title of Respondent…………………………………………………

1. How do you evaluate the impacts of climate change/variability on yam farming activities in this district? (Identify impact at each level along yam value chain).

2. Do you think the current rainfall amounts/temperature levels are conducive for yam cultivation?

3. What is an average temperature/rainfall requirement for yam growth?

4. How is the MoFA promoting the adoption of adaptation strategies by yam farmers (type adaptation promoted and reasons for promotion, types training, incentives, motivation, equipment etc)?

5. To what extent are MoFA driven adaptation strategies sustainable for yam productivity?

6. Apart from MoFA which other institutions/agencies are promoting climate adaptation strategies in this district?

7. How integrated are institutional adaptation strategies (government, NGOs, CBOs – Mention NGOs, CBOs, FBOs implementing adaptation policies in your district)?

8. What policies are in place to promote yam production in your district?

9. What are the challenges faced by the agricultural research and extension services to address climate change issues?

10. What success stories have you observed in relation to coping and adaptation strategies adopted by yam farmers to mitigate climatic shocks?