ASSESSING THE IMPACT OF RAINFALL VARIABILITY ON TOMATO FARMERS IN TANO SOUTH DISTRICT: A CASE STUDY OF TECHIMANTIA.

BY

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THIS LONG ESSAY IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE CLIMATE CHANGE AND SUSTAINABILITY STUDIES

MAY, 2018
DECLARATION

I do hereby declare that this long essay is the result of my own research undertaken under supervision and has not been submitted in part or in full to this institution or any other institution by any other person for an academic award. All citations and quotations have all been identified and acknowledged. I bear sole responsibility for any shortcomings.

KOJO ASARE-BEDIAKO
(10636624)
CERTIFICATION

This is to certify that this long essay was supervised in accordance with the laid down rules and procedures as required by the University of Ghana.

……………………………………………………………………………………………………………………………………………………………………

DR THEOPHILUS MALOREH-NYAMEKYE DATE
(SUPERVISOR)
DEDICATION

This phenomenal work is dedicated to my parents (Mr. & Mrs. Darkwah Ocran) and the entire family whose greatest desire is to see me achieve greater academic laurels.

INTEGRI PROCEDEAMUS
ACKNOWLEDGEMENT

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<tr>
<td>ENSO</td>
<td>El Niño-Southern Oscillation</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
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<td>MIS</td>
<td>Management Information System</td>
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<tr>
<td>MM</td>
<td>Millimeters</td>
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<tr>
<td>MoFA</td>
<td>Ministry of Food and Agriculture</td>
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<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
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<td>NHIS</td>
<td>National Health Insurance Scheme</td>
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<td>PRA</td>
<td>Participatory Research Approach</td>
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<td>SSPSS</td>
<td>Social Package for Statistical Service</td>
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<tr>
<td>TWN</td>
<td>Third World News</td>
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<td>USHCN</td>
<td>United States Historical Climatology Network</td>
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ABSTRACT

Rainfall variability is one of the most critical environmental challenges that has received a lot of attention across some parts of the world, especially Sub-Saharan African countries. It affects various economic sectors such as agriculture, energy and industries. Considering agriculture, it is due to the fact that farmers in the Sub-Saharan countries are highly dependent on rainfall for their agricultural production. Unfortunately, there has been severe rainfall pattern changes during the past decades and food production has declined partly due to this climate challenge. The study thus sought to assess the impact of rainfall variability on tomato farmers at Techimantia in the Tano South District of the Brong-Ahafo Region of Ghana. A mixed method approach and a case study design were used for the study. Data collected instruments used involved structured questionnaire, in-depth interview guide and some participant observations were the tools used for data collection involving eighty (80) tomato farmers who were purposively selected from the Techimantia community in the study area. The results of the study indicate that rainfall is the most observed climate variability over the past decade as compared to temperature and humidity changes. The study also identified the yield and availability of tomato to mostly be in a fluctuating manner since the past decade due to changes in the onset and duration of the rains. It was also observed that in the heat of adverse effect of rainfall variability in play, farmers have also adopted several on-farm and off-farm adaptation mechanisms to deal with the shock. It is therefore recommended that certified seed/seedling units (such as CSIR and Bechem seed/seedling units) should concentrate on developing climate resistant tomato varieties that are easily accessible by farmers.
CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter focuses on the background of the study. It goes on to elaborate on the research problem, research questions, objectives of the study, justification of the study, scope and limitation of the study, organization of work and summary and conclusion.

1.1 Background of the study

Tomato is known to be a fruit that is cultivated universally as a vegetable and also a perennial plant cultivated annually (Rick, 1978). Tomato (*Lycopersicon esculentum* (L)) is the most commercially cultivated vegetable throughout the world and has high nutritional contents of vitamins A, B and C. Its fruit can either be used in the raw or ripe state for cooking purposes or processed into juice, ketchup, pickles and sauce, among others. It purifies the blood and acts as an enhancer in gastric secretion. Suitable varieties in Ghana include Roma VFN, Pectomech VF, Tropimech, Rio Grande, Jaguar, Lindo, Titao Derma, and Ada Cocoa and it requires warm days, bright sunshine and cool nights for high yields. High temperatures and low humidity may cause excessive flower drop and reduce yields drastically and soils should be well drained and fertile (MOFA, 2017). These varieties are able to survive the atmospheric conditions of Ghana due to the geographical location and soil conditions available.

The El Niño-Southern Oscillation (ENSO) phenomenon is the major cause of yearly rainfall variability and stream flow in the world (Nicholls and Wong, 1990). Both the El Nino and La Nina phenomena are the major causes of both the rainfall being below normal and above normal
respectively. These fluctuations could have an adverse effect on food security in the world. A study by Warner and Afifi (2014) showed that in Guatemala, rainfall affects food production and economies of households. Relating this to rainfall patterns, households reported concerns about the long-term variability of their farming systems and food availability. In Peru, two-thirds of households sustained crop damages and lower crop yields. Most of the farmers experienced substantial negative effects on household income from rainfall variability. Rainfall changes affected the ability of households to feed themselves and earn livelihoods, with over 80% of households responding to survey experienced decrease in harvest, livestock, and own food consumption in the past 5–10 years. Again, in Vietnam, the respondents perceived that the amount of rainfall during the rainy season has increased and it was in line with the data given by the meteorological services department within the area. Some respondents also had witnessed heavy occurrences of rainfall events (Warner and Afifi, 2014).

Rainfall is the most variable climate elements and therefore determines the growing season in developing countries like Nigeria, Kenya, and Uganda among others which are known to practice rain-fed agriculture. Rainfall is one of the most essential climatic elements affecting crop production such as tomato (Ayoade, 2004), thus causes changes inter-annually which affect crop yield in the tropical environment since it determines the amount of water to plants (Adejuwon, 2010). Most farmers therefore rely mostly on the outcome of the expected rainfall as it may determine the success or failure of their crops. Rainfall duration seasonally (length of growing season) as well as the annual distribution and number of rainy days also vary remarkably. The variable weather pattern has serious implications for the farmers and it greatly blocks all efforts being put in place by individuals, local, state and federal governments to ensure agricultural viability, abundant food supply and food security (Adamgbe et al., 2013). Famine Early Warning
Systems (2005) noted that more than three quarters of people in Tabora Region, semi-arid Tanzania, rely on climate sensitive rain-fed agriculture for their livelihood. Von Braun (1991), for instance, argued after a study in Ethiopia that, a 10% reduction in seasonal rainfall from the long-term average generally translates into a 4.4% decrease in the country’s food production. Since rainfall in most parts of the tropics are unreliable and unpredictable, rainfall variability and its associated drought has been the major causes of famine and food shortage in the country (Pankhurst and Johnson, 1988). Generally, the impact of rainfall variability on crop production varies with the type of crop, soil-type and climatic conditions and, even in wet areas, rainfall variability is very critical during the early stages of rain due to the amount being built up in the soil within that period.

Ghana, like other developing countries, rely mainly on rain-fed agriculture and therefore rainfall variability becomes a major determinant of the growing season and also the one of the most essential climatic elements affecting crop production. Morton (2004) argues that most of the effects of rainfall variability in developing countries are felt by a category of people known as smallholder farmers and African countries such as Ghana has about 90% of its farm holdings being less than 2 hectares in size and producing under rain-fed conditions. Rainfall variability impacts are widely experienced in African countries, such as Ghana and therefore affect rainfall-dependent activities and indirectly impact on social aspect such as poverty, conflict, education and health (Orindi and Murray, 2005). In Ghana, a study by Warner and Afifi (2014) shows that rainfall variability changes affect food production in 91.1% of households surveyed, and negatively impact 89.2% of surveyed household economies. On the whole, 92.4% of households reported lower crop yields affecting household income when unexpected rain patterns occur, while 37.3% also reported increase in food prices (Warner and Afifi, 2014)
1.2 Statement of the problem

Ghana is among the highest agricultural production countries in the West African region, however, rainfall variability is adversely affecting production of crops, such as tomatoes. There has been a drastic reduction in production as well as having adverse effects on the livelihoods of smallholder farmers in the country. Scenarios of past and present climatic trends from climatic predictions and analysis indicate that smallholder farming households in the tropics and sub-tropics will continue to be more and more vulnerable to climatic risks (Igwebuike et al., 2010). This scenario study projects an increase in hunger and food security, thereby placing a high demand on food at the household and national levels. Most smallholder farmers in Ghana depend solely on rainfall as their main source of irrigation and the amount of rain water retained in the soil enhances production. Most smallholder farmers in Ghana practice agriculture as their main source of livelihood, and therefore any changes in rainfall pattern may affect rainfall-dependent activities like crop production, and indirectly impact on social aspect such as poverty, conflict, education and health (Orindi and Murray, 2005). Many governments, non-governmental organizations and research institutions have put in various alerting mechanisms to inform farmers on the onset and duration among others of rainfall so as to reduce the adverse effect it has on agriculture and food scarcity throughout the year. As part of the objectives of agriculture, the Ghana government is poised at ensuring food security for its citizens throughout the year (Ministry of Food and Agriculture, 2007). However, majority of the research that has been done relating to impacts of rainfall variability are very general and considers the issue from a national or regional perspective. For example, a study by Owusu, 2013 on farmers’ observations on climate change impacts on maize production in a selected agro-ecological zone in Ghana indicates that changes in the onset and duration of rain have negative impact on maize production and thus, pose a serious threat to
household food security since maize is the staple food of most Ghanaians (Owusu et al., 2013). It appears little work has been done to understand the impacts of rainfall variability on agricultural farmers since most of the research work done mostly tend to focus much on how rainfall variability affects agriculture itself. Most especially, Onumah (2010) studied the trends in agriculturally-relevant rainfall characteristics for small-scale agriculture in Northern Ghana. In this type of study, interviews were used to identify the characteristics of rainfall which are deemed important by the farmers in their food production (Onumah et al., 2010).

The study therefore seeks to assess the impact of rainfall variability on tomato farmers in Techimantia, and subsequently seek to understand the adaptation or coping strategies tomato farmers use in order to reduce this impact on their livelihoods.

1.3 Objective of the study

1.3.1 General objective

The main objective of the research is to assess the impact of rainfall variability on tomato farmers in the Techimantia community within the Tano-south district in the Brong-Ahafo Region of Ghana.

1.3.2 Specific objectives

Specifically, the study seeks to:

(i) examine the trend of tomato yield output from farmers as a result of changes in rainfall pattern.
(ii) assess the implications of decline in tomato production (if any) on the livelihood and living standards of the farmers.

(iii) the adaptation or coping mechanisms adopted by farmers in dealing with the adverse effect of rainfall variability.

1.4 Research questions

(i) How does rainfall variability affect tomato production in Techimantia?

(ii) How do these challenges affect their livelihood and living standards?

(iii) What adaptation or coping mechanisms have tomato farmers put in place in dealing with the rainfall variability?

1.5 Justification for the study

The primary beneficiaries of the research are the tomato farmers within Techimantia, Derma, and Subriso, among other neighboring communities. The results of the research could provide a reference data to the beneficiary communities of the study setting to know the adverse effects rainfall variability is likely to have on their tomato production which serves as the main source of livelihood within the Tano-South district of the Brong Ahafo Region. The result could also provide MOFA district office with relevant information that could help to ensure reliability of policy decisions made on rainfall to farmers within the district. The study aims at contributing to the literature on rainfall variability and livelihood of tomato farmers and also further provide knowledge and educational information to the academic community to research more into adaptation strategies used by farmers. The study would inform policy makers in the country on the
most appropriate and effective adaptation strategies that could reduce adverse effects caused by rainfall variability to farmers such as early warning signs among others.

1.6 Scope and Limitation of study

Specifically, tomato farmers within the Techimantia community were used in this study because tomato production is known to be the major source of livelihood for the people of Techimantia, Derma and Subriso among other neighboring communities. The study only considered all farmers who cultivated tomatoes since according to MoFA in Ghana, it is the crop that produces the most socio-economic benefit to farmers within the Tano-South district (MOFA, 2017).

1.7 Organization of the study

Chapter one of the study deals with the introduction, background of the study, statement of the problem, research questions and objectives, justification of the study, scope and limitation of the study and the, summary and conclusion of the whole chapter one.

Chapter two also deals with the review of the relevant literature pertaining to the impacts faced by tomato farmers during rainfall variability (e.g. rainfall variability, adaptation or coping mechanisms or strategies, challenges among others).

Chapter three sheds much light on the research methodology used in order to gather the data needed in the study. It describes the research approach, study design, study area, sources of data which in this study includes both the primary and secondary data to used, sampling techniques adopted, sample size used, data collection tools employed in the study and finally, the data management and analysis techniques used.
Chapter four deals with the results and discussions of the outcome which have been accurately analyzed.

Finally, chapter five deals with the summary, recommendations and conclusions drawn during the study.

1.8 Summary and Conclusion

The whole chapter is concerned with the background behind tomato production and rainfall variability. Again, a statement that tended to shed more light on the need for the study was also made. This led to leading research questions to ask during data collection and also brought out the objectives of the study. Justification as well as scope and limitation of the study were also made.
CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction
This chapter reviews literature relevant to the study. It shows evidences of global climate variability. It also discusses rainfall variability trends and sheds much light on the overview of tomato production in Ghana. Again, it seeks to explain much about the linkages between both extreme climatic conditions and rainfall variability, and crop production. It goes on further to review the socio-economic benefits of tomato production in relation to tomato farmers and lastly, the livelihood adaptation of farmers.

2.1 Evidence of Global climate variability
The changing global temperature and rainfall could attest to the fact that the climate is always changing. Due to the existence of global warming which has become a global phenomenon and known to be caused by either natural variability or anthropogenic-induced factors, global temperature and precipitation trends should be recorded and updated at both the regional and national levels.

The IPCC (2014) has argued that if the generation of atmospheric greenhouse gases such as carbon dioxide, nitrous oxide, methane, chlorofluorocarbons among others are not reduced, there would be increase in future temperatures including extreme weather conditions such as drought, in most
part of the world especially Sub-Saharan African countries. Statistical variations recorded over the years agree to the fact that the climate has been changing over decades ago (Raman et al., 2011). Burning of fossil fuel, agricultural land-use and deforestation among others have contributed significantly to climate variability with impacts observed from sea-level rise, melting of ice to extreme weather conditions including different rainfall patterns and others. IPCC (2007) acknowledged the fact that rises in the sea level in conjunction with melting of the Artic sea ice could prove as evidence to the changing of the global climate. However, the evidence by IPCC failed to elaborate on the extreme weather changes associated with this climate change. For example, the global sea level rise had increased from 12-22 centimeters (cm) during the 20th century but satellite records show that it has doubled to about 3.4 millimeters (mm) per year (IPCC, 2007).

Due to the variations in the global temperatures as well as atmospheric carbon concentrations, there is evidence of changing climatic conditions over time and these may affect certain divisions of the economy, such as agricultural division which is very vulnerable (Walthall et al., 2012). On the contrary, Mitchell et al., (2000) found out that there was no significant increment in sea level rise as compared to recordings from global climate models.
2.1.1 Trend in rainfall variability

Petrie et al., (2014) showed in their study at northern Chihuahuan Desert, United States that the regional precipitation patterns portray various trends in average event timing and magnitude. Their study however showed that the indemnifying changes did not cause change in the average total monsoon precipitation at the United States Historical Climatology Network (USHCN) site over the past century. The main explanation given to the non-changing average total precipitation in effect to no changes in the average monsoon precipitation was that small number of large events could contribute to most of the total precipitation and the small events could be insignificant in terms of total precipitation.

According to Jidauna et al., (2011), the amount and duration of rainfall pattern experienced over the years in Nigeria has decreased tremendously by 78.6 % and the intensity of rain experienced during the rainy season has also decreased 77.3%. Again, according to study, the stream flow data within the past 20 years in Nigeria shows a decrease in rainfall of about 76.8% affecting the rate of stream flow and annual recharge. This significant reduction in rainfall has a great tendency of affecting agriculture and subsequently causing food insecurity in the country. 40 years recorded data and climate model implementation showed a reduction in annual rainfall pattern and shortening of rainy seasons in the coastal areas of Benin after a rainfall analysis was done (Teka et al., 2010). The result was indifferent to the previous findings.
In Ghana, research has found out variability in rainfall pattern within years and decades and this has caused identification of long-term trends very difficult. In the 1960s, Ghana recorded high rainfalls but decreased to very low levels during the late 1970s to early 1980s. This caused an overall country-wide decreasing trend within the years of 1960 to 2006 by an average of 2.3mm/month or 2.4 percent/decade (McSweeney et al., 2008). Comparing the mean annual rainfall between 1951-1970 and 1981-2000 at meteorological stations across Ghana indicates a reduction in rainfall (Owusu and Waylen, 2009 cited in Stanturf et al., 2011). This reduction in rainfall within 1981-2000 could originate from the severe drought experienced across Ghana in 1983 which caused great hunger and famine, and people had to travel to other jurisdictions for food and shelter. The adverse effect of the reduction in rainfall at the long-run affects plant growth. Therefore, this raises questions about the fact that the reduction of rainfall among Sub-Saharan African countries may have adverse effect on food security since most of the crops cultivated within the continent are rain-fed.

2.2 Overview of tomato production in Ghana

Tomato, (Solanum lycopersicum L.) is one of the major vegetables usually cultivated by smallholder farmers in Ghana (Osei et al., 2010) and supports vastly to the socio-economic development of the country. Major production of tomato could be seen in the Northern, Upper East
and Southern Volta Regions of Ghana and also some areas in the middle belt such as Offinso North
and Wenchi districts in the Ashanti and Brong-Ahafo Regions respectively (Third World
Network [TWN], 2007). Tomato production in Ghana is done all year round though it is mainly
rain-fed. In the southern part of the country, it is cultivated mainly in the rainy season which span
from June to November and has a dry-season system between October and April in the Northern
part of the country, usually Upper East Region (Asante et al., 2013). Ghana has huge land for
cultivating arable crops and apart from Tomato production serving as a major source of livelihood
to most farmers, especially in the Offinso North district, the fruit also provide nutritional benefits
to the body such as Vitamins A, B and C. A medium sized ripe tomato (~ 145 grams) can provide
the body with up to 40% of Vitamin C and 20% of Vitamin A (Kelley and Boyhan, 2010). Tomato
can be cultivated on a wide range of soil types but the most suitable is the medium texture sandy
loam or loamy soil, fertile and well-drained soil (Kelley and Boyhan, 2010). This soil type provides
physical support, nutrients and water to the crop. This clearly shows that soil which lacks these
above-mentioned factors will cause low crop yield or production. During land preparation stages,
tilling should be encouraged to help in the seedling transplanting process and also help build a soil
with good structure for growth and root development (Kelley and Boyhan, 2010).

There are different varieties of tomato cultivated in Ghana and the varieties include both local and
exotic breeds. Some of the local varieties include Power Rano, Rasta and Wosowoso but the Power
Rano is known to be the most preferred due to its high tolerance and resistance to diseases (Robinson & Kolavalli, 2010). The fruits contain more seeds and produce high yield when favorable conditions such as well-drained fertile soil, enough fertilizer application, weed control and disease-free land are being provided (Appiagyei, 2010). Domestic cultivation is known to be on the rise in the country but it cannot meet the dynamic population requirement and therefore more tomatoes have to be imported from other countries, such as Burkina Faso, to support food security (Horna et al., 2006). Exotic breeds of tomato cultivated in Ghana include Pectomech, Royal, Marglobe, Marvel, Money-maker, Roma and Fireball and cannot be cultivated on a large scale within our traditional systems of management, especially in the more humid areas of the forest zones (Appiagyei, 2010). Some factors farmers consider in choosing the type of variety depends on the availability of seeds, market demand, price among others (Robinson and Kolavalli, 2010).

It has been concluded by Kalibbala (2011) that excessive rainfall and high relative humidity can adversely affect the tomato crop, due to its susceptibility to leaf diseases during high humidity situations. Evenly distributed annual rainfall of about 750mm is very satisfactory for the growth of tomato (Mensah et al., 2013). This implies that when the annual rainfall exceeds 750 mm, there can be unfavorable conditions created for the crop. They have therefore recommended that in areas where rainfall is unpredictable, irrigation should be a great necessity in order to boost production.

In contrast with earlier submission, Romain (2011) maintains that tomato requires high relative
humidity and long hours of day to grow well. This assertion means that low relative humidity can negatively affect tomato growth and high relative humidity impacts significantly to the growth of the crop. Therefore, Agricultural Extension Officers should be well trained to give relevant and important information to farmers and advice well on the adaption strategies to use in order to curtail such situations.

2.3 Linkage between rainfall variability and crop production

Precipitation has a direct linkage with agriculture production and increase or decrease in its quantity, has a significant impact on the total yield output (Walthall et al., 2012). Rainfall variability does not necessarily affect yield out but rather reducing the amount of agricultural inputs (e.g. fertilizer) needed for plant growth (Walthall et al., 2012). For instance, corn is vulnerable to excess water at the early growth stages and can result in lower plant growth while reduction in soil water can also cause lower growth and yield if stress condition persists during the grain filling period of growth (Hatfield and Prueger, 2011).

A study by Adamgbe and Ujoh (2013) on the effect of variability in rainfall characteristics on maize yield in Gboko, Nigeria reveals that 1983 recorded the lowest maize output per hectare (610 kg/ha), reasonably due to the slow onset date (5th May), earliest cessation date (28th September), shortest duration (146 days), lowest number of rain days (51 days) and annual rainfall amount
(903.6 mm) that occurred in the same year. This suggests that decrease or increase in rainfall has a significant effect on crop output.

A study by Molua and Lambi (2006) shows a decrease in net revenue when precipitation decreases or temperature increases amongst farms in Cameroon. The above study certifies the assertion that precipitation have some level of influence on crops. Since there is a direct correlation between precipitation and crop production, situations where precipitation decreases, farmers need to resort to irrigation as an alternative the boost the water level for plant growth. It can be understood that, no matter the adverse effects of climate variability on crop production, there are positive synergies that exists between the two. Sudarkodi and Sathyabama (2011) suggests that though high carbon concentration tends to increase warming conditions of the climate which affect growth rate, it also increase photosynthesis activities of plants which may increase yield. According to them, the doubling of carbon dioxide increases photosynthesis rate by about 30-100%.

2.3.1 Linkage between extreme climate conditions and crop production

The development of most agricultural crops, typical of those which are rain-fed, are hindered greatly by extreme climatic conditions such as drought and flooding. Easterling et al., (2000) argues that societal infrastructure is much sensitive to extreme climatic condition and cannot easily be overlooked. For example, extreme climatic conditions (e.g. droughts and flooding) have direct effect on crop output than the mean optimal conditions. Water availability to a great extent have
high sensitivity to climate changing with severe water stress conditions which affects crop productivity, especially vegetable crops (Pena and Hughes, 2007). In situations where decreased precipitation is submerged with elevated temperature, there is low irrigation water availability as well as evapotranspiration, which subsequently leads to severe crop water-stress conditions (IPCC, 2001). Thus, water significantly affects the yield and quality of vegetables with drought conditions adversely reducing vegetable productivity. Most crops are vulnerable to flooding conditions and therefore their production tends to limit when there is excessive moisture caused by flood rains. Most vegetables show high sensitivity to flooding and genetic variation associated with this phenomenon is limited, especially in tomato. In a nutshell, damage to vegetables through flooding happens due to the reduction of oxygen at the root zone where aerobic processes take place (Pena and Hughes, 2007). The total effect of reduction of oxygen in plants is the adverse effect on crop yield leading to food insecurity and according to Naeve (2002), the effects of flooding for six days may significantly affect crop yield but flooding for longer periods may destroy the entire production.

2.4 Local perception of Rainfall Variability

Rainfall variability is perceived differently by different people, especially in the agricultural sector. These various perceptions can be attributed to some extent, both the educational background of the individual and indigenous knowledge. Rainfall variability could also be perceived based on
regional differences. Various research studied in Africa reveals that the perception of large number of farmers on rainfall variability is changes in rainfall durations and onsets (Gbetibouo, 2009). According to a study by Tunde (2011) on farmers’ perception of climate variability on agriculture in Nigeria, most of the farmers (47.2%) in the region perceived climatic variability as delayed rainfall. Again, the study showed that 22.2% perceived climate variability as high temperature, 5.6% said it is flood, 2.8% observed it as unusual rainfall and 22.2% perceived it as undefined season. The author therefore inferred that farmers in Nigeria perceived rainfall variability as inadequate or excessive rainfall. This variation as perceived by farmers in the country will enhance good decision making toward adaptation or coping measures to undertake in order to cope with this adverse effect. Mengistu (2011) studied farmers’ perception and knowledge of climate change and their coping strategies in Adiha, Nigeria. The results showed that about 75% of the farmers perceived the temperature of Adiha to have increased in the last two decades. Likewise, 90% of the respondents observed changes in the rainfall pattern in the last two decades. This shows that the local people, especially farmers, were much aware of the changes in the climatic conditions observed over the past years.

2.5 Adaptation or coping mechanisms of African farmers to climate variability

Many farmers in Africa apply adaption mechanisms whenever they are faced with changes in the climate. Agricultural adaptation mechanisms may depend on certain available factors such as
economic, institutional, location and political among others (Smit and Skinner, 2002). Adaptation can be grouped into two types, namely, autonomous and planned adaptations. Planned adaptation is done at the government level where changes are made during decision making to provide relevant information and technical advice. Autonomous adaptation, on the other hand, focuses at the farmer level where innovative changes are made to agricultural practices through trial-and-error, farming practices and changes to decisions that are made concerning the environment when planned adaptation strategy has been taken (Easterling et al., 2007). A study by Zorom et al. (2013) on climate variability and adaptation strategies by farmers in the Sahel region show various mechanisms adopted by farmers to cope with adverse condition of drought. These mechanisms include diversification of non-farm activities such as rearing of poultry and livestock as well as reduction in food intake while some farmers also indulged in growing of dry season irrigated vegetables. These practices help farmers to withstand any stress caused by climatic stimuli and are able to raise their economic activities which strengthens their financial abilities in order to raise their power to purchase (Solórzano et al., 2014).

Again, Mary and Majule (2009) studied climate variability and change and adaptation strategies in semi-arid areas of Tanzania. The study used the Participatory Research Approaches (PRA) method and found out that most farmers in Kamenyanga and Kintinku in Tanzania used crop diversification as an adaptation strategy by introducing mixed cropping method where farmers grow different crops on the same piece of land. This was used as a means of compensation in
situations where one crop fails and the other survives and also spreads risks and increase farm profit in times of changing climate (Uddin et al., 2014).

Hassan and Nhemachena (2008) study on the determinants of African farmers’ strategies for adapting to climate change in Pretoria using the multinomial econometrics analysis proves that farmers adopted agro-chemicals application and fertilizer usage as a means of adapting to the impact of changes in the climate. However, agro-chemical application and changes in the agro-chemicals used as an adaption strategy was possible due to the availability of credit facilities that enhanced the financial strength of the farmers to adopt to such strategies. Similarly, Tshiala and Olwoch, (2010) revealed in their study that farmers in Limpopo Province, South Africa increased their tomato yield by some adaptation strategies such as applying agro-chemicals needed. Tshiala and Olwoch (2010) showed that irrigation was one of the efficient adaptation strategies that improves tomato yield. On a contrary, the study by Calzadilla et al., (2014) in South Africa on the impact and adaptation to climate change shows that irrigation can be a good adaption strategy practice but will not be sufficient to diminish the impact of climate change. A study by Bryan et al. (2013) in Kenya showed that access to irrigational facilities is one of the key determinant factors that influences farmers’ adoption of changing crop types to cope with changing climate.
2.5.1 Factors influencing adaptation strategies

Various factors and obstacles prevent or influence people, especially farmers’ decision on effective mechanisms that helps them in responding to shock from changes in the climate. According to Eakin et al., (2012), the differences in farmers’ capacity, either as an individual or a community, to adapt or cope is influenced by a wide set of area-specific socio-economic, historical, environmental and institutional factors which act conjointly. Farmers could adapt to exposure or sensitive situation through two ways, firstly, through livelihood mediums in no-farm/off-farm adaptation and secondly, through innovations aiming at adaptation in the crop farming system (Li et al., 2010). For the non-farm adaptation, they realized the employment policy and migrant workers’ ability to be the two most vivid reasons that influence farmers’ decision in their bid to cope with the changing climate. They further ascertained that farmers’ experience through “learning by doing” as a coping or adaptation strategy to combat the impact of climate stimuli. Community-based governance system is one of the coping strategies farmers use to respond to the adverse climatic variability (Campos et al., 2014). The structural arrangements put in place during the governance system informs farmers on the adaptation measures to take regarding climate variability. It is regarded as one of the important factors that influences farmers’ decision making. Studies performed by both Maddison, (2007) and Deressa et al. (2009) have all found out the importance of socio-economic factors such as education, wealth status and resource availability (including credit, land and water storage facilities) in adaptation activities by the farmers. Again,
one of the socio-economic factors that determines adaptation mechanisms is age and has been concluded by various studies that age is not an influential variable during farmers’ decisions on water and soil management practices (Anley et al., 2007). On a contrary, the study by Owombo et al., (2014) in Ondo State, Nigeria on farmers’ adaptation to climate change shows that age, to some large extent, has a positive relationship with adaptation strategies. Most smallholder farmers need financial empowerment in order to adapt to climate variability (Ngigi, 2009 cited in Mudombi, 2011).
The whole research is aimed at improving livelihood and food security mainly at the local level. The variations in these major factors are influenced by climate variability (that is, rainfall variability) on agricultural farmers (that is, tomato farmers). To understand rainfall variability from...
a global perspective, evidences of global climate variability and trends in rainfall are gathered from various studies as shown in Figure 1. A general overview of tomato production in Ghana has also been elaborated. Linkages between rainfall variability and extreme weather conditions, and crop production have been well elaborated to further understand the effects they both have on crop production. Much review is done about local perceptions on rainfall variability as well as adaptation or coping strategies employed by farmers in dealing with the menace of climate change which is negatively affecting agricultural production.

2.6 Summary and conclusion

This chapter reviewed relevant literature on evidences of global climate variability and the trends in rainfall variability. It also presented an overview of tomato production in Ghana. It again presented in details the linkage between rainfall variability and crop production, as well as extreme climatic conditions and crop production. It reviewed in detail the local perception on rainfall variability and finally, adaptation strategies adopted by African farmers to cope with adverse climatic changes.
CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter focuses on the methods and procedures that were used in achieving the research objectives. The chapter delves into the research approach, as well as the design adopted for qualitative and quantitative data collection procedures. It also discusses the sampling techniques, target population, data analysis and sample size used for the study. Ethical considerations pertaining to confidentiality and consent have also been presented.

3.1 Research Approach

This study employed the mixed method approach. Creswell (2012) defined mixed method as a procedure for collecting, analyzing, and ‘mixing’ both qualitative and quantitative method in a single study to understand a research problem. The qualitative method of approach was used to understand further how the trend in rainfall pattern has affected tomato production as well as livelihood of the tomato farmers within the Tano-South district, Brong Ahafo Region of Ghana. The quantitative method of approach was also employed to seek farmers knowledge on some impacts of rainfall variability on their tomato production and livelihood, as well as adaptation mechanisms they have adopted to cope with those impacts within the Techimantia community.
3.2 Study Design

A case study design was employed to ascertain the knowledge of tomato farmers on the possible impacts of rainfall variability on their production and livelihood and also adaptation or coping mechanisms that they have employed in dealing with the impacts. A case study design is known to offer holistic form of inquiry (Gangeness and Yurkovich, 2006). The design is very appropriate since the researcher seeks to find out the impact of rainfall variability on tomato cultivation and also livelihood of farmers in the Techimantia community and how they are adapting or coping with those impacts. The researcher is again, able to give clearly assessment of each of the specific objectives without seeking to generalize the findings but to talk directly to what pertains in the Techimantia community.

3.3 Study area

Tano-South District lies in the southern part of the Brong Ahafo Region between latitudes 7°00” N and 7°25” N and longitudes 1°45” W and 2°15” W. The District is bordered to the north and east by the Offinso and Ahafo-Ano South Districts respectively. Again, it is bordered to the south by the Ahafo-Ano North District and on its west and south-west by Tano-North District. It covers an area of 489.0 square kilometers. The District capital, Bechem, is about 54 km from Sunyani and 76 km from Kumasi. The population of Tano-South District, according to the 2010 Population and Housing Census, is 78,129 with relatively more males (50.0%) than females (49.0%), giving a sex ratio of 96.2. More than three-quarters (76.1%) of households in the District are engaged in agricultural activities. An overwhelming majority (97.1%) of the households are involved in crop farming and about one-third (32.9%) are also involved in livestock rearing. The topography of the District is mostly made up of undulating land which rises gently from a height of about 270m to a
peak of 760m. The District lies in the Semi-equatorial climatic zone which experiences double maximum rainfall pattern. The first rainfall season is from April to June, with the heaviest in June. The second period is from September to October. The annual rainfall is between 1250mm and 1800mm. The dry season is pronounced and occurs from the months of November to February (Ghana Statistical Service, 2014).

3.3.1 Profile of Techimantia community

Techimantia is a city located in the Tano-South District. It is located at an elevation of 304 meters above sea level and its population amounts to 41,345 (www.getamap.com). It is about fifteen (15) minutes’ drive from the district capital, Bechem. Again, it is the head of the Techimantia zone, which forms part of the three zonal divisions done by the Tano-South, MoFA district office. Every Wednesday is a market day in Techimantia, where traders from inward and other communities come to do business. Tomato cultivation is known to be one of the major farming activities within the community and done thrice within the year. It is also a peaceful community with less business activities.

3.4 Sources of Data

Both primary and secondary data sources were employed for this study.

3.4.1 Primary Data

In this study, administering structured questionnaires with few open-ended questions was one of the means by which primary data was collected from farmers within the Techimantia community. This allowed the researcher to have one-on-one discussions with the farmers to gather much information regarding their own personal experiences with rainfall pattern changes on tomato
farming activities and, also their livelihood and living standards in the community. Also, primary data collection was done by having in-depth interview with some officials of the MoFA office within the district.

3.4.2 Secondary Data

In addition to the primary data, secondary data containing rainfall distribution patterns within the district was obtained from the Management and Information Systems (MIS) department of the MoFA district office. Also, various journals and articles among others (both published and unpublished) were used in this study.

3.5 Sampling Technique

The purposive sampling technique was used to sample both tomato farmers (with five (5) and more years of experience) and some officials of MoFA office within the district. These type of tomato farmers were selected because they are believed to have more experience (as far as rainfall variability is concerned) over some period of time (five (5) and more years) in the production cycles and therefore such information from them will be rich and more satisfactory for the study. The snow balling technique was used for selecting farmers. In this technique, the Assembly member for the Zongo community was contacted (who was a farmer himself) and he led us to others and the process continued until the sample size was obtained. Again, officials from the MoFA district office were selected based on their portfolio and their constant interactions with the farmers in the district.
3.6 Sample size

A total of eighty (80) tomato farmers, with 5 or more years of experience in tomato cultivation, were selected for this study. An in-depth interview was also conducted with two (2) District Crop Officers and the District Management Information Officer of the MoFA district office. The sample size for the quantitative study was due to the purposive sampling technique used. Farmers who have been in continuous production for the stipulated period of time were difficult to come by since most of the farmers had been in ‘truancy’ form of cultivation and therefore had little or no facts about the changing rainfall patterns among others.

3.7 Data Collection Tools

Both structured questionnaires with few open-ended questions, and interview guide were used this study. The structured questionnaires were used by the researcher to garner adequate information about how rainfall variability was affecting the cultivation of tomato in the community, as well as livelihood and living standards and adaption or coping mechanisms that have been employed by farmers. During the questionnaire administration, the researcher explained vividly what each question means and gave options to the respondents as to which one will be very appropriate to him or her.

Interview guide was also employed to guide the researcher, as well as monitor the process of interview with the officials of MoFA. As the interview was ongoing, the researcher took several important notes to crosscheck whether he was on point with whatever information the interviewee gave. All the interview did approve of a recorder to be used. Each interview actually spanned for a period of 25-30 minutes.
3.7.1 Pilot-testing the questionnaire

The questionnaire was pilot-tested to make sure each respondent in the sample not only understands the questions but understands them in the same way. Again, it was to find out if any of the questions made the respondents feel uncomfortable. The pilot-testing was done with tomato farmers within the Techimantia community. It was done by selecting farmers who have 5 years and more experience in tomato cultivation within the community. The selected respondents were asked to present their individual views and feedback on the following:

i. Did you understand the questions very clearly?

ii. Do you think some question needed to be altered in order to suit the research problem?

iii. Do you think the questions followed logically as they were being asked?

All respondents used for the pilot-testing gave answers as ‘sometimes increasing and other times decreasing’ pertaining to questions which seek to find out the ‘extent’ and ‘state’ of a situation throughout the administration process. Thus, ‘fluctuate’ was included in the options for such questions. All other necessary modifications were made and a final version of questionnaire was produced.

3.8 Data Management and Analysis

The quantitative data collected during the study were analyzed using SPSS 2014 statistical software. Analytical tools frequency, percentages, graphs were used to analyze the quantitative data. With the qualitative analysis, the transcribed data were reviewed and categorized based on themes. In the analysis, important statements were quoted verbatim.
3.9 Ethical consideration

Ethical issues are very paramount since human beings are at the center of the whole study. This is because, though the researcher seeks to garner knowledge and ideas in the area of study, the right and privacy of the human beings involved needs to be respected and considered appropriately.

An introductory letter was first sought from the Centre for Climate Change and Sustainability Studies of the University of Ghana and sent to the district’s MoFA office for appropriate clearance. The researcher issued his student identification card to all respondents to authenticate his presence in order to gain full participation from them. Consent from all participants who took part in the study were first sought before any engagements took place. They were also fore informed about the confidentiality of their identity and also all their responses would be used for only academic purposes. In conclusion, privacy, confidentiality, respect and safety of participants was highly maintained and well adhered to in this study.
CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF FINDINGS

4.0 Introduction

This chapter presents and extensively discusses the empirical data gathered on assessing the impact of rainfall variability on tomato farmers in Tano-North District of Brong-Ahafo Region through a case study of Techimantia community. The study sought to assess the implications of decline in tomato production (if any) on the livelihood and living standards of the farmers; examine the trend of tomato yield output from farmers as a result of changes in rainfall pattern; and the adaptation or coping mechanisms adopted by farmers in dealing with the adverse effect of rainfall variability. The chapter is presented in the following sections: socio-demographic characteristics of the respondents (tomato farmers within the community); local perceptions about rainfall variability in the community; effect of rainfall variability on tomato production in the community; other non-climatic factors that can affect production and yield output; indirect impact of rainfall variability on livelihood and living standards of the tomato farmers; and adaptation or coping mechanisms to rainfall variability impact.

4.1: Socio-Demographic Characteristics of Respondents

4.1.1 gender

Table 4.1 shows that out of the total of 80 respondents, 69 (86.3%) of them were males while 11 (13.8%) were females. This implies that a greater portion of the percentage were males while females formed the least percentage group out of the total number of respondents. The sex distribution in Table 4.1 reveals that tomato production in the district is mainly controlled by males
than females. This could be attributed to the fact that tomato production is labour intensive and demands much energy in the process.

4.1.2 Age

Again, age distribution in the table also shows that majority of the farmers (27 or 33.8%) were between the ages of 41 and 50 years. This was followed by those between the ages of 31 and 40 years with a frequency of 26 (32.5%) of the total respondents. 14 (17.5%) respondents were aged between 21 and 30 years. This was again followed by 13 (16.3%) respondents who were above the age of 50 years. Due to the fact that majority of the respondents were between the ages of 31 and 40 years followed by 41 and 50 years imply a youthful farming population. This means that tomato farming in the community is mostly done by the youth. This youthful exuberance could potentially enhance sustainable tomato production within the community in the years to come. However, 41-50 (18%) years could mean that there is ageing of the population in tomato production and this could affect the tomato business.
Table 4.1: Socio-demographic characteristics of the respondents (tomato farmers within the community)

<table>
<thead>
<tr>
<th>Sex</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>69</td>
<td>86.3</td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>13.8</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-30</td>
<td>14</td>
<td>17.5</td>
</tr>
<tr>
<td>31-40</td>
<td>26</td>
<td>32.5</td>
</tr>
<tr>
<td>41-50</td>
<td>27</td>
<td>33.8</td>
</tr>
<tr>
<td>Above 50</td>
<td>13</td>
<td>16.3</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Marital Status</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>64</td>
<td>80.0</td>
</tr>
<tr>
<td>Single</td>
<td>13</td>
<td>16.3</td>
</tr>
<tr>
<td>Widowed</td>
<td>3</td>
<td>3.8</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of Education</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
</table>


Table 4.1: Socio-demographic characteristics of the respondents (tomato farmers within the community) (cont’d)

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No education</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Primary</td>
<td>7</td>
<td>8.8</td>
</tr>
<tr>
<td>Middle School</td>
<td>60</td>
<td>75.0</td>
</tr>
<tr>
<td>Secondary</td>
<td>9</td>
<td>11.3</td>
</tr>
<tr>
<td>Tertiary</td>
<td>3</td>
<td>3.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years lived in Techimantia</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-20</td>
<td>10</td>
<td>12.5</td>
</tr>
<tr>
<td>21-30</td>
<td>19</td>
<td>23.8</td>
</tr>
<tr>
<td>31-40</td>
<td>23</td>
<td>28.8</td>
</tr>
<tr>
<td>41-50</td>
<td>18</td>
<td>22.5</td>
</tr>
<tr>
<td>Above 50</td>
<td>10</td>
<td>12.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years into tomato production</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-20</td>
<td>58</td>
<td>72.5</td>
</tr>
<tr>
<td>21-30</td>
<td>17</td>
<td>21.3</td>
</tr>
<tr>
<td>31-40</td>
<td>5</td>
<td>6.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>
### Table 1

<table>
<thead>
<tr>
<th>Size of Farmland</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 acre</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>1-5 acres</td>
<td>64</td>
<td>80.0</td>
</tr>
<tr>
<td>6-10 acres</td>
<td>13</td>
<td>16.3</td>
</tr>
<tr>
<td>11-15 acres</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Above 15 acres</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

**Data Source:** Field work (2018)

### 4.2: Local Perception About Rainfall Variability in The Community

Most of the people across the world depend much on the natural resources that are available for survival, especially the poor, who are often vulnerable to climate variability and change (Morton, 2007). For this reason, there is the need to understand the different ways by which local people in communities observe, experience and respond or adapt to such variability and that could go a long way to help them devise effective adaptation or coping strategies.
4.2.1 Most experienced climate variability

Generally, out of a total of 80 respondents, majority (82.5%) of them alluded to the fact that the prevailing climate variability which was most experienced during the last decade was rainfall. This was followed by temperature (16.3%) and the least observed climate variability in the community was humidity (1.3%). From the findings, rainfall variability was realized to be frequently persistent in the community than its counterparts (temperature and humidity) and it could have direct or indirect impact on farming.

Figure 4.1 Climate variability experienced most since the last decade. Data Source: Fieldwork (2018)
Figure 4.2: Manifestation of variability in climate. Data Source: Fieldwork (2018)

4.2.2 Manifestation of rainfall

Again, out of the 80 respondents, (78.8%) reported unpredictable rainfall patterns to be how climate variability had been manifesting in the last decade. (11.3%) of the respondents reported high temperatures to be how its manifesting to them while heavy rainfall was reported by 6 respondents representing 7.5%. Strong winds (1.3%) was least reported, and only one (1.3%) respondent claimed not to have any idea about how climate variability is manifesting in the community though he alluded to the fact that rainfall variability was most predominant in the community. Again, the distribution could imply that farming is a very difficult livelihood activity to do in the community since it is generally rain-fed and farmers would have to adopt other forms of irrigation systems in order to survive the adverse effect of rainfall pattern changes. When this happens, soil water availability could be reduced and could also affect the yield output of crops.
Various research in Africa reveals that the perception of large number of farmers on rainfall variability is changes in rainfall durations and onsets (Gbetibouo, 2009). Out of 80 respondents used in this study, majority (76.25%) of them perceived rainfall variability to be changes in onset of rains, while 23.8% of the respondents perceived it to be the changes in duration of rains. They both showed a high level of severity in the community in the last decade. The implication of the results from this study is that, as farmers in the community have various variations in perceiving rainfall variability, it will inform the decision of farmers on the kind of adaptation strategies to implement to help cope with the variations and its effects.

Figure 4.3: The perception of rainfall variability in the community. Data source: Field work (2018)
In an attempt to find out how rainfall variability is perceived in the community, a farmer commented that:

*The changes in rainfall pattern has been very bad about five (5) years. Now we cannot predict the onset of the rains as we use to do some years back. The rains used to start in April and we start nursing our seeds but now we have to fetch water to irrigate the nursery and even rains to transplant has become a problem* (Farmer interview, 2018).

During an interview at the MoFA District Directorate office, an officer also commented on the perception of rainfall variability in the district. He commented that:

*Currently, the rainfall pattern in the district has changed. We normally have rains beginning heavily in February or March every year but the rains come in a heavy manner that are sometimes unbearable and stops. At times, we will be expecting the rains to come in June, July but it will not. While the farmers have prepared themselves to start planting, they will not get the rain* (Official of MoFA).

TABLE 4.2: Rainfall amount (mm) in rainy days in Tano-South District (2010 - 2017)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Quarter</td>
<td>8</td>
<td>11</td>
<td>6</td>
<td>8</td>
<td>14</td>
<td>8</td>
<td>5</td>
<td>6</td>
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<td>2&lt;sup&gt;nd&lt;/sup&gt; Quarter</td>
<td>24</td>
<td>21</td>
<td>32</td>
<td>31</td>
<td>19</td>
<td>23</td>
<td>18</td>
<td>33</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Quarter</td>
<td>23</td>
<td>17</td>
<td>16</td>
<td>14</td>
<td>19</td>
<td>20</td>
<td>19</td>
<td>29</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; Quarter</td>
<td>-</td>
<td>16</td>
<td>11</td>
<td>20</td>
<td>16</td>
<td>15</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total (avg.)</strong></td>
<td><strong>55</strong></td>
<td><strong>65</strong></td>
<td><strong>65</strong></td>
<td><strong>73</strong></td>
<td><strong>68</strong></td>
<td><strong>66</strong></td>
<td><strong>53</strong></td>
<td><strong>88</strong></td>
</tr>
</tbody>
</table>

Data source: Secondary data from MoFA District directorate MIS department
There had been a significant trend in rainfall pattern in the Tano-South District of Brong Ahafo Region from 2010 to 2017 as shown in the graph above. Total average rainfall recorded within the three quarters of 2010 was 55mm. There was a significant rise to an average of 65mm in 2011 when the amount of rainfall was calculated for the year, which meant that an average of 10mm increase in rainfall amount was recorded for that particular year. In 2012, the average amount of rainfall was maintained at 65mm which signified no changes in average amount of rainfall recorded. The following year (2013) also recorded a significant rise in average amount of rainfall of 73mm. There was a drop in average rainfall in the district in 2014 from 73mm to 68mm. The significant drop in average rainfall continued till 2016 when it was recorded to be as low as 53mm. This was followed by a tremendous rise in average rainfall by 88mm in 2017 which was an average increase of 27mm. The pattern of rainfall amounts from 2010 to 2017 as shown in the graph alludes to the fact that rainfall within the district had really been unpredictable.
4.3: Effect of Rainfall Variability on Tomato Production in The Community

4.3.1 Relationship between rainfall and tomato production

From this study, majority of the respondents (77, 96.3%) alluded to the fact that there is a positive relationship that exists between rainfall and tomato production in the community with only 3 (3.75%) respondents suggesting a negative relationship between them. The implication of this is that, there is a positive correlation between both variables and the changes in rainfall patterns could increase or decrease tomato production. Precipitation has a direct linkage with agriculture production and increase or decrease in its quantity, has a significant impact on the total yield output (Walthall et al., 2012). This could also imply that tomato could not be cultivated in the community without much reliance on the outcome of the rains. Rains are much needed during the nursery stage, transplanting of seedlings, fertilizer application, among others. It is not much needed during the flowering stage, ripening stage, among others. According to Masahumi et al., (2011), vegetable production is influenced by climate variability in the area of rainfall availability. There could be direct and indirect effects of rainfall variability on the tomato yield. The yield could be affected indirectly when rainfall variability has the potential of limiting agricultural input application on the farm such as agrochemical and fertilizer, among others (Kassie et al., 2014).

Table 4.3: Relationship between tomato production and rainfall

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentages (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>77</td>
<td>96.25</td>
</tr>
<tr>
<td>Negative</td>
<td>3</td>
<td>3.75</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>
4.3.2 Rainfall variability effect on tomato yield

Again, from this study, most of the respondents (49, 61.3%) said that rainfall variability affected tomato yield in a fluctuating manner, which meant that rainfall was needed at different stages in tomato cultivation. Most of the times, much rain is needed during the early stages to increase the rate of survival of seedlings while excessive rains at certain times could cause flower abortions during the flowering stage and these could either increase and reduce total yield output respectively. During an interview with an official at the District Directorate of MoFA, these were his comments about how rainfall variability was affecting tomato yield in the district:

*When the farmers are expecting the rains in June and July, the rains stop. So, while the farmers will be timing to meet the rains for good harvest, it fails and the tomato will start scorching and dying-back* (MoFA official, 2018).

Another official from the MoFA District Directorate also had this to say:

*Due to lateness in the coming of the rains, most farmers practiced personal irrigation, that is, they fetched their own water from different sources to irrigate their crops during fertilizer application. Since the water probably was not quite enough for the soil, the total yield was affected drastically* (MoFA official, 2018).
13 out of 80 respondents in each case alluded to the fact that, rainfall variability increases and decreases tomato yield respectively. Only one (1.3%) respondents saw no trend in effect of rainfall variability on tomato yield.

4.3.3 Type of variety used for cultivation

Again, almost all the respondents (79, 98.75%) except (1, 1.25%) agreed to using the local type of variety known as Power during cultivation. Some normally mixed it with PectoMech VF (foreign variety) during cultivation. Reason for mixing was that, in situations where the local variety (Power) could not survive the adverse weather conditions, the PectoMech VF was likely to survive to some extent and that became a reliable source for yield output. They also alluded to the fact Power produced bigger fruits which sometimes was priced differently. A farmer had this to say:

_I like the local variety (Power) very much because it produces higher yields with bigger fruits and less seeds. The wooden box gets filled up easily with less fruits and the women (traders) sometimes price a box very higher because of its attractive nature_ (Farmer interview, 2018).

Rainfall variability has certain effects on the variety of tomato being cultivated and this could be either positive or negative. Such effects include high or low yield, early or late maturity, and flower abortion, among others.
Table 4.4: Seed variety cultivated by farmers

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentages (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>79</td>
<td>98.75</td>
</tr>
<tr>
<td>PectoMech VP</td>
<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

Data source: Field work (2018)

Figure 4.6: How rainfall affected cultivated seed variety. Data source: Field work (2018)
4.3.4 Effect of rainfall variability on variety

From this study, it was realized that most of the respondents (92.5%) alluded to its negative effect on their cultivation, which was low yield. 4 (5%) of the respondents said it caused flower abortion when it is excessive and (2.5%) of them testified it caused late maturity of the variety they cultivated. This was said by an official of MoFA during the interview:

Rainfall variability in the district normally reduces the sizes of the tomato fruits and also causes flower abortion. This is sometimes also caused by high temperatures and all put together affect the yield of tomatoes (interview with MoFA Official, 2018).

4.3.5 Effect of rainfall variability of tomato availability

Majority of the respondents (96.25%) said that rainfall variability had a significant effect on tomato availability. Only few of the respondents (3.75%) had a contrary view to this assertion. They stated that rainfall variability was not causing tomato availability in the community. Again, 39 (48.8%) of the total respondents stated that tomato availability in the community was in a fluctuating trend, that is, when the rains came at right times, there was more tomato available within the community and vice versa. 21 (26.3%) respondents had a contrary view and said that it was actually increasing the availability of tomato in the community, just as 16 (20.3%) of them thought it was rather decreasing the availability of tomato. The remaining 4 (5%) had no idea about such effect. The implication of this whole assertion is that, gradually the community was losing its status as one of the major tomato growing area in the district and most of the youth would be coerced to migrate from the community due to the prevailing situation or divert their attention to growing other crops such as green pepper, cashew, among others. The sustainability of tomato cultivation in the community could be jeopardized because most farmers would lose interest in cultivating it due to the too much stress involved in cultivation and the continuous crop failure which led to low income
levels. Respondents were asked to comment on whether they had access to weather information, through which means do they received such information and finally how frequent they listened to such information.

Table 4.5: Respondents significance of rainfall on tomato availability

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentages (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>77</td>
<td>96.3</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>3.75</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

Data source: Field work (2018)

4.3.6 Farmers access to weather information

77 (96.25%) of the respondents responded positively to having access to weather information with only 3 (3.75%) respondents answered negatively. Again, 79 (98.75%) of the respondents attested to the fact that radio and television were their source of getting such information while the remaining (1, 1.25%) actually got such information through newspapers. Concerning the frequency of listening to such information, 70 (87.5%) respondents actually listened daily to such information while 10 (12.5%) respondents listened weekly. This implication of the whole finding is that farmers could be much glued to their radios and televisions for weather forecast news and therefore planned their farm activities based on the information gathered. However, the reliability
of these information was an issue to most of them and that led to the discrepancies which finally led to low crop yield. In finding out the views on receiving weather information, a farmer said that:

*I take my radio along with me when going to the farm and therefore listens to weather forecast after news each time of the day. The major problem with weather broadcast is its reliability. Most of the time, we are persuaded to believe it will rain only to realize it does not and I have to suspend my fertilizer application or hire motor king to fetch water to my farm to aid in mixing the fertilizer as well as irrigation. All these come with extra cost and if not done on time, will lead to crop failure and subsequent low yield* (Farmer interview, 2018).

Table 4.6: Farmers accessibility to weather information

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>77</td>
<td>96.25%</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>3.75%</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

Data source: Field work (2018)
4.7: Other Non-Climatic Factors That Affect Tomato Production and Yield

Figure 4.7: How farmers obtained their seed variety. Data source: Field work (2018)

4.4.1 How farmers obtained variety

Generally, it can be observed that 44 (55%) of the respondents obtained their seed variety from their own farms. 28 (35%) of them obtained their seed variety from local seed sellers while 5 (6.75%) respondents obtained theirs from extension officers. Only the remaining 3 (3.75%) obtained seed variety from a certified seed/seedling unit. This could have maximum implication on tomato yield and availability. Since most of the respondents obtained their seeds from their own farms, it implied that the seeds could produce more fruits for high yield, disease resistant and lastly, an early maturing type which are all good characteristics, but since it had been a long-time seed bank for them, many disease pathogens found in the soil could grow resistance to any agrochemicals (pesticides and insecticides) used to destroy them. Secondly, their high level of weather tolerance and high rate of germination could decline after some time. Again, few farmers resorting to buying seeds and/or seedlings from certified seed units imply that there could be high
cost involved in obtaining certified seeds from the seed units and also the rate of demand could highly exceed the level of supply. They termed the act of obtaining seeds from their own farms as ‘washing’, which meant that they selected special tomato trees which bore strong and more fruits, wash and dry these seeds in the sun and store for the next planting seasons. Some farmers also took recognition of the fact that high yield from their friends’ farms could also mean good seeds for cultivation and therefore bought or obtained such seeds for free from them. Several factors may affect the reason for farmer’s preference of the local variety and some of the important influential factors are access to seeds, growing technologies, available markets, potential yields, prices, and risk (Robinson and Kolavalli, 2010). A farmer had this to say when asked about his choice of seed variety:

Our fathers and grandfathers used to the plant this variety (Power) and we have also come to continue. It produces bigger fruits and on good days (during good rainfall patterns, among others), produced high yield as well as withstanding most of the harsh weather conditions in the community (Farmer interview, 2018).

To buttress the points being made about seed variety, an official from MoFA District Directorate also said this:

Resilient seed is the major challenge we are facing here (within the district) right now because, the farmers have been planting their seeds for the past 20 to 40 years without changing. For their local seeds, it is better but they have been faced with soil borne disease attacks. We complained to the researchers and they brought in the PectoMech variety which is not the rainfall type (that is, does not really survive well in the rains) (Interview with MoFA official, 2018).
4.4.2 Type of soil for cultivation

Land preparation should adequately include enough tillage operations to make the soil suitable for seedling or transplant establishment and to provide the best soil structure for root growth and development (Kelley and Boyhan, 2010). It was realized from the study that, 76 (95%) of the respondents cultivated on a loamy soil when questioned about the type of soil they used for their cultivation. 3 (3.8%) alluded to the fact that they cultivated on a sandy-loamy soil while only 1 (1.3%) person cultivated on a sandy soil. 79 (98.8%) of the respondents again alluded to fact that the loamy and sandy-loam soils were well drained since they were not too compact, fine and also very fertile when they were questioned about the physical characteristics of their soils. The implication of this finding is that, soils within the community could be highly favorable for tomato cultivation and therefore farmers had little or no issue with soil type.

To continue with findings on other non-climatic factors that could affect tomato production and yield, it was revealed that the fluctuations observed in the rainfall pattern in the community
currently is having great impact on the application of fertilizer and also agrochemicals to the farm. To elaborate further on the implication, the fluctuations in rainfall patterns could affect the timing of the farmers as to when to apply fertilizer or other agricultural inputs to the soils. The rains actually melted the compounds used for fertilizer preparation so as to dissolve faster and uniformly into the soil but the absence of rains could cause the piled up of more fertilizer compounds which eventually could lead to severe soil compaction with less aeration and water infiltration. This could all contribute to low yield and cultivation difficulties. Since timing for fertilizers application becomes difficult, it could affect the quantity that needs to go into the soil to improve fertility, likewise agrochemicals application. According to Kassie et al., (2014), there could be direct and indirect effects of rainfall variability on tomato yield. The yield could be affected indirectly when rainfall variability has the potential of limiting agricultural input application on the farm such as agrochemical and fertilizer, among others.

4.5: Indirect Impact of Rainfall Variability on Livelihood and Living Standards of The Tomato Farmers.

4.5.1 Main source of livelihood
Out of 80 respondents, 72 (90%) responded to having their main source of livelihood to be tomato cultivation. The remaining 8 (10%) responded the opposite. The reason may be that tomato cultivation could be one of the major source of livelihood in the community and most of the respondents derived their income from that source. It could also be that, the major means of survival in the community is tomato farming and the respondents may have ineffective alternative livelihood activity. A farmer had this to say when finding out about the main source of livelihood in the community:
Since there are no jobs in the community, we those who could not continue our education have to venture into tomato cultivation in order to survive. Our parents have since been cultivating it and it is now our turn to continue. We need the government to come in and support us since it is cultivated massively in the community but there are no monies to purchase fertilizers which is our major concern (Farmer interview, 2018).

Table 4.7: Tomato cultivation as main source of livelihood

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<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentages (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>72</td>
<td>90.0</td>
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<tr>
<td>No</td>
<td>8</td>
<td>10.0</td>
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<tr>
<td>Total</td>
<td>80</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Data source: Field work (2018)

Figure 4.9: Description of seasonal income. Data source: Field work (2018)
4.5.2 Description of seasonal income

Again, 51 (63.75%) of the total respondents described their seasonal income to be regular but accepted that there were fluctuations in the amount of income received every season, that is, it goes up and down season after season. 25 (31.25%) of them said it was generally decreasing with the remaining 4 (5%) describing it as increasing season after season. This implies that seasonal income could be unstable due to the various effects rainfall variability have on yield output which eventually affect the pricing during purchase. Also, the farmers could be faced with a lot of monetary challenges when all their income generated goes into expenditure (hiring of motor king, labour, among others) leaving them with nothing or something little, all because of getting water for irrigation and other works on the farm. An official of MoFA District Directorate had this to say about tomato cultivation being the major source of livelihood and how it is affecting living standards of farmers in the district:

There are serious issues concerning the current outcomes of tomato production in the district. Most of the youths within the district have stopped growing tomatoes and are now into cashew and mango plantation which was previously done in Kintampo areas. They are migrating to the urban areas to trade in secondhand clothing, among others because there is no sustainable income from tomato cultivation nowadays and the production has reduced drastically in the district (Interview with an official of MoFA, 2018).

Another MoFA official also had this to say concerning livelihood issues in the district:

Tomato cultivation in the district has been very bad since farmers sometimes apply fertilizer and there are no rains to dissolve it. They face serious financial issues, especially those who took loans from the banks and cannot repay back and how can such a person do something better for himself or herself (Interview with a MoFA official, 2018).
4.5.3 Catering for basic needs

In finding out the living standards of farmers in response to low production, 55 (68.75%) of the total respondents responded positively to being able to cater for the basic needs of their household during low production. 22 of them said they were not able to cater for their household in such times with the remaining 3 (3.75%) respondents having real doubts about how to rate their level of commitment in such times. The earlier respondents (55, 68.75%) were all quick to add that “catering for household needs was not a joking matter and as such, the unavailability of money should not deter anyone from taking care of their household needs”. This implies that household basic needs (such as clothing, housekeeping money and school fees) could be seen as a responsibility to most of the respondents and they would even borrow money from other sources to cater for such needs.

Table 4.8: Farmers ability to cater for basic needs during low production

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentages (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>55</td>
<td>68.75</td>
</tr>
<tr>
<td>No</td>
<td>22</td>
<td>27.5</td>
</tr>
<tr>
<td>Indecisive</td>
<td>3</td>
<td>3.75</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

Data source: Field work (2018)
4.5.4 Catering for health care

33 (41.25%) of the total respondents alluded to the fact that they were able to seek some level of health care assistance from clinics and other herbal centers in the community as well as near-by communities. 28 (35%) of the respondents agreed they were not all the time able to seek health care assistance while 19 (23.75%) respondents providing a total ‘no’ to the question. Responses from 22 (27.5%) respondents could also suggest that, quite a significant number of respondents would be seen as irresponsible by their families during hard times like this. Meaning that, most of youth could actually venture into other sources of livelihood (such as mango and cashew production, among others as alluded by a MoFA official in an earlier submission) in order to adapt to the situation or save themselves from being disgraced by family members. Again, some of the farmers could adopt local herbs as their main source of medicine since it could be cheaper and more accessible rather than going to the hospital or clinic which sometimes costs more especially
when prescribed drugs are not available at their pharmacy units. And also, since most of them have registered under the National Health Insurance Scheme (NHIS), they visited the clinics for free and that could have accounted for more farmers being able to purchase drugs prescribed by the doctor. Thus, any hinderances in health care delivery would cause farmers switch to the local herbs. A farmer had this to say when finding out his views about hospital care:

*I hardly go to the hospital for treatment. For the past ten years, I cannot recollect when I went there. In this our tomato crisis period, I always need money to cater for my family rather than spending on drugs. My sickness is seasonal and it is due to my work on the farm. I boil some local herbs and drink frequently in order to avert such occurrences. There are quite some few times that I go to the drug store to purchase paracetamol when I felt unusual headache* (Farmer interview, 2018).

![Figure 5.1: Farmers ability to purchase tomato in the market for food preparation.](image)

**Figure 5.1:** Farmers ability to purchase tomato in the market for food preparation.

**Data source:** Field work (2018)
4.5.5 Farmers ability to purchase on the local market

73 (91.25%) of the total respondents interviewed actually alluded to the fact that though prices of tomato on the market goes high during low production seasons, they are still able to purchase some for their household food preparation. 6 (7.5%) respondents had a different view on that since they were not able to purchase for their households, with only 1.25% of the respondent actually not always being able to purchase tomatoes during such times. The reason could be that since tomato was a major requirement in daily household meals due to its nutritional values, respondents could have no choice than to purchase no matter the market prices and this could account for them being able to purchase it. The prices of tomato being high or low on the market was partly due to the middle men who came to purchase the fruits at the farm gate. There is a positive correlation between tomato prices and demand from middle men. Prices of the commodity usually went down when there was high influx of tomato on the market and the demand of the middle men to purchase was very low and vice versa. At that juncture, they (middle men) determined the price of one box of tomato which could go as low as 20ghc per box and as high as 500ghc per box (farmer interview, 2018). All these contribute immensely too high and low tomato prices on the local market and farmers’ ability or inability to purchase for household consumption.

4.6: Farmers’ Adaptation or Coping Mechanisms to Rainfall Variability Impact.

Farmers face a lot of shocks and risks from the challenges posed by the climate, and therefore need adaptation or coping strategies to reduce those impacts. This section seeks to examine the adaptation or coping strategies adopted by farming in dealing with the adverse effects of rainfall variability in the Techimantia community. In this study, adaptation and coping strategy are used
interchangeably. The adaptation or coping strategies are in different fold, that is, whiles some are on-farm adaptation strategies, others are off-farm adaptation strategies.

4.6.1 Farmers’ on-farm adaptation option

From the study, 73 (91.25%) of the total respondents mostly employed mixed cropping as their on-farm coping strategy to adapt to rainfall variability. 2 (2.5%) respondents each alluded to the fact that they used agrochemical and fertilizer application as their non-farm coping strategy to increase their yield, while (1.25%) respondent each agreed to using crop diversification and irrigation farming as a major on-farm adaptation strategy to increase yield. Again, (1.25%) respondent used the change farm location as an adaptation strategy to crop failure.

Table 4.9: On-farm adaptation options employed by farmers

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentages (%)</th>
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</thead>
<tbody>
<tr>
<td>Mixed cropping</td>
<td>73</td>
<td>91.25</td>
</tr>
<tr>
<td>Agrochemical application</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>Fertilizer application</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------</td>
<td>-----</td>
</tr>
<tr>
<td>Crop diversification</td>
<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>Irrigation farming</td>
<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>Change farm location</td>
<td>1</td>
<td>1.25</td>
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<tr>
<td></td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

**Data source:** Field work (2018)

**Figure 5.2:** Mixed cropping as an on-farm adaptation strategy. Data source: Guodaar (2015)
Figure 5.3: Fertilizer application as an on-farm adaptation strategy. Data source: Guodaar (2015)

Majority of the farmers never preferred change of location even though factors such as loss of nutrients and invasion of soil borne diseases and pests, among others could set in. During the interview, a farmer alluded that:

_We are faced with challenges from the land tenure system in our community. We find it difficult to move because, it is either your own share from family land and there is no extra money to buy a different one or you hired the piece of land and cultivating on it depends on how long you hired it_ (Farmer interview, 2018).
4.6.2 Farmers’ off-farm adaptation option

35 (43.75%) of the total respondents chose the option of diversification to non-farm activities as their off-farm adaptation option they employed when there was crop failure due to rainfall variability. 43 (53.75%) of the respondents agreed not to apply any off-farm adaptation strategy while only 2 (2.5%) of the respondents chose the option of migration as an off-farm adaptation option when there was crop failure. The implication of this finding is that, farming could be the major work or source of livelihood in the community and majority of the farmers who were challenged with crop failure had no other job to do or it could be that no other work strived better within the community. This could raise the level of unemployment in the community to a higher...
degree during bad growing seasons and there is the likelihood of the youth indulging in other mischievous activities such as timber logging and stealing, among others. Some farmers could migrate because they want to escape from being pursued by their financiers for non-payment of loans. Again, some respondents choosing to divert to off-farm activities could mean that the zeal to work is there but the jobs are very few. However, it is very important to note that off-farm adaptation activities such as building works may not necessarily be sustainable because its survivability depends on high income of tomato farmers.

There are several factors that influence adaptation strategies of farmers such as local government support, education, experience, availability of finance, among others. 43 (53.75%) of the total respondents had no adaptation options and 37 of them had it.
4.6.4 Factors influencing farmers’ adaptation option

Out of the 37 respondents, 19 (51.3%) responded the fact that they chose their form of adaptation due to experience. Again, 12 (32.4%) of the respondents identified the availability of finance as what influenced their choice of adaptation. Furthermore, 4 (10.8%) of the respondents affirmed that local government support actually influenced their choice of adaptation strategy. The remaining 2 (5.4%) of the respondents alluded to education as the factor that influences their choice of adaptation strategy. One reason could be that there is low level of education of farmers and it could pose a great challenge as to which adaptation strategy to use and the reason for using it.
Figure 5.6: Shows presence of any local government support to farmers. Data source: Field work (2018)

4.6.5 Local government support

From the study, 52 (65%) of the total respondents did not receive any support from the local government while 28 did receive. Out of the remaining 28 (92.85%) respondents, alluded to the fact that they received extension services from the MoFA officers while 2 (7.15%) of the respondents agreed to receiving subsidized agrochemicals from the local government. This affirms what a farmer said during an interview:

*We cannot purchase fertilizers because, the banks always demand high collateral which could be half the amount you are borrowing. I usually asked myself that, what would be the essence of going for the loan if I had such an amount in my possession. The government is not considering the agricultural needs of the people in this town* (Farmer interview, 2018).
4.7 Discussion

4.7.1 Manifestation of climate variability

The study showed that unpredictable rainfall patterns was manifesting most in the community. The trend of the result for manifestation of climate variability within the community supports a study conducted by Mengistu (2011) whose results showed that about 90% of the farmers observed changes in the rainfall pattern in the last two decades while 75% of the farmers perceived increase in temperature in the last two decades.

4.7.2 The local perception on rainfall variability in the community

The study revealed that farmers perceived changes in onset of rainfall as being more observed than changes in rainfall duration. The result trend supports the study conducted by Tunde (2011) which revealed 47% of farmers in the region perceived climatic variability as delayed rainfall. It again supports a study conducted by Kemausuor et al. (2011) and the results showed that majority of farmers (82%) perceived climate change to be evident through changes in rainfall timing from 1993 -2006.

4.7.3 How farmers obtained variety

The result showed that, farmers within the community mostly used the local variety (Power) for cultivation. This supports Appiagyei’s findings in 2010 that, the fruit of the local tomato variety contain more seeds and the yields are relatively higher under favourable conditions such as adequate moisture, disease-free conditions (Guodaar, 2015). The finding again, is in support of what was mentioned by Robinson and Kolavalli in 2010 that there are several
local varieties of tomatoes cultivated in Ghana such as Raster, Power Rano and Wosowoso but Power Rano is often being preferred due to its high tolerance and/or resistance to disease (Guodaar, 2015).

4.7.4 Type of soil for cultivation

The study identified that most of the farmers cultivated on loamy soils which are well drained. This supports the work done by Kelley and Boyhan in 2010 which concluded that, tomato needs suitable soil and climatic condition for growth and even though, tomato can be produced on a variety of soil types, they grow optimally in deep, medium textured sandy loam or loamy, fertile and well-drained soil (Kelley & Boyhan, 2010).

4.7.5 Mixed cropping as an on-farm adaptation option.

The study shows clearly that most of the farmers employed mixed cropping as their adaptation strategy. Mixed cropping as an adaptation strategy by farmers supports Mary and Majule’s study in 2009 which concluded that farmers used crop diversification as an adaptation strategy by introducing mixed cropping method where farmers grow different crops on the same piece of land (Mary & Majule, 2009).
4.7.6 Crop diversification

It was realized that crop diversification was one of the coping strategies adopted by farmers to adapt to rainfall variability. It supports the view of Uddin et al., 2014 that, crop diversification as form of adaptation was used as a means of compensation in situations where one crop fails and the other survives and also spreads risks and increase farm profit in times of changing climate (Uddin et al., 2014).

4.7.7 Fertilizer application as an on-farm adaptation option

The finding shows that fertilizer application was one of the coping strategies farmers used to adapt to rainfall. Agrochemical and fertilizer usage as an adaptation strategy in the study supports assertions made by Tshiala and Olwoch in their 2010 studies which revealed that farmers increased their tomato yield by some adaptation strategies such as applying agro-chemicals needed (Tshiala & Olwoch, 2010).

4.7.8 Farmers’ off-farm adaptation options

The option of diversifying to other non-farm activities helped them to absorb more of the shocks of the climatic variations and it supports the study of Solórzano et al. (2014) who alluded that engagement in non-farm activities help farmers to overcome the pressures of the climatic variations and thus, allow them to distribute the climate risks over different economic activities.
4.7.9 Experience as a factor influencing farmers’ adaptation option.

The study found out experience was one of the factors influencing farmers’ adaptation option. The finding is in support of that of Below et al. (2010), who identified experience as one of the major factors that influence farmers’ ability to adapt to climate variability. Farmers may use experience to influence their adaptation strategy because of low level of education.

4.6.10 Financial support as a factor influencing farmers’ adaptation option

Financial support was one of the factors influencing farmers’ adaptation option and is in support of the findings of Ngigi (2009) which stated that, most smallholder farmers need financial empowerment in order to adapt to climate variability (Mudombi, 2011).

4.6.11 Local government

The result identified local government support as another factor influencing farmers’ adaptation option. The findings support Campos et al. (2014) findings which concluded that community-based governance system is one of the coping strategies farmers use to respond to the adverse climatic variability (Campos et al., 2014).
Fig 5.7: Fresh Power tomato

Data source: Fieldwork (2018)
CHAPTER FIVE

SUMMARY, CONCLUSION, AND POLICY RECOMMENDATIONS

5.0 Introduction

This chapter finalizes the whole research by summarizing the main findings, draw conclusions, and policy recommendations from the study. It assesses the impact of rainfall variability on tomato farmers in Techimantia in the Tano-South District.

5.1 Summary

In assessing the impact of rainfall variability on tomato and adaptation strategies adopted by farmers during rainfall variability, this study was conducted in the Techimantia community in Tano-South District. Three (3) specific objectives guided the study. First, the study investigated the trend of tomato yield output from farmers for the past decade which was as a result of changes in rainfall pattern. Secondly, the study assessed the implications of decline in tomato production (if any) on the livelihood and living standards of the farmers. Finally, the study assessed the adaptation or coping mechanisms adopted by farmers in dealing with the adverse effect of rainfall variability.

In order to ensure such objectives are met, a total of 80 individual farmers were purposively selected based on their experience in tomato cultivation and rich information from the Techimantia community in Tano-South District. Structured questionnaires were administered personally to
these farmers. Again, in-depth interviews were done to gather rich qualitative responses from some key informants. Participant observation was adopted to receive firsthand information on the ground. Descriptive statistics was the statistical tool used to analyze the quantitative data with the support of the IBM SPSS statistical version 17. Also, the qualitative data was analyzed thematically through transcription, categorization and interconnecting.

5.1.1 Research objectives

Tomato farmers in Techimatia mostly rely on rainfall for their cultivation and this creates series of challenges for them. The study sought to assess the implications of decline in tomato production (if any) on the livelihood and living standards of the farmers; examine the trend of tomato yield output from farmers as a result of changes in rainfall pattern; and the adaptation or coping mechanisms adopted by farmers in dealing with the adverse effect of rainfall variability.

5.1.2 Research method

A mixed method approach was used to gather both qualitative and quantitative data. Qualitative data collection used tools such as in-depth interview, field observation and recorder. Quantitative data collection also used tools such as structured questionnaire with few open-ended questions. The quantitative data were analyzed using the SPSS 2014 software while the qualitative data were analyzed through categorization of themes.
5.1.3 Summary of Key Findings

After the result and discussions, the key findings of the study are summarized below:

5.1.3.1 Local Perception about Rainfall Variability in The Community

From the study conducted, most of the farmers in the Techimantia community alluded to the fact that they had observed several variabilities in the climate since the past decade and posited that, rainfall variability was the most prevailing climate variability in the community since the past decade among temperature and drought and that climate variability manifested in their observations as unpredictable rainfall pattern as against heavy rainfalls, high temperatures and strong wind. Also, the study found out that rainfall variability in the community was perceived as both changes in the onset and duration of the rains. Further investigations showed that both changes in onset and duration of rainfall in the community had been very severe since the last decade. Flooding was not majorly observed in farms, which meant that though the rainfall could be heavy at times, its tendency of causing flooding was low.

5.1.3.2 Effect of Rainfall Variability on Tomato Production in The Community

In regards to tomato production and the effect of rainfall variability on it, the findings from the community revealed that there was a significant relationship between rainfall and tomato production. This meant that, tomato production cannot be done without rainfall which was as a major determinant of its success. From the study, the farmers pointed out the relationship between them (rainfall and tomato production) to be positive because they relied on it to some large extent
during cultivation. This ranged from nursery, transplanting, and agrochemical-input application (such as fertilizer and agrochemicals). It was realized from the study that rainfall variability affected the tomato yield mostly in a fluctuating manner. This meant that was needed at different stages in tomato cultivation. Most of the times, much rain is needed during the early stages to increase the rate of survival of seedlings while excessive rains at certain times could cause flower abortions during the flowering stage and these could either increase or reduce total yield output respectively. From the study, it was again realized that the availability of tomato in the community was also affected by rainfall variability such that when the rains came at right times, there was more tomato available within the community and vice versa. This also led to majority of the farmers alluding to the fact that rainfall variability affected tomato availability in a fluctuating manner, which is similar to the previous assertion made. From the study, majority of farmers cultivated the local variety (Power) most of the times because it produced bigger fruits, higher yield and could also withstand the local climatic conditions in the community. Though it was affected by rainfall variability at certain times by causing low yield, late maturity and flower abortion, farmers still preferred it based on several reasons.

5.1.3.3 Non-Climatic Factors That Can Affect Tomato Production and Yield.

As part of investigating the trend of tomato yield output since the last decade, the study sought to investigate other non-climatic factors that can also has the potential of affecting tomato production and yield. Majority of the farmers alluded to that they obtained the seed variety they cultivated from their previous cultivation through a process called ‘washing’, that is, they selected special tomato trees which bore strong and more fruits, wash and dry these seeds in the sun and store for
the next planting seasons. While only few obtained their seed variety from certified seed/seedling units. Tomato production needed suitable soil and climatic condition for growth and even though, it could be produced on a variety of soil types, they grew optimally in deep, medium textured sandy loam or loamy, fertile and well-drained soil. Majority of the farmers cultivated on well-drained loamy soils which support this assertion. Finally, the study found out that rainfall determined the effectiveness of agricultural inputs such as fertilizer and agrochemical application since it was needed to melt the fertilizer compounds and enhance dissolving or infiltration.

5.1.3.4 Indirect Impact on Livelihood and Living Standard of Tomato Farmers

Techimantia community has over the years been noted for its tomato production, which is regarded as a major source of livelihood in the Tano-South District even though there are several other sources of livelihood such as carpentry, building works, driving, operating of lotto kiosks, among others. The study revealed that tomato production was actually their major source of livelihood but rainfall pattern changes had indirectly affected the seasonal income of most of the farmers. Majority of the farmers pointed out that seasonal changes in rainfall had caused their seasonal income to be in a fluctuating state, that is, it goes up and down season after season. Majority of the farmers were able to cater for the basic needs of their household during low production but added that household basic needs (such as clothing, housekeeping money and school fees) were seen as a responsibility to household heads and they would even borrow money from other sources to cater for such needs. From the study, majority of the farmers could also take care of their household daily meal though low production really affected their income levels. Most of the farmers rarely sought health care but usually applied orthodox medications due to the fact that there was not
enough money to attend to such facilities during low production. Again, from the study, majority of farmers posited that prices of tomato on the local market was in a fluctuating manner depending on the demand of middle men. This always predicted the price and quantity of tomato they (farmers) could purchase for their household meal preparation.

5.1.3.5 Farmers’ Adaptation and Coping Mechanisms to Rainfall Impact

The last objective of the study was to assess the adaptation or coping mechanisms adopted by farmers in dealing with the adverse effect of rainfall variability. The study revealed that, though there were a number of on-farm adaptation options such irrigation farming, agrochemical and fertilizer application, crop diversification, change of location, among others, farmers mostly employed mixed cropping on-farm adaptation to reduce the adverse effect of rainfall variability on tomato. In respect to off-farm adaptation options, majority of the did not have any form of adaptation measures, even though some alluded to diversification of non-farm activities such as illegal timber logging, fashion designing, hairdressing, trading, among others. From the study, it was revealed that majority of farmer alluded that their choice of adaptation was influenced by their experience. Other farmers were influenced to make their choices through availability of finance, local government support, education, among others. The study revealed again that, majority of farmers did not receive any support from the local government while some alluded to the fact that they received extension services from some MoFA officials.
5.1.4 Limitations of study

The only main limitation encountered through the study was the difficulty in reaching farmers due to the onset of the rains which marks the beginning of their cultivation. Thus, the reason for the number of respondents used.

5.2 CONCLUSION

Significant contributions have been made by the study through additions to previous methodologies when studying rainfall variability and crop production. The study has unraveled some effects regarding rainfall variability and tomato production, and the adaptation strategies of farmers. Previous studies always sought to adopt only the quantitative methodologies (Awotoye and Matthew, 2010), unlike this study which adopted the mixed method approach.

The mixed method approach has provided rich findings and therefore its usage has been promoted. A qualitative research approach was used to gather rich data about both the trend in tomato yield output since the last decade and the implication of decline in tomato production on the livelihood and living standards of the farmers in the district through instruments such as in-depth interviews and field observations. The quantitative research approach was used to gather knowledge from much experienced farmers about the adaptation and coping strategies they employed to reduce the impact of rainfall variability on the tomato and also sought knowledge about the implication of decline in tomato production on their livelihood and living standards in the community. Instruments used included structured questionnaires with few open questions. The data was analyzed through descriptive statistics with the help of IBM SPSS statistical version 17. Thematic analysis was used to complement the descriptive analysis to bring out the synergies between qualitative and quantitative analysis to make the issues much appreciative.
5.3 RECOMMENDATIONS

This section of the study seeks to guide policy makers in designing programmes that will enhance the adaptive capacities of farmers in responding to the shocks and perturbations produced by rainfall variability as well as improving their livelihood and living standards as observed in the Tano-South District. In view of the findings and the conclusions, the following are recommended:

1. The government and certified seed/seedling units should concentrate much on producing climate resistant tomato varieties that are easily accessible by farmers.

2. Efforts should be made by government and Non-Governmental Organizations (NGOs) to make weather information available on a regular basis to farmers through radio stations in the district and other electronic communication channels such as WhatsApp, text messages, among others.

3. Agricultural inputs such as fertilizers should be subsidized by government to allow poor farmers purchase some for their agricultural activities.

4. Government and other financial services should come together and provide farmers with credit facilities with low interest to empower farmers to be able to increase their adaptive capacities.

5. In order to improve the financial capabilities of the farmers, government and other individuals could establish a tomato factory in the district to make the tomato business attractive to the farmers, especially the youth. There could be reduction in unemployment since this could encourage the youth into the tomato business. This will also serve as a ready market to farmers’ produce, thereby reducing the influx of middle men into the marketing structure.
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Appiagyei, F. (2010). *Effects of two neem kernel extracts in the control of whitefly (Bemisia tabaci) on tomato.* A thesis submitted to the Department of Theoretical and Applied Biology, In partial fulfillment of the requirements for doctoral degree (Environmental Science), Kwame Nkrumah University of Science and Technology


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Warner, K., & Afifi, T. (2014). Where the rain falls: Evidence from 8 countries on how vulnerable households use migration to manage the risk of rainfall variability and food insecurity. *Climate and Development, 6*(1), 1-17.


APPENDIX I: INTRODUCTORY LETTER

UNIVERSITY OF GHANA
CENTRE FOR CLIMATE CHANGE AND SUSTAINABILITY
STUDIES (C₃SS)

Ref. No.: ..................................................

20th March, 2018

The Director
Ministry of Food and Agriculture
Sunyani, Brong Ahafo Region

Dear Sir,

LETTER OF INTRODUCTION

I would be very grateful if you could provide Mr. Kojo Asare Bediako with information for his research work.

Mr. Kojo Asare Bediako is a student at the University of Ghana Centre for Climate Change and Sustainability Studies pursuing a Master of Science degree in Climate Change and Sustainable Development.

He is undertaking a research on the topic “Assessing the impact of rainfall variability on tomato farmers in Tano South District: A case study of Techimantia community” as part of his studies.

I would very much appreciate your assistance in any form to enable him complete his work.

Thanks very much.

Yours Faithfully,

Jane Osei,
Administrator
For: Director, C₃SS

COLLEGE OF BASIC AND APPLIED SCIENCES
P.O. Box LG 25, Legon, Accra, Ghana
Telephone: +233-302905269
Email: C3SS@ug.edu.gh
Website: www.ug.edu.gh
### APPENDIX II: QUESTIONNAIRE FOR TECHIMANTIA TOMATO FARMERS

**SECTION A: DEMOGRAPHIC CHARACTERISTICS OF TOMATO FARMERS**

<table>
<thead>
<tr>
<th>NO.</th>
<th>QUESTIONS</th>
<th>RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Name</td>
<td></td>
</tr>
</tbody>
</table>
| 2   | Age                                           | 1. 10-20 years ( )  
2. 21-30 years ( )  
3. 31-40 years ( )  
4. 41 years and above ( ) |
| 3   | Marital status                                | 1. Married ( )  
2. Single ( )  
3. Widower ( )  
4. Divorced ( ) |
| 4   | Gender                                        | 1. Male ( )  
2. Female ( ) |
| 5   | Have you had formal education                  | 1. Yes ( )  
2. No ( ) |
|     | What is your highest level of education?       | 1. Primary school ( )  
2. Middle school ( )  
3. Secondary ( )  
4. Tertiary ( ) |
| 6   | How many years have you lived in Techimantia? | 1. 10-20 years ( )  
2. 21-30 years ( )  
3. 31-40 years ( )  
4. 40 years and above ( ) |
| 7   | How many years have you been into tomato production? | 1. 5-10 years ( )  
2. 11-16 years ( )  
3. 17-22 years ( )  
4. 23 years and above ( ) |
| 8   | What is the size of your farm land?            | 1. 0.5-3 acres ( )  
2. 4-6.5 acres ( )  
3. 7-9.5 acres ( )  
4. 10 acres and above ( ) |
SECTION B: LOCAL PERCEPTION ABOUT RAINFALL VARIABILITY IN THE COMMUNITY

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Have you observed any variability in the climate since the last decade?</td>
<td>1. Yes ( ) 2. No ( ) 2. No idea ( )</td>
</tr>
<tr>
<td>10</td>
<td>Which climate variable have been varying most since the last decade?</td>
<td>1. Temperature ( ) 2. Rainfall ( ) 3. Drought ( ) 4. Others, specify ..........</td>
</tr>
<tr>
<td>11</td>
<td>How has the variability in climate manifested in your observation?</td>
<td>1. Unpredictable rainfall pattern ( ) 2. Heavy rainfall ( ) 3. High temperatures ( ) 4. Strong winds ( ) 5. Others, specify ...............</td>
</tr>
<tr>
<td>12</td>
<td>How do you perceive rainfall variability to be?</td>
<td>1. Changes in onset of rain ( ) 2. Changes in duration of rain during rainy season ( ) 3. Others, specify .................</td>
</tr>
<tr>
<td>13</td>
<td>To what extent has the rainfall onset been changing over the past decade?</td>
<td>1. Severe ( ) 2. Moderate ( ) 3. Not at all ( )</td>
</tr>
<tr>
<td>14</td>
<td>To what extent has the rainfall duration been changing over the past decade?</td>
<td>1. Severe ( ) 2. Moderate ( ) 2. Not at all ( )</td>
</tr>
<tr>
<td>15</td>
<td>Have you experienced any flooding in your farm?</td>
<td>1. Yes ( ) 2. No ( ) 2. No idea ( )</td>
</tr>
<tr>
<td>16</td>
<td>If yes, how frequent is it on your farm?</td>
<td>1. Quarterly ( ) 2. Yearly ( ) 3. Seasonally ( )</td>
</tr>
<tr>
<td>17</td>
<td>Do you have any means of getting weather information?</td>
<td>1. Yes ( ) 2. No ( )</td>
</tr>
<tr>
<td>18</td>
<td>If yes, through which means?</td>
<td>1. Weather forecast on radio/tv ( ) 2. MoFA extension officers ( ) 3. Indigenous experience ( )</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Options</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>19</td>
<td>If 1 or 2 above, how often do you get that information?</td>
<td>1. Daily ( ) 2. Weekly ( ) 3. Monthly ( ) 4. Yearly ( )</td>
</tr>
<tr>
<td>20</td>
<td><strong>SECTION C: EFFECT OF RAINFALL VARIABILITY ON TOMATO PRODUCTION IN THE COMMUNITY</strong></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Is there any significant relationship between rainfall and tomato production?</td>
<td>1. Yes ( ) 2. No ( ) 3. No idea ( )</td>
</tr>
<tr>
<td>22</td>
<td>If yes, what type of relation exist?</td>
<td>1. Positive ( ) 2. Negative ( )</td>
</tr>
<tr>
<td>23</td>
<td>Does rainfall variability affect tomato yield?</td>
<td>1. Yes ( ) 2. No ( )</td>
</tr>
<tr>
<td>24</td>
<td>If yes, to what extent does it affect tomato yield?</td>
<td>1. Increase ( ) 2. Decrease ( ) 2. No effect ( )</td>
</tr>
<tr>
<td>25</td>
<td>Does rainfall variability affect tomato availability?</td>
<td>1. Yes ( ) 2. No ( )</td>
</tr>
<tr>
<td>26</td>
<td>If yes, to what extent does it affect tomato availability?</td>
<td>1. Increase ( ) 2. Decrease ( )</td>
</tr>
<tr>
<td>27</td>
<td>Which type of tomato variety do you cultivate?</td>
<td>1. Power ( ) 2. Burkina ( ) 3. Wosowoso 4. Royal ( ) 5. Other, specify…….</td>
</tr>
<tr>
<td>28</td>
<td>Does rainfall variability affect the type of tomato variety you cultivate?</td>
<td>Yes ( ) 2. No ( ) 3. No idea ( )</td>
</tr>
<tr>
<td>29</td>
<td>How does it affect the above variety?</td>
<td>1. Low yield ( ) 2. Late maturity ( ) 3. Flower abortion ( )</td>
</tr>
<tr>
<td>30</td>
<td>Do you harvest the same quantity of tomato yield now as compared to the past years?</td>
<td>1. Yes ( ) 2. No ( )</td>
</tr>
</tbody>
</table>
|   | What is the trend of quantity of tomato yield? | 1. Increasing ( )  
2. Decreasing ( ) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SECTION D: INDIRECT IMPACT ON LIVELIHOOD AND LIVING STANDARD OF THE TOMATO FARMERS</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 30 | Is tomato cultivation your main source of livelihood? | 1. Yes ( )  
2. No ( ) |
| 31 | If yes, what is your average seasonal income? | 1. Less than 100ghc ( )  
2. 110ghc-200ghc ( )  
3. 210ghc-300ghc ( )  
4. 310ghc-400ghc ( )  
5. 410ghc-500ghc ( )  
6. Above 500ghc ( ) |
| 32 | How will you describe your seasonal income? | 1. Regular ( )  
2. Not regular ( ) |
| 33 | What is the state of your seasonal income for the past decade? | 1. Increasing ( )  
2. Decreasing ( )  
3. Constant ( ) |
| 34 | Are you able to cater for the basic needs of your household during low production? | 1. Yes ( )  
2. No ( ) |
| 35 | Are you able to afford daily meal for your family? | 1. Yes ( )  
2. No ( ) |
| 36 | How often do you seek health care? Clinic or Orthodox. | 1. Monthly ( )  
2. Quarterly ( )  
3. Seasonally ( ) |
<table>
<thead>
<tr>
<th></th>
<th>37</th>
<th>Are you able to purchase or pay drugs being prescribed by your doctor or herbalist?</th>
<th>1. Yes ( ) 3. Not always ( ) 2. No ( )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>38</td>
<td>What happens to the prices of tomato when there is low production?</td>
<td>1. Increasing ( ) 2. Decreasing ( ) 3. Constant ( )</td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>Are you able to purchase tomatoes frequently for your household food preparation?</td>
<td>1. Yes ( ) 2. No ( ) 3. Not always ( )</td>
</tr>
</tbody>
</table>

**SECTION E: OTHER NON-CLIMATIC FACTORS THAT CAN AFFECT PRODUCTION AND YIELD**

<table>
<thead>
<tr>
<th></th>
<th>40</th>
<th>How do you obtain the tomato variety you cultivate?</th>
<th>1. Extension officers 2. Certified seed/seedling unit 3. Local seed sellers</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>Why do you cultivate that type of variety above?</td>
<td>1. High yield ( ) 2. Disease resistant ( ) 3. Early maturity ( ) 4. Low rate of flower abortion during high rainfall ( )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When do you begin planting?</td>
<td>1. Beginning of the rains ( ) 2. Middle of the rains ( ) 3. Right after slash and burn ( )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>What is the type of soil you cultivate on?</td>
<td>1. Loamy soil ( ) 4. Clayey soil ( ) 2. Sandy-loam ( ) 3. Sandy soil ( )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>How does the soil look like?</td>
<td>1. Very compact ( ) 2. Very fine ( ) 3. Well drained ( ) 4. Very fertile ( )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Options</td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>44</td>
<td>Do you rely only on rainfall for cultivation during the rainy season?</td>
<td>5. Yes ( ) 6. No ( )</td>
<td></td>
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<tr>
<td>45</td>
<td>If no, what other means do you adopt?</td>
<td></td>
<td></td>
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<tr>
<td>46</td>
<td>Which of the following on-farm adaptation option do you employ when there is crop failure due to rainfall variability?</td>
<td>1. Mixed cropping ( ) 2. Irrigation farming ( ) 3. Change farming location ( ) 4. Crop diversification ( ) 5. Use of agrochemicals ( )</td>
<td></td>
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<tr>
<td>47</td>
<td>Which off-farm adaptation option do you employ when there is crop failure due to rainfall variability?</td>
<td>1. Diversification to non-farm activities ( ) 2. Migration ( ) 3. Non-adaptation ( )</td>
<td></td>
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<tr>
<td>48</td>
<td>Which non-farm activities do you do apart from farming?</td>
<td>1. Illegal timber logging ( ) 2. Fashion designing and hairdressing ( ) 3. Trading ( ) 4. Other, specify........................</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Why do you choose that form of adaptation?</td>
<td>1. Local government support ( ) 2. Education ( ) 3. Experience ( ) 4. Availability of finance ( ) 5. Other, specify..................</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>What is the level of effectiveness of the adaptation option you have chosen?</td>
<td>1. Very effective ( ) 2. Not effective ( ) 3. Moderately effective ( )</td>
<td></td>
</tr>
</tbody>
</table>
| 51 | Do you receive support (e.g. extension services, finance etc.) from the government? | 1. Yes ( )  
2. No ( )  
3. No idea ( ) |
| 52 | What support do you receive from government? | 1. Extension services ( )  
2. Financial ( )  
3. Agro-chemicals ( )  
4. Others, specify………………………… |
| 52 | Do you receive any form of training from any institution in the district to help boost your adaptive capacity? | 1. Yes ( )  
2. No ( )  
3. No idea ( ) |
| 53 | What kind of training do you receive? | |
APPENDIX III: INTERVIEW GUIDE FOR KEY INFORMANT (OFFICIAL OF MoFA)

1. Are you aware of climate variability in the district?
2. In your personal opinion, have you observed any variability in the rainfall pattern in the district for the past decade?
3. How frequent do you make this observation?
4. In your personal opinion, what have been the trend in rainfall pattern over the past decade?
5. In your own opinion, how does rainfall variability affect tomato production?
6. Is there any positive effect of rainfall variability on tomato production? Yes (    ) No (    ). If yes, what are some of these effects?
7. In your own opinion, has rainfall variability affect the livelihood of tomato farmers in the district? Yes (   ) No (    ). If yes, how?
8. Do you provide any assistance to farmers in times of crop failure due to rainfall variability?
9. Does your office provide any training programmes to farmers to enhance their adaptive capacity in response to climate variability? Yes (    ) No (    ). If yes, how?
10. In your own opinion, how effective are those training activities to improve their adaptive capacity?
11. What are the challenges you encounter in training activities with the farmers?
12. What are the possible measures your office putting in place to solve these challenges?
13. In your personal opinion, are there other non-climatic factors that affect tomato production in the community?