

THE EFFECTS OF CLIMATE CHANGE ON CASSAVA PRODUCTION IN NKHOTAKOTA

A CASE STUDY OF LINGA EXTENSION PLANNING AREA

SUNGENI MOLANDE

(MEC/007/17)

Thyolo, Malawi

Dissertation submitted to Ndata School of Climate and Earth Sciences of the Malawi University of Science and Technology in partial fulfilment of the requirements for the Bachelor of Science degree in Meteorology and Climate Science

July 2021

DISSERTATION APPROVED BY:

SUPERVISOR:

DR. MATTHEW FULAKEZA Signature. 

ASSESSOR: Signature: _____

DISCLAIMER

This document describes work undertaken as part of a program of study at Ndata School of Climate and Earth Sciences of the Malawi University of Science and Technology. All views and opinions expressed therein remain the sole responsibility of the author(s) and do not necessarily represent those of the School.

COPYRIGHT STATEMENT:

This copy of the dissertation has been supplied on condition that anyone who consults it is understood to recognize that its copyright rests with its author and that no quotation from the dissertation and no information derived from it may be published without acknowledgment.

ABSTRACT

Climate change is referred to as a long-term change in global weather patterns which is associated especially with the increase in temperature, precipitation, and storm activities. Climate change is a global challenge especially in developing countries, and its impacts are experienced in agricultural productivity. In recent studies the effects of climate change on cassava were evaluated over a large scale but not downscaled to specific areas, therefore this study was aimed at downscaling the effects of climate change on cassava in Nkhotakota District. The main objective of the study was to investigate the effects of change in climate parameters like rainfall and temperature on cassava yields at Linga EPA in Nkhotakota District. The objective was achieved by addressing the following specific objectives; Evaluating the relationship between the change in temperature and cassava yields in Linga EPA from 1989-2019, determining the relationship between the change in rainfall and cassava yields in Linga EPA from 1989-2019, and assessing other factors that were responsible in a change of the cassava yields. The secondary data employed in the study was sourced from the archive of the Malawi Department of climate change and meteorological services and Linga AEDC and the primary data was collected through the aid of a well-structured questionnaire which was administered to the cassava farmers in Linga EPA. The study made use of a simple random method to select the 2 representatives of the villages in traditional authority (T/A) Malengachanzie and a snowball sampling method was used to reach the cassava farmers in the selected villages. Both secondary and primary data were analyzed using a Microsoft Excel application where correlation of variables, graphs, tables and pie charts were produced. The results showed that temperature and rainfall do not affect the cassava yields in Linga EPA; however, other factors were suggested to affect cassava yields such as lack of good quality plantings, pest and diseases, and limited extension and research. Therefore it is recommended in this study that institutional support such as research and extension on development of high yielding varieties and good management on cassava farming and the cultivation areas should be increased in Malawi.

ACKNOWLEDGEMENTS

I would like to thank the Almighty God in Heaven for the blessing of life and for keeping me safe and healthy from the day I was born up to date. I also thank Him most for the love and care he gave me for the whole time I've been studying at MUST, I thank Him for strengthening me spiritually, physically, and mentally as well as giving me wisdom throughout this studies, glory, and honor be to him in Jesus Christ name, Amen.

On a special note, I want to say thank you to FDH bank under the initiative called FDH cares which have been there to support my studies financially. Their support was really helpful to me, may the good Lord bless FDH BANK.

Many thanks to all who contributed to the completion of this project especially my supervisor: Dr. Mathew Fulakeza for the wonderful job you've done in giving me your time and guidance in the course of doing this research project. Thanks for your professionalism, you worked tirelessly in perfecting this work day and night, may the Almighty God continue blessing you abundantly.

Many thanks also to the entire MUST community: from the staff members to my fellow students especially my classmates: "Meteorology and Climate Sciences class of 2022" for your technical support, encouragement, and guidance that made my studies at MUST successful and wonderful.

Lastly, I want to thank my parents, family, and friends for your encouragement, moral, physical, and financial support, and also for your prayers, they have carried me throughout my stay at MUST, may the good Lord bless you all.

TABLE OF CONTENT

Contents

ABSTRACT 6

ACKNOWLEDGEMENTS 7

1. CHAPTER 1: GENERAL INTRODUCTION 12

1.0. Introduction 12

1.1. Background 12

1.2. Problem Statement 15

1.3. Objectives 15

1.3.1. Main objectives 15

1.3.2. Specific objectives 15

1.4. Research Questions 15

1.5. Significance of study 16

2. CHAPTER 2: LITERATURE REVIEW 16

3. CHAPTER 3: METHODOLOGY 21

3.1. Research design 21

3.2. Area of study 21

3.3. Material 22

3.4. Participants and procedures 22

3.5. Data analysis 24

4. CHAPTER 4: RESULTS AND DISCUSSION 24

5. CHAPTER 5: CONCLUSION AND RECOMMENDATION 33

5.1. Conclusions 33

5.2. Recommendations 33

6. CHAPTER 6: LIMITATION OF STUDY 34

7. REFERENCE; 35

Bibliography 35

8. Appendix 1 37

ACRONYMS/ABBREVIATIONS

EPA: Extension Planning Area

AEDC: Agricultural Extension District Coordinator

DCCMS: Department of Climate Change Meteorology Services

MUST: Malawi University of Science and Technology

MUSTREC: Malawi University of Science and Technology Research Ethics Committee

T/A: Traditional Authority

LIST OF FIGURES:

Figure 1: MAP OF LINGA EXTENSION PLANNING AREA, NKHOTAKOTA DISTRICT.....22
Figure 2: Annual temperature for Nkhotakota district from 1989-2019 25
Figure 3: Linga Extension Planning Area (EPA) Cassava yields trend from 1989-2019.....26
Figure 4: Annual rainfall on Nkhotakota from 1989-2019.....27
Figure 5: Number of the respondents affected by the change in temperature 28
Figure 6: The suggested reasons to be responsible for change in cassava yields 32
Figure 7: Farmers who were trained in cassava farming.....33

LIST OF TABLES:

Table 1: Demographic characteristics of the survey respondents 23
Table 2: The perceptions of the affected respondents change in rainfall patterns and requirements. 29
Table 3: The correlation table of variables 30

1. CHAPTER 1: GENERAL INTRODUCTION

1.0. Introduction

The ongoing agricultural investments in Nkhotakota district were not to be delivering until the effects and ways to mitigate the impacts of climate change was to be discovered. Based on the extreme weather events different districts in Malawi were experiencing, it triggered a need to investigate the effects of climate change on cassava production in Nkhotakota

1.1. Background

Cassava is believed to have its center of origin in Amazon region of South America, despite the lack of consensus regarding the exact botanical origins of the progenitors of modern cultivated cassava (Chipeta & Bokosi, 2013). Its existence in Africa dates back to the 16th century, especially to the west coast of Africa and later to East Africa from Madagascar and Zanzibar carried by Portuguese navigators from Brazil (Chipeta & Bokosi, 2013). Further spread of cassava in Africa took place during the 20th century probably under the influence of colonial masters in which it was grown as a reserve famine crop and due to its ability to counteract locust's attack (Chipeta & Bokosi, 2013). At present, it is grown in all countries in Africa. In Malawi, cassava mainly came from Tanzania and Mozambique (Chipeta & Bokosi, 2013). Cassava is a staple food crop for almost 30-40% of the population in Malawi contributing about 7% of total caloric intake and ranks second as the most important food crop and third as a cash crop (Chipeta & Bokosi, 2013). It is mainly produced by smallholder farmers and a few large-scale farmers and its yields have increased by 4.6% during the period between 1997 and 2007 even though it is produced on marginal soils with no chemical inputs (Chipeta & Bokosi, 2013).

Cassava is mostly grown along with the lakeshore areas of the central and northern regions and is mainly for food in these areas (Chipeta & Bokosi, 2013). In southern Malawi and some parts of central Malawi, it is mainly grown for sale rather than for household consumption (Chipeta & Bokosi, 2013). While cassava is utilized as a staple food in cassava growing areas, it is used mainly as fresh cassava eaten raw or boiled to be eaten as a snack in substitution with bread in non-cassava belt areas. Other uses of cassava are in the

manufacturing industries where cassava is used as a substitute for wheat in making bread and biscuits, on the other hand, the use of cassava is industrial in which one factory and others in pipeline are being produced to manufacture starch which is in high demand and therefore offers a new and large demand for starch (Chipeta & Bokosi, 2013). Although cassava can withstand periods of drought, it is very sensitive to soil water deficit during the first three months after planting (Food and agriculture organisation of the united nation, 2013). Water stress at any time in that period reduces significantly the growth of roots and shoots, and impairs subsequent development of the storage roots besides that once it is established, cassava can grow in areas that receive just 400 mm of average annual rainfall. But higher yields can be obtained with many high levels of water supply (Food and agriculture organisation of the united nation, 2013). Cassava is considered to have a huge potential to alleviate rural poverty and contribute to national economic development and is known to produce reasonable yields under marginal conditions such as poor soil, drought, and extreme rainfall. It is among the few crops projected to not be adversely affected by global warming (Droppelmann, Gunther, Kamm, Rippke, Volgt, & Walenda, 2018)

The inconsistencies of these climate systems are a potential consequence of the greenhouse effect by greenhouse gases and its concentration in the atmosphere has increased due to different anthropogenic activities. Climate change is either direct or indirect to anthropogenic activities that have an impact on the natural composition of the global climate elements (Philander, 2008). Besides it, climate change can also be a result of natural external forces such as solar emission and natural internal processes of the earth's climate system (Philander, 2008). The effects of climate change include the variation in atmospheric temperature which can lead to changes in rainfall patterns, heat stress, sea-level rise, loss of biodiversity, drought, habitat loss and freshwater depletion, and pollution (Philander, 2008).

Malawi has a subtropical climate with three seasons. The cool dry winter from May to August with mean temperatures between 17^{0}C and 27^{0}C and minimum temperature from -3^{0}C to 10^{0}C particularly in June and July. This is followed by a hot and dry season between September and October when temperatures can reach 37^{0}C with 50-70% humidity. About 95% of annual precipitation falls in the warm wet season between November and April, with February being the wettest month (Msowoya, Maden, Davtalab, Mirchi, & Lund, 2016). Climate change is real in Malawi and is more enhanced with different anthropogenic activities and it has different effects on food production. Due to climate change, the average annual temperature has increased, increasing the number of hot days by 30 in the same period and resulted in shorter but heavier rainy seasons (Kocke, 2019). The increase of annual temperatures due to climate change is already making worse the contrast between the rainy and dry season and also these higher temperatures are linked with a shorter and intensive rainy season which also causes flooding and increases the number of consecutive days without rain leading to droughts (Kocke, 2019).

Nkhotakota is among the nine districts in the central part of Malawi, it has a tropical type of climate that consists of two main seasons; wet and dry season (Council, 2020). The district receives an annual rainfall of about 1000mm but may vary to as low as 400mm and as high as 1700mm; it has experienced fluctuations in the amount of rainfall on monthly basis attributed to deforestation and other forms of environmental degradation practiced in different parts of the districts (Council, 2020). The district has an average monthly maximum temperature of 28.7 ^{0}C and a minimum of 20 ^{0}C, and the warmest month is November and the coolest is July. Studies by the department of climate change and meteorological services show that there are long-term changes in rainfall and temperature patterns and it has been noted that the temperatures have been above normal (Council, 2020). The changes in weather patterns have had some effects and the district has experienced several extremes events ranging from floods, dry spells, strong winds, and pests and disease outbreaks and it is observed that the rain season has changed starting late and ending early (Council, 2020).

1.2. Problem Statement

Climate change is a global challenge especially in developing countries (Byishimo, 2017). Many developing countries have experienced the impacts of climate change on agricultural productivity (Byishimo, 2017). The changes observed and experienced in Malawi include high temperatures and heavy rainfall; however, these changes have translated into extreme weather events such as floods and droughts (Kocke, 2019). Recent studies have evaluated the effects of climate change on cassava over a large scale but not downscaled to specific areas. For instance, Tilasto (2019) determined that the effects of climate change on the production of cassava were done on a large scale in Malawi. It is for this reason that the study aimed at downscaling the effects of climate change on cassava at Nkhotakota District. The approach used was to investigate the effects of temperature and rainfall climate parameters on cassava yields in Linga EPA, Nkhotakota District.

1.3. Objectives

1.3.1. Main objectives

The main objective of this study was to investigate the effects of change in climate parameters like rainfall and temperature on cassava yields at Linga EPA in Nkhotakota District.

1.3.2. Specific objectives

The specific objectives addressed in the study were to:

i. Evaluate the relationship between the change in temperature and cassava yields in Linga EPA from 1989-2019
ii. Determine the relationship between the change in rainfall and cassava yields in Linga EPA from 1989-2019
iii. Assess the other factors that are responsible for the change in cassava yields.

1.4. Research Questions

To achieve the specific objectives, the study attempted and answered the following questions:

i. What is the relationship between the change in temperature and cassava yields in Linga EPA from 1989-2019?
ii. What is the relationship between the change in rainfall and cassava yields in Linga EPA from 1989-2019?
iii. What are the other factors that are responsible for the change in cassava yields?

1.5. Significance of study

Climate change tends to have no effects on cassava yields as cassava was known with the potential to withstand extreme weather events, however, at a large scale, climate change was known to affect the yields of cassava. Therefore, the study was significant in investigating the relationship between the change in climate parameters and the cassava yields to come up with ways to mitigate the impacts of climate change on food security in Malawi.

2. CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

Climate change impacts on agriculture shaped this review, which was of relevance for a broader audience because although there were some sources on cassava cultivation and the history of agriculture in Malawi no other sources weave together the effect of climate change on cassava production in Nkhotakota district as it was intended. Case studies about perceptions, cultivation, and production of cassava like Chipeta & Bokosi (2013), Kambewa (2008), or Kocke (2019) focus on specific regions, however, Malawi is diverse and there was a need to reflect on the effect of climate change which is enhanced by anthropogenic activities.

2.2. Definition of key concepts

Climate change is referred to as a long-term change in global weather patterns which is associated especially with the increase in temperature, precipitation, and storm activities. Climate change has many impacts affecting biological and human systems in different ways.

Global average temperature increase masks considerable differences in temperature rise between land and sea and between high latitudes and low; while decreases are likely in most of the tropics and subtropical land regions (Moshefi & Almasi, 2015). Climate change is inevitably resulting in changes in climate variability and extreme weather and climate events (Moshefi & Almasi, 2015), it was observed and projected that one of the most significant impacts of it was likely on the hydrological system and the principal climate variables affecting water availability are precipitation, temperature, and potential evaporation. Consequently, the likely impacts of climate change on the agricultural sector have prompted concern over the magnitude of future global food agriculture, following that soil moisture was determined not only by the volume and timing of precipitation but by a complex interaction and feedbacks with evaporation and temperature (Moshefi & Almasi, 2015).

Furthermore, the temperature is the intensity aspect of heat energy and its paramount importance is for organic life, it governs the physical and chemical processes that in turn control biological reactions within plants (Harpal & Tupper, 2004). Organisms have a specific range of temperature at which their biological activities operate, for common soil organisms the temperature range at which they can be active ranges from 0^0C to about 60^0C although no single species is likely to act throughout the entire range (Harpal & Tupper, 2004). Those organisms which have a high-temperature limit would tend not to be so active at a lower temperature compared to those suited in the lower limits (Harpal & Tupper, 2004). Temperature is a very important factor in determining the weather because it influences or controls other elements of the weather such as precipitation, humidity, clouds, and atmospheric pressure which are of equal importance to plant growth therefore it determines which species to survive in a particular region as different plants have different temperature requirements (Harpal & Tupper, 2004). Ninety percent of Malawi's population depends on wood fuel for their energy needs and the demand for wood fuel and curios for tourists and clearing of marginal areas for agriculture are the major causes for deforestation in Malawi's dry lands (Capacity Strengthening in the least developed countries for

adaptation to climate change , 2004). However, poverty plays a major role in deforestation and it needs to be emphasized that loss of tree cover affects the temperatures and causes climate change. Climate change impacts on agricultural crop production vary from place to place and from crop to crop (Msowoya, Maden, Davtalab, Mirchi, & Lund, 2016). Higher temperatures can reduce crop production in parts of the world although crop yields could increase with warm wet climate change in some areas, long-term implications of crop yield reduction are significant for food security (Msowoya, Maden, Davtalab, Mirchi, & Lund, 2016).

2.3. Overview of climate change effects on agriculture

Due to climate change in Malawi, the average annual temperature was increasing by 0.9^{0}C with an average rate of 0.12^{0}C per decade between 1960 and 2006 (Kocke, 2019). This increased the number of hot days by 30 in the same period and resulted in shorter but heavier rainy seasons. The rain itself is influenced to a large extent by the movements of the inter-tropical convergence zone (ITCZ) and the moisture brought from the Indian Ocean, due to its vicinity to the east Africa coast (Kocke, 2019). However, the increase of annual temperatures due to climate change was already making worse the contrast between the rainy and dry season and also these higher temperatures are linked with a shorter and intensive rainy season which also causes flooding and increases the number of consecutive days without rain leading to droughts (Kocke, 2019). In addition to the trends, rainfall anomalies resulted from the inter-annual EL-NINO-La Nina southern oscillation and Indian Ocean sea surface temperature (SST) anomalies (Kocke, 2019). The occurrence of large cyclones in the Indian Ocean before and after the monsoon season affects agriculture negatively. Examples of the climatic anomalies were the adverse effects of the EL-NINO event in 2015/16, which led to extreme droughts followed by heavy flooding, and the cyclone Idai in 2019 (Kocke, 2019). Furthermore, in years 2015 and 2016 climate change had serious implications on Malawi such as floods and drought (Ministry of Natural Resources, Energy and mining Environmental Affairs Department, 2016); the conjunction of all these climatic events puts a lot of pressure on the production of different crops in the country.

A research which was done at Ulugad University by Cumhur Aydinalp and Malcolm S. Cresser on the effects of climate change on agriculture highlighted that climate change was expected to affect agriculture and the crop productivity was to be altered due to the changes in climate parameters like temperature and rainfall and due to the increase in weather events and changes in patterns of pests and diseases.

Research done in Nigeria (Adejuwon et al, 2019) on the impacts of climate variability on cassava yields describes that even though Nigeria was known as one of the largest cassava producers in Africa, its production was also being affected by the changes in climate variability most especially with the change in temperature and rainfall. Hence, in conclusion, the study showed that the annual maximum and minimum temperature was affecting the cassava yields.

According to the technical report of the Malawian innovation activity in 2016, Malawi was among the world's dozen countries most vulnerable to adverse effects of climate change and among those with the least resources to adapt or mitigate them. Its agriculture sector was most vulnerable to climate shocks, particularly droughts and flooding, which threatens food security, a major share of exports value, and the livelihoods of 85% of Malawi's predominantly rural and densely distributed 16 million people. Most Malawians were poor farmers depending on low input, low output rain-fed agriculture, and small landholdings, which make them more limited to climate change adaptation options and capacity. However, understanding the impacts of climate change on rain-fed maize yields, of which maize is the main staple food crop cultivated by up to 97% of the farmers making up over 54% of the caloric intake (Chipeta & Bokosi, 2013) it was necessary to draw attention to the need of minimizing the effect of climate change on cassava production as it was a second staple food for Malawi.

Furthermore, a case study (Grist, 2015) entitled "Malawi's agriculture, climate change, and food security country analysis and programming recommendation" indicated that climate change in Malawi was lowering production and yields due to an increase in extreme events (flooding and drought) following the increase in temperatures causing crop failure. Maize-based systems were among the most vulnerable to climate change, with estimated yield losses from 18-22% across sub-Saharan Africa and consistently negative effects on all major cereal crops were projected to 2050 (Grist, 2015).

Cassava production faced serious biotic constraints such as diseases and pests, poor handling of planting material, poor agronomic practices, limited technical knowledge of how to cropping new varieties, and poor post-harvest handling and processing (Bayitse, Tornyie, & Bjerre, 2017). However, the major highlighted factor affecting cassava production was pests and diseases like green mites, grasshoppers, mosaic disease, cassava bacterial blight, anthracnose disease and root rot (Bayitse, Tornyie, & Bjerre, 2017). Furthermore, the drop was partly attributed to the El Nino, therefore worldwide cassava production was increasing remarkably but due to the unfavorable weather conditions, cassava production was depicted to reduce in 2015 due to drought in the Sub Sahara African region (Bayitse, Tornyie, & Bjerre, 2017).

Research done in Cambodia by a group of researchers from royal university agriculture reported a yield decline (38 to 42 percent) in cassava for a period of 2010 to 2013 besides the exponential expansion in cassava yields in 2011 of more than 400 thousand hectares (Penh, 2015). However, one of the causes suggested was heavy rainfall, which tells that climate change was attached to the poor yield in Cambodia as a result of its impacts.

The research was done in Asia (Howeler, 2007) highlighted that cassava yields were seriously reduced if either low rainfall or low temperature was limiting the growth during 3-5 months after the planting besides cassava being the hardy crop that grows reasonably well on poor soils and in areas with low or unpredictable rainfall. It also explained that in

regions with a distinct dry and wet season and a mono-modal rainfall distribution the best time to plant cassava was early in the wet season since at planting times there was a need to have enough moisture to get at least 80-90% germination while the soils should not be so wet as to prevent adequate aeration and root formation therefore high yields were to be obtained.

A study done in Nigeria by Ajayi (2015) on the effects of climate change on cassava production and profitability used a structured questionnaire assisted with scheduled interviews and it involved sixty respondents in collecting data and the data was analyzed using descriptive statistics and regression model. The study's findings indicated that climate change had some effects on cassava production hence it was responsible for dwindling cassava production figures.

3. CHAPTER 3: METHODOLOGY

3.1. Research design

The research was based on both qualitative and quantitative data collection methods which involved collecting the non-numerical concepts on the effects of climate change on yields and collecting the numerical data for temperature, rainfall, and yields. The study was conducted as a case study on the experiences of people in cassava farming and analyzing the temperatures, rainfall amounts, and the trends of yields. Statistical analysis was done using Microsoft excel where its produced results reflect the experiences of the cassava farmers from the questionnaire. Furthermore, the analysis was done which reflects the relationship between temperature, rainfall, and the yields in Linga EPA.

3.2. Area of study

The survey was done in Nkhotakota district, one of the nine districts in the central region of Malawi. It borders Nkhatabay to the North, Mzimba to the North West, Kasungu to the West, Ntchisi to the South West, and Salima to the South. The district was the third-largest in the central region having an approximate area of 7500 square kilometers and it covers

6.2% of the country's land (Council, 2020). Nkhotakota was divided into 8 extension planning areas however to be specific with limited time and resources, the study was done in Linga Extension planning area (EPA) where some villages were randomly selected to represent the EPA. Below was the map of the study area.

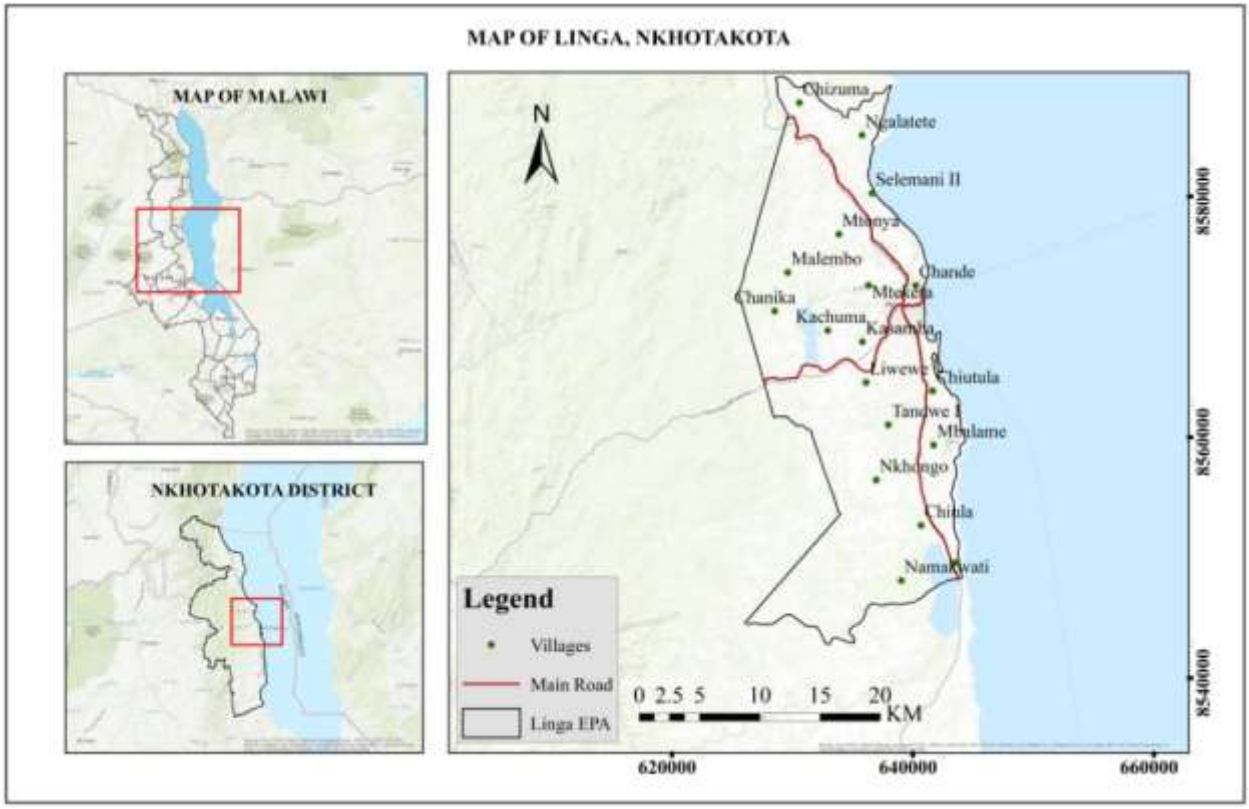


Figure 1: MAP OF LINGA EXTENSION PLANNING AREA, NKHOTAKOTA DISTRICT

3.3. Material

The survey used the questionnaire attached in appendix 1 in assessing the effects of climate change on cassava production in Nkhotakota, Linga EPA.

3.4. Participants and procedures

Before the study was implemented, it undergoes a screening and ethical clearance process and an ethics approval letter was obtained from MUSTREC. The survey was conducted in May 2021, where participants filled out questions (Q) from the questionnaire handouts which were used given to them. The estimated time to complete the survey was 15 minutes and 21 volunteer respondents participated in the survey. The survey was done on a

volunteer basis hence participants, therefore, were probably strongly interested in the topic of the survey. The survey used the snowball sampling method to choose respondents from different age groups, sex, and education levels in 2 villages that were randomly selected. All the respondents were chosen from T/A Malengachanzie in Liwewe and Chiwaula villages. According to the self-declarations, the majority of the respondents 33.3% were aged between 20 and 34 years followed by 47.6% of respondents aged 35 and 59 years, then 19% of those aged 60 years and above. The survey had no equal number of males and females and in terms of education, the majority of the respondents 42.9% had attended primary school, followed by 38.1% of secondary school, and then 19% for those that did not attend school and none of them attended tertiary and other high-level education. Overall the results of the demographic characteristics of the survey respondents are shown in table 1 below. To some extent, the results cannot be considered representative of the wider population for age group, sex, and education levels. However, this is itself a result of the survey, providing several experiences, in terms of the changes in yields and all the challenges faced by the farmers with those who were interested and participated in the study area at the time the survey was conducted.

Table 1: Demographic characteristics of the survey respondents

		Percentage of the respondents (%)
Age	20-34	33.3
	35-59	47.6
	60 and above	19
Sex	Male	19
	Female	81
Education	Primary	42.9
	Secondary	38.1
	Tertiary	0
	No education	19

3.5. Data analysis

A descriptive statistical analysis was done on the collected data. Both secondary and primary data were collected to address the objectives of the study. The secondary data from 1989-2019 was collected from the DCCMS and Linga AEDC while the primary data was collected with the aid of a well-structured questionnaire administered among the cassava farmers in Linga. The collected qualitative data on cassava yields, temperature, and rainfall for Nkhotakota was analyzed together with the quantitative data which was coded and entered in Microsoft Excel and statistically analyzed. Using this software, the correlation of variables, simple and descriptive graphs discussed in detail in the next section were produced. Pie-charts showing percentages have concurrently been used together with tables to represent and summarize the data.

4. CHAPTER 4: RESULTS AND DISCUSSION

This section presents the findings of the research questions, one research question in each subsection below based on the analysis of the responses to the questions in the questionnaire presented in appendix 1 and the analysis of the secondary data.

4.1. Temperature trend

According to the temperature values collected from the DCCMS, which were analyzed the figure below demonstrates the findings;

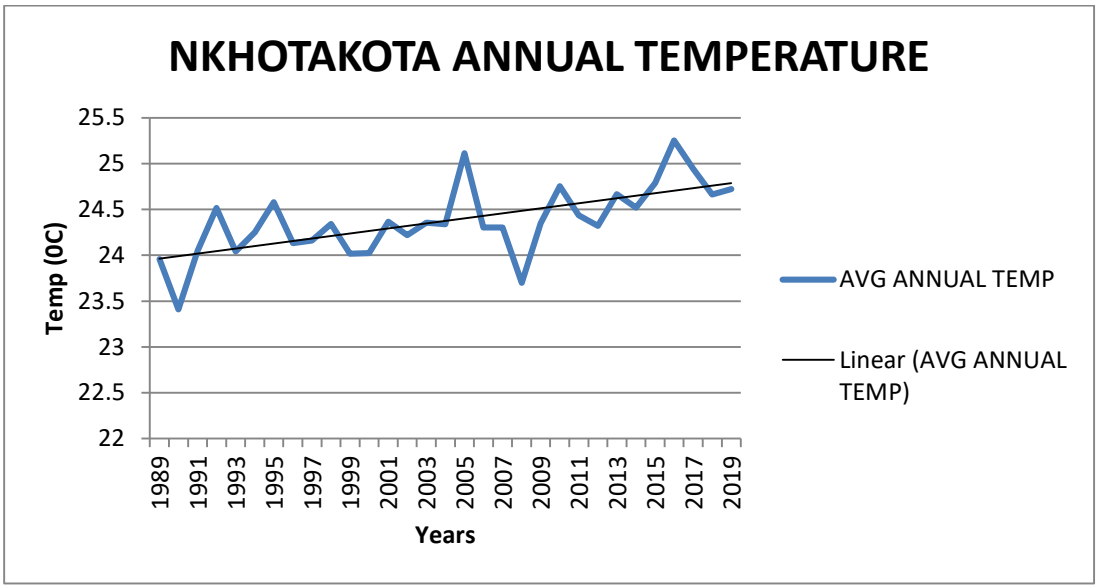


Figure 2: Annual temperature for Nkhotakota district from 1989-2019

Using the collected monthly secondary temperature data mean annual temperature was calculated and figure 2 above was produced, in general the trend of the findings indicated that temperature was increasing continuously from 1989-2019 in Nkhotakota. The figure 2, shows that there was the highest temperature between 2016-2019 and the smallest temperature observed between 1989-1992. Furthermore, the figure indicated some slight fluctuations observed between 1992-2004 and a dramatic change between 2004-2010 which was observed.

However, the findings in figure 2 above were in-consistence with the findings of a study which was done by Ajeire and Weli in Nigeria in assessing the impacts of climate change on maize and cassava yields from 1987-2016 where it was also revealed that temperatures were increasing with the maximum temperature in 1992 due to high population growth and deforestation. Therefore that may imply that the findings in figure 1 above were caused by population growth in Malawi which was influencing the clearing of land for cultivation and settlements.

Furthermore, the findings in figure 2 above were inconsistent with the findings of Warnatzsch et al (2018) in the study on temperature and precipitation change in Malawi

from 1961-2005 which indicated that there was a warming trend in Malawi with the mean temperature increasing.

According to the respondent's perceptions, on question 6 in section B, 57% of the respondents revealed that the temperatures were changing in Linga EPA while 43% of the respondents revealed that the temperatures of Linga were not changing.

4.2. Cassava yields trend

The results on cassava yields were based on the secondary data which was collected for cassava yields from 2007-2019. As such, figure 2 below summarises its findings.

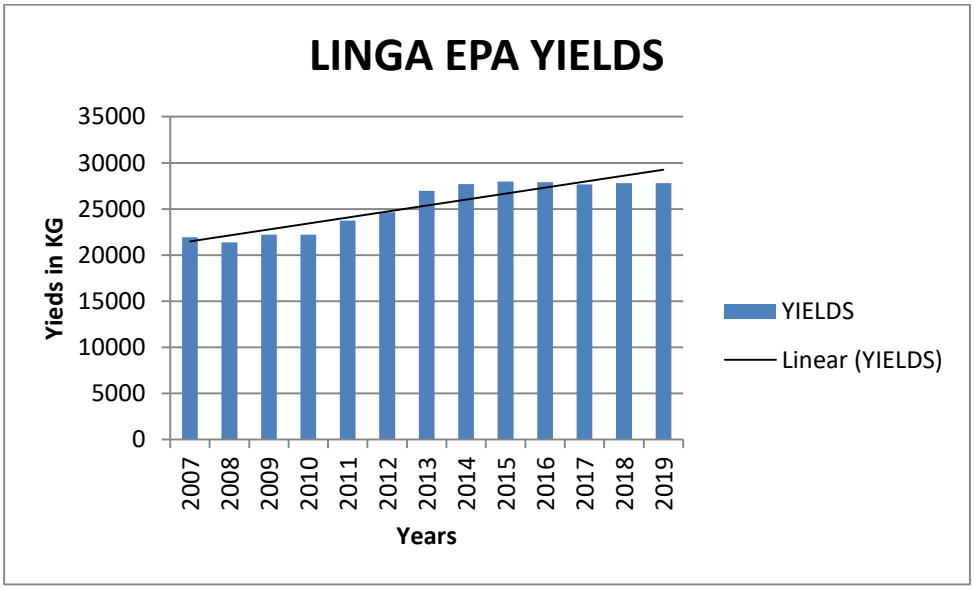


Figure 3: Linga Extension Planning Area (EPA) Cassava yields trend from 1989-2019

Using the secondary yield data figure 3 above was produced, the trend of cassava yield was increasing from 2007-2019 in Linga EPA, however, there was the smallest cassava yield value in 2008 with the highest cassava yield value in 2015.

The findings above were in agreement with the findings of Chipeta and Bokosi (2013) on the status of cassava production and utilization in Malawi which revealed that there was an increase in cassava yields from 1999-2007 due to the increase in cassava cultivation areas in the same period and also due to the increase in reliance on cassava for food security

especially in maize deficit years which therefore led to the increase of the institutional support such as research and extension on development of high yielding varieties and good management on cassava farming. Therefore that implies that the increase in yields in the findings in figure 2 were due to the increase in cultivation area and reliance on cassava crop in Linga EPA.

4.3. Rainfall Trend

The figure 4 below summarises the findings of the analysis which was done on rainfall data collected for 1989-2019

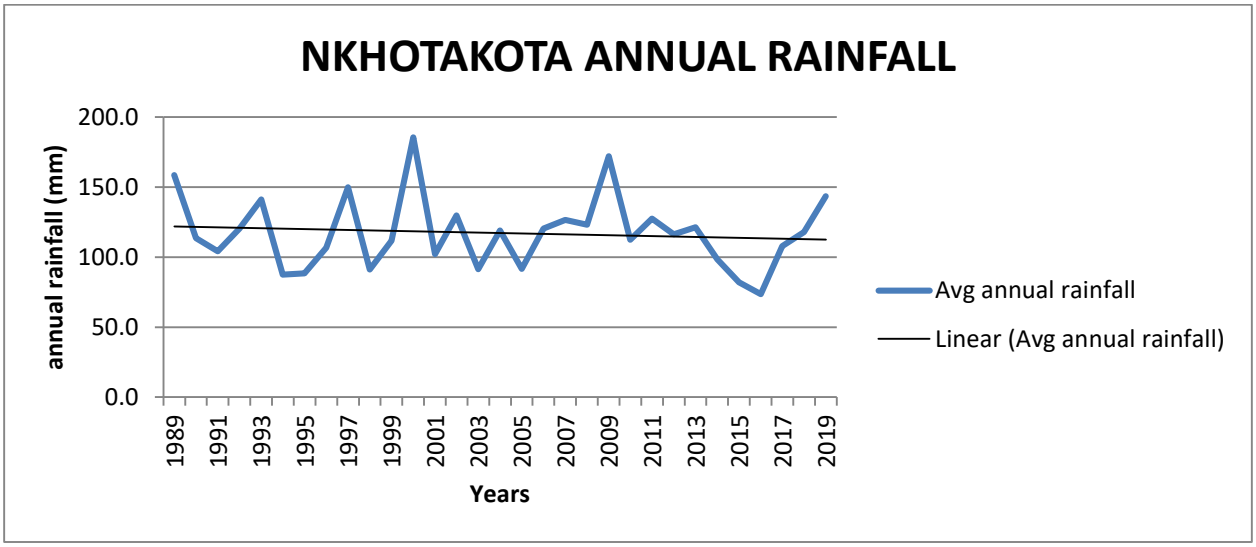


Figure 4: Annual rainfall on Nkhotakota from 1989-2019

The figure 4 shows that annual average of rainfall has the fluctuations of increasing and decreasing as it moves from 1989-2019. With reference to figure 4 the highest rainfall amount was revealed between 1999-2001 and the lowest rainfall amount was between 2014-2017, and it presented some slight fluctuations between 1991-1993 and between 1996-1998 and a dramatic change between 2009-2011.

However, the findings above were in-consistence with the results in the previous study by Tadeyo et al (2020) on the characteristics of Spatio-temporal trends and periodicity of precipitation over Malawi during 1979-2015, the results which were obtained by averaging

the rainfall of 31 weather stations highlighted that precipitation over Malawi was declining by displaying an increase during the 1980s and 1990s which was followed with a decrease in 21st century.

Furthermore, the findings in figure 4 were in agreement to the socio-economic profile for Nkhotakota district council (2020) report which revealed that rainfall were decreasing due to deforestation and other forms of environmental degradation that most parts of the district were experiencing, hence it may imply that deforestation and other forms of environmental degradation were the cause for the changes in rainfall in figure 4 findings.

4.4. Relationship between the change in temperature and cassava yields

The findings from **figure 2** and **figure 3** indicated that there was an increase in cassava yields while the temperature was increasing from 2007-2019.

However from the perceptions of the respondents Q7 section B, in understanding if the change in temperature affects their cassava yields,67% of the respondents indicated that the change in temperature hard some implications on them as it affects the cassava yields.

Below is a figure which was presenting the number and percentage of respondents on their responses in question 7 on the questionnaire.

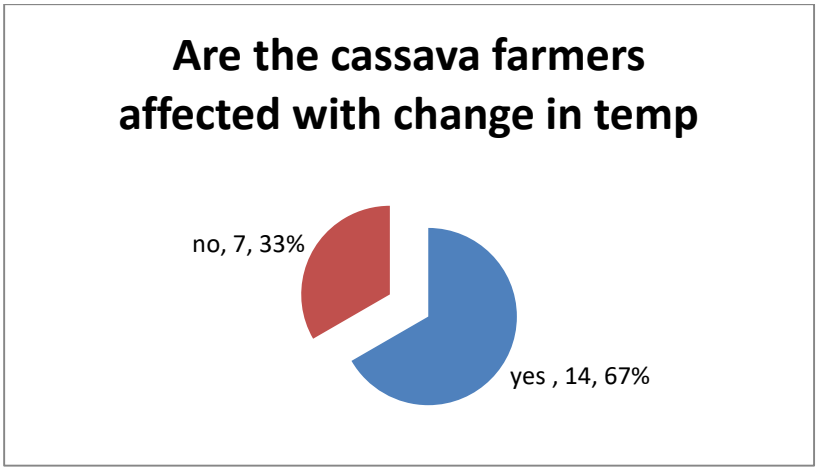


Figure 5: Number of the respondents affected by the change in temperature

4.5. The relationship between the change in rainfall and cassava yields

Regarding **figure 3** and **figure 4** findings, it was revealed that there was an increase in cassava yields while the rainfall amounts were decreasing from 2007-2019.

However, from the perceptions of the respondents on Q2 section B, 90% of the respondents revealed that rainfall change at some point affects the number of yields harvested since cassava plantings require some amounts of water during the first three months after planting. Hence on their perceptions to Q4 section B on the estimated rainfall percentage which was required in cassava plantings, 67% of the respondents suggested estimation of 60% of rainfall to be required followed by an estimation of 40% rainfall requirements in cassava plantings during the first 3 months after planting suggested by 33% of the respondents. Below is a table showing the percentage of the respondents on Q 1, 2&4 in section B of the questionnaire.

Table 2: The perceptions of the affected respondents change in rainfall patterns and requirements

	Respondents in percentages (%)	
Percentage of rainfall requirements in cassava	60% 40%	66.7 33.3
Are the rainfall patterns changing	Yes No	95 5
Are the cassava farmers get affected by the change in rainfall	Yes No	90 10

4.6. The correlation of variables in the study

There was different correlations between variables in the study, therefore table 3 below summarises their relationships.

Table 3: The correlation table of variables

	Yield	*temperature*	*Rainfall*
yield	1		
temperature	0.707745963	1	
rainfall	-0.519695772	-0.508397355	1

The findings on table 3 above, demostrates that there was a strong direct positive relationship between the variable of temperature and yields with a correlation of 0.71 which means temperature was increasing together with yields. And there was a medium negative relationship between the variable of yield and rainfall with a correlation of 0.52, hence yield was increase with a decrease in rainfall. However there was a medium negative relationship between temperature and rainfall with a correlation of 0.51 therefore there was an increase in temperature with decrease in rainfall.

However, scientifically the results demostrated on the change of rainfall and temperature it may mean that there was an increase in anthropogenic activities such as deforestation, industrialisation and the land use change which are causing the increase in greenhouse gases in the atmosphere hence leading to the increase in temperature. Furthermore the change in temperature had an influence on the rainfall amounts since temperature was known to influence and control other climate parameters thus according to Harpal and Tupper (2004), therefore a decreasing in rainfall trend for Nkhotakota district.

4.7. Other factors that were suggested to be responsible for the change of cassava yields

4.7.1. Lack of good quality planting materials

According to Chipeta and Bokosi (2013), the lack of good quality of the planting materials was one of the factors which were responsible for the change in cassava yields. The stability yields and its environmental development were largely dependent on the quality of planting clean materials, high vigor, and no pest or pathogenic infections(chipeta and

Bokosi, 2013). However, it was in-consistence to the respondents on Q12 on the questionnaire, 53% of them in their perceptions they suggested the lack of quality planting materials for cassava crop to be responsible for the change. And in Q11 section B, one of the participants, Mr. Faston A Chiwaula was quoted saying that: "…Cassava being a root crop it depends on stem cuttings for propagation and production but the use of virus-infected cuttings for plantings due to lack of knowledge is affecting our cassava production despite the availability of a good distribution of planting materials….." .

4.7.2. Pest and disease

In responding to Q12 in suggesting other reasons for the change in cassava yield, 27% of the participants suggested that their cassava yields were affected by the pest and diseases. Their responses were in-consistence with a survey done by Chipeta and Bokosi(2013), were insects pest and diseases such as cassava mosaic disease, cassava mealybug, cassava bacterial blight, and anthracnose were revealed in Malawi to have a major threat on cassava production by compromising the yields of the tuber up to 70% and impairs the sales values of the stems.

4.7.3. Scarcity of land

In Q12, 13% of the participants suggested that the scarcity of good land for cassava cultivation was a challenge to the cassava yields increase in Linga since some available land was with sand soils hence not good to keep water for long period to sustain the cassava plantings. In a survey done by Chipeta and Bokosi (2013) it was also revealed that the scarcity of land was a challenge to cassava production. There is land scarcity in Malawi because of the high population and lack of non-agricultural employment opportunities (Chipeta and Bokosi, 2013), and according to the survey, there was no adequate land for cassava production since the available little land was known to be manlily utilized for maize production.

4.7.4. Poor management

In Q12, 7% of the participants suggested that poor management of the cassava farms was responsible for change in cassava yields. However, it was revealed by 95% of the

participants on Q2 section A that the farmers were in cassava farming for many years hence they hard more knowledge on how to manage the cassava farms.

Below is the figure, demostrating the number of respondents in all above suggested reasons for change in cassava yields for Linga EPA.

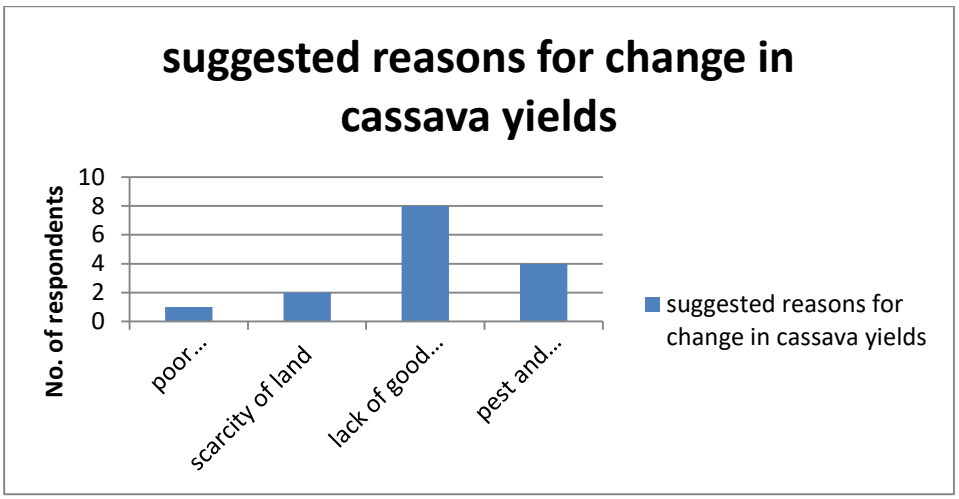


Figure 6: the suggested reasons to be responsible for change in cassava yields

4.7.5. Limited extension and research

In a survey done by kanyamuka et al (2018) on the analysis of the value chain of the root and tuber crops in Malawi, a case of cassava; revealed that the limited extension and research lead to poor agronomic practices, use of inappropriate varieties, and post-harvest losses which affect the yields of cassava. It was inconsistence to the figure 7 below, from Q4 section A, 76% of the respondents revealed that they were not trained in cassava farming while 24% of them revealed that they were trained in cassava farming. That showed that there was limited extension and research on cassava farming hence little or no training for the respondents.

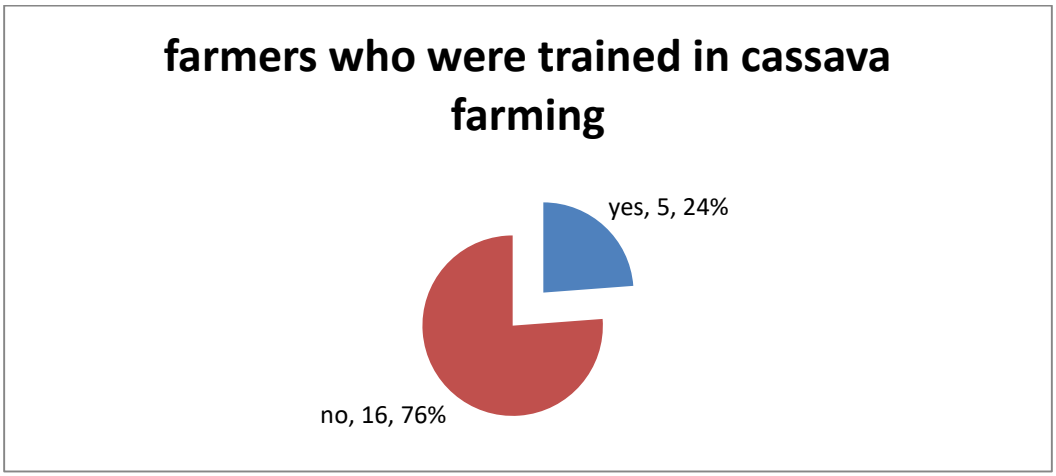


Figure 7: farmers who were trained in cassava farming

5. CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1. Conclusions

This study has shown that in Linga EPA Nkhotakota district, the temperature does not affect the cassava yields. It has also shown that rainfall does not affect the yields of cassava. According to the secondary data, there was a medium negative relationship between rainfall and temperature with a positive relationship between temparature and yields and an inverse relationship between yields and rainfall, hence it is shown that the change of climate parameters such as temperature and rainfall has no effect on cassava yields. However, according to the perceptions of the farmers temperature and rainfall change tends to have an effect on the yields of cassava, and some other factors are suggested to be responsible for affecting cassava yields in Linga EPA such as pest and disease, lack of good quality planting material, scarcity of land for cassava cultivation, and limited extension and research.

5.2. Recommendations

The study recommends that there must be an increase in institutional support such as research and extension on development of high yielding varieties and good management on cassava farming in all cassava belt areas to ensure food security in Malawi. Furthermore it is recommended to increase the cultivation area for cassava crop and the reliance on cassava crop in Malawi in all regions to ensure food security in the country. Hence all

policymakers need to consider improving and more investments in cassava farming so that Malawi as a country remains food secured in the most known staple food (maize) deficit years.

It is also recommended that climate information from the department of climate change and meteorology services should be made available and well understood to all small holder cassava farmers in Nkhotakota, to improve the knowledge of people on the climate change.

6. CHAPTER 6: LIMITATION OF STUDY

Based on the findings, the study hard some limitations as follows;

- For efficiency and true representation of the effects of climate change and cassava yields in Nkhotakota district, the study area was to cover a large area and reach many cassava farmers of Nkhotakota, however with the minimal number of farmers reached in this survey, there is no good representation of how the farmers are affected with the change in climate parameters.
- For completeness' sake, in conclusion the researcher have ignored some primary data, however there was a need to consider that primary data since in agriculture primary data is more vital than secondary data.
- The researcher's results has no emphasis on some other factors that may be the cause for the change of yields which may have been revealed by the primary data which was causing a contradiction between primary and secondary data in the survey.

7. REFERENCE;

Bibliography

Bayitse, R., Tornyie, F., & Bjerre, A. B. (2017). CASSAVA CULTIVATION, PROCESSING AND POTENTIAL USES IN GHANA. In C. Klein, *HANDBOOK ON CASSAVA* (pp. 2433-2511). ACCRA: NOVA SCIENCE PUBLISHERS.

Byishimo, P. (2017). *Assessment of climate change inputs on crop yields and farmers adaptation measures.* University of Zimbabwe.

Capacity Strengthening in the least developed countries for adaptation to climate change . (2004). *adverse impacts of climate change and development challange:Integrating adaptation in policy development in malawi .* Harare: Regional and Interbational networking group.

Chipeta, M. M., & Bokosi, J. M. (2013). STATUS OF CASSAVA PRODUCTION AND UTILIZATION IN MALAWI. *INTERNATIONAL JOURNAL OF AGRONOMY AND PLANT PRODUCTION* , 3637-3644.

Council, N. D. (2020). *Socio-Economic Profile .*

Droppelmann, K., Gunther, P., Kamm, F., Rippke, U., Volgt, C., & Walenda, B. (2018). *Cassava, the 21th Century Crop for Smallholder .* Berlin: SLE PUBLICATION SERIES S274.

Food and agriculture organisation of the united nation. (2013). *SAVE AND GROW:CASSAVA.* Rome: FAO.

FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS. (2013). *A GUIDE TO SUSTAINABLE PRODUCTION INTENSIFICATION.* Rome: FAO.

Grist, N. (2015). *malawi's agriculture,climate change and food security country analysis and programming recommendation.* UK: Evidence on demand.

Harpal, M. J., & Tupper, G. J. (2004). *AGROMETEOROLOGY, PRINCIPLES AND APPLICATION OF CLIMATE STUDIES IN AGRICULTURE.* Binghamton, NY: Food procuct press.

Howeler, R. H. (2007). *PRODUCTION TECHNIQUES FOR SUSTAINABLE CASSAVA PRODUCTION IN ASIA.* BANGKOK: CASSAVA OFFICE IN ASIA .

Kocke, S. (2019). *The perception of cassava in malawi.* uppsala: master's thesis in global environmental history.

Ministry of Natural Resources, Energy and mining Environmental Affairs Department. (2016). *National Climate Change Management Policy .* Lilongwe.

Moshefi, P., & Almasi, A. B. (2015). effects of climate change on agriculture. *Biodiversity journal* , 633-636.

MSOWOYA, K., MADEN, K., DAVTALAB, R., MIRCHI, A., & LUND, J. R. (2016). CLIMATE CHANGE IMPACTS ON MAIZE PRODUCTION IN THE WARM HEART OF AFRICA. *WATER RESOUR MANAGE* , 5299-5312.

Msowoya, K., Maden, K., Davtalab, R., Mirchi, A., & Lund, J. R. (2016). CLIMATE CHANGE IMPACTS ON MAIZE PRODUCTION ON NTHR WARM HEART OF AFRICA. *Waer Resour manage* , 5299-5312.

Penh, P. (2015). *Cassava Handbook .* cambodia: PHNOM PENH.

Philander, G. s. (2008). Global Warming and Climate Change. *cyclopedia of global warming and climate change* , 210-214.

TILASTO. (2019, March 12). Malawi: Cassava, production quantity(tons). Malawi.

8. Appendix 1

Attached below is the questionnaire used in the survey which was administered among the cassava farmers in collection of the primary data.

QUESTIONNAIRE

FOR INVESTIGATING THE EFFECTS OF CLIMATE CHANGE ON CASSAVA PRODUCTION IN NKHOTAKOTA LINGA EPA

Date of interview……..

Identification of the respondents

1. Name ……..
2. Sex (male/female)(tick)
3. Village ……
4. Relationship to the household head: 1 husband 2. Wife 3. Child (tick)
5. Level of education:
    I. Secondary
    II. Primary
    III. Tertiary
    IV. Other levels
    V. No educational
6. Age ……

SECTION A: The perception of people on cassava farming

1. Are you a cassava farmer? Yes/no (tick)
2. If yes, for how long……months/ years
3. What was the motivation to become a cassava farmer?
    .....
    .....
    .....
4. Were you trained in cassava farming? Yes/no(tick)
5. What are the benefits of becoming a cassava farmer?
    ……
    ……
    ……....
6. Do you rely on cassava only as a staple food in your family? yes/no (tick)

7. If No, what other crops do you rely on……..
8. If yes, do you manage to get all your family necessities through cassava production? Yes/no(tick)
9. How can you describe your harvest per year for the past years?
   A. high yields
   B. medium yields
   C. low yields

SECTION B: The perception of temperature and rainfall change on cassava yields

1. Do you experience any change in rainfall patterns with different years? Yes/no (Tick)
2. If yes, as a farmer are you affected by the change? Yes/no (Tick)
   If yes,
   how……
   ……
   And
   why……
   ……..
3. Do you rely on rainfall only for the cassava plantings to grow well? Yes/no (tick)
4. If yes, to estimate the percentage of cassava plantings that requires water?
   A .20%
   B .40%
   C. 60%
   D .80%
   E. 100%
5. What temperatures do you experience? (tick)
   A. high
   B .medium
   C. low
6. Is the temperature changing with different years? Yes/no(tick)
7. If yes, as a cassava farmer do you get affected? And
   how……
   ……
8. Have you ever heard about climate change? Yes/no(tick)
9. If yes, do you climate change is real? (tick)
   A. yes
   B. no
   C. not sure

10. What is the evidence of climate change in Nkhotakota, Linga EPA (tick)

A. high temperature, B. heavy rains, C. floods, D. dry spells

i. A&B
ii. A&D
iii. A B&C
iv. A only
v. B only
vi. C only

11. With climate change is the production of cassava gets affected? Yes/no(tick)

If yes, explain why?

……
……
……
…

If no, explain why?

……
……
……

12. What do you think are the reasons for the change in cassava yields? (Tick)

A. poor management

B. scarcity of land

C. lack of good quality planting material

D. pest and disease

14. Can you recommend cassava farming in many areas of Malawi? Yes/no (tick)

If yes, what can you advise to be put in place to have an increase in cassava production in Malawi?

……
……
……