ASSESSING THE IMPACT OF CLIMATE CHANGE ON CROP PRODUCTIVITY OF SUBSISTENCE FARMERS IN NAMIBIA: A CASE STUDY OF THE OMUSATI REGION

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF BUSINESS ADMINISTRATION NATURAL RESOURCE MANAGEMENT

OF

THE UNIVERSITY OF NAMIBIA

BY

VICTORIA HAUWANGA

200848925

MAY 2022

SUPERVISOR: DR SIMON CHIUTSI (NUST)

ABSTRACT

Climate change, one of the challenges facing the world today, is increasingly affecting people's livehood in the Omusati Regionlike other developing countries. The objective of this study was to investigate the impact of climate change on crop production for subsistence farmers in the Omusati region. The study was based on quantitative methodological approaches. Data was collected through questionnaires with structured questions that were administered to 100 house head farmers, randomly selected from the Etayi and Elim constituencies. Descriptive research design was used to determine the impact of climate change on crop yield productivity, adaptation and mitigation. The study findings also revealed that subsistence farmers experienced prolonged drought and floods as the main factor affecting crop production. Drought and floods often lead to low crop yields and high crop failure. Subsistence farmers in the Omusati Regionare vulnerable as they have limited adaptive strategies to withstand climate change. This could be due to lack of information, labour, time and financial resources. It is recommended to increase farmers' knowledge regarding climate change so as to reduce the effect of climate change on crop production. Therefore, initiatives should be taken to improve farmer perceptions and adaptation through the involvement of farmer organisations, extension officers, policy makers and the farmers themselves.

Key words: climate change, variability, crop productivity, subsistence farmers, farmers' perception.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS/ACRONYMS

IPCC	Intergovernmental Panel on Climate Change
UNISDR	United Nations office for Disaster Risk Reduction
WFP	World Food Programme
FAO	Food and Agriculture Organisation
NCN	Northern Central Namibia
UNDP	United Nations Development Programme
MDGs	Millennium Development Goals
GDP	Gross Domestic Product
MET	Ministry of Environmental and Tourism
AFDB	African Development Bank
NSA	Namibia Statistic Agency
HDRO	Human Development Report Office
SOWPGR	State of World's Plant Genetic Resource for Food and Agriculture
SPSS	Statistical Packaging of Social Sciences
IAEA	International Atomic Energy Agency
IAC	Intertribal Agriculture Council
OECD	Organisation for Economic Co-operation and Development

DEA	Department of Environmental Affairs
ADAS	Agricultural Development and Advisory Service
DFID	Department for Food and International Development
CIAT	International Central for Tropical Agriculture
ICRISAT	International Crops Research Institute for the Semi- Arid Tropics
GRN	Government of the Republic of Namibia

ACKNOWLEDGEMENTS

First and foremost, I would like to give special thanks to my supervisor Dr Simon Chiutsi for his excellent supervision and support throughout the preparation of this thesis. I would like to also thank Mr Andrew Nicodemus for always being there to provide support whenever I needed it.

I am also grateful for the moral support, financial support and encouragement from my family during the study. Moreover, I am giving appreciation to my friends for their support and encouragement.

I am also extending special thanks to Councillors for the following constituencies: Etayi (Hon. Hans Haikali) and Elim (Hon. Gerhard Shiimi) for showing interest in this research and for all their input. Furthermore, I give thanks to the farmers who sacrificed their time to make valuable contributions to this research. Above all, I would like to thank the Lord for giving me wisdom, strength and courage until I finished this thesis.

DEDICATIONS

I dedicate this thesis work to my grandmother; Lucia for the kind of person she has moulded me into and friends for their genuine love, care and faith in me.

I dedicate this thesis to my mother Iyaloo Shuundifonya and my Aunties (Sam Secilia and Albertina Ashipala) for their endless love and support. Furthermore, I would like to dedicate this study to my colleagues at the Quality Department for Namibia Dairies for allowing me some time off from work to carry out my studies.

DECLARATIONS

I, Victoria Hauwanga, declare that the present work "Assessing the impact of climate change on crop productivity of subsistence farmers in Namibia: A case study of Omusati region" carried out under the guidance of Dr Simon Chiutsi is my original work and has not been submitted in any degree. Where the work of other authors has been used, it has duly been acknowledged.

Date: **Signature:**

Place: Windhoek Victoria Hauwanga

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Climate change is considered as one of the threats to crop production and is rapidly emerging as a global critical development concern. Increasing occurrences and intensity of extreme weather events such as drought and floods are some of the consequences of climate change (Field, 2014). Studies (Reed et al., 2017; Arshad et al., 2018) established that climate change in low-income countries affects crop production and crop yield significantly and destructively. Similarly, the IPCC (2014) and Arshad et al. (2018) affirm that climate change will ominously affect crop productivity and lead to vital changes in agricultural outcomes.

Africa is more susceptible to climate change impact in relation to other continents. UNISDR (2011) asserts that this is the biggest challenge the current generation of Africa is facing. Nelson et al. (2017) points out that the reduction in crop production by 17% globally without accounting for good fertilised land estimated as an outcome of climate change. Furthermore, Thompson et al. (2007) stated that subsistence farmers in the developing world find it challenging to cope with climate-related hazards as they do not have capital to invest on new adaptation and most households rely on rain-fed crops for their livelihood. Equally, Elahi (2016) emphasised that the underdeveloped and developing countries are most vulnerable to climate change due to its direct impact on the socio-economic status. Agriculture is expected to pay a momentous cost through damage caused by climate change.

Studies have indicated that farmers whose livelihood depends on crop production face adverse consequences of climate change. Research shows that subsistence farmers are highly populated in the Sub-Saharan regions where families highly depend on crop production. These households are known to produce for consumption purpose only (Moyo, Mvumi, Kunzekweguta, Mazvimavi, Craufurd & Dorward, 2012 & Kaya 2016).

Namibia is facing the same fate. Namibia is not immune to climate changes, with the country recording poor harvests in recent years. (Scholars Nakanyete, Shikangalah and Vatuva, 2020) found that Namibians largely farm to sustain their families without commercializing their products. Due to recent floods and droughts, they too have been affected. Sixty-two percent 62% of Namibians are living in rural areas and heavily depend on rain-fed agriculture, which is highly vulnerable to changes in climate, seasonal shifts and precipitation patterns (WFP, 2017; FAO, 2016). This resulted in a devastating impact on the subsistence farmers, particularly in the northern parts of the country, where people relied mostly on crop production. According to Kaundjua, Angula and Angombe (2012) recurring drought, heavy rainfall events, incidences of higher temperature and unpredictable and inconstant rainfall associated with the El Niño effect have been experienced in the past 30 to 40 years in Namibia. Precipitation and temperature are parameters that are used as the indicators to measure climate change.

Furthermore, studies conducted (Sarker et al., 2012; Amin et al., 2015; Chowdhury & Khan, 2015) proved to be insufficient as there is no proper tackling of the impact of climate change on subsistence farming and its mitigation. Studies also indicate that women face more challenges in adopting mitigation strategies. Research indicates that women have less access to resources that would aid them in tackling the effects of climate

change. Due to gender inequality, women have limited access and control over resources which their livelihood depend on (Nchu et al, 2020). In addition, Osman-Elasha, (2022) suggest that adaptation initiatives identify and address gender-specific impacts of climate change such as food security, agriculture, and inequalities in access to resources. This research is timely because recently flooding and droughts in Namibia have been aggressive, destructive and frequent. This study presents an opportunity to attain the degree of the impact of climate change in the Omusati region.

1.2 Problem statement

Namibia's climate is distinctly arid in the greater parts of the country, except in the north and north-eastern areas. As a result, the country has experienced the impact of climate change on agricultural productivity, particularly in crop production (Nickanor & Kazembe, 2016). Frequent drought over the past 5 years has diminished crop production to the extent that farmers have had repeatedly insufficient supplies of Mahangu (pearl millet) to last them through the dry season (Hegga et al., 2016).

According to Shikangalah (2020) overall crop production fell in 2019. Pearl Millet harvests were estimated to be 53% lower than in 2018 and 42% lower than the 20 years average. Moreover, Angula and Kaundjua (2016) affirmed that the reduction in crop production in the Northern-Central Namibia (NCN) is projected to decline by 50%. Similarly, Climate change is well recognised to be one of the worries for subsistence farmers, particularly in the Omusati Regionas their ability to cope with the prolonged drought period and floods is reduced. For example, over the past couple of years, the Northern regions of Namibia have been experiencing erratic rainfall, particularly drought and floods (United Nations Development Programme (UNDP), 2015).

Barnes et al. (2012) concur that Namibia is expected to have as much as a 5% - 20% decrease in rainfall by 2080. Despite tremendous progress and improvements towards government and sector strategies aimed at improving agriculture, crop production is still vulnerable among subsistence farmers and remains a challenge as it is linked to food insecurity and poverty. Therefore, it is crucial to investigate the impact of climate change on the crop productivity of subsistence farmers in the northern parts of Namibia. It is also crucial for farmers to acquire new ecological and farming knowledge, such as adaptation and mitigation strategies for climate change in the Omusati Region.

1.3 Research objectives

Main objective: To investigate the impact of climate change on crop productivity of subsistence farmers in the Omusati Regionof Namibia.

- To determine the effects of crop harvests in terms of yields over the past ten years
- To identify the variety of crops farmed by subsistence farmers in response to climate change
- To determine crop cultivation methods used by subsistence crop farmers in response to climate change

1.4 Research hypothesis

H1: Climate change events such as droughts and floods have a significant impact on major food crops (yields) of subsistence farmers in Omusati region, Namibia.

H0: Climate change events such as droughts and floods have no significant impact on major food crops (yields) of subsistence farmers in Omusati region, Namibia.

1.5 Significance of the study

The problem of the decline in the crop productivity has motivated the researcher to undertake an in-depth study that evaluates the impact of the climate change situation in Etayi and Elim Constituencies in the Omusati Region. This, with a view to understand the situation and make practical recommendations on possible solutions to policy and decision makers, especially in helping the affected communities to cope with climate change in the future and minimise its negative impact. The study also serves as a baseline for future studies addressing the same subject.

1.6 Limitations of the study

Some respondents failed to understand and complete the questionnaires due to illiteracy. However, the researcher interpreted the questionnaire for the respondents in their native language. The issue of COVID-19, and the associated state of emergency regulations might restrict data collection. However, the researcher applied all the necessary precautionary measures to fight against COVID-19, such as, sanitisers, face masks and keeping 1-2 meters apart when interacting with the participants during the interviews.

1.7 Delimitations of the study

This study was geographically limited to Omusati Regionand not the entire country. This study was restricted to subsistence farmers only. Therefore, the findings in this study might not represent all types of farmers in the Omusati Region. Furthermore, these findings may not represent all subsistence farmers in Namibia.

1.8 Scope of the thesis

This section provides the reader a synoptic view of the thesis. Thus, this study comprises of the following chapters:

- **Chapter one:** This chapter presents a general introduction, problem statement, objectives of the research and hypotheses of the research to be tested. Moreover, the significant of the study, the limitation and delimitation are reflected in this study
- **Chapter two:** Some key terms and concepts to understand climate change is outlined. The chapter also presents the literature review and theoretical framework that shaped this study.
- **Chapter three:** The methodological approaches used are emphasized in this study. It also describes the research design, the study area, population, sampling, research instrument, data collection and data analysis.
- **Chapter four:** This chapter presents the findings of this study and discussions of the findings.
- **Chapter five:** This chapter entails the conclusion of the study and the recommendation made by the researcher.
- **References:** The lists of references used in this study are portrayed in this section.
- **Appendices:** The research instruments, consent forms, ethical clearance, language editing certificate and research permission documents are attached in this section.

1.9 Chapter summary

The chapter highlighted the problem Namibia faces as one of most vulnerable countries to the effects of climate change. This mainly due to the aridity of most parts of the country. Subsistence farming suffers most under climate change, and this has become a great concern for Namibia as, close to two thirds of the population survive through this form of agriculture, particularly, crop production. Therefore, it is crucial to investigate the impact of climate change on the crop productivity of subsistence farmers in the Northern parts of Namibia. Also, to help in acquiring new ecological and farming knowledge, such as adaptation and mitigation strategies to deal with climate change. This chapter also explained the aims, objectives, significance, limitations as well as the delimitations of the research. The next chapter (Chapter 2) looks at the literature review of the study carried out in the Omusati Region.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Vast literature has been produced portraying the effects of climate change. Considering the density of this literature, this review serves as a foundation and provides context to the impact of climate change on crop yields or production for subsistence farming globally, in Africa, and in Namibia. The literature identified climate indicates such as temperature, droughts and floods that affect crop productivity. Furthermore, studies show that subsistence farmers in developing countries are more severely affected by climate variability compared to developed nations. However, some scholars in this review argue that women face harsh consequences of climate change compared to their male counterparts all over the world. This they argued was due gender inequality and lack of resources. Literature also affirms the existence of various mitigation strategies. However, due to economical and/or gender disparities or lack of information, such strategies are not fully adopted by farmers. Thus, the literature in this study outlines the climate patterns and the extent of the impact of climate change on crop production for subsistence farmers within the various communities.

2.2 Conceptual literature: Definition of key terms

2.2.1 Climate change

Pepela, Nabiswa and Mugalavi (2019) define climate change as the change in the traditional mean climatic condition of the global environment, which can be noticed from observed year to year change in the space-time characteristics of weather parameters.

Similarly, some studies (IPCC, 2007; Fraser, 2009) have defined climate change as the significant variation of the mean state of climate-relevant variables such as temperature, precipitation/rainfall, carbon dioxide, solar radiation and the interaction of these elements and wind in a certain period, commonly over 30 years.

Moreover, Tadesses and Dereje (2018) describe climate change as an alteration in the state of the climate that can be recognised through changes in the mean and unpredictability of its properties and is ongoing for an extended period due to global warming. On the other hand, they also defined climate change as any long-term and significant change in the expected patterns of a specific region's average weather for an appropriately significant period.

Climate change is characterised by increasing temperature and related climate phenomena, including an increase in the frequency and intensity of extreme weather events such as hot spells, drought and floods, and an increase in climatic uncertainty (Fraser, 2009; IPCC, 2013).

2.2.2 Climate variability

According to FAO (2012, p. 2), "Climate variability refers to the climatic parameter of a region varying from its long-term mean". FAO (2012) further indicates that this condition portrays the variations in the mean state of the climate on all temporal and spatial scales beyond that of individual weather events. This variation is caused by natural internal processes within the climate system or external forcing.

2.2.3 Mitigation

This is the process of taking action to reduce pollutant emissions (UNESCO, 2019). World Wildlife Fund (2022) define climate change mitigation as the strategies of avoiding and/or reducing emissions of heat-trapping greenhouse gases into the atmosphere so as to prevent the planet from warming to more extreme temperatures. Thus, UNESCO (2019) asserts that mitigation strategies entail the increase of renewable energy use and the implementation of efficient energy practices.

2.2.4 Adaptation

Adaptation is the method of reducing the aversive effects associated with extreme weather events such as floods, droughts etc. Adaptation thus is the deliberate act of responding to the existing or anticipated climatic stimuli and their impacts (IPCC, 2014). Climate change adaptation means entails individual behavioural change and the change of current systems so as to protect families, economies and the environment. The aim therefore is to live from the impacts of climate change by adapting to the changes that we can no longer avoid (World Wildlife Fund, 2022). Hence, an adaptation measure necessitates several actions that aid in reducing the Earth's vulnerability to the consequences of climate change (UNESCO, 2019).

2.2.5 Adaptation intentions

These are the planned or intended adaptation measures. Adaptation intention is expressed as continuation expansion of environmental-friendly or organic production, which is perceived as the basis for taking advantage of new opportunities (Mitter, Larcher, Schönhart, Stöttinger & Schmid, 2019).

2.3 Review of empirical studies: International discourse

2.3.1 Climate change variability

Climate change is one of the most challenging and complex problems facing the world. It has become a great distress around the world and a major global health threat of the 21st century. It is one of the severe barriers to attaining sustainable development goals (Shumetie & Alemayehu, 2017 & Mahmood, 2014; IPCC, 2014). This is corroborated by the fact that Africa is expected to lose 0.13 to 2 per cent of its GDP by 2100 because of the negative effect of climate change on agriculture (IPCC, 2014). Angela and Ngozi (2019) and Abdelzaher et al. (2020) suggest that many developing countries are predominantly vulnerable to climate change, since most of their economies are primarily dependent on weather-sensitive agricultural production systems.

The physical effects of climate change are encountered all over the world. Nzuma, Waithaka, Mulwa, Kyotalimye and Nelson (2010) suggest that the climate change indicators include changes in vegetation, ice cores, dendrochronology, sea-level change and glacial geology. Equally, Komba and Muchapondwa (2012) affirms that the effects of climate change are characterised by changes in rainfall variability, an increasing number of seasons without enough rainfall and increased temperatures which lead to extensive drought and heat stress/ This results in lower crop productivity. According to Eva (2009) climate change and variability are becoming a strong threat to food security in the twenty-first century. Climate change will significantly affect crop productivity and will lead to important changes in agricultural outcomes (IPCC, 2014; Arshad et al., 2018).

Climate change has enormously significant effects on agriculture, especially in crop production. Studies Angela and Ngozi (2019) and Abdelzaher et al. (2020) suggest that many developing countries are predominantly vulnerable to climate change, since most of their economies are primarily dependent on weather-sensitive agricultural production systems. Other studies have revealed that mostly in the vulnerable areas, agricultural land, agricultural production and food security are prone to be flattened by climate change (HDRO, 2007; Ngaira; 2007). Equally, some studies have revealed that agricultural products are regularly affected, particularly for subsistence farmers in Africa, as they depend on rain-fed agriculture, which is severely affected by climate change (Adams et al., 1998; Crosson, 1997; Pant, 2009). Thus, one may deduce that climate change severely affects subsistence farmers.

2.3.2 Global subsistence crop farming and climate change

Subsistence agriculture is one of the least feasible and most abandoned farming types. Subsistence farming remains a myth and insignificant phenomenon in a globalised, market-oriented world (Kostova, 2001). At a global level, concerning the farmland, farms over 100 ha in size occupy more than half of the world farmland, whereas the share of farms up to 2 ha is only about 12% (Food and Agriculture Organisation, 2014). Other studies have revealed that mostly in the vulnerable areas, agricultural land, agricultural production and food security are prone to be flattened by climate change (HDRO, 2007; Ngaira; 2007). Equally, some studies have revealed that agricultural products are regularly affected, particularly for subsistence farmers in Africa, as they depend on rain-fed agriculture, which is severely affected by climate change (Adams et al., 1998; Crosson, 1997; Pant, 2009).

Subsistence farming is common in Sub-Saharan Africa. Families widely opt to cultivate crops and to rear of animals for consumption by family rather than selling proceeds to the market. This denotes that an agricultural yield produced through subsistence farming is not for commercial purposes. Thus, crops are produced is on a small scale as it predominantly meant only for household consumption (Moyo et al, 2012 & Kaya 2016).

Subsistence farmers are among the people most vulnerable to current climate variability. Climate change adds a new threat to rural livelihoods, especially for subsistence or smallholder farmers because it affects economic growth and efforts to reduce poverty. Furthermore, Climate change will significantly affect crop productivity and efficiency and will lead to important changes in agricultural outcomes (IPCC, 2014; Arshad et al., 2018).

The impact of climate change for subsistence farmers are thus characterized by failure of crops, death of livestock and low crop yields. Consequently, they heavily rely on agricultural productivity and decline in this regard severely affects their livelihood (Wilhelm, 2012).

A study conducted in Zimbabwe (Moyo et al, 2012; Tayengwa, Tirivangasi & Rankoana, 2020) that emphasised that subsistence farmers in the developing world find it particularly difficult to cope with such climate-related hazards, as they do not have the capital to invest in new adaptive practices to protect their homes and families. These studies emphasised that subsistence farmers in the developing world find it particularly difficult to cope with climate-related hazards. Participants in their study reported low levels of rainfall which was affecting the crop production. The rainfall shortages brought drought which inevitably cause decline in crop production. This situation has negatively impacted production of

crops which is marked by poor harvest. To that effect, one of the participants indicated that: Furthermore, Tayengwa et al., (2020) stressed that climate change highly affected subsistence farmers on a large scale, affecting many aspects of their everyday lives of the participants.

African women are typically vulnerable to the impact of climate change in relation to men. This is due to the huge responsibility of caring for subsistence agriculture (Viatte, 2009). Out of 1.3 billion people living in conditions of poverty, 17% are women. In urban areas, 40% of the poorest households are headed by women. Moreover, women dominate in the world's food production. However, women own less than 10% of the land (Osman-Elasha, 2022). A study by Nchu, Kimengsi and Kapp (2019) in Cameroon captured the impact of climate change on female headed households. The study established that women mostly occupy land for subsistence farming. They were found to farm with food crops and cash crops which constituted 85% of the rural income. Moreover, they affirmed that the women in the study used majority of their income to sustain their families. Nchu et al (2019) revealed that due to climate change, women in subsistence farming face 70% income loss, decline in crop productivity, food insecurity, crop failure, the loss of plant species, pest and disease attack as well as a reduction in soil fertility.

Similarly, a Ghanaian study (Glazebrook, Noll & Opoku, 2020) found that female farmers are culturally suppressed to overwork themselves with fewer resources. They have access less access to resources that would aid to their economic development in farming. The study also uncovered challenges of gender bias challenges with economic disparities which exasperate poverty in women.

2.3.3 Global adaptation and mitigation strategies

Coping and adaption to climate change such as drought is essential. It is also important to understand the coping and adaptation strategies in order to generate the most appropriate and effective intervention (Pepela et al., 2019). Despite the different measures available to cope with variable climate, not all farmers can or do apply these measures, e.g., there is limited crop and livelihood diversification and many of the existing crops and livestock are susceptible to drought, heat stress and disease (Newsham, 2009). Another key issue in the consideration of changing variety traits is the availability and accessibility of adapted varieties. Literature suggests that both improved and traditional variety will have an important role to play here (SOWPGR, 2010).

Studies show that women face more challenges in adopting mitigation strategies. Research indicates that women have less access to resources that would aid them in tackling the effects of climate change. Due to gender inequality, women have limited access and control over resources which their livelihood depend on (Nchu et al, 2020). In addition, Osman-Elasha, (2022) suggest that adaptation initiatives identify and address gender-specific impacts of climate change such as food security, agriculture, and inequalities in access to resources.

Notwithstanding, the effort in many African continues, climate change remains a challenge to rural development adaptation and continues to be widely unrecognised in development programs and projects (Orindi & Murray, 2005). With the notion that climate change will have long-term impact on agriculture, it is almost obvious that many farmers will remain vulnerable to the widespread effects of climate change (FAO, 2009). Therefore, enhancing farmers' adaptive capacity should be a priority.

Due to expansion of the global impact; coping and adaption to climate change such as drought is essential. It is also important to understand the coping and adaptation strategies in order to generate the most appropriate and effective intervention (Pepela et al., 2019). Thus, there is a need for investigation into how crop yields are affected by climate change, adaptation and mitigation measures and if there is a need to increase investment.

2.4 Climate change indicators

2.4.1 Global warming in Namibia

Namibia is one of the arid countries situated south of the Sahara. The country is known for its high variable climatic conditions as it experiences frequent dry spells and drought with sporadic occurrences of flooding in water basins. These basins are the Cuvelai drainage, Cubango-Okavango, Zambezi, Kunene and Orange-Senqu rivers. Generally, Namibia's climate is hot and dry, resulting in 92% of its land being defined as semi-arid, arid, or hyper-arid. It is, in fact, the driest country in sub-Saharan Africa (Ministry of Agriculture, Water and Rural Development, 2000).

Namibia has experienced significant increases in temperature over the past century. Namibia will become hotter throughout the year with an estimated increase in temperature (Keja-Kaereho & Tjizu, 2018). Daron (2014) posits that over the past 50 years the temperature increases have been greater in winter with the largest increases of up to 0.5°C in the northeast.

2.4.2 Precipitation

Historical changes in precipitation differ across Namibia. According to James (2013) Namibia has experienced a decrease in annual average rainfall over the past years, with the largest decreases in the March to May season. On the other hand, the country has witnessed increases in annual rainfall inconsistency, resulting in more frequent heavy rainfall events and more intense and widespread drought. During the period 1961 to 2009, the country experienced between 8 and 14 droughts, and between 11 and 19 wet periods (Gilau et al., 2011). More studies indicate that, even though some model projections show increasing precipitation for parts of Namibia, most models show reasonable agreement in a signal of decreasing precipitation across of Namibia over the next century (Davis, 2010; James, 2013; Mariotti et al., 2014; Niang et al., 2014).

In addition, average annual rainfall is less than 250 mm per year: 83% of this moisture evaporates, 14% goes to vegetation, 1% recharges groundwater, and 2% becomes runoff (MET, 2010). The northeast is the wettest part of the country, with a mean annual rainfall of 700 mm, most of which falls during the austral summer months, between November and March. Moreover, in the dry west and southwest of the country, the average annual rainfall is just 25 mm (MET, 2011). However, in the austral winter months, Namibia receives little to no rain (Daron, 2014).

2.4.3 Floods and droughts

Republic of Namibia (2015) is exposed to large irregularities in rainfall between seasons and years resulting in the country being prone to water scarcity, drought, and flooding, associated with low rainfall, and floods, resulting from heavy precipitation events,

occurring frequently. African Development Bank (AfDB) (2018) report that around 1.2 and 1.1 million people in Namibia were affected by drought and flooding respectively, between 1996 and 2016. Uniformly, various regions of the country are experiencing frequent drought occurrences and an increase in frequency of unpredictable flood and drought. Flood has increased in recent years affecting around 70,000 people annually in Namibia (UNESCO, 2021). In addition, as global temperature rises by 1.5°C and higher, droughts and flooding will exacerbate Namibia's situation. There were drought conditions in 2018 which led to the death of 300 cattle and relocation of 1700 animals in the Omaheke zone from the arid north (Reliefweb, 2018).

Rural communities are the mostly affected by drought in Namibia. Nakanyete et al. (2020) observed that rural communities who depend on crop and/or livestock farming on communal land are most affected by drought spells. They further maintained that Namibians are highly populated in rural communities where they highly depend on natural sources. When drought occurs, these communities become vulnerable to food insecurity, economic losses and civil strife. Thus, Nakanyete et al. (2020) allude that subsistence farmers are vulnerable to crop failure and loss of livestock.

2.5 Subsistence farming and climate change in Namibia

Subsistence farming is the most common form of farming in Namibia. Subsistence farming is the practice of growing crops and raising livestock only sufficient for one's use, without any surplus for trade (Mubita, 2018). These farmers are mostly smallholders and small-scale operators who rely on the rainy season to be productive. This form of agricultural activity is highly labour-intensive and requires low skilled labour.

The land is accessible in the communal areas of the country (i.e. largely the northern parts of the country), allowing Namibians to grow crops for household use and farm livestock on a small scale. Subsistence farming is especially important for communities living in the Omusati, Ohangwena, Kavango and Oshikoto regions (NSA, 2012; Wilhelm, 2012). Pearl millet, predominantly known as Mahangu, is the main staple crop.

Subsistence farming suffers mostly under climate change and this has become a great concern for Namibia as close to two-thirds of the population survive on this form of agriculture (Nickanor & Kazembe, 2016). Studies by Zeidler et al. (2010); Angula (2010); Kuvare et al. (2008) state that for the past years, subsistence farmers in North-Central Namibia (NCN) have observed the impact of climate change on the quality of soil and productivity of agricultural arable land.

The primary impact of observed climate changes on land productivity has led to a decline in crop yields. The secondary impact of reduced crop yield will result in decreased household food security, increased poverty and increased rural-urban migration for subsistence farming communities in NCN. Also, it is commonly recognised that the impact of climate change are extremely unpredictable, particularly with poor nations (IPCC 2014; Rurinda et al., 2014). As such, North-Central Namibia (NCN) is more vulnerable to the effects of climate change and inconsistencies.

Additionally, the Republic of Namibia (2011) indicated that the reduction in crop production in the NCN is anticipated to grow to 50%. Equally, Reid et al. (2008) appraised that crop productivity is expected to drop by 5-10% at 1.5°C and 2°C, with a decrease of

20% at 3°C. This loss will be even larger for subsistence farmers, with expected decreases of 20-80% between 1.5°C and 3°C.

Besides, a reduction in potential rained agriculture and crop failures in many areas in the Northern parts of the countries is resulting in climate change (Reid et al., 2007; Newsham & Thomas, 2009; Barnes et al., 2012). According to Reid et al. (2008) circumstances of loss in agricultural production expected by experts are substantial, with estimates indicating around 50% loss in production over the next 50 years. A study by Chappel (2018) found that frequent droughts in the Onesi Constituency Namibia over the past 15 years have diminished food production. As a result, farmers have had insufficient supplies of mahangu (pearl millet) that would have last them through the dry season. These dry spells mostly affected farmers who grow their own food. Chappel (2018) further observed that subsistence farmers in Namibia are in a state of poverty in say that they have no means to purchase for their families. This in return, makes then rely on food relief from the government and other. Hence, Chappel (2018) maintains that dry land regions in sub-Saharan Africa are more vulnerable to climate change due to their sensitivity to projected changes and their low adaptive capacity.

2.6 Mitigation strategies in Namibia

In Namibia, climate change generally has a low priority relative to other issues. This means that insufficient resources are allocated to address the complex problem in an effective way (MET, 2011). There is sufficient evidence to prove the reality of climate variability in Namibia. As per findings by Dirkx et al. (2008) vulnerability to climate change can be due to lack of coping mechanisms.

The diversification of livelihood activities into off-farm activities is increasingly employed to reduce dependence on subsistence agriculture and increase resilience to uncertain rainfall regimes (Dirkx et al., 2008; Newsham & Thomas, 2009; Angula, 2010; Turpie et al., 2010; Newsham & Thomas, 2010; Wilhelm, 2012). Likewise, Kuvare et al. (2008; David et al., 2013) suggest that the diversification of crops and animals has been undertaken to increase adaptive capacity in agricultural production. Furthermore, growing of drought-resistant crops such as early maturing Okashana millet with a three-month growing season have been the practice to most of the subsistence farmers (Kandjinga et al., 2010; Zeidler et al., 2010; MET, 2011; Newsham & Thomas, 2011; Wilhelm et al., 2012; David et al., 2013).

Despite this, all those coping mechanisms that have been used in the past have the potential to increase the resilience of communities. However, they are not always adequately employed or sufficient. These coping mechanisms would be considered unproductive as they have been carried out unconventionally and have not necessarily been applied with climate change in mind. Spear et al. (2018) revealed that regardless, of their history of coping with harsh environmental and climatic conditions, many communities today are struggling to deal effectively with increasing climate variability and extremes that include: shifting seasonal rainfall patterns, drought and floods.

Furthermore, there is sufficient evidence to prove the reality of climate variability in Namibia. As per the findings by Dirkx et al. (2008) vulnerability to climate change can be due to lack of coping mechanisms. According to Angula and Kaundjua (2016)'s study, the coping strategies currently being implemented in Ohangwena Region are very weak. They therefore, need to be strengthened in order for the farmers to be able to cope with

challenges associated with climate variability in future. Similarly, Newsham and Thomas (2011) argued that subsistence farmers opined that existing adaptation options are insufficient to cope with more frequent episodes of drought and floods and farmers have no capacity to manage risks by planning and investing in the future.

Additionally, the effects of the 2008, 2009 and 2011 floods illustrated that the subsistence farming system, even in communities where agro-ecological knowledge is strong, remains vulnerable to extreme climate-related events (Amadhila et al., 2013; Newsham & Thomas, 2011). Therefore, unless community-based adaptation strategies are developed to enhance the level of managing risk and future planning, households in NCN are not able to cope and adapt to the projected impact of climate change in rural Namibia.

Moreover, several studies reveal that climate change impacts increase existing susceptibility of rural livelihoods and reduce household adaptive capacity (Heltberg, Siegel & Jorgensen 2009; Kaundjua et al., 2012; Shah et al., 2013). This is due to their different levels of exposure to climate risks as well as their limited adaptive capacity. A combination of climate related impacts and a non-climatic driver also increases contextual exposure of rural subsistence farmers in Namibia as in the rest of Africa.

Namibia has a sub-tropical climate and it remains vulnerable to climate change. As a result, crop production is affected and results in food insecurity and poverty. There is a need to assess measures in place, for responding to the impact of climate variability and change on agriculture (Crop Production). This study will further place some effort in proposing future adaptation strategies for climate change which should allow farmers to effectively address the impact of climate change in future.

In addition, this research identifies the coping strategies currently in place to strengthen them. Similarly, looking at the Omusati region, the impact of climate change on crop productivity is much higher, since a large proportion of the population depends on crop production for their livelihood. In order for the community of the Omusati Regionto become more sustainable, there is a need to strengthen the coping strategies and adaptation which are more effective.

Given the fact that the Omusati Regionhas recently experienced severe floods and drought that are related to climate change, it is thought to be sensible to investigate how its main source of livelihood: crop productivity is impacted and for one to assess how communities can better cope with climate change in terms of crop production.

2.7 Theoretical framework/underpinning

2.7.1 Integrated assessment model

These models predict how agriculture will be affected by climate change. The integrated assessment model of climate change begins with the assessment of GHG emissions and its future concentrations, the identification of the effects of these concentrations on global warming, the determination of climate change patterns and the effect these changes have on climate sensitivity of an ecosystem namely the crops (Mqadi, 2005). This model thus emphasize that the greenhouse gas emissions affect concentration which in turn leads to global warming. In return, global warming leads to climate change (floods and draughts) which then severely impacts crop productivity and yields. This study thus affirms with this model and draws guidance from it.

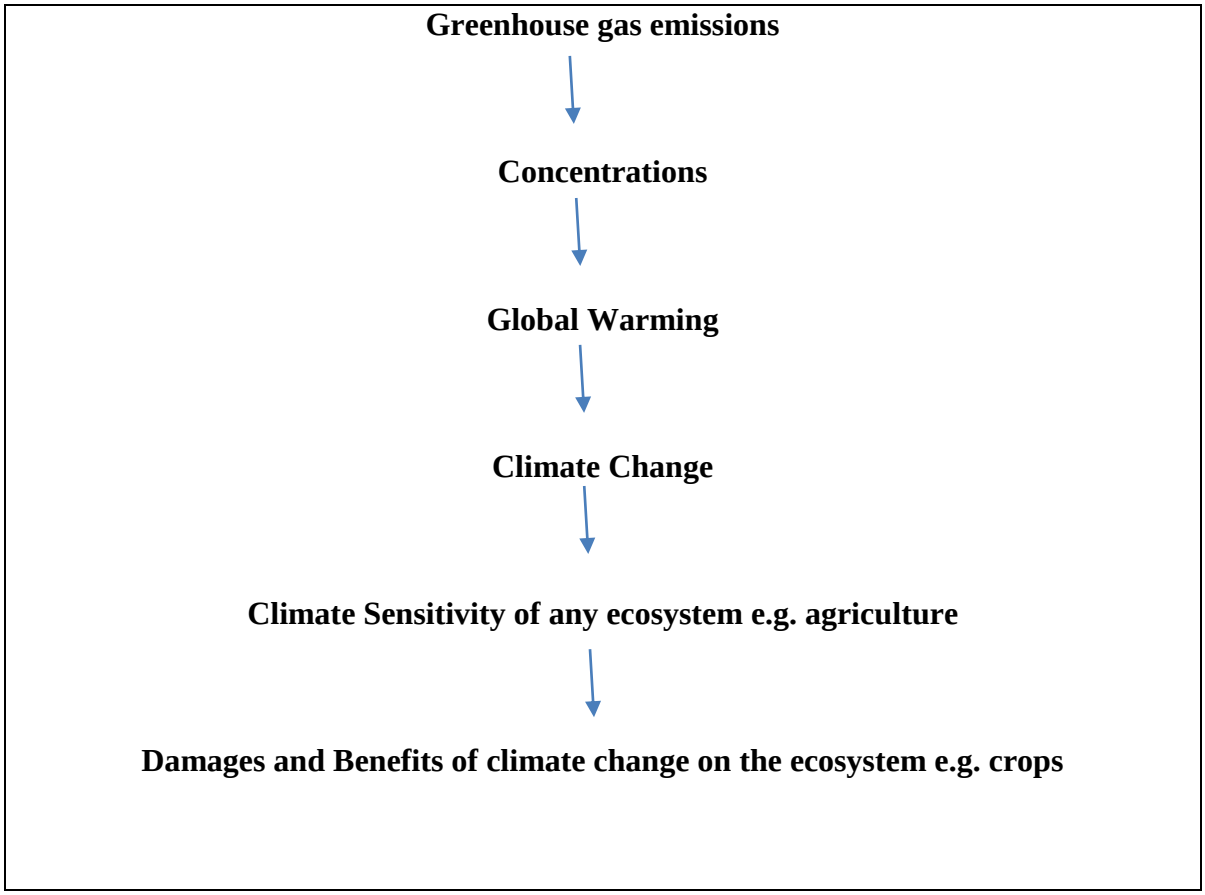

Figure 2.1: Integrated assessment model. *Source: Mqadi (2005)*

2.8 Summary

The reviewed literature has demonstrated that changes in rainfall patterns and temperature are some of the notable signs of climate change. Subsistence farmers are at risk of being impacted by climate change, as they mostly depend on rain-fed agriculture. Africans, mostly poor communities are vulnerable to climate change, given the fact that they lack resources to support themselves. Farmers in Africa are already making use of some coping and adaptation strategies. However, they need further support, particularly when the situation gets out of their control. Specifically, for Namibia, farmers need to have

adaptation strategies for floods, especially after the recent events experienced over the past years, and the fact that more flood events are likely to occur in the future.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The methodology used for this research is described in this chapter under the following sections: research design, research site, target population, sampling technique, sampling size, data collection, and data analysis. A highlight has also been given on the limitations to this study. The research was conducted in two selected constituencies Elim and Etayi, whose selection criterion is highlighted in one of the sections below.

3.2 Research philosophical assumptions

This study follows the positivist paradigm based on the thoughts of French Philosopher August Comte. Comte asserted that observation and reason are the very basis of understanding human behaviour. Knowledge is acquired through observation and experiment. Ontologically, positivists view reality as being objective which is measurable using properties which are independent of the researcher and his or her instruments. Thus, knowledge is objective and quantifiable. Positivistic thinkers adopt scientific methods and systematise the knowledge generation process with the help of quantification to enhance precision in the description of parameters and the relationship among them. Thus, this study adopted quantitative methods of collecting data to test a hypothesis. Thus, this research subscribes to the ideas held by realists that belief that society exists objectively and independently of human belief and subjectivity. This knowledge is obtained through (Pearce, 2019).

3.3 Research design

Designing a study helps the researcher to plan and implement the study in a way that helps the researcher to obtain the intended results, thus increasing the chances of obtaining information that could be associated with the real situation (Bryman & Bell, 2003). Therefore, the study used a case study design. Simons (2009) explained that a case study is an in-depth exploration from multiple viewpoints of the complexity and uniqueness of a specific project, policy, institution program or system in real life. Moreover, a case study has the potential to accomplish high identification and capacity of indicators that best present the theoretical concept that the researcher wants to measure (Flyvbjerg, 2011). Also, Flyvbjerg (2006) outlines some of the advantages of case studies such as the contribution to knowledge growth and providing actual, circumstantial experience that enhances the researcher's skill.

Furthermore, the study adopted a quantitative approach, whereby a descriptive design was selected to describe the status of the phenomenon. The study used the quantitative approach to collect data. The study is a case study, intended to gain in-depth insight on how farmers in Etayi and Elim constituencies have been impacted and are coping with climate change. In order to understand the impact of climate change and strategies mitigating its impact on these two constituencies.

The quantitative approach was selected because it has advantages such that quantitative findings are likely to be generalised to a whole population or a sub-population because it involves a larger sample which is randomly selected. Also, data analysis is less time-consuming as it uses statistical tools such as Microsoft Excel, Statistical Package for Social Sciences (SPSS) (Shidur, 2016; Rahman, 2017).

Additionally, a descriptive survey design was employed in this research. This helped the researcher to obtain information from a sample population representing the larger population (Hamed, 2016). The research used primary data which did not exist before, such as: Do you expect the weather to change in future or years to come? Have you noticed change in crop yield or crop quality since you started? Are you willing to change your crop choice or seed variety so as to cope with climate change? Has the land changed and the level of yields that you receive from your farm changed in any way in the time that you have been farming here?

3.4 Research site

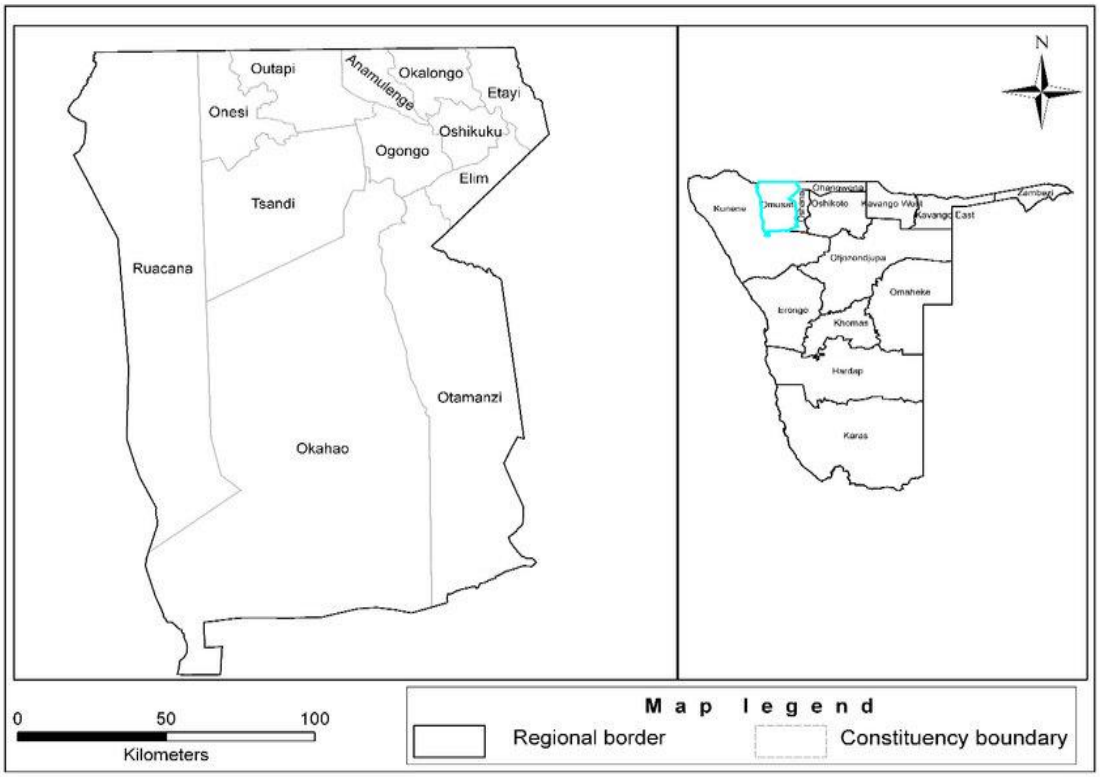

Figure 3.1: A map of Omusati Regionand its constituencies. *Source: National Remote Sensing Centre (2016)*

Omusati Regionis one of Namibia's geographical regions that is located Northern-Central Namibia. It is bordered with Cunene province of Angola It also borders the following regions: Ohangwena-North-east, Oshana- East and Kunene- South and West. It is divided into 12 constituencies namely: Anamulenge, Elim, Etayi, Ogongo, Okahao, Okalongo, Onesi, Oshikuku, Otamanzi, Outapi, Ruacana and Tsandi.

Ideally, the research covered all the constituencies in the Omusati region. However, the available resources and time constraints were not allowing such wide coverage. It's therefore for these reasons that two constituencies were selected as the focal area for this research. They served as a pilot site for the study, after which outcomes of the study were

replicated in other constituencies within the region and northern central part. The lessons obtained from focal research areas were documented. The two pilot sites for the study were namely: Etayi and Elim constituencies.

3.5 Population

Quantitative data was collected using questionnaires and directed to household heads in selected villages in the two constituencies namely: Etayi and Elim. According to the Namibia Statistics Agency (2014) there are approximately 5000-6000 households and 96 villages in the Etayi Constituency and 2000-3000 households and 51 villages in the Elim constituency.

A household head is defined as a person of either sex who is looked upon by other members of the households as their leader or main decision-maker during fieldwork (Namibia Statistic Agency, 2011). The questions in the household case study questionnaires were mainly, structured questions focusing on the identification of household livelihood and the occurrence and intensity of natural disasters as well as the impact on their livelihood. In addition, the household survey questionnaires included questions on the impact and mitigation strategies for coping with climate change in crop production.

3.6 Sampling

The sample was drawn from Etayi and Elim constituencies in the Omusati Region. Sample sizes of 100 farmers were selected from the two constituencies, of which 30 farmers were selected from Etayi and 70 farmers from Elim. This is one of the geographically defined areas of particularly high climate change risk and vulnerability.

Table 3.1: Sample size distribution

Characteristics of population	Population	Questionnaires distributed	Questionnaires returned	Percentage (%)
Elim Farmers	70	70	63	90
Etayi Farmers	30	30	27	90
Total	100	100	90	90

The sample was drawn based on purposive sampling and questionnaires with structured questions. The Purposive sampling includes the areas that give reliable information because of their experience with climate change effects on their crop farming activities, particularly floods and drought. According to Denscombe (2010) purposive sampling operates on the principle that we can get the information through focusing on a relatively small number of instances deliberately selected on the basis of their known attributes. He further adds that purposive sampling works where the researcher already know something about the specific people because they are seen to give the most valuable data.

3.7 Research instruments

Quantitative data was collected using a survey with structured questions (Appendix 1). The survey was divided into three sections: Section A covers demographic information, Section B covers the weather conditions, farmers' perceptions and impact of climate change, Section C covers the effects of climate change on crop yield and livelihood and Section D covers adaptation and mitigation strategies. Questionnaires were selected due

to the following reasons: they are one of the effective means of gathering data on a large-scale basis, structured questionnaires can be explored in a straightforward way and when similar questions are administered simultaneously to many people, the acquired data is more identical, correct, and standard (Gillham, 2000).

A five-point Likert scale was used for this study to measure the impact of climate change on crop productivity of subsistence farmers in the Omusati Regionof Namibia. The scale comprised of these options: strongly agree, agree, not sure, disagree, and strongly disagree. Strongly agree equated a score of 1, Agree=2, Not sure=3, Disagree=4 and strongly agree = 5.This five-point scale allowed the respondent freedom to air their opinions. The respondents' feedback was tabulated according to five scales options in the questionnaire.

3.7.1 Reliability and validity of research instrument

According to Mohajan (2017), reliability measure expresses the extent to which a research instrument yields consistent results. It shows whether an instrument can measure a variable accurately and yield consistent results over a longer span. Thus, testing reliability in research assures the accuracy of the data collected.

Table 3.2 Reliability analysis

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of items
0. 855	0.877	44

The Table 3.2 illustrates the results obtained from the Cronbach's Alpha test. The test indicates an alpha coefficient of 0.855 which shows a high level of internal consistency with the items used in this scale. This then signifies the applicability of the questionnaire used in this study.

3.8 Data collection procedures

Data was collected using structured questionnaires. COVID-19 regulations were adhered to. A translator assists in asking farmers, in the local language of Oshiwambo, about their demographic information and agricultural practices, any adaptive strategies and mitigation in place, their perception regarding climate change and its effects on their livelihood and crop production yield. What barriers are preventing farmers from using other different farming practices as climate mitigation and adaptation strategies? The surveys were coded for different themes, taking into consideration relevant quotes.

3.9 Data analysis

Information from questionnaires was analysed using SPSS. The responses to each question were recorded, coded, and analysed in SPSS. Descriptive statistics were used to

analyse the data and included percentages and means. According to Kaur et al. (2018), descriptive statistics are used to summarise data in an organised manner by describing the relationship between variables in a sample or population. Descriptive statistics include types of variables (nominal, ordinal, interval and ratio) as well as measures of frequency, central tendency, dispersion/variation and position.

3.10 Ethical considerations

Resnik (2015) posit that research ethics refers to the right or professional way of doing research. Furthermore, research ethics speaks to the morals and rules of doing right and wrong. Ethics provide a code of professional conduct and speak to acceptable behaviours to promote research aims and minimise errors. Equally, research ethics governs the standards of conduct for scientific researchers.

Before data collection, human rights, the law, safety, and wellbeing of the participants must be respected by researchers always. Therefore, the researcher obtained an ethical clearance from the University of Namibia (Namibia Business School). During data collection, participants were informed about their right to withdraw from the study at any point they wish or withdraw from answering questions that they did not want to answer. After data collection, confidentiality was assured and respondents remained anonymous. Data is being kept in a safe place and will be destroyed five years after the completion of the study.

3.11 Chapter summary

In this chapter, the researcher outlined the methods which were used to collect the data in order to address the research objectives. The research design which was chosen was case study using the quantitative approach. The research instrument administered was a questionnaire with structured questions. The chapter also presented the sampling methods and its justification, as well as the target population. The methods that were used to analyse the data were elaborated. The researcher also explained the ethical considerations. The next chapter presents the results and discussions of the study, taking into consideration results from previous studies as covered in the literature review.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter focuses on the analysis and interpretation of the responses acquired through the questionnaire. Data analysis and interpretation of data are closely related. According to Moore and Llompart (2017) in data analysis, the collected data is broken down into groups or elements which the researchers examine separately. On the other hand, in interpretation, the immediate results are translated into integrated and meaningful general references and findings (Antoniadou, 2017). The findings must be relevant to the objective of the research. However, if both data analysis and interpretation are not carried out properly, the success of the study cannot be assured (Punch, 2001). Descriptive statistics such as pie charts and bar charts were used to aid the analysis of the data, since; they are effective illustrations of relations and trends.

Furthermore, the chapter presents the findings of the study with respect to the impact of climate change on crop production of subsistence farmers in the Omusati region. This chapter highlights the demographic information of the respondents, the farmers' perceptions and impacts of climate change, the effect of climate change on crop production (yield) and livelihood, crop variety and plant techniques used by subsistence farmers in response to climate change. Finally, the research looks at the mitigation and adaption strategies used by the farmers in response to climate change. It also covers a discussion of the results under literature control to come up with the findings of the study.

4.2 Response rate

The aim of this study was to sample 100 respondents. However, out of the 100 respondents selected, only 90 respondents responded to the survey. As a result, 10 respondents (10%) failed to respond. Nonetheless, this amounted to a high response rate of 90%. The results are illustrated in table 4.1 below:

Table 4.1 Response rate

Target Response	Actual Response	Response Rate (%)
100	90	90%

4.3 Demographic information

4.3.1 Farmer respondents by gender

Approximately 61% (n= 55) of the farmers are female while, 39% (n=35) of the farmers are male as it is indicated in Fig 4.1. The findings from this study are consistent with other studies, revealing that the majority of households in these two constituencies are female headed. The study suggests that the decline in participation in subsistence agriculture among male headed families is due to their travelling out of the community to search for off-farm employment in urban areas (Onakuse, 2012).

The respondents indicated that female-headed households have less access to resources, information and other socio-economic opportunities and bear more of the burden of the household than males. This makes them more prone to climate change effects and poor implementation of climate adaption and mitigation strategies. On the other hand, male

headed households often have a higher probability of adopting new agricultural technology (Asrat & Simane (2017b, Guetta & Abegaz, 2015), Deresa et al., 2011, Buyinza & Wambede, 2008).

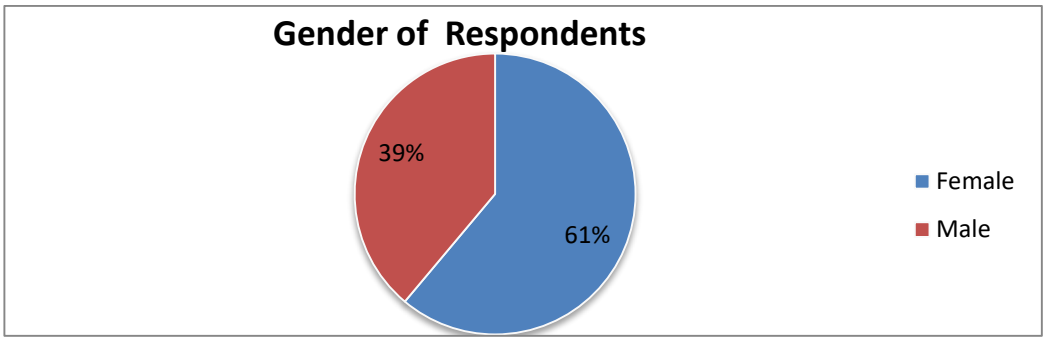

Figure 4.1: Gender distribution for the sample population

According to the data analysis of this study, as is indicated in table 4.2, the majority of the farmer respondents were aged between 65 - 64 and 85 and above with 33% (n=30) and 29% (n=26) farmers respectively, whereas, 15% (n=14) of the farmers are aged between 55 - 64 followed by 12% (n= 11) of the farmers between the ages of 34 to 44 and lastly 10% (n=9) of the farmers of the age range 25-34. The study indicated that most of the farmers are in the age range of 65-64 and above 85, and this age group has a high economic effect, especially for the crop production sub-sector which demands more labour in a short period and adaptation of new strategies. According to Talebi and Tajeddin (2011) age is one of the most significant demographic factors, which has a great influence on behavioural change, not only among humans, but also, in all living creatures on earth.

Table 4.2 Respondents age groups

Age	Frequency	Percentage
16-24	0	0
25-34	3	3.3
34-44	6	6.6
45-54	11	12.1
55-64	14	15.4
65-74	26	28.6
85 and above	30	33.0
Total	90	98.9

4.3.2 Educational level of farmer respondents

According to the outcome of this study Figure 4.2 illustrates that the largest proportion of 38% n = 39 farmer respondents have no formal education, followed by 19% n= 20 farmers have completed their secondary school. 15% n= 16 farmers have primary education, lastly, 13% n=14 and 8% n=9 farmers have obtained their certificate/diploma/vocational and degree/masters, respectively. These results are worrisome and are risky in that the community may fail to interpret instructions on inputs for farming, and may create difficulties in expanding new technologies as uneducated people are reluctant to adopt new technologies.

Lee et al. (2015) reported the level of education to be the single strongest predictor of climate change awareness, based on survey data from 119 countries. Furthermore, Paulus

(2015) stated that the level of education and awareness has been closely associated with the reduction in the impact of climate change particularly on crop production and adaptation of sustainable land management practices. Correspondingly, Asrat and Simane (2017) emphasised that climate change perception and adaptation decisions suggesting that educated farmers tend to better recognise the risk associated with climate change due to more access to information and various adaptation possibilities. Equally, Ahmed (2016) and Ali and Ehrenstein's (2017) results suggested that educated farmers are more likely to be aware of climate change and agricultural innovations and technologies to address it.

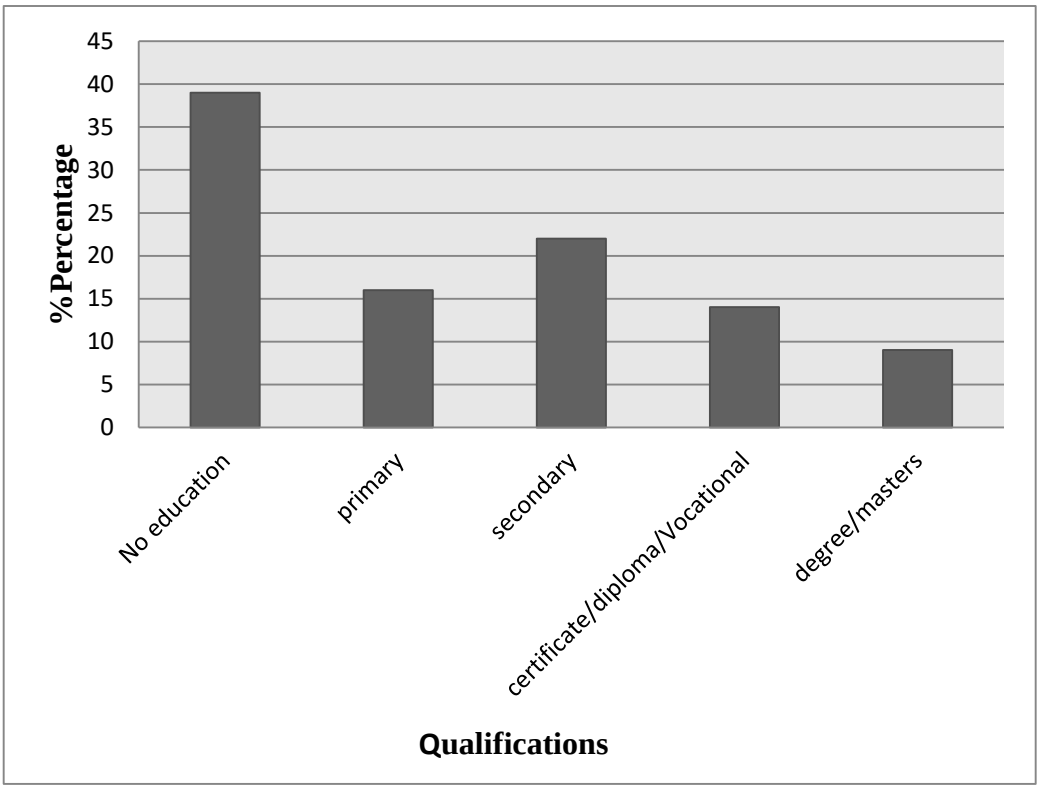

Figure 4.2: Education level respondents.

In addition, Kassie et al. (2012) noted that educated farmers tend to be aware of the benefits of land management practices. The case study in Kwara State Nigeria established

that the educational level of the farmers has positively influenced the use of fertiliser (Muhammad-Lawal et al., 2014). Gbetibouo (2009) together with Muller and Shackleton (2014) posit that farmers with low levels of education are more likely to be less aware and have limited understanding of climate change. Therefore, the educational levels among farmers in the Omusati Regionare low, thus, it will affect the adoption of new technology.

4.3.3 Farmer respondents by occupation

The respondents were asked to indicate their occupation as it shows in figure 4.3. The graph shows that the majority of the farmers: 50% n= 58 respondents depend on social grants/pension as their source of livelihood followed by employed 16% n=18 farmers, then 6% n= 7 farmers are self-employed without employees and lastly, 3% n=4 farmers are self-employed without employees. As discussed earlier on educational level and age of respondents, the study area is mainly occupied by subsistence farmers. It is thus, not surprising that only 16% of the respondents were employed.

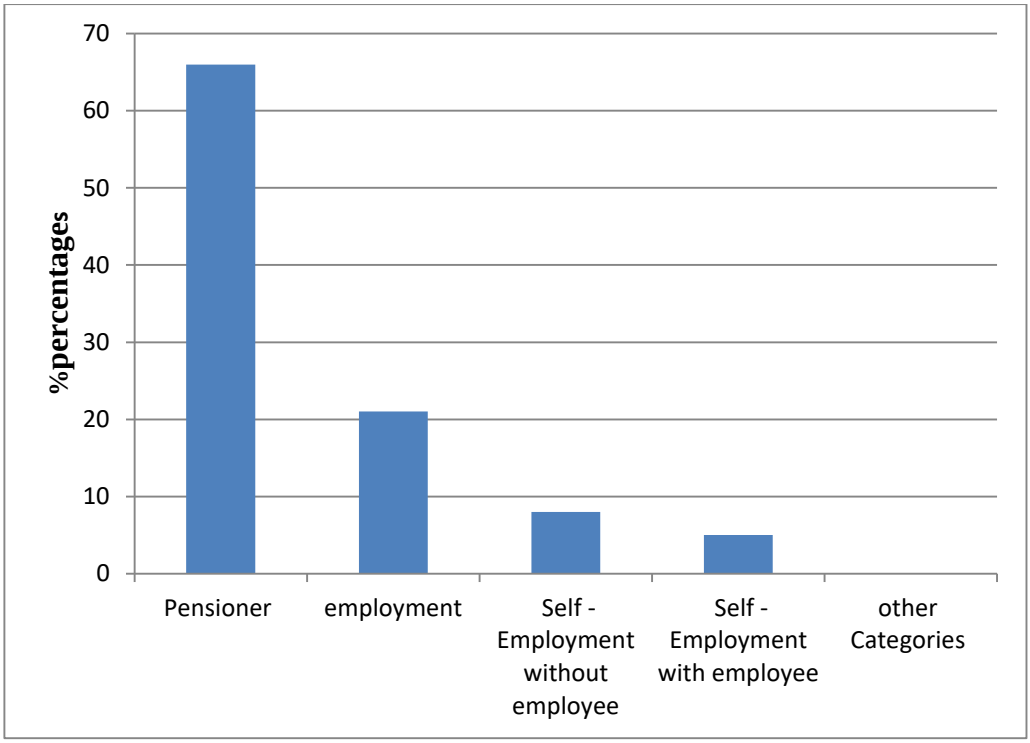

Figure 4.3: Occupation of respondents.

4.4 Empirical findings of the study

This section aims at responding to the research objectives of the study. As a result, this section outlines the descriptive findings so as to address the objectives. The answers derived from the respondents are summarised. This was ideal as it yielded frequencies of respondents.

4.4.1 Farmer respondents on knowledge of climate change

This subsection captured the perception of respondents on climate. The aim was to attain if farmers are aware of climate change. Their perceptions are captured below in Table 4.3.

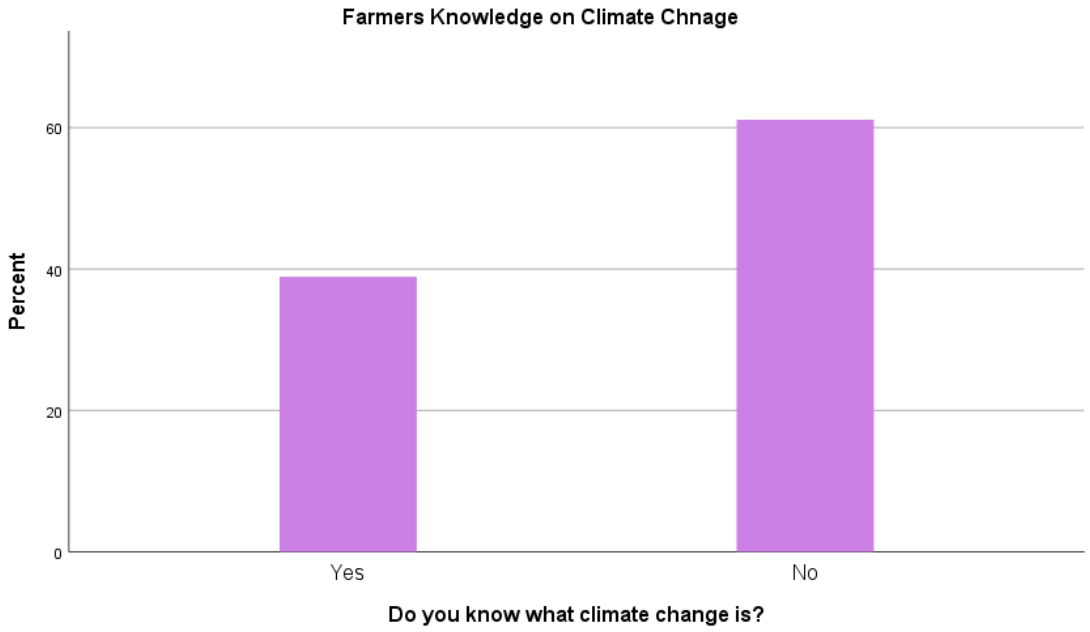

Figure 4.4 Farmers' knowledge of climate change

The results of this study, Figure 4.4 shows that farmers are well aware of climate change 39% n=35 farmer respondents perceived a change in the climate. Whereas, 61% n=62 farmers responded that they don't have any ideas on what is climate change. Several studies in Namibia, Africa and around the world have already yielded similar results (Angula & Kaundjua, 2016); Wilhelm et al., (2012); Mustapha et al., (2012), Muzamhindo (2015), Tazeze & Ketema (2012). Despite, findings indicating farmers were aware of climate change and variability, they do not have a depth of understanding of climate change. Ashworth et al. (2011) emphasised that low understanding can be caused by farmers treating the climate change problem as a distant problem. On the other hand, Rakgase and Norris (2015) highlighted that farmers' awareness of climate change increases farmers resilience and helps them to embrace effective mitigation and adaptation

measures. Moreover, this can be done through various media and by their observation could help them to plan easily for future mitigation and strategies.

4.4.2 Farmer perceptions on the change of weather conditions

Table 4.3 Farmers' views on weather conditions

Perception on climate change	**Yes**		**No**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Did you experience the weather change over the last 5 to 10 years?	47	52	43	47
Do you expect the weather to change in future or years to come?	72	79	18	20
Do you believe climate change has an impact on crop production in general?	63	69	27	30
Does the weather become more unpredictable from years to years?	41	45	49	54
Do you believe that perceived change of weather condition is caused by climate change?	27	30	63	69
Do you think rainfall has changed since, you started farming?	64	70	26	29

Do you think an average temperature has changes since you started farming?	38	42	52	57
Do you believe that climate change will cause decrease rainfall in the future?	56	62	34	37

According to the findings of the study depicted on the Table 4.3, farmers have observed a frequent change in the overall climate pattern and weather conditions. As indicated in table 4.3, about 87% n= 82 farmers stated that weather such as rainfall patterns had changed (delays, early ending, bad disturbance, and the rainy season started later and stopped earlier, increasing of temperature and sometimes, violent winds and extreme events such as floods and drought). Besides, the farmers indicate that they are aware of change in climatic conditions in the form of increase in temperature and erratic rainfall patterns which lead to less rainfall expectations. Furthermore, most farmers believe that change of weather conditions is caused by climate change and climate change has an impact on crop production. The observations agree with the results reported by Limantol et al. (2016) in Ghana.

Similarly, farmers observed an increase in the length of the long dry seasons, floods, as well as increases in temperature. These results are corresponding to the changes in climate indicators which were established by Van Wilgen et al. (2015) on the changes in rainfall patterns and rising temperatures in 19 national parks in neighbouring South Africa. Madzwamuse (2010) discovered that increases in temperature and rainfall had a negative effect on crop production. A comparable, study in Laikipia, Kenya by Ogalleh et al. (2012)

showed that the perception of decreased rainfall and increased temperature led smallholder farmers to respond by planting early maturing crops and mulching to reduce water loss. Nevertheless, farmers do not always respond to perceived changes.

Generally, Kaundjua et al. (2012) believes that changes in temperature and precipitation have a direct effect on crop production yield and indirectly through change in soil quality, pests and diseases as a result of climate change. Also, the overall sanitation and human health conditions are predicted to be wedged by flash floods. Equally, Angula (2010) establishes there is a general perception that current climate trends differ significantly from the past with climate hazards such as floods and drought becoming frequent. Also, the rainfall seasons have shifted, become shorter and irregular thus affecting the potential growth period for Mahangu, sorghum, beans, nuts and cowpeas. Muller et al. (2011) affirm that changing rainfall patterns have a negative impact on crop production.

4.4.3 Intensity of drought and floods

The study findings indicate that about 69% n=85 farmer respondents experienced severe heavy rains and drought for the past 10 years and identified these as major constraints to their seasonal crop productivity as indicated in figure 4.7. In addition, almost all farmer respondents also noted the extensive impact of floods on crop production. Nonetheless, 26% n = 16 farmers revealed that the intensity of heavy rains and drought experienced for the past 10 years is mild and lastly, only 5% n = 2 farmers observed no changes. Moreover, Mishra and Singh (2010) underlined that drought and floods threaten economic sectors such as agriculture. Furthermore, Li et al. (2009) revealed that Africa is most vulnerable

to low yields caused by drought and floods compared to other regions. Farmers also reported that floods had a significant impact on the long- term productivity of their land.

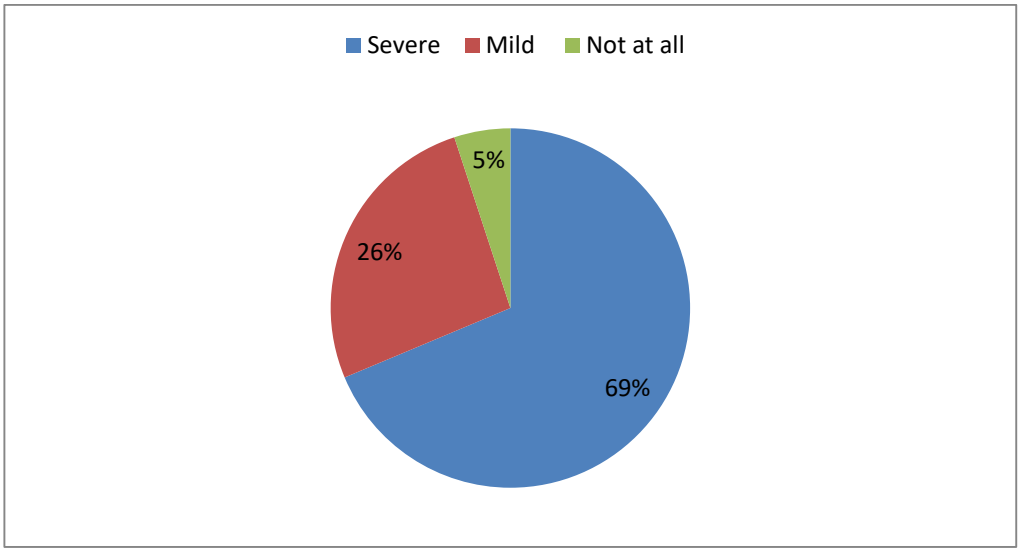

Figure 4.5: Intensity of drought and floods

4.4.4 Effect of climate change on crop production and livelihood

Table 4.4: Farmers views on crop yield

Perceptions on effect of climate change on crop production	**Mean**	**Standard deviation**
Did you lose more crops during the last 5-10 years, due to floods or drought?	1.93	1.305
Have you noticed change in crop yield or crop quality over 10 years?	2.27	1.279

Do you think that the crop yields on your farm will change in the future?	2.04	1.090
Has the land changed and the number of yields that you receive from your farm changed in any way in the time that you have been farming here?	2.17	1.183

4.4.5 Farmer respondents on crop yields

Majority of the farmers in this study strongly agreed that climate change has led to a decrease in crop yields. Thus, these farmers reported farmers losing their crops. As a result, this study revealed that changing climatic conditions have negatively affected farmers regarding crop production. This was represented by a mean of 1.93 as indicated in table 4.4. Most of the participants (2.27) also noticed a change in crop and quality respectively. Farmers observed that there have not been many years of good rains for the past 10 years. For this reason, many farmers yield poor harvests and the quality of crops is poor when very little rainfall is received. Furthermore, farmers point out that the rainfall that has lately been experienced is no longer as good as it used to be over the past years. Muller, et al. (2011) confirmed that the effect of climate change on the rainfall patterns has a negative impact on crop production.

In addition, Farmers agreed (mean 2.17) that the quality of their land and the yields that they receive have decreased. Three farmers did not notice any change in their land as shown in table 4.4. Previous studies observed in some Africa countries including Ghana, Kenya, Mozambique, Zambia and Zimbabwe showed that floods can affect crop production by causing changes in soil fertility, reducing crop yields or land productivity

and by damaging and destroying crops (Agricultural Development and Advisory Service (ADAS), 2007; Armah et al., 2010; McGuigan et al., 2002; Mirza, 2003; Nunes et al., 2010; Tol, 2002). Also, Arshad et al. (2018) indicate that lower soil fertility, scorching sun on the crops; pests, drought and elusive rainfall are some of factors that cause decline in crop quality. Li et al. (2009) emphasise that Africa is most susceptible to low yields caused by drought when compared with other regions.

4.4.6 The respondents on the source of their food supply in future

The findings in this study as displayed in figure 4.6 show that 62% n= 66 farmers are strongly worried about their future food supply, whereas 12% n= 13 farmers agree and 8% n=9 farmer respondents are not sure or neutral. However, 5% n=6 farmers disagree on their future food supply and 2% n=3 farmers strongly responded as not worried. Despite, the livelihood the yields are going to decline in the future because of the expected effect of climate change. The results imply that current crop production systems are sensitive to the effects of climate change and farmers are worried for their future food supply. Furthermore, Pachauri et al. (2014) stated that smallholder farmers who are heavily dependent on rain-fed agriculture are greatly affected by climate change. Moreover, climate change is the most serious environmental threat to the subsistence farmers' fight against hunger, malnutrition, diseases and poverty in Africa, essentially because, of its impact on crop production (Makate et al., 2016).

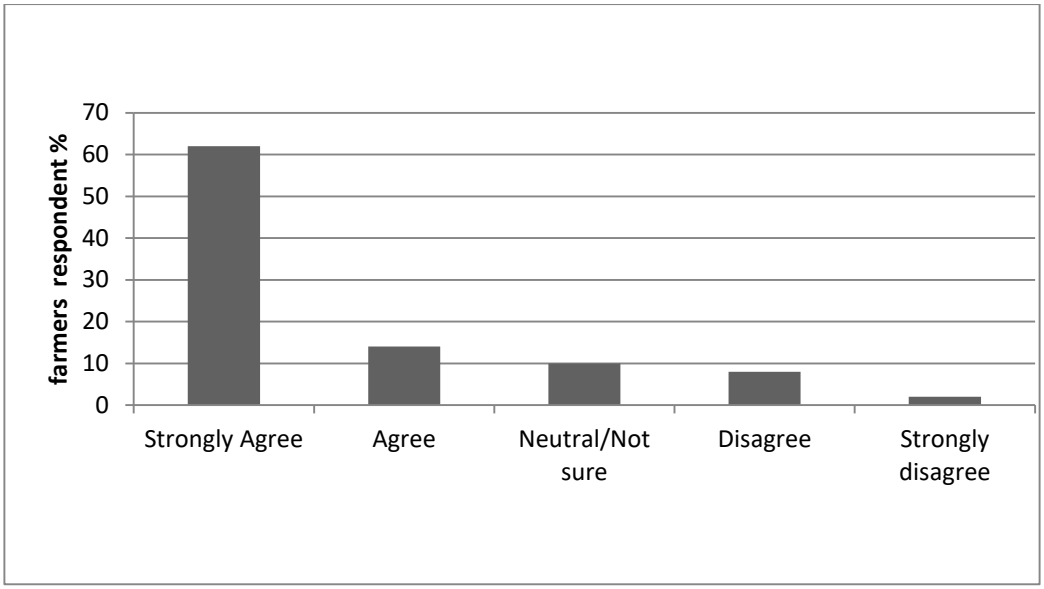

Figure 4.6: Farmers worry about source of food supply in future

4.4.7 The impact of climate change on individual crops

Lastly, according to the data analysis, the study outlines that all crops, mainly: Maize (2.86), Sorghum (2.32), Pearl Millet (1.59), Ground and Bambara nuts (2.61) yields were severely affected by climate change. These mean scores in this regard are illustrated in the table (4.5) below. The study thus shows that Pearl Millet (Mahangu) was most affected crop yield compared to the rest of the crops produced.

Nevertheless, other crops such as cowpeas and pumpkins were least affected with a mean difference of 2.93. Correspondingly, studies have shown that an increase in temperature and drought during growing seasons reduced maize, sorghum and pearl millet yields (Rowhani et al., 2011). Similarly, the climate suitability of most major crops is also projected to shift as climate warms (Rippke et al., 2016; Zabel et al., 2014).

Table 4.5: Impact of climate change on individual crops

Specific crop yields	Mean	Standard deviation
Maize	2.86	1.195
Sorghum	2.32	1.460
Pearl millets	1.59	0.886
Ground and Bambara nuts	2.61	1.371
Another crop	2.93	1.331

4.4.8 Adaptation strategies in subsistence farming

Table 4.6 Responses on crop production mitigation

Responses on crop production mitigation	Mean	Standard deviation
Do you plan on continuing to farm the way that you are currently farming?	3.07	1.397
Would you be willing to grow new crops?	1.99	1.096

Have you changed the crops that you grow or planting techniques in response to the change in yields?	2.49	1.318
Use of drought resistant varieties (such as Kangara and Okashana #2 instead of Ongonga	1.77	1.071
Change of farming practices or crops?	1.77	1.061

This study demonstrated that majority of the respondents were willing to grow new crops. This was stipulated by a mean of 1.99. Average proportions (3.07) of farmers in this study were not sure of whether they would continue to farm where they currently are farming. In addition, a significant proportion of respondents strongly agreed to use drought resistant varieties and of changing their farming practices. This study thus concludes that improving the available crop varieties is a key mid-term strategy to increase productivity, improve production stability and adapt to projected climate changes, for example use of maize seed which is heat-tolerant and Pearl Millet such as Kangira and Okashana #1 and 3 which are drought resistant.

Tesfaye (2016) concurs that the planting of drought-tolerant crop varieties is an important adaptive strategy practiced by farmers in developing countries in response to climate change. In the same way, the director of research at the Ministry of Agriculture stated that crop varieties are contributing to the national goal of producing high yielding crops with better tolerance to physical conditions such as drought and biological stress as well as improved nutritional value (International Atomic Energy Agency (IAEA), 2019).

Furthermore, Swe et al. (2015) establish that farmers in Myanmar use drought resistant plant varieties as a strategy to cope with water scarcity. Hence, Rippke et al. (2016) also agrees that drought- tolerant varieties could be a great opportunity as an adaptation strategy to reduce the impact of inconsistent rainfall. IAEA (2019) indicate that farmers in Namibia have new verities that are more tolerant to drought and these enhance the quality and high yield.

4.4.9 Agricultural diversification

The findings of the study in table 4.7 show that majority of the farmers strongly asserted the importance of choosing varieties of crops or seed that cope with climate change. McGuire and Sperling (2013) affirmed that shifting of crop or seed variety portfolios in response to climate change allow farmers to have multiple sources. For instance, adoption of climate- resilient crops such as early- maturing cereal crop varieties, heat- tolerant varieties, drought- tolerant legumes or varieties with enhanced salinity tolerance, can help farmers to better cope with climate shocks. Furthermore, Lipper et al. (2014) accentuated that farmers' resistance to climate change is influenced by climate- resilient crops. Also, despite the benefits of drought resistant varieties, adoption rates by small- scale producers is not sufficient due to lack of information and access to finance (Lin, 2011).

Table 4.7: Farmers' perceptions on crop variety and diversification

Farmers' perceptions on crop variety and diversification	Mean	Standard deviation
It's important to change crop choice or seed choice or varieties that can cope with climate?	2.08	1.516
Do you use improved crop variety?	1.89	1.203
Agriculture diversification is important in reducing the impact of climate change on crop production?	2.50	1.318
It's necessary to dig trenches in and around crop fields to inundation?	2.69	1.496

The findings further established that a high proportion of farmers strongly agreed on using improved crop varieties. Similarly, Patt et al. (2005) argue with the findings that subsistence farmers plant drought-resistant crops to adapt to moisture stress. Moreover, in this study, most respondents (2.50) agreed that crop diversification is important in the reduction of the impact of climate change on crop yield as is shown in the table above. Tibesigwa et al. (2015); Afolami et al. (2015); Bola et al. (2012) and Asfaw (2010) also discovered the same results that climate change adaptation measures like crop diversification improve households' well-being through high yields of crop production.

Similar, results were reported by Kuntashula et al. (2014); Di Falco et al. (2011); Bhattacharyya (2008) and Bradshaw et al. (2004) that using crop diversification as an adaptation strategy, helps reduce the effects of climate change and improve crop yields.

Furthermore, the other studies stated that crop diversification liberates subsistence farmers from negative effects of climate change. Howden et al. (2007) upheld that the general adaptation techniques suggested by much literature include crop diversification, enhancing the ability of different crops to thrive under different weather conditions.

Additionally, Makate et al. (2016) encouraged that crop diversification is theoretical as one of the most ecologically realistic, cost effective and rational ways of reducing uncertainties in agriculture, especially among smallholder farmers. Several studies have shown that crop diversification; especially in food crops has positive effects on crop yields (Mofya-mukuka & Kuhlgatz, 2014; Chen & Salas, 2018).

4.5 Mitigation strategies used by the farmers in response to climate change

4.5.1 Factors inhibiting farmers from using modern farming practices

The results of this study, in fig 4.7 reveal 42%, n= 47 farmers stated that financial limitations are one of the major factors obstructing the use of modern farming practices. The majority of the farmers indicated that they depend on pension funds for their living which limits their possibilities to hire labour to assist in the field. Equally, whereas, the findings of the study revealed that 17% n= 15 farmers' lack of information had prevented farmers from using different farming practices. Furthermore, 11% n=9 farmers indicated that they have no knowledge of alternative farming practices, apart from traditional farming methods. Lastly, time and labour play a role in inhibiting farmers from using farming practices. The results are in line with those of Moser and Ekstrom (2010), Birkmann and Von Teichman (2010), Jones and Boyd (2011); and Masud et al. (2017).

According to Ogalleh et al. (2012); Mengistie et al. (2015) posits that perception is the continuity mainly determining beliefs and plays a significant role in farmers' decision-making toward the implementation of some coping strategies. Moreover, Gbetibouo (2009) articulated that barriers that inhibit farmers from using farming practice and adaptation measures include: poverty, lack of money and information. Biber-Freudenberger et al. (2016) agreed that the farmers of African countries are susceptible to climate change due to financial implications, lack of information and alternative farming practices. Previous, studies demonstrate that farmers with access to credit, higher levels of wealth and better agricultural knowledge and skills are more likely to invest in adaptation measures (Deressa et al., 2011); Gbetibouo, 2009). Moreover, Nicholas et al. (2010) approved that lack of money hampers farmers from getting the necessary resources and technologies which facilitates adaptation to climate change. Similarly, Adimasu and Kessler (2012) established that well-off farmers in Ethiopia invest more in land management, particularly because, they have financial means to adapt to new farming strategies.

Correspondingly, Dirkx et al. (2008) and Stern et al. (2009) claimed that investing in alternative approaches such as installing rainwater tanks or buying farm implements or seed remains a big challenge on subsistence farmers due to insufficient access to financial capital. Besides, the main determination of adaptation is financial factors, particularly in subsistence farming communities, together with the utmost noticeable restrictions emerging from literature being a lack of credit, inadequate financial capacity and frequency of poverty (Yaro., 2013; Cohn *et al.*,2017; IPPC., 2014). Thathsarani and Gunaratne (2018) confirmed that the ability of individual households to adapt to climate

warming impacts concerning the reinvesting in their farming activities is negatively influenced by scarcity of economic resources at the household level.

Moreover, the large proportion of subsistence farmers with poor education and skills is as a result of hardships in terms of acquiring financial and technical resources to acquire knowledge. Additionally, adaptation to climate change requires more intensive labour use and it's costly. Therefore, if farmers do not have adequate family labour and financial capacity to hire labour, it's difficult for them to adapt to climate change. Correspondingly, farmers outlined those issues such as accessibility and usefulness of climate change information, the institutional environment and socio- economic situation of households affect farmers' capacity to adapt to climate change. Kabir advocated that other important challenges faced by most of the farmers are lack of own land, irrigation water and labour shortages**.** Further, Desessa (2008) reported that most of the problems or constraints encountered by farmers in adaptation to climate change are associated with poverty.

In addition, limited access to information is a common barrier and, consequently enhancing access to information is an enabler to successful adaptation. This corresponds with the Omusati Regionresearch as reported by Hegga et al. (2016) in which inadequate information was cited as the primary reason stopping farmers from changing their practices. Also, Pandey et al. (2018) advocated that poor access to information, lack of awareness and inadequate knowledge on how to cope with climate change are some of the constraints to adaptation. In addition, inappropriate adaptation strategies can be caused by lack of knowledge about climate change through indecision (Lorenzoni et al., 2007).

Likewise, Michie et al. (2011) affirmed that providing of information and enhancement of knowledge on climate change adaptation strategies through education, training and communication is a dynamic component of changing behaviour and initiating action. Therefore, extension officers from the ministry of Agriculture, local and regional authorities as well as traditional and religious leaders need to assist with enhancing access to information, enabling information sharing on adaptation options in order to improve the livelihood of rural communities in north-central Namibia. On the other hand, farmers have little knowledge of new or alternative methods due to poor education, training or extension services. MET (2011) and Thomas (2012) revealed that there is lack of advisors, such as, extension officers to provide guidance to farmers and guide their decision on the affordable and best adaptation options. Equally, Khanal et al. (2018) supports the view that farmers' decisions to adapt to climate change depend on certain factors such as access to extension services and credit facilities, educational accomplishments, experience with the impact of climate change and awareness of climate change issues.

Lastly, Greet et al. (2011) suggested that educational levels, cultural practice, skills acquired and access to financial assets are also linked to farmers' capability to cope with climate change mitigation and adaptation technologies. Generally, there are different constraints that impede farmers' ability to use different adaptation mechanisms to reduce the impact of climate change to crop productivity. Awareness of climate change may urge farmers to use adaptation strategies in their agricultural activities if they know about the potentially positive effect that adapting to climate change may have on their production (Marshall, et al., 2013; Nhemachena et al., 2014).

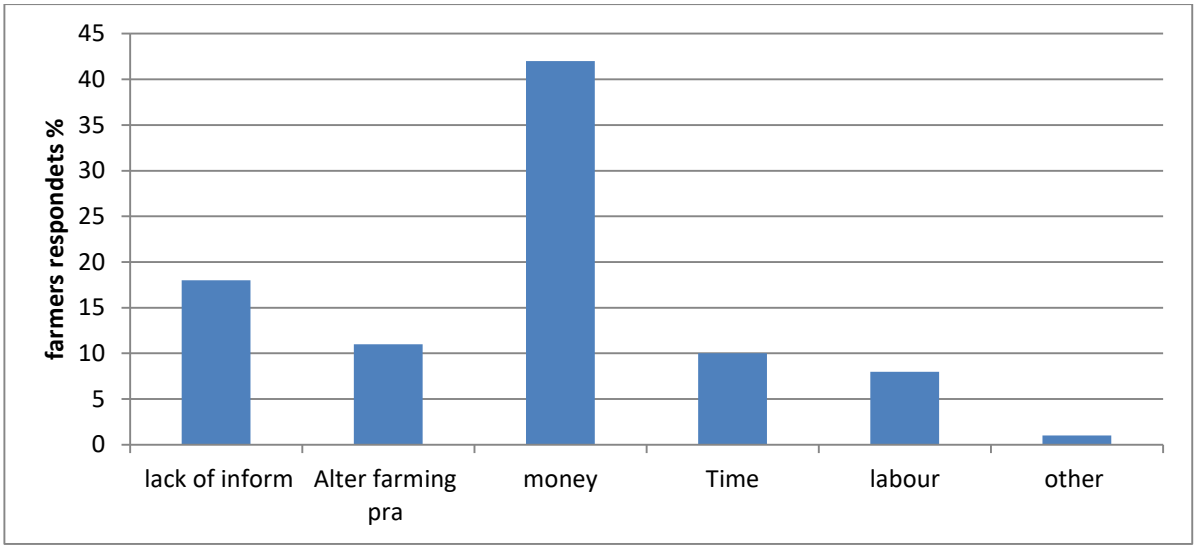

Figure 4.7: Factors that inhibit farmers from using different types of farming practices.

4.5.2 Cultivation methods used by farmers as mitigation strategies

The study highlighted the list of all the cultivation methods that subsistence farmers use to mitigate climate change (Table 4.9). The commonly used methods of climate change mitigation used by subsistence farmers include intercropping (mixed cropping), mulching, diversifying crop, ripper furrowing, drip irrigation and crop rotation. According to the results, intercropping is the main cultivation strategy used by farmers to mitigate climate change. This is indicated in Table 4.10 at a mean of 1.94. In addition to intercropping, farmers also indicated that they practice crop rotation (mean 1.90) and 2.52 farmers adapted diversifying crops as some of the main cultivation methods to mitigate climate change. Furthermore, the study highlighted that drip irrigation is the cultivation method that is barely used for climate mitigation by the subsistence farmers.

Furthermore, the results are consistent with Martaleni (2012); Piya et al. (2013); Gentle et al. (2018) and Khanal et al. (2018) who reported that the vulnerable communities in

different parts of Nepal have adopted different forms of adaptation strategies like use of fertilizers, crop diversification, income diversification, mulching and adoption of soil conservation strategies to cope with the adverse impacts of climate change and sustaining their livelihood. Similarly, Ogalleh et al. (2012) established that intercropping systems seemed to be the most practiced adaptation strategy on the most farms in Umande and Muhonia, Kenya. Intercropping is defined as crop mixing, whereby farmers plant different types of crops and varieties at the same time. This is done because all crops are not equally affected by low rainfall or drier conditions. Thus, some harvest of some crop is guaranteed. Further, farmers' use of intercropping is meant to give them alternatives. This means that if one crop fails, at least others are harvested and there will be something to eat.

IAC (2004) indicate that the intercropping method can reduce the risk of crop failure and losses from pests and diseases and can make efficient use of labour, making it a better system in coping with climate change and other stress. In addition, diversification is found to be high in significance in terms of adaptation measures in crop production in irrigated and non- irrigated areas. Orindi and Eriksen (2005); Adger et al. (2003) demonstrated that in Tanzania, farmers rely on diversified crop types as a way of dissemination risk on the farm. They further, stated that crop diversification can serve as insurance against rainfall erraticism. In Kordofan and Darfur state of Western Sudan, strong varieties have been introduced as food crops as an alternative for cash crops (DFID, 2004).

Moreover, in the Omusati region, farmers hardly use drip irrigation. Nonetheless, (Manka, 2014; Partey et al. (2018) (Manka, (2014); Partey et al. (2018), outlines the significance of investment in drip irrigation that can be used as a climate- smart strategy to improve water accessibility on farmlands. A drip irrigation system is one of the cost effective

methods that leads to increased crop yield and household income, thus cause a reduction in poverty and improvement in food security in the Sudano-Sahel zone of West Africa (Partey et al., 2018; Wanvoeke et al., 2016; Woltering et al., 2011). However, high cost of installation and maintenance of drip irrigation hinders the use of drip irrigation for subsistence farmers (FAO et al., 2018).

Table 4.8: Cultivation methods used by farmers as mitigation strategies

Farmers' cultivation methods	**Mean**	**Standard deviation**
Intercropping	1.94	1.095
Mulching	2.48	1.229
Diversifying crop	2.52	1.351
Ripper- Furrowing	2.71	1.283
Drip Irrigation	2.28	1.341
Crop Rotation	1.90	1.142

4.5.3 Adaptation strategies used to mitigate climate change

In addition to cultivation methods, farmers have other alternatives to mitigate climate change as indicated in Table 4.10. Alternative methods for climate change identified in this study include livestock diversification, agroforestry, non-farm activities (transport

facility, shop keeping, tailoring and wholesale and retail trading), adjusting of sowing dates, integrated farming systems, soil conservation activities and hydro irrigation crop seeds. According to the results, soil conservation (mean 1.84) and livestock diversification (mean 2.16) identified as the most used method of climate change mitigation. Furthermore, adjusting to sowing dates was revealed as another commonly used method (mean 2.48) as a mitigation method towards climate change.

The IPCC (2007) define adaptation "as initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effect". Organisation for Economic Co-operation and Development [OECD] (2012) outlines that adaptation still remains essential to farming and farmers are expert at adapting agricultural practices to environmental change. Examples of adaptation strategies of agriculture to the impacts of climate change includes: adjustments in planting dates, crop varieties, Agro-forestry, non-farmer activities, integrated farming, livestock diversification and soil conservation of the land to maintain yields and soil fertility.

Moreover, Schipper et al. (2008) reported that adaptation strategies help to alleviate impact of climate change on crop production. Furthermore, the reduction of negative impacts of climate change can be achieved through making appropriate adjustments and changes as well as adapting to climate change measures. Furthermore, Kurukulasuriya and Mendelsohn (2008); Di Falco (2014) established that mixed crop – livestock system is the most effective adaptation strategy used by most of subsistence farmers as a technique to improve crop yield and reduce crop failure. Mixed cropping involves growing two or more crops in proximity in the same field. The system is commonly practiced in Tanzania where

cereals (maize, sorghum), legumes (beans) and nuts (groundnuts) are grown together (Di Falco, 2014).

A research conducted by Mendelsohn et al. (2000) reveals that for all countries in Africa apart from Cameroon and South Africa, planting of different varieties of crop is considered to be one of the strategies based on adaptation analysis made in Africa. Besides, diversify of farming systems gives more options to farmers to choose to grow different crops on different fields or on the same field and mixed crop - livestock systems. Gebrehiwot & van der Veen (2013) articulated that farmers with more diverse farming systems are more advantaged and less vulnerable to climatic impacts and stresses.

Additionally, this study perceived that adaptation action of changes in planting dates is consistent with the works of Bradshaw et al. (2004); (Deressa et al., 2009); Tingum et al. (2008); Molua (2008); Gbetibouo (2008); & Nhemachena et al. (2007). Similarly, Liwenga (2003) claimed that some farmers planted immediately after rain and others, a few days after the first rain. In Tanzania, socked planting crop (planting before rains onset on uncultivated land) is the most common strategy used (Liwenga, 2003). Thus, the method is used to avoid production risk by low rainfall variability and drought. Their dependency on rain-fed agriculture makes them to maintain flexibility with regards to input decisions on uncertain weather conditions, for instance shifting when crops are planted.

Sparks et al. (2000) implied that shifts in planting dates are frequently used to reduce yield production and fleeing coincidence of the sensitive flowering stage with the hottest part of the growing season. Instead of farmers directly sowing after ploughing, they wait for

the rains to come before seeds are sown. Farmers routinely shift planting dates by month or more from year to year in response to variability in when monsoon rains arrive. Sonko et al. (2020) indicates that farmers' efforts to adjust to the shifting rain pattern through changing planting dates and careful handling during germination and establishment of crops, helps farmers to reduce risk of crop failure. Moreover, Fisher et al. (2015) postulated that the most preferred strategies used in Sub-Saharan Africa are switching to crop varieties and cultivars less sensitive to climate stress. However, it is not really a guarantee that changing planting dates will improve crop yields since most growing season lengths would be reduced.

According to Chazovachii et al. (2010) farmers grow drought tolerant grain crops such as pearl millet, sorghum, cowpeas and maize with the main aim of reducing the impact of issues of low and unpredictable rainfall which are caused by climate change. Likewise, Ngugi (2009) recounted that the use of drought - resistant crop varieties has been used by smaller farmers as adaptation strategies to climate change in Nigeria, Senegal, Burkina Faso and Ghana. Reduction in crop yield production and vulnerability to climate change can be mitigated by using more drought resistant crops in drought- prone areas. On the other hand, Fisher et al. (2015) claimed that drought-resistant seeds are restricted and not easily accessible to the farmers. Equally, Alene et al. (2009); Cairns et al. (2013); Zougmoré et al. (2018) emphasised that there are challenges in developing and delivery of crop varieties and drought resistant crops that are resilient to climatic and non- climatic stresses.

In addition, the farmers indicated soil conservation as another adaptive strategy. The Department of Environmental Affairs (DEA) (2014) informed that farmers are adopting

climate-smart agricultural practices such as conservation tillage practices to reduce soil moisture loss, reduce erosion and control weed. Further, in countries such as; Burkina Faso, Kenya, Senegal, and Niger, soil conservation techniques are commonly practiced. A study carried out by Lemma and Majule (2009) in Manyoni district of Tanzania revealed that farmers in Kamenyanga and Kintinku use different farming methods, in particular, soil conservation through burying of crop residues which replenish soil fertility, enhance releasing of nutrients and improve soil organic matter.

Moreover, Nyong et al. (2007) acknowledged that local farmers in the Sahel use zero tilling practices in cultivation, mulching and other soil management techniques to conserve carbon in the soil. He further, noted that the traditional mulches improve soil temperatures and extremes, Suppress diseases, harmful pests and conserve soil moisture. Niggli et al. (2009) uphold that soil conservation practice characteristics in ecological agriculture decreases the decline effects of droughts while increasing crop productivity. Improvements in agricultural practice or agronomic practices contribute a huge potential in mitigation and simultaneously the adaptation of farmers to climate change.

Another major strategy is agro-forestry which was agreed upon at a mean of 3.02. Atangana et al. (2014) define agro-forestry as a land -use system where woody perennials are growing together with agricultural crops in the same land unit. Valdivia et al. (2002); Zoysa and Inoue, (2014) displayed that agro- forestry offers many economic and environmental benefits. Moreover, Bayala et al., 2014; Garrity et al. (2010); Mbow et al. (2014a); Mbow et al. (2014b); Partey et al. (2018) reported on West African farmers' incredible achievement on the impact for climate change adaptation, mitigation and improved food security through agroforestry technologies. Bayala et al. (2014); Garrity et

al. (2010); Mbow et al. (2014a); Mbow et al., 2(014b) further explained that agroforestry technologies and practices contribute to crop productivity by improving soil fertility through the increase of soil organic matter, nutrient cycling and biological nitrogen fixation by leguminous trees.

Equally important is the improvement of soil moisture and water infiltration provision of soil cover that decreases erosion and buffers the impact of climate change as the results of agroforestry technologies and practice adaptation (Bayala et al., 2014; Garrity et al., 2010; Mbow et al., 2014a; Mbow et al., 2014b). Partey et al. (2018) further outline the benefits of agro- forestry such as trees, serves as windbreaks and shelterbelts therefore the cultivated fields are robust to wind storms posed by climate extremes. Besides, Torquebiau (2013) validated that "agro- forestry has a double potential to address climate change issues such as greenhouse gas mitigation strategy through carbon sequestration and sustainable adjustment to changing conditions". Agro- forestry has a significant impact on crop performances as trees can decrease climate extremes that affect crop growth (Bayala et al., 2014; Mbow et al., 2014a). Lastly, Torquebiau (2013); Murthy et al. (2016) accentuated that agro-forestry is the most sustainable strategy through its effect on soil conservation, protection of biodiversity and carbon confiscation.

Finally, off- farm income activities could as well play a role in the economic livelihood of the farmers. A significant amount of farmers were not sure of venturing into non-farming activities. However, a survey carried out by Mertz et al. (2010) points out that in Southern Burkina Faso, farmers adapt dry season market gardening and non- farm income sources due to the effect of low yield production during the rainy season. Since, non-

agricultural income sources are less sensitive to climate change, farming activities that diversify farmers' incomes are perceived as an adaptation strategy.

Despite, farmers having alternatives to adaptation climate change, Hassan & Nhemachena (2008); Bunce et al. (2010); Dube et al. (2016) point out that farmers' capacity to adapt to climate change is extremely limited in Africa. Generally, farmers are uncertain on how to cope with climate change. Several studies revealed that climate change remains a fundamental vulnerability of rural livelihoods and reduces households' adaptive capacity (Heltberg, Siegel & Jorgensen 2009; Kaundjua et al., 2012; Shah et al., 2013). Equally, Lobell et al. (2008) affirm that without appropriate adaptation procedures for climate change in Southern Africa, staple crops, food-security and human populations will likely be badly affected. Furthermore, Pienaar et al. (2021) revealed that climate adaptation strategies implementation and planning are influenced by various ranges of limitations in numerous contexts.

Table 4.9: Methods used as adaptation strategies

Methods of adaptation strategies used	**Mean**	**Standard deviation**
No adaptation strategies	2.77	1.551
Crop- livestock diversification and other good practice (mixed cropping, crop rotation, Mulching, organic fertiliser. Use of improved varieties, chemical fertiliser and pesticides	2.16	1.332

Agro forestry and perennial plantation (oil palm, orchard, tree species).	3.28	1.290
Diversification of income- generating activities/ non -farm activities	3.02	1.22
Adjusting sowing dates	2.48	1.343
Integrated farming system	2.19	1.348
Soil conservation activities	1.84	1.217
Use of hybrid irrigation crops seed	3.10	1.237

4.6 Hypothesis testing

H1: Climate change events such as droughts and floods have a significant impact on major food crops (yields) of subsistence farmers in Omusati region, Namibia.

H0: Climate change events such as droughts and floods have no significant impact on major food crops (yields) of subsistence farmers in Omusati region, Namibia.

Table 4.10: Spearman's correlation results

Correlations

			Weather Events	Crop Yields
Spearman's rho	Weather events	Correlation Coefficient	1	.080
		Sig. (2-tailed)	.	.045
		N	90	90
	Crop yields	Correlation Coefficient	.080	1
		Sig. (2-tailed)	.045	.
		N	90	90

This study conducted a Spearman's correlation test to ascertain the impact climate change events such as droughts and floods on crops yields by subsistence farmers in the Omusati region. The normality assumption was violated after transformations were performed. In this light, the researcher had to conduct a non-parametric test. Hence, the uses of the Spearman's correlation test. The findings presented in table 4.10 shows that the P value equal to 0.045 which is less than 0.05. This implied that the null hypothesis is rejected. Thus, the alternative hypothesis is accepted. Therefore, the study affirms climate change events such as droughts and floods have a significant impact on major food crops (yields) of subsistence farmers in Omusati region, Namibia.

4.7 Chapter summary

The main objective of this chapter was to present the study findings on the impact of climate change on subsistence farming on crop productions in Etayi and Elim consistencies in the Omusati region. The chapter also represents the farmers' perceptions on weather conditions, influence of climate change on crop production yield and adaptation strategies that were adopted by the Elim and Etayi communities. The impact of climate change on crop production, demographic information, farmer perceptions on weather conditions and adaptation strategies and mitigation were analysed, based on the respondents in the survey. The information was collected using questionnaires with structured questions. The next chapter presents a summary of the research findings, conclusions, recommendations, and recommendations for further studies.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter focuses on findings, conclusions, and recommendations. It analyses each objective, summarises the results of the study, and provides conclusions based on the results. It also provides recommendations of the study.

5.2 Conclusions of findings

It is clear that climate change is one of the biggest challenges that agriculture is facing in the Omusati Regionand internationally. Moreover, Namibia is highly exposed to unpredictable weather conditions and the effect of climate change, which are projected to decline in the coming decades. In addition, the majority of Namibia's population resides in rural areas, and communities have historically relied on agricultural activities, particularly crop production. The major problems of the study area, that create a severe threat to most of the smallholder households is irregularities of rainfall.

Furthermore, the farmers highlighted that they have experienced extreme weather events such as drought and reduced rainfall, leading to crop failure due to prolonged drought. Additionally, educational level, age, occupation, and house head gender are some of the factors determining the choice of adaptation strategies. The findings of this study have indicated that educational level of the house heads, strongly affected perception and adaptation decisions. Nonetheless, there are barriers affecting the ability of farmers to cope with climate change and these include lack of information, money, time and labour.

Moreover, the farmers worked around this situation employing some adaptation strategies such as, improved drought resistant seeds, mixed cropping, adjusting sowing dates and diversification (crop-livestock and non- farm activities). Adaptation of off-farm and non-farm activities is one method of reducing the effect of climate change through having a diversified source of income. However, from their history of coping with harsh environmental and climatic conditions, many communities today are struggling to deal effectively with unpredictable weather conditions; such as extreme high temperature, shifting seasonal rainfall patterns, drought and floods.

5.2.1 Impact of climate change on crop productivity

The study findings disclose that climate change has negative impacts on subsistence farming and farmers in Etayi and Elim constituencies in the Omusati Regionare well aware of the impacts, particularly on crop production. Furthermore, the farmers point out that current crop production systems are sensitive to the effect of climate change and farmers are worried for their future supply, since, most of the farmers depend on rain-fed agriculture.

Climate change is the almost serious environmental threat to subsistence farmers' fight against hunger, malnutrition, disease and poverty. Even through the government has been subsidising the farmers with implements such as tractors for ploughing, fertiliser and drought resistant seeds, still the farmers found them expensive to buy. For this reason, policies need to be amended to encourage farmers to invest more in drought resistant crops.

5.2.2 Effect on crop harvests in terms of yields

The study findings revealed that farmers stated that floods affect crop production through change in soil fertility by reducing crop yield, land productivity or damaging and destroying crops. Also, low fertility, decline in crop quality. Moreover, the findings of the study show that the current crop production is sensitive to the effects of climate change and farmers are worried for their future food supply. Also, many farmers revealed that they have not been receiving good rains for the past 10 years and for this reason, many farmers yield poor harvests.

Similarly, Hegga et al. (2016) confirmed that Frequent drought over the past 5 years has diminished crop production to the extent that farmers have had repeatedly insufficient supplies of Mahangu (pearl millet) to last them through the dry season. Likewise, Shikangalah (2020) agreed that overall crop production fell. In 2019 Pearl Millet harvests were estimated to be 53% lower than in 2018 and 42% lower than the 20 years average. Angula and Kaundjua (2016) affirmed that the reduction in crop production in the Northern- Central Namibia (NCN) is projected to decline by 50%.

5.2.3 Variety use of crops by subsistence farmers in response to climate change

The study findings indicated that most of the farmers are using drought- resistant varieties, such as using maize seeds which are heat- tolerant and pearl millet such as Kangira and Okashana #1 and 3 which are drought resistant. Similarly, a research conducted by Mendelsohn et al. (2000) confirmed that all countries in Africa, apart from Cameroon and South Africa, planting of different varieties of crops is considered to be one of the most popular adaptations based on analysis made in Africa.

Furthermore, the farmers indicated that farmers with more diverse crops have an advantage and are less vulnerable to climatic impacts and stress. However, farmers stated that drought resistant variety seeds are restricted and not easily accessible to the farmers. Therefore, it is recommended for agricultural extension workers to provide information on the benefits and ensure easy accessibility to crop diversification.

5.3 Recommendations

This section presents some recommendations based on the analysis and results of the study.

5.3.1 Policymakers in Etayi and Elim Consistencies/Ministry of Agriculture

Based on the findings on the adaption of land management practices and use of drought-resistant crops, it is recommended that measures be put in place to mitigate climate factors that affect crop production. There is a need to focus more specifically on planned adaptation and to introduce more targeted responses that consider openly, how the climate might change in future. Furthermore, there is a need for developing more drought resistant dry land crops and adopting more effective environmentally friendly farming practices. Equally, the results of this study show lack of experience, lack of education, limited perception and adaptation decisions of subsistence farmers as challenges. Hence, facilitating effective and reliable information and improving farmers' awareness of potential adaptation will be significant intervention measures.

For example, farmers shifting to planting crops and varieties that are deemed less risky to climate change and variability require further government support in promoting such crops. Similarly, for better support of subsistence farmers in further developing

appropriate coping strategies and adaptation measures, policies are needed. Newsham and Thomas (2011) call for climate change adaptation policy engagement with local knowledge systems, given the uncertainties inherent in the projected impacts of climate change in Africa. Such recommendations include strengthening research capacity for the development of new cultivars and farming techniques with the changes in climate, enhancement of various enterprise diversification activities, making provision of crop insurance programs and strengthening agricultural extension systems for disseminating up-to-date agricultural adaptation technologies to the farmers. Diversifying and generating off-farm employment opportunities in rural Omusati Regionmay also be crucial measures for the sustenance of the rural masses.

Also, there is a need to train extension officers on climate change and adaptation strategies as well as conservation agricultural practice. So, they could also have dispersed correct and accurate information to farmers for betterment adaptation and improved well-being of farmers. Likewise, promoting climate change among extension officers so, that they contribute to the body of knowledge that will mitigate or adapt to climate change. Literacy programmes to access climate information are also encouraged.

Additionally, the analysis suggests that in order to promote the adoption of adaptation strategies, policy makers should focus on improving access to meteorological information, primarily among older, lower income and less-educated farmers. It's of significance to expand and strengthen farmers' access to climate information to improve crop management. The study further suggests that as the impact of climate change is intensifying day by day, it should be addressed through policy perspectives at the earliest stages to avoid short term effects such as yield and income loss and long-term effects such

as quitting the agricultural profession by the rain-fed farmers. Agricultural policies in terms of adaptation to climate change should integrate, at the same time equitable access to the means of production.

Despite, the study revealed that lack of finance is one of the barriers that hinder farmers from adopting new climate change adaptation and mitigation strategies. These studies recommend financing of the rural area by setting up suitable financial systems that will allow subsistence farmers to have access to credit. These Policies will allow easy access of farmers to different sorts of adaptation measures for both the short- and long–term. Agricultural policies in terms of adaptation to climate change should integrate equitable access to the means of production.

Finally, the current strategies used by subsistence farmers should be considered in the country's national adaptation plan of action, for local and indigenous knowledge serves as a sink and could act as a facilitator in the formation strategies that could aid local farmers.

5.3.2 Farmers

Farmers in the Etayi and Elim constituencies should organise themselves so they can help themselves on the impact of climate change on crop production. These could include, informing each other on better adaptation strategies of climate change. Farmers should invest in drought resistant crops that can be used as adaptation strategies and these crops will help mitigate the impact of climate change on crop production. Furthermore, the farmers need to diversify on agro-forestry and non- farm and off– farming activities in

order to have different sources of income rather than rely on crop production as a source of food supply.

5.4 Limitations of the study

The Covid-19 pandemic led to many limitations, such as travelling to respondents to administer surveys, social distancing and wearing of facemasks which made it difficult to reach out to more.

5.5 Suggestion for further research

Future studies may consider analysing the climate change impact on other agricultural sectors, e.g., fisheries and livestock to assess the impact of climate change on economic benefits or losses. The research also suggests more research efforts in future for in-depth analyses of the economic impact of climate change on farm income at the rural household level using a more holistic approach.

Further studies should also consider the preliminary outcomes of this study as a benchmark for determining key factors that can affect the adaptive capacities to climate adaptation strategies to develop a more vigorous understanding of the farmers' perceptions on weather conditions and the effect of climate change on crop production yield. This study opens the door to ongoing and comprehensive studies on the determinants of smallholder farmers' adaptive capacities to climate adaptation strategies, which can inform policymakers, particularly in Namibia to adapt interventions to facilitate adequate climate adaptation, which will reduce smallholder farmers' susceptibility to the impacts of changing climatic conditions.

5.6 Summary

The main objective of this study was to assess the impact of climate change on crop production on subsistence farmer in Omusati region. The first chapter explained the aims, objectives, significance, limitations as well as the delimitations of the research. Furthermore chapter two looks at the literature review of the study carried out in the Omusati Region. The reviewed literature has demonstrated that changes in rainfall patterns and temperature are some of the notable signs of climate change.

In addition, in chapter three, the researcher outlined the methods which were used to collect the data in order to address the research objectives. The research design which was chosen was the case study using the quantitative approach. The research instrument administered was a questionnaire with structured questions. Moreover, chapter four outlined the study findings on the impact of climate change on subsistence farming on crop productions in Etayi and Elim consistencies in the Omusati Regionbased on the respondents in the survey.

Finally, the last chapter covered the conclusions of the study according to the study objectives. Recommendations were made to the Government and Policy maker particularly in the Ministry of agriculture water and land reform, Omusati regional council, Farmers and the Educational sector. The chapter concludes with recommendations for areas for further research.

References

Abdelzaher, D. M., Martynova, A., & Zaher, A. M. A. (2020). Vulnerability to climate change: Are innovative countries in a better position? *Research in International Business and Finance, 51*. Retrieved from ttps://doi.org/10.1016/j.ribaf.2019.101098

Adegnandjal, M.R.F & Dominique, B (2018). *Farmers' adaptation strategies to climate change and their implication in Zou Department of South Beni*. Zurich Switzerland.

Adger, W.N., Huq, S. Brown, K., Conwa, D., & Hulme, M., (2003). Adaptation to climate change in the developing world. Progress Dev. Stud.

Adimasu T.Z, & Kessler A., (2012). Farmers' investments in land management practices in the CRV of Ethiopia. Paper presented at the 8th International Symposium Agro Environ, Wageningen, Netherlands, agriculture. Preliminary analysis prepared for the World Bank, Washington, District of Columbia,

Afolami, C.A., Obayelu, A.E. & Vaughan, I. (2015), "Welfare impact of adoption of improved cassava varieties by rural households in South Western Nigeria", Agricultural and Food Economics.

African Development Bank. (2018). Namibia: National Climate Change Profile. Climate Change and Green Growth Division, African Development Bank.

Agricultural Development and Advisory Service (ADAS), (2007). *Impacts of 2007 Summer Floods on Agriculture*. Cambridge. ADAS Boxworth

Ahmed, M. H. (2016). Climate change adaptation strategies of maize producers of the Central Rift Valley of Ethiopia. *Journal of Agriculture and Rural Development in the Tropics and Subtropics,*

Alene, D., Menkir, A, Ajala, S.O., Badu-Apraku, B., Olanrewaju, A.S., Manyonga V.M., & Ndiaye A (2009). The economic and poverty impacts of maize research in West and Central Africa. Agricultural Economics

Ali, A., & Ehrenstein, O., (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Climate Risk Management,*

Amadhila, E., Shaamhula, L., Van Rooy, G. & Siyambango, N., (2013), 'Disaster risk reduction in the Omusati and Oshana regions of Namibia', *Jàmbá: Journal of Disaster Risk Studies*

Amin, R.M., Zhang, J., & Yang, M., (2015). "Effects of climate change on the yield and natural resource use in Namibia: exploring economically efficient responses *Pastoralism Journal.* (2)

Angela, A, & Ngozi, J., (2019). The Developing World's Contribution to Global Warming and the Resulting Consequences of Climate Change in These Regions: A Nigerian Case Study, Global Warming and Climate Change, John P. Tiefenbacher.

Angula M., (2010). *Gender and climate change: Namibia case study*. Heinrich Boell Foundation, Cape Town.

Angula, M.N.& Kaundjua, M.B., (2016). The changing climate and human vulnerability in north-central Namibia', Jàmbá*: Journal of Disaster Risk Studies* 8(2). Retrieved from http://dx.doi.org/10.4102/jamba.v8i2.200

Antoniadou, V., (2017). Collecting, organizing, and analysing multimodal data sets: the contributions of CAQDAS. In E. Moore & M. Dooly (Eds), Qualitative approaches to research on plurilingual education.

Armah, F.A.; Yawson, D.O.; Yengoh, G.T.; Odo, J.O., & Africa, E.K.A., (2010). Impact of Floods on Livelihoods and Vulnerability of Natural Resource Dependent Communities in Northern Ghana. *Water*.

Arshad, M., Amjath-Babu, T.S., Aravindakshan, S., Krupnik, T.J., Toussaint, V., Kächele, H. & Müller, K. (2018), "Climatic variability and thermal stress in Pakistan's rice and wheat systems: a stochastic frontier and quantile regression analysis of economic efficiency", Ecological Indicators, Vol.89 pg,496-506

Ashworth, P., Jeanneret, T., Gaedner, J., & Shaw, H. (2011). Communication and climate change: What Australian public thinks. National Research Flagships Energy Transformed, CSIRO.

Asrat P, & Simane B (2017), Characterizing vulnerability of crop-based rural systems to climate change and variability: agro-ecology specific empirical evidence from the Dabus watershed, North-West Ethiopia. Am J Clim Change.

Barnes J., MacGregor J & Alberts M. (2012), Expected climate change impacts on land and natural resource use in Namibia: exploring economically efficient responses. Pastoralism: Research, Policy and Practice,

Bayala, J, Sanou J, Teklehaimanot Z, Kalinganire A, & Ouédraogo S.J (2014) Parklands for buffering climate risk and sustaining agricultural production in the Sahel of West Africa. Current Opinion in Environmental Sustainability

Bhattacharyya, R. (2008), “Crop diversification: a search for an alternative income of the farmers in the state of West Bengal in India”, International Conference on Applied Economics.

Biber- Freudenberger, L.; Ziemacki, J.; Tonnag, H.E.Z; & Borgemeister, C. (2016). Future risks of pest species under changing climate conditions. Plus one.

Birkmann, J., & Von Teichman, K. (2010). Integrating disaster risk reduction and climate change adaptation: Key challenges—Scales, knowledge, and norms. Sustainability Science,

Bola, A.A., Diagne, A. & Omonoma, B.T. (2012), “Inclusive growth in Africa”, A paper presented at the African Economic Conference, Kigali

Bradshaw, B., Dolan, H. & Smit, B. (2004), “Farm-level adaptation to climatic variability and change: crop diversification in the Canadian prairies”, Climatic Change.

Branca, G., McCarthy, L., Lipper, L., & JoleJoli, M.C., (2011). Climate smart agriculture: A synthesis of empirical evidence of food security and mitigation benefit from improved crop management. FAO working paper, Draft.

Bunce, M., S. Rosendo, & K. Brown. (2010). Perceptions of climate change, multiple stressors and livelihoods on marginal African coasts. Environ. Dev. Sustainability,

Buyinza M, & Wambede N (2008) Extension of agroforestry technology adoption: mixed intercropping of crotalaria (Crotalaria grahamiana) and maize (Zea mays L.) in Kabale District, Uganda. In Environ Res J

Cairns J.E, Hellin J, Sonder K, Araus JL, MacRobert JF, Thierfelder C, & Prasanna B.M (2013) Adapting maize production to climate change in sub-Saharan Africa. Food Security 5 (3)

Cameroon. Theoretical and applied climatology.doi:

Challinor, A. J., Wheeler, T.R. Garforth, C Craufurd, P, & Kassam A. (2007). "Assessing Vulnerability of Food Crop Systems in Africa to Climate Change." Climatic Change

Chappel, A. (2018). Barriers and enablers to the adoption of practices to improve crop production and reduce vulnerability to climate risks in the semi-arid Omusati Region, Namibia (Masters Dissertation, University of Cape town, South Africa).

Chazovachii, B., Chigwenya, A., & Masuku, A. (2010). Adaptation of climate resilient rural livelihoods through growing of small grains in Munyaradzi communal area. Gutu District. Afr. J. Agric. Res.

Chen, S.E.; & Salas, P.C (2019). The effect of Agricultural Diversification and Commercialization on the Anthropometric outcomes of children: Evidence from Tanzania

Chowdhury, I.U.A. & Khan, M.A.E. (2015), "The impact of climate change on rice yield in Combating Desertification with Tools for local level decision making. World Resource Report, Washington DC.

Cohn, A.S, Newton. P, & Gil, J.D., (2017). Smallholder agriculture and climate change. Ann Rev Environ Res.

Da Silva-Rosa, T.; Bonatti, M.; Vanini, A.; & Zuffo, C. (2014). Vulnerability and climate change perceptions: A case study in Brazilian biomes. Environ. Pollut.

Daron, J.D. (2014). Regional climate messages: Southern Africa. Scientific report from the CARIAA Adaptation at Scale in Semi-Arid Regions Project. Ottawa: CARIAA and Adaptation at Scale in Semi-Arid Regions

David A, Braby J, Zeidler J, Kandjinga L & Ndokosho J. (2013). Building adaptive capacity in rural Namibia: Community information toolkits on climate change. International Journal of Climate Change Strategies and Management,

Davis CL. (2011). Climate risk and vulnerability: a handbook for Southern Africa. Council for Scientific and Industrial Research, Pretoria, South Africa,

Denscombe M., (2010). The Good Research Guide for Small-Scale Research Projects, Open University Press, Glasgow.

Department for Food and International Development (DFID). (2004). Adaptation to climate change: The right information can help the poor to cope. Global and local environment team, policy division.

Department of Environmental Affairs (DEA), (2014). Climate Change Adaptation: Perspectives on Food Security in South Africa towards an Integrated Economic Analysis. Report No. 5 for the Long-Term Adaptation Scenarios Flagship Research Program (LTAS). Pretoria, South Africa.

Deresa T.T., Hassan R.M., & Ringler, C., (2011) Perception of and adaptation to climate change by farmers in the Nile Basin of Ethiopia. J Agric Sci

Di Falco, S., (2014'). Adaptation to climate change in sub-Saharan agriculture: Assessing the evidence and rethinking the drivers. Eur. Rev. Agric. Econ.

Di Falco, S., Veronesi, M. & Yesuf, M. (2011), "Does adaptation to climate change provide food security? A micro-perspective from Ethiopia", American Journal of Agricultural Economics.

Dirkx. E, Hager. C, Tadross. M, Bethune. S, & Curtis. B. (2008), climate change vulnerability & adaptation assessment Namibia. Desert Research Foundation of Namibia & Climate Systems Analysis Group for the Ministry of Environment and Tourism.

Dube, T., P. Moyo, M. Ncube, & D. Nyathi, (2016). The impact of climate change on agroecological based livelihoods in Africa: A review. J. Sustain. Dev. *Journal of Agriculture, Food Systems, and Community Development,*

Elahi, K.M., (2016). Climate change and health impacts in Bangladesh. In climate change and health, present and future risks. The lancet.

Eva, L. (2009), Climate Change, Water and Food Security, Background Note, Overseas development institute, UK.

FAO, (2010a). ―Climate-smart‖ agriculture: policies, practices and financing for food security, adaptation and mitigation. *In*: The Hague Conference on Agriculture, Food Security and Climate Change. Food and Agriculture Organization of the United Nations, Rome,

FAO, (2010b). ―Climate-smart‖ agriculture: policies, practices and financing for food security, adaptation and mitigation. *In*: The Hague Conference on Agriculture, Food Security and Climate Change. Food and Agriculture Organization of the United Nations, Rome,

FAO, ICRISAT, CIAT (2018) Climate-Smart Agriculture in the Gambia. CSA Country Profiles for Africa Series. International Centre for Tropical Agriculture (CIAT); International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

FAO. (2016). Food and Agriculture Organization of the United Nations. Southern Africa.

Field, C. B. (2014). *Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects*. Cambridge University Press.

Fisher M, Abate T, Lunduka RW, Asnake W, Alemayehu Y., & Madulu RB (2015) Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: Determinants of adoption in eastern and southern Africa. Climatic Change.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. Qualitative Inquiry, 12, Issue 2,

Flyvbjerg, B. (2011). Case study. In: N. K. Denzin and Y. S. Lincoln (Eds.). The Sage Handbook of Qualitative Research, 4th ed. Thousand Oaks, CA: Sage,

Food and Agriculture Organization (FAO), (2009). International Treaty on Plant Genetic Resources for Food and Agriculture. Food and Agriculture Organization of the United Nations, Rome,

Food and Agriculture Organization (FAO) (2014). *The state of food insecurity in the world, strengthening the enabling environment for food security and nutrition*. Food and Agriculture Organization, Rome

Food and Agriculture Organization (FAO), (2009). International Treaty on Plant Genetic Resources for Food and Agriculture. Food and Agriculture Organization of the United Nations, Rome,

Fosu-Mensah, B.Y.; Vlek, P.L.G.; & Manschadi, A.M. (2010) Farmers' Perception and Adaptation to Climate Change; A Case Study of Sekyedumase District in Ghana. In Proceedings of the World Food System—A Contribution from Europe Farmers', Tropentag, Zurich, Switzerland,

Fraser, E. (2009). "Crop yield and climate change", Retrieved on September 14, 2009 (http://www.epa.gov/climate change/effects/agriculture.html)

Garrity D.P, Akinnifesi F.K, Ajayi OC, Weldesemayat SG, Mowo JG, Kalinganire A, Larwanou M, & Bayala J (2010). Evergreen Agriculture: a robust approach to sustainable food security in Africa. Food Security

Gbetibouo G.A. (2009). Understanding farmers' perceptions and adaptations to climate change and variability: the case of the Limpopo Basin, South Africa. Washington DC: International Food Policy Research Centre. IFPRI Discussion Paper

Gentle, P., Thwaites, R., Race, D., Alexander, K., & Martaleni, T. (2018): Household and community responses to impacts of climate change in the rural hills of Nepal. *Clim. Change,*

Glazebrook, T., Noll, S, & Opoku, E. (2020). Gender Matters: Climate Change, Gender Bias, and Women's Farming in the Global South and North. *Agriculture, 10*. Retrieved from https://www.mdpi.com/journal/agriculture

Gilau A.M, Dayo F.B, Abraham L.Z & Mundia L. (2011). Drought and flood risk assessment tool for gender specific decision-making. Summary Report. Triple "E" Systems Inc., USA for Africa Adaptation Project - Namibia. United Nations Development Programme and Republic of Namibia, Windhoek,

Gillham, B. (2000). *Case study research methods*. Bloomsbury Publishing.

Government of the Republic of Namibia (GRN), (2015). Third National Communication to the United Nations Framework Convention on Climate Change. Ministry of Environment and Tourism, Windhoek.

Greg, E., Anam, B.E., William, M.F. & Duru, E.J.C. (2011), "Climate change, food security and agricultural productivity in Africa: issues and policy directions", International Journal of Humanities and Social Science, Vol.

Guetta D, Abegaz A (2015). Factors influencing scaling up of agroforestry-based spatial land- use integration for soil fertility management in Arsamma Watershed, Southwestern Ethiopian Highlands. J Environ Plan Manag.

Hamed, T (2016). Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. International Journal of Academic Research in Management (IJARM).

Hassan, R., & C. Nhemachena, C., (2008). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. Afr. J. Agric. Resour. Econ.

He, X & Mkonda, M. (2018). Climate Variability crop yield; environmental sustainability; Vulnerability, Tanzania.

Heltberg, R., Siegel, P.B., & Jorgensen, S.L., (2009), 'Addressing human vulnerability to climate change: Towards a "no-regret" approach', *Global Environmental Change*

Nchu, I. N., Kimengsi, J.N., & Kapp, G. (2019). Diagnosing Climate Adaptation Constraints in Rural Subsistence Farming Systems in Cameroon: Gender and Institutional Perspectives. *Sustainability*, *11*(14). Retrieved from https://doi.org/10.3390/su11143767

Nhemachena, C., Hassan, R., & Chakwizira J., (2014). Analysis of determinants of farm-level Change: Crop Diversification in the Canadian Prairies. Climatic Change

Howden, S.M, Soussana, J.F, Tubiello, F.N, Chhetri N, Dunlop, M, & Meinke H. (2007). Adapting agriculture to climate change. Proceedings of the National Academy of Sciences of the United States of America

Hulme. M, Doherty R, Ngara T, New M and Lister D. (2001) African climate change: 1900-2100. Climate research,

Human Development Report Office (HDRO). (2007). *Human Development Report 2007/2008. Fighting Climate Change: Human Solidarity in a divided world*. New York. United Nations Development Programme (UNDP).

Intergovernmental Panel on Climate Change (IPCC), (2014), 'Glossary', in J. Agard & L. Schipper (eds.), *Contribution of working group II to the fifth assessment report*, n.p., Cambridge University Press, Cambridge

International Atomic Energy Agent (IAEA), (2019.) Drought- tolerant crops to contribute to food Security in Namibia.

IPCC (2014), "Climate change (2014)", Fifth Assessment Synthesis Report, Intergovernmental Panel on Climate Change, Geneva.

IPCC (Intergovernmental Panel on Climate Change) (2014). Africa. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

IPCC, (2013). Climate Change: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, and G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley. P.M (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC. (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK, New York, US, Cambridge University Press

IPCC. (2014). "Climate Change: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the International Panel of Climate Change.

James R & Washington R. (2013). Changes in African temperature and precipitation associated with degrees of global warming. Climatic Change,

Kabir, M.D.H, (2015), Impact of Climate Change on Agriculture Especially in Jessore and Sathkhira Districts According to Farmers' Mitigation Strategies to Climate Change; Evidence from Farmer Level Data. J Geogr Nat Disast

Kandjinga. L, Zeidler. J, Nunes I, Chunga. R & Ndokosho. J. (2010). How to reach out to local communities and assist them to adapt to climate change. ICID+18, 2nd International Conference: Climate, Sustainability and Development in Semi-arid Regions. Fortaleza – Ceara, 20.

Karki. S., Burton, P & Mackey. B (2020). Climate change adaptation by subsistence and smallholder: insight from three Agro-ecological region of Nepal.

Kassie M, Jaleta M, Shiferaw B, Mmbando F, & Muricho G (2012). Plot and household-level determinants of sustainable agricultural practices in rural Tanzania.

Kato, E., Ringler, C., Yesuf, M., & Bryan, E., (2009). Soil and water conservation technologies: A buffer against production risk in the face of climate change? IFPRI Discussion Paper 00871.

Kaundjua, M.B., Angula M.N. & Angombe, S.T., (2012). 'Community perceptions of climate change and variability impacts in Oshana and Ohangwena regions', *Journal for Studies in Humanities and Social Sciences* 1(1), 21–32. [Google Scholar.

Kaur P, Stoltzfus J, &Yellapu V. (2018). Descriptive statistics. Int J Acad Med.

Kaya, H.O. (2016). Cultural Values and African Indigenous Knowledge Systems in Climate Change Adaptation, Journal of Social Sciences, 46:2, 130-136, DOI: 10.1080/09718923.2016.11893520

Keja-Kaereho, C., & Tjizu, B. R. (2019). Climate Change and Global Warming in Namibia: Environmental Disasters vs. Human Life and the Economy. *Management and Economics Research Journal*, *5*(1). DOI:10.18639/MERJ.2019.836535

Khanal, U., Clevo, W., Boon, L., & Viet-Ngu, H. (2018): Smallholder farmers participation in climate change adaptation programmes: Understanding preferences in Nepal. *Climate Policy*, 18(7):

Komba, C., & Muchapondwa, E. (2012). Adaptation to climate change by smallholder farmers in Tanzania, Economic research Southern Africa, Tanzania. Climate Change, Water and Food Security, Background Note, Overseas development institute, UK.

Kostova, P. (2001): Assessing and Measuring the Importance of Small-Scale Subsistence Farming in Bulgarian Agriculture, PhD Thesis, University of Newcastle, forthcoming.

Kumari, K.; Kumar, K.N.R. & Narasimba Rao, C.H (2018). Adverse Effects of Chemical Fertilizers and Pesticides on Human Health and Environment. HTTPs://www.jchps.com

Kuntashula, E., Chabala, L.M. and Mulenga, B.P. (2014), “Impact of minimum tillage and crop rotation as climate change adaptation strategies on farmer welfare in smallholder farming systems of Zambia”, Journal of Sustainable Development.

Kurukulasuriya, P., & R. Mendelsohn. (2008). Crop switching as an adaptation strategy to climate change. Afr. J. Agric. Resour. Econ.

Kuvare, U. Maharero, T & Kamupingene, G. (2008) Research on farming systems change to enable adaptation to climate change. University of Namibia for the Ministry of Environment and Tourism and the United Nations Development Program Namibia, Windhoek,

Lee, T. M., E. M. Markowitz, P. D. Howe, C. Y. Ko, & A. A. Leiserowitz, (2015): Predictors of public climate change awareness and risk perception around the world. Nat. Climate Change,

Lema, M.A. & Majule, A.E., (2009). Impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas of Tanzania: The case of Manyoni District in Singida Region, Tanzania. African Journal of Environmental Science and Technology.

Li, Y. P., W.; Ye, M.; Wang, and X. D. Yan, (2009): Climate change and drought: A risk assessment of crop-yield impacts. Climate Res.

Lin, B.B., 2011. Resilience in agriculture through crop diversification: adaptive management for environmental change. *Bioscience.*

Lipper, L., Thornton, P., Campbell, B. (2014). Climate-smart agriculture for food security. *Nature Clim Change.*

Liwenga E.T. (2003). Food insecurity and coping strategies in semi-arid areas

Lobell, D. B., M. B. Burke, C. Tebaldi, M. D. Mastandrea, W. P. Falcon, & R. L. Naylor, (2008). Prioritizing climate change adaptation needs for food security in 2030. Science,

Lorenzoni, I.; Nicholson-Cole, S. & Whitmarsh, L. (2007): Barriers perceived to engaging with climate change among the UK public and their policy implications. Global Environ. Change.

Mubita, L. (2018). "Is Agricultural productivity an engine for growth?'' Office of the President.

Madzwamuse, M. (2010). *Climate Change Vulnerability and Adaptation Preparedness in South Africa.* Document prepared for Heinrich Böll Stiftung Southern Africa

Mahmood, S., (2014). Impact of climate change in Bangladesh, Role of two governments', journal of ecology and the natural environmental vol

Makate, C.; Wang, R.; Makate, M.; & Mango, N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: Adaptive management for environmental change. Springer Plus

Manka K.S., (2014). Irrigation and Agricultural Water Management Systems in Gambia. Irrigation in West Africa: Current Status and a View to the Future. Proceedings of

the Workshop held in Ouagadougou, Burkina Faso, December 1-2, 2010. International Water Management Institute (IWMI), Colombo, Sri Lank

Maree, K. (2007). First Steps in Research. Van Schaik Publishers. Pretoria, South Africa

Mariotti L, Diallo I, Coppola E & Giorgi F. (2014) Seasonal and intra seasonal changes of African monsoon climates in 21st-century CORDEX projections. *Climatic Change*,

Marshall, N.A, Park, S., Howden, S.M., Dowd, A.B & Jakku, E.S., (2013). Climate change awareness is associated with enhanced adaptive capacity. Agric Syst.

Mbow, C, Smith, P, Skole, D, Duguma L, & Bustamante, M., (2014a) Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. Current Opinion in Environmental Sustainability Mbow, C., Van Noordwijk, M., Luedeling, E., Neufeldt, H, Minang P.A, & Kowero G., (2014b) Agroforestry solutions to address food security and climate change challenges in Africa. Current Opinion in Environmental Sustainability.

McCarthy, L., Lipper, L., & Branca, G., (2011). Climate-smart agriculture: smallholder adoption and implication for climate change adaptation and mitigation. FAO working paper, Draft.

Mendelsohn, R., Dinar. A.; & Deflect, A (2000). Climate change impacts on African Change: C

Mengistie, B. T., Mol, A. P; & Oosterveer, P. (2015): Pesticide use practices among smallholder vegetable farmers in Ethiopian Central Rift Valley. Environ. Dev. Sustain.,

Mertz O., C Mbow, C., Nielsen, J.Ø., A Maiga, A. & Diallo, D., A Reenberg, A., Diouf, A., B Barber., Moussa, I.B., M Zorom, M., Ouattara, I., & Dab,. D. (2010). Climate factors play a limited role for past adaptation strategies in West Africa. Ecology and Society.

Michie, S.; Van Strallen, M.M.; & West, R. (2011). The behaviour change wheel: A new method for characterizing and designing behaviour change interventions. Implement. Sci.

Ministry of Agriculture, Water and Rural Development. (2000). National water policy white paper. Windhoek: Government of Namibia.

Ministry of Environment and Tourism (MET). (2010). National policy on climate change for Namibia. Windhoek: Government of Namibia.

Ministry of Environment and Tourism (MET). (2011). Namibia Second National Communication on Climate Change to the United Nations Framework Convention on Climate Change. Ministry of Environment and Tourism, Windhoek,

Mirza, M.M.Q. (2003). Climate Change and extreme weather events: can be developing countries adapt? *Climate Policy.* V

Mishra, A. K. &Singh, V. P. (2010): A review of drought concepts. J. Hydrol.,

Mitigation and adaptation potential of sustainable farming systems. April 2009, Rev. 2

Mkonda, M. Y. He, H.X & Fustiness (2018). “Comparing Smallholder Farmers’ Perception of Climate Change with Meteorological Data: Experiences from Seven Agroecological Zones of Tanzania. “Weather Climate and Society Journal A.

Mofya-mukuka, R. & Kuhlgatz, C.H. (2014). Nutritional Effects of Agricultural Diversification and Commercialization in Children in Zambia. In Proceedings of the AAEA Annual Meeting, Minneapolis, MN, USA.

Molua, E. L (2008). Turning up the heat on African agriculture: The impact of climate change on Cameroon’s agriculture, African Journal of Agricultural and Resource Economics, 2(1),

Mongi, H., A. E. Majule, & J. G. Lyimo. (2010). “Vulnerability Assessment of Rain-Fed Agriculture to 70 M. Y. MKONDA AND X. HE Climate Change and Variability in Semi-Arid Areas of Tanzania.” African Journal of Environmental Science and Technology

Moore, E., & Llompart, J. (2017). Collecting, transcribing, analysing, and presenting plurilingual interactional data. In E. Moore & M. Dooly (Eds), Qualitative approaches to research on plurilingual education. Research-publishing.net.

Morton, J. F, (2009). The impact of climate change on smallholder and subsistence agriculture. PNAS

Mouton, J. (2001). How to Succeed in Your Masters and Doctoral Studies. A South African Guide and Resource Book. Pretoria. Van Schaik Publishers

Moyo, M., Mvumi., B.M., Kunekweguta, M., Mazvimavi, K., Craufurd, P. & Dorward, P. (2012). Farmer perceptions on climate change and variability in semi-arid Zimbabwe in relation to climatology evidence, *African Crop Science Journal*, *20*(2), 317–335.

Muhammad-Lawal, A. Funm, O.K, Fatimat, A.O, & Dayo, A., (2014). Assessment of land management practices in food crops production among small scale farmers in Kwara State, Nigeria. International Journal of Agricultural Management and Development 4:105-116

Muller, C. & Shackleton, S. (2014). Perceptions of climate change and barriers to adaptation amongst commonage and commercial livestock farmers in the semi-arid Eastern Cape Karoo. Afr. J. Range Forage Sci.

Müller, C., W. Cramer, W. L. Hare, & H. Lotze-Campen, (2011): Climate change risks for African agriculture. Proc. Natl. Acad. Sci. USA,

Murthy, I.K.; Dutta, S.; Varghese, V, &.; Kumar, P. (2016). Impact of Agroforestry System on Ecological. GloJ..j Sci. Front. Res.

Mustapha, S.B.; Sanda, A.H.& Shehu, H. (2012) _ Farmers' Perception of Climate Change in Central Agricultural Zone of Borno State, Nigeria. J. Environ. Earth Sci.

Muzamhindo, N.; Mtabheni, S.; Jiri, O. & Hanyani-Mlambo, B. (2015). Factors Influencing Smallholder Farmers' Adaptation to Climate Change and Variability in Chiredzi District of Zimbabwe. J. Econ. Sustain. Dev.

Namibia Statistic Agency (2014). 2011 Population and Housing Census National Planning Commission.

Nakanyete, N. F., Shikangalah, N. R., & Vatuva, A. (2020). Drought as a Disaster in the Namibian Context. *International Journal of Science and Research, 9*(3). 377-386. Retrieved from www.ijsr.net

Nelson, G.C., Valin, H., Sands, R.D., Havlik, P., Ahammad, H., Deryng, D., Elliott, J., Fujimori, S., Hasegawa, T., Heyhoe, E., & Kyle, P. (2017). Climate change effects on agriculture: economicresponsestobiophysicalshocks.*Proc.Natl.Acad.Sci.*

Nelson, G.C., Valin, H., Sands, R.D., Havlik, P., Ahammad, H., Deryng, D., Elliott, J., Fujimori, S., Hasegawa, T., Heyhoe, E., & Kyle, P. (2014). Climate change effects on agriculture: economic responses to biophysical shocks. Proc. Natl. Acad. Sci

Newsham, A.J. & Thomas, D. (2009). Agricultural Adaptation, Local Knowledge and Livelihood Diversification in North-Central Namibia; Research Technical Report; Tyndall Climate Change Research Centre: Norwich, UK.

Newsham, A.J. & Thomas, D.S.G., (2011), 'Knowing, farming and climate change adaptation in North-Central Namibia', *Global Environmental Change* 21, 761–770. http://dx.doi.org/10.1016/j.gloenvcha.2010.12.003

Ngaira, J, K.W. (2007). Impact of Climate Change on Agriculture by 2030. *Scientific Research and Essays*. Vol. 2 (7).

Ngugi, S.N. (2009). Climate change adaptation strategies: Water resources management options for smallholder farming systems in Sub-Saharan Africa. The MDG Centre for East and Southern Africa, the Earth Institute at Columbia University, New York.Pp.

Niang I, Ruppel OC, Abdrabo MA, Essel A, Lennard C, Padgham J & Urquhart P. (2014) Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Cambridge University Press, Cambridge, United Kingdom.

Nicholas.O, Madukwe.M.C., Enete A.A., Amaechina E.C, Onokala P. Eboth.E.C., Ujah.O., & Garforth.C.J., (2010). Barrier to climate change adaptation among farming households of Southern Nigeria.

Nickanor, N.M & Kazembe, L.N. (2016). Climate Change and Food Security in Namibia. University of Namibia: Windhoek. Omusati Regional profile.

Niggli U, Fließbach A, Hepperly P, Scialabba N (2009). Low greenhouse gas agriculture: Mvumi in Central Tanzania. Ph.D. Dissertation No. 11. Stockholm Studies in Human Geography, Stockholm University Stockholm, Sweden.

Nunes, I.; Kinyaga, V.; Lepaleni, E.; Hasheela, R. & Ishila, J. (2010). *Understanding How Communities in Ohangwena Region are Adapting to Climate Variability and*

Change. Windhoek. Desert Research Foundation & Integrated Environmental Consultant Namibia (IECN).

Nyong, A., Adesina, F., & Elasha, O., (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. Mitig. Adapt. Strat. Glob. Change.

Nzuma, J.M., Waithaka, M. Mulwa, R.M., Kyotalimye, M &. Nelson, G. (2010). Strategies for adapting to climate change in rural Sub-Saharan Africa. A review of data sources, poverty reduction strategy programs (PRSPs) and national adaptation plans for agriculture (NAPAs) in ASARECA Member Countries.

Ogalleh, S. A., Christian, R.V., Eitzinger, J., & Hauser, M., (2012). Local perceptions and responses to climate change and variability: The case of Laikipia District, Kenya. Sustainability,

Olzewski, J. (2010). *Consideration of Climate*. Windhoek. Desert Research Foundation of Namibia (DRFN)

Onakuse, S. (2012). The future of subsistence agriculture in the rural community of Uzanu,

Organization for Economic Co-operation and Development (OECD). (2012). Farmer behaviour, agricultural management and climate change. Paris, France:

Osbahr, H., Twyman, C., Adger, W.N & Thomas, D.S.G. (2010): Evaluating successful livelihood adaptation to climate variability and change in southern Africa. Ecol. Soc.

Osman-Elasha, B. (2022). *Women...In the Shadow of Climate Change.* Retrieved from https://www.un.org/en/chronicle/article/womenin-shadow-climate-change

Pearce, A. (2019). *Access to and knowledge of sexual and reproductive health services among adolescent school girls in Gobabis, Namibia* (Master's thesis, University of Namibia, Windhoek, Namibia). Retrieved from http://repository.unam.edu.na/bitstream/handle/11070/2481/pearce2019.pdf?sequence=1&isAllowed=y

Paavola, J. (2008). "Livelihoods, Vulnerability and Adaptation to Climate Change in Morogoro, Tanzania." Environmental Science & Policy 11: 642–654. Leeds, UK

Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., Church, J.A., Clarke, L., Dahie, Q., & Dasgupta, P., (2014). Climate Change Synthesis Report. Contribution of Working Groups I, Ii and Iii to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change: IPCC.

Pandey, R., Kumar, P., Archie., Gupta, A.K., Joshi, P., Valente, D., & Petrosillo, I. (2018). Climate change adaptation in the Western- Himalayas: Household Level Perspective on impacts and barriers. Ecological indicator.

Pant, K. P. (2009). Effects of Agriculture on Climate Change: A Cross Country Study of Factors Affecting Carbon Emissions. *The Journal of Agriculture and Environmen*t. Vol. 10. June 2009. Review Paper.

Pepela, M.M, Nabiswa, F & Mugalavi, E., (2019). Household indigenous drought coping and adaptation strategies in Baringo country, Kenya., Asia journal of environmental a& ecology,

Phiri, I.M.G & Saka, A.R., (2008). The Impact of Changing Environmental Conditions on Vulnerable Communities in the Shire Valley, Southern Malawi. In C. Lee and T. Schaaf (eds.), The Future of Drylands. 545, UNESCO.

Pienaar A, Coetzee C, & Nemakonde L., (2021). Ongoing climate crises and obstacles to adaptation: Observations from the Ditsobotla Local Municipality, South Africa. Jtransdiscipl res S Afr.

Piya, L., Maharjan, K.L., & Joshi, N.P., (2013): Determinants of adaptation practices to climate change by Chepang households in the rural Mid-Hilss of Nepal. *Regional Environmental Change,*

Punch F.K., (2001). Introduction to Social Research – Quantitative & Qualitative Approaches, Sage, London

Rakgase, M.A & Norris, D. (2015). Determinants of livestock farmers' perception of future droughts and adoption of mitigating plans Int. J. Clim. Change Strategies Manage.

Reed, B., Abidoye, B., & Mendelsohn, R. (2017). The economics of crop adaptation to climate change in South East Asia. Climate change Econ.

Reid H, Sahlén L, Macgregor J & Stage J., (2007). The economic impact of climate change in Namibia: how climate change will affect the contribution of Namibia's natural resources to its economy. Environmental Economics Programme, Discussion Paper 07-02, International Institute for Environment and Development, London,

Reid, H, Sahlén, L, Stage, J, & James MacGregor, J, (2008) "Climate change impacts on Namibia's natural resources and economy", Climate Policy,

Reliefweb., (2018). Namibia: Drought kills over300 livestock in Aminius. https://reliefweb.int/report/namibia/namibia-drought-kills-over-300-livestock-aminius

Republic of Namibia, (2011), *Second national communication of the Republic of Namibia to the United Nations framework convention on climate change*, Ministry of Environment and Tourism, Windhoek.

Republic of Namibia. (2015). Third National Communication to the United Nations Framework Convention for Climate Change.

Resnik, D.B., (2015), What is ethics in research & why is it important? National Institute of Environmental Health Sciences, viewed 11 November 2018, from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm

Rippke U, Ramirez-Villegas J, Jarvis A et al (2016) Timescales of transformational climate change adaptation in sub-Saharan African agriculture. Nat Clim Change

Rodenburg, J., Diagne, A.,Oikeh, S.,Futakuchi, K.,Kormawa, P.M.,Semon, M.,Akintayo, I., Cissè, B.,Sié, M.,Narteh, L.,Nwilene, F.,Diatta, S., Sere, Y.,Ndiondjop, M.N.,Youm, O., & Keya, S.O., (2006).Achievements and impact of NERICA on sustainable rice production in sub-Saharan Africa. International Rice Commission Newsletter

Rosenzweig, C., Iglesias, A., Yang, X.B., Epstein, P.R.& Chivian, E. (2001), "Climate change and extreme weather events; implications for food production, plant diseases, and pests", Global Change and Human Health, Vol. 2.

Rowhani, P.,. Lobell, D.B. Linderman. M & Ramankutty. N. (2011). "Climate Variability and Crop Production in Tanzania." Agricultural and Forest Meteorology, Science Direct

Rurinda, J., Mapfumo, P., Van Wijk, M.T., Mtambanengwe, F., Rufino, M.C., & Chikowo, R. (2014), 'Sources of vulnerability to a variable and changing climate among smallholder households in Zimbabwe: A participatory analysis', *Climate Risk Management* 3

Sarker, M.A.R., Alam, K. & Gow, J. (2012). "Exploring the relationship between climate change and crop production.

Schipper, E.L.F.; Cigarán, M.P. & Hedger, M.M. (2008). *Adaptation to climate change: the new challenge for Development in the Developing World*. An Environment & Energy Group Publication. Stockholm. Stockholm Environment Institute. UNDP

Shackleton, S., Ziervogel, G., Sallu, S., Gill, T., & Tschakert, P. (2015). Why is socially just climate change adaptation in sub-Saharan Africa so challenging? A review of

barriers identified from empirical cases. *Wiley Interdisciplinary Reviews: Climate Change*.

Shah, K.U., Dulal, H.B., Johnson, C. & Baptiste, A., (2013), 'Understanding livelihood vulnerability to climate change: Applying the livelihood vulnerability index in Trinidad and Tobago', *Geoforum*, 47, 125–137. http://dx.doi.org/10.1016/j. geoforum.2013.04.004

Shikangalah, R.N. (2020). The 2019 drought in Namibia: An Overview Journal of Namibian Studies, ISSN: 2197-5523 (online).

Shiningayamwe E.N. (2012). Crop rotation as a soil fertility improvement strategy using different legumes on a pearl millet field. Agricola.

Shumetie, A. & Alemayehu, M. (2017), "Effect of climate variability on crop income and indigenous adaptation strategies of households", International Journal of Climate Change Strategies and Management, Vol.

Sonko, E., Florkowski, W.J, Agodzo S., & Antwi-Agyei P., (2020) Subsistence farmer knowledge of strategies alleviating food insecurity in the context of climate change in the lower river region of the Gambia. Food Security

Sparks, T.H, Jeffree, E. P, & Jeffree, C.E (2000). An examination of the relationship between flowering times and temperature at the national scale using long-term phenological records from the UK. Int. J. Biometeorol.

Spear, D., Zaroug, M.A.H., Daron, D.D., Ziervogel, G., Angula, M.N., Haimbili, E.N., Hegga, S.S., Baudoin, M., New, M., Kunamwene I., Togarepi, C. & Davies J.E. (2018). Vulnerability and responses to climate change in drylands: The case of Namibia. CARIAA-ASSAR Working Paper. The University of Cape Town, Cape Town, South Africa. *Subtropics*,

Swe, L. M. M., Shrestha, R.P., T. Ebbers, T., & Jourdain, D., (2015): Farmers' perception of and adaptation to climate-change impacts in the dry zone of Myanmar. Climate Dev.

Tadesses, G & Dereje, M. (2018). Impact of climate change on smallholder dairy production and coping mechanism in sub-Saharan Africa- Review. Watchemo University, Animal Science Department, Hosanna and Haramaya University, School of Animals and range Science, Dire Dewa,

Talebi, K. & Tajeddin, M. (2011). The adoption of new and innovative knowledge by small and medium enterprises of Iran: opportunities and constraints for growth. African Journal of Business Management

Tazeze, A.; Haji, J.& Ketema, M., (2012), Climate Change Adaptation Strategies of Smallholder Farmers: The Case of Babilie District, East Harerghe Zone of Oromia Regional State of Ethiopia. J. Econ. Sustain.

Tesfaye, W. (2016), Climate change perception and choice of adaptation strategies Empirical evidence from smallholder farmers in east Ethiopia. *International Journal of Climate Change Strategies and Management*,

Thomas, D.S.G., Twyman, C., Osbahr, H., & Hewitson, B., (2007). Adaptation to climate change and variability: farmer responses to intra-seasonal precipitation trends in South Africa. Climatic Change.

Thompson J, Millstone E, Scoones I, Ely A, & Marshall, F (2007), STEPS Centre Working Paper 4. Agri-food System Dynamics: Pathways to Sustainability in an Era of Uncertainty, Brighton, UK: STEPS Centre.

Tibesigwa, B., Visser, M., Hunter, L., Collinson, M. & Twine, W. (2015), "Gender differences in climate change risk, food security, and adaptation: a study of rural households' reliance on agriculture and natural resources to sustain livelihoods", Environment for development discussion paper series (EfD)

Tingum M, Rivington, M, Bellocchi G, & Colls, J.J., (2008) Crop yield model validation for subsistence Farming

Tayengwa, D., Tirivangasi, H. M., & Rankoana, S. A. (2020). Rural Community Perceptions on the impact of climate change on subsistence farming: Mutoko Community in Zimbabwe. *Journal of Social Sciences and Humanities, 17*(7). 89-104. Retrieved from http://journalarticle.ukm.my/16990/1/41601-133082-1-SM.pdf

Torquebiau, E. (2013). Agroforestry and Climate change; Working Paper; CIRAD: Montpellier, France.

Turpie, J., Midgley, G., Brown, C., Barnes J., Pallett, J., Desmet, P., Tarr, J., & Tarr, P., (2010). *Climate change vulnerability and adaptation assessment for Namibia's biodiversity and protected area system.* Windhoek: Ministry of Environment and Tourism.

United Nations Development Programme (UNDP). (2015). PIMS 4711: scaling up community resilience to climate variability and climate change in Northern Namibia, with a sp on women and children

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2019). *Climate change mitigation and adaptation simple guide to schools in Africa.* Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000372168/PDF/372168eng.pdf.multi#:~:text=Mitigation%20measures%20are%20those%20actions,while%20adaptation%20addresses%20its%20impacts.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2021). Namibia Flood and Drought Monitor and Early Warning - A Participatory Workshop Addressing Disaster Risk Reduction Towards the National Framework for Climate Services. Retrieved from https://en.unesco.org/news/namibia-flood-and-drought-monitor-and-early-warning-participatory-workshop-addressing-disaster#:~:text=Many%20parts%20of%20Namibia%20are,affecting%20around%2070%2C000%20people%20annually.

Valdivia, C.; Hodge, S.S.; & Raedeke, A. (2002). Rural Livelihoods and agro-forestry Practice in the Missouri Flood Plains. In Proceedings of the17th Symposium of the International Farming system Association, Lake Buena Vitsa, FL, USA.

Van Wilgen, N. J., Goodall, V., Holness, S., Chown, S.L. & McGeoch, M.A., (2015) Rising temperatures and changing rainfall patterns in South Africa's national parks. Int. J. Climatol.

Viatte, G., (2009). *Responding to the food crisis: Synthesis of medium-term measures proposed in inter-agency assessments*, Rome: Food and Agriculture Organization of the United Nations (FAO).

Wambugu, F & Mburu, N, (2014). Potential for Sorghum in Food Security and Economic Development among Communities in Arid and Semi-arid Lands in Africa. Research report Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA).

Wanvoeke J, Venot J-P, De Fraiture C, & Zwarteveen, M., (2016) Smallholder Drip Irrigation in Burkina Faso: The Role of Development Brokers. The Journal of Development Studies 5

Wilhelm M. (2012). The impact of climate change in Namibia: a case study of Omusati Region. Submitted in partial fulfilment of the award of Master of International Business, Polytechnic of Namibia, 89.

Wisner, B., Blaikie, P., Cannon, T. & Davis, I. (2004). At risk: Natural hazards, people's vulnerability and disaster, 2nd edn., p. 472, Routledge, London.

World Wildlife Fund. (2022). *What's the difference between climate change mitigation and adaptation?* Retrieved from https://www.worldwildlife.org/stories/what-s-the-difference-between-climate-change-mitigation-and-adaptation

Woltering, L., Pasternak, D., & Njenga, J., (2011). The African market garden: The development of a low-pressure drip irrigation system for smallholders in the Sudano Sahel. Irrigation and Drainage.

World Food Programme. (2017). Namibia | WFP | United Nations World Food Programme - Fighting Hunger Worldwide. Available Online: http://www.wfp.org/node/3530

Yanda, P. Z. (2015). "Climate Change Implications for Management and Use of Agricultural Biodiversity Resources in Africa." Environment and Ecology Research

Yaro, J.A., (2013). The perception of and adaptation to climate variability/change in Ghana by small-scale and commercial farmers. Reg Environ Change.

Zabel F, Putzenlechner B, & Mauser W (2014). Global agricultural land resources—a high resolution suitability evaluation and its perspectives until 2100 under climate change conditions. PLoS One 9: e107522. https://doi.org/10.1371/journal.pone.0107522

Zeidler J., Kandjinga, L. & David, A. (2010), Study on the effects of Climate Change in the Cuvelai Etosha Basin and possible adaptation measures. Integrated Environmental Consultants Namibia, Windhoek, 34.

Zougmoré R.B., Partey S. T, Ouédraogo, M., Torquebiau E., & Campbell, B.M. (2018). Facing climate variability in sub-Saharan Africa: analysis of climate-smart agriculture opportunities to manage climate-related risks. Cahiers Agricultures.

Zoysa, M.D & Inoue, M (2014). Climate Change impacts, Agroforestry Adaptation and Policy Environmental in Sri Lanka. J

APPENDICES

Appendix A: Questionnaire

ASSESSING THE IMPACT OF CLIMATE CHANGE ON CROP PRODUCTIVITY OF

SUBSISTENCE FARMERS IN NAMIBIA: CASE STUDY IN OMUSATI REGION

Researcher

Victoria Hauwanga

University of Namibia (Namibia Business School)

Phone: +264816673055

Email: vickyh.hauwanga@gmail.com

Thank you for choosing to participate in the study. I am conducting research to learn more about the impact of climate change in Omusati Regionparticular in Etayi and Elim Constituencies in Namibia. The participation will direct to the household head. A household head is defined as a person of either sex who is looked upon by other members of the households as their leader or main decision-maker during fieldwork (Namibia Statistic Agency, 2011). Your answers are very important because they will help me to achieve the objective of my study.

Your participation in this case study is strictly voluntary and you may refuse to participate or discontinue participation at any time. You may also skip any question that you don't wish to answer. This research is for academic purpose only not for rewards your decision

to participate will not affect you or any family members' present or future relation with the researcher or the University of Namibia.

All responses will be kept strictly confidential No need to write your name. Your responses will be seen only by authorized researcher working on this project. Data gathered for this project will be analysed as a whole. The results of analysis will be shared with researchers and government authorized especial in Agricultural sector who will be interested in the study the impact of climate change on crop production in subsistence farming in northern part of Namibia.

The questionnaire sessions will take you about 10- 15 minutes to complete.

Thank you very much. I appreciate the effort and your time.

SECTION A- BACK GROUND INFORMATION

The questions gather some background information about you that will help us to understand your answers to the following sections.

1. Please indicate gender of the house head
    - Female
    - Male
    - Prefer not to say

2. Please indicate age group of the house head
    - 16-24
    - 25-34

- 35- 44
- 45-54
- 55-64
- 65-74
- 85 or above
- Prefer not to say

3. What is the highest qualification for the house head?

- No formal education
- Primary school
- Secondary school
- Vocational
- Degree or equivalent
- Postgraduate qualification
- Other (please write……

4. Total number of household members

- 1-3
- 4-6
- 7-9
- 10-12
- 13-15

- 16-17
- 18-20

5. Occupation of the house head
   - Pensioner
   - Employment
   - Self-employment without employee
   - Self-employment with employee
   - Self-employment with employee

Other categories please write…….

SECTION B -WEATHER CONDITIONS.

May you kindly indicate by ticking or mark (X) the YES or NO on the following statements	Yes	No
Do you know what climate change is?		
Did you experience the weather change over the last 5 to 10 years?		
Do you expect the weather to change in future or years to come?		
Do you believe climate change has an impact on crop production in general?		
Does the weather become more unpredictable from years to years?		

Do you believe that perceived change of weather condition is caused by climate change?		
Do you think rainfall has changed since, you started farming?		
Do you think an average temperature has changes since you started farming?		
Do you believe that climate change will cause decrease rainfall in the future?		

Indicate the intensity of drought and floods experienced during period of ten years

- Severe
- Mild
- Not at all

SECTION C - CROP PRODUCTION (YIELD)

Kindly indicate by ticking or mark with an X the extent to which you agree or disagree with the following statements	Strongly agree	Agree	Not sure	disagree	Strongly disagree
Did you lose more crops during the last 5-10 years, due to floods or drought?					

Have you noticed change in crop yield or crop quality over 10 years?					
Do you think that the crop yields on your farm will change in the future?					
Has the land changed and the number of yields that you receive from your farm changed in any way in the time that you have been farming here?					
Are you worried about your food supply in the future?					
Do you plan on continuing to farm the way that you are currently farming?					
Would you be willing to grow new crops?					
Have you changed the crops that you grow or planting techniques in response to the change in yields?					

Use of drought resistant varieties (such as Kangara and Okashana #2 instead of Ongonga					
Change of farming practices or crops?					

Kindly indicate by ticking or mark with an X the impacts of climate change on a specific crop yields on the following crops	Very severe	Severe	Moderate	Slight	Very slight
Maize					
Sorghum					
Pearl millets					
Ground and Bambara nuts					
Another crop…… …..					

SECTION D- ADAPTATION AND MITIGATION

1. What is preventing you from using different farming practices? (Circle your response)

   - Lack of information
   - Alternative farming practice
   - Money
   - Time
   - Labour
   - Other…….

Kindly indicate by ticking or mark with an X on cultivation methods you have use used: as mitigation strategies?	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
Intercropping					
Mulching					
Diversifying crop					
Ripper- Furrowing					
Drip Irrigation					
Crop Rotation					

Kindly indicate by ticking or mark with an X the extent to which you agree or disagree with the following statements; which method of adaptation strategies are you using?	Strong Agree	Agree	Not Sure	Disagree	Strongly Disagree
No adaptation strategies					
Crop- livestock diversification and other good practice (mixed cropping, crop rotation, Mulching, organic fertilizer Use of improved varieties, chemical fertilizer and pesticides					
Agro forestry and perennial plantation (oil palm, orchard, tree species)					

Diversification of income-generating activities / non - farm activities					
Adjusting sowing dates.					
Integrated farming system					
Soil conservation activities					
Use of hybrid irrigation crops seed					

Kindly indicate by ticking or mark with an X the extent to which you agree or disagree with the following statements	Strongly agree	agree	Not sure	Disagree	Strongly Disagree
It's important to change crop choice or seed choice or varieties that can cope with climate?					
Do you use improved crop variety?					
Agriculture diversification is important in reducing the impact of climate change on crop production?					
It's necessary to dig trenches in and around crop fields to inundation?					

Appendix B: NBS research permission letter

NBS
NAMIBIA BUSINESS SCHOOL
UNIVERSITY OF NAMIBIA

14 April 2021

TO WHOM IT MAY CONCERN

Re: MBA Natural Resource Management ,Student – Ms. Victoria Hauwanga Student Number-200848925

As part of our Masters Programme, students are expected to submit a research report after completion of their course-work. They need to explore in detail, some concepts and issues pertaining management strategies. To do that effectively, they need to conduct interviews and obtain practical examples.

Ms. Hauwanga has chosen your organization to approach for information. It is against this background that I wish to kindly request you to assist Ms. Hauwanga with the information she requires. Accept our assurance that the data will be used for academic purposes only. A copy of the completed document will be available at the Namibia Business School for perusal. Her research synopsis indicates that her topic touches on "Assessing the impact of climate change on crop production of subsistence farmers in Namibia: Case study in Omusati Region(Elim and Etayi constituencies).".

Your kind assistance is highly appreciated.

Yours sincerely

NAMIBIA BUSINESS SCHOOL
NBS
2021-04-14
UNIVERSITY OF NAMIBIA
Inspiring Minds & Shaping the Future

Greenfield Mwakipesile. Dr
Senior Research Co-Ordinator
Namibia Business School
University of Namibia
Tel: +246 61 413 500
Fax: +246 61 413 512
Email: mwakipg@nbs.edu.na

340 MandumeNdemufayo Ave. – Private Bag 16004 – Pionierspark – Windhoek – Website: www.nbs.edu.na
Tel: + 264 (61) 413500 – Fax +264 (61) 413512 – E-mail: info@nbs.edu.na

Appendix C: Language editing certificate

Dr.GM

The Rev. Dr. Greenfield Mwakipesile

ThD, MBA, HBS | mwakipg@outlook.com

CONTACT

PO Box 99539,
UNAM,
Namibia

LANGUAGE & COPY-EDITING CERTIFICATE

21st January 2022

RE: LANGUAGE, COPYEDITING AND PROOFREADING OF VICTORIA HAUWANGA's THESIS FOR THE MASTER OF BUSINESS ADMINISTRATION DEGREE OF THE NAMIBIA BUSINESS SCHOOL OF THE UNIVERSITY OF NAMIBIA

This certificate serves to confirm that I copyedited and proofread **VICTORIA HAUWANGA's** Thesis for the **MASTER OF BUSINESS ADMINISTRATION DEGREE** entitled: **ASSESSING THE IMPACT OF CLIMATE CHANGE ON CROP PRODUCTIVITY OF SUBSISTENCE FARMERS IN NAMIBIA: A CASE STUDY OF THE OMUSATI REGION**

I declare that I professionally copyedited and proofread the thesis and removed mistakes and errors in spelling, grammar, and punctuation. In some cases, I improved sentence construction without changing the content provided by the student. I also removed some typographical errors from the thesis and formatted the thesis so that it complies with the University of Namibia's guidelines.

I am a trained language and copy editor and have edited many Postgraduate Diploma, Masters' Thesis, Dissertations and Doctoral Dissertations for students studying with universities in Namibia, Zimbabwe, Eswatini, South Africa and abroad. I have also copy-edited company documents for companies in the region and abroad.

Please feel free to contact me should the need arise.

Yours Sincerely,

The Rev. Dr. Greenfield Mwakipesile

greenfield.mwakipesile

@mwakipg

+264813901701

Dr. Greenfield Mwakipesile