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DEPARTMENT OF ECONOMICS

MASTERS IN FINANCIAL ECONOMICS

PERCEIVED IMPACTS OF CLIMATE VARIABILITY AND CHANGE: AN EXPLORATION OF FARMERS' ADAPTATION STRATEGIES IN ZIMBABWE`S INTENSIVE FARMING REGION. CASE OF MAZOWE DISTRICT

BY

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We, the undersigned do hereby certify that we have read and therefore recommend to Great Zimbabwe University for acceptance; a research project titled "Perceived impacts of climate variation and change: an exploration of farmers' adaptation strategies in Zimbabwe's intensive farming region. Case of Mazowe district" submitted by Janet Tanaka Mupfawi in partial fulfillment of the requirements of the Master of Financial Economics

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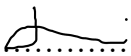
DECLARATION

I, Janet Tanaka Mupfawi, do hereby declare that this research project is a presentation of my own work except to the extent indicated in the acknowledgements, references and by comments included in the body of the report, and that it has not been submitted in part or in full to another University or any other Institution of Higher Learning.

SIGNED: ……  ……,

DATE: ……06/10/2023…….

DEDICATIONS

To my dearest mom Helen Mupfawi, my kids (Tadisa, Taida and Ceejay), my sister Pamela Masvaya as well as my friends Tatenda Zibizapanzi and Palmer Mahlahla.

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ABSTRACT

The primary aim of the study was to examine the perceived impacts of climate variation and change: an exploration of farmers' adaptation strategies in Zimbabwe's intensive farming region using the Mazowe district as the case study. The specific objectives of the study were to determine the level of awareness of farmers about climate variability and change effects, to examine the perceived impacts of climate variation and change on farming output, to determine the effect of climate adaptation strategies on agricultural production and to recommend alternative sustainable adaptation strategies to climate variability and change. The mixed-method approach was employed and the cross-sectional research design was adopted. Both quantitative and qualitative primary data were collected using semi-structured survey questionnaires and key informant interviews. The target population for the study included the commercial farmers, extension officers, district administrators, district representatives from the ARDA, district representatives from the Ministry of Lands, Agriculture and Rural Resettlement as well as district GMB officials in Mazowe district. The study used the simple random sampling and the purposive sampling techniques. Quantitative data was analysed using descriptive and regression analyses whilst qualitative primary data was analysed using the content analysis technique. The study revealed that the climate change adversely impacted agricultural production whilst climate change adaptation had significant positive effects on agricultural production. The study also found the farmers were aware of the effects and threats of climate variability and change. The research concluded that climate variability and change have significant negative effects on agricultural production in the intensive farming region of Zimbabwe particularly in Mazowe district. The study recommended education and training programs to farmers regarding the impacts of climate variation and change to ensure adoption of innovative adaptive strategies such as SMART agriculture, artificial insemination and underground water harvesting.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

FAO	Food and Agriculture Organization
NDS1	National Development Strategy 1
OLS	Ordinary Least Square
SLF	Sustainable Livelihoods Framework
SSA	Sub-Saharan Africa

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE: INTRODUCTION

1.1 Introduction

Climate variability and change evidenced by extreme climatic conditions have been major threats to achieving sustainable agricultural production and food security in many developing countries including Zimbabwe (Shirazu, Doke & Yahaya, 2022). The adverse impacts of climate variation and change have been found to be high in most African developing countries including the Sub-Saharan African (SSA) countries as most farmers depend on rain-fed farming (Byshimo, 2018; Popoola, Monde & Yusuf, 2018). According to the Food and Agriculture Organisation (2022), SSA is among the most vulnerable African regions to climate change shocks and hazards. The severity of climate variability and change effects on agriculture in SSA is believed to be mostly caused by inability to adapt by most farmers (FAO, 2022; Ochieng, Kirimi & Mathenge, 2017). In this concern, existing studies have shown that one way of reducing the severity and vulnerability of climate variability and change effects is through adaptation (Atube *et al.*, 2021; Mavhura, Manyangadze & Aryal, 2022; Popoola *et al.*, 2018).

Nevertheless, there is lack of comprehensive empirical studies on the impacts of climate variation and change as well as adaptation strategies of farmers in the context of SSA countries including Zimbabwe. The issue of lack of related studies in the context of Zimbabwe was also highlighted by Jiri (2020) and Mavhura *et al.* (2022). Precisely, Jiri (2020) stated that although extensive research has been done on the impacts of climate variation and change across Africa, little has been done in Zimbabwe. This gap in literature represented an opportunity for this study which aimed to determine the climate variability and change effects and explore the farmers' adaptation strategies in Zimbabwe.

1.2 Background of The Study

The issue of climate variability and change has been a global concern. Due to globalisation, climate variability and change evidenced by extreme climatic conditions such as high temperatures, low and unpredictable rainfall, pest and disease invasion, floods and drought have been witnessed over the past decade (Mavhura *et al.*, 2022; Popoola *et al.*, 2018). At global level, the agriculture sector has been the most vulnerable to climate variability and change as temperature, rainfall and humidity are key success factors for high agricultural production (Atube *et al.*, 2021). The agricultural sector is sensitive to climate conditions and has become one of the most vulnerable sectors to the threats and impacts of climate change and global diversity (FAO, 2022). Despite its great contribution to the economies of developing nations, the agricultural sector in most developing countries has faced persistent and severe challenges due to a number of factors (Jiri, 2020, Shirazu *et al.*, 2022). For example, climate-related risks, such as floods and droughts, are major risks. Climate change and variability have always adversely affected the agricultural sector and are expected to worsen in the future (Ochieng *et al.*, 2017; Oduniyi, 2018).

In Africa, the SSA countries have been found more vulnerable to the impacts of climate variation and change and Zimbabwe is of no exception. In Zimbabwe, climate variability and change have been of concern as these have been attributed to the decline in agricultural production which ultimately hamper national food security. As reported by FAO (2022), Zimbabwe's food security and agricultural production has significantly declined over the past three decades. This has also been witnessed by the decline in the contribution of agriculture sector to gross domestic product (GDP) from over 30% to less than 20% between 2000 and 2020 (Runganga & Mhaka, 2021). In addition, over the past decade, Zimbabwe has witnessed significant decline in the production of major crops such as maize and wheat (FAO, 2022). These have been attributed to climate variability

and change (Jiri, 2020; Mavhura *et al.*, 2022). According to FAO (2022), with the changing climate, agricultural production in Zimbabwe is expected to see a 33% yield reduction by 2030. The decline in agricultural production in Zimbabwe has been a national concern as the economy's economic growth is dependent on the agricultural sector (Runganga & Mhaka, 2021).

Hence, improving and intensification of the agricultural sector and improving agricultural production particularly, maize production has been the main focus of the government of Zimbabwe towards achieving the Vision 2030 Agenda where the Zimbabwe is expected to become a middle upper income economy by the year (Government of Zimbabwe, 2021). For instance, in the recent National Development Strategy 1 (NDS1) (2021-2025), one of the priority areas of the government of Zimbabwe is increased agricultural production, food security and nutrition. Specifically, the goal of NDS1 is to increase food self-sufficiency and maintain the country's position as a regional breadbasket until the year 2025. The main goals are to increase food self-sufficiency from the current 45 percent to 100 percent by 2025 and reduce food insecurity from the current peak of 59 percent to below 10 percent in 2020 (Government of Zimbabwe, 2021). Nevertheless, climate variability and change has been found to be a threat towards achievement of these national objectives. In doing so, climate change adaptation and mitigation has been found one of the ways to achieve the stated national objectives.

In this regard, there have been efforts by the Government of Zimbabwe and other stakeholders to put in places that address the adverse impacts of climate variation and change and promote adoption of adaptation strategies (Mavhura *et al.*, 2022). Nevertheless, the policies tend to be ineffective as they have been drafted based on little empirical evidence. As argued by Mumbengegwi (2020), using agricultural policy instruments to affect agricultural activities without empirical knowledge may result in inappropriate use of policy instruments thereby producing unintended results. Hence, this

study given lack of empirical evidence aims to make significant contributions to both practice and policy by understanding the climate variability and change effects and explore the farmers' adaptation strategies in Zimbabwe using micro-level data. The study's focus is on the intensive farming region of Zimbabwe using a case study of Mazowe district.

The intensive farming region in Zimbabwe popularly known as Region II is among the five major farming regions in the country with an average rainfall between 750 and 1000 mm (FAO, 2022). In this region, both crop and livestock farming are practiced. The major crops grown in this region in maize, flue-cured tobacco, wheat, coffee, cotton, sugar beans and other horticultural crops whilst cattle, poultry and pig production are also practiced (FAO, 2022). This region covers Mashonaland West, Mashonaland East and Mashonaland Central provinces and is considered the stronghold of agricultural production in Zimbabwe. According to FAO (2022), region II has the highest contribution of 33% to the total agricultural output of Zimbabwe. Nevertheless, despite being intensive, the region is one of the regions prone to climate variability and change and extreme weather conditions (Mavhura *et al.*, 2022, Nyahwo, Hlalele & Ncube, 2020). Precisely, over the past two decades, the region has been vulnerable to drought, localised intense precipitation, pests and diseases, long dry-spells and storms (Mavhura *et al.*, 2022, Tawodzera & Ncube, 2020). These have been found to have adverse effects on agricultural production in the region resulting in 20-30% decline in production of major cash crops such as maize and tobacco over the past decade (FAO, 2022). On the other hand, livestock production declined by 34.3% between 2010 and 2021 (Government of Zimbabwe, 2022).

From this region, Mazowe district is one of the districts in region II that has been mostly vulnerable to climate variability and change (Mavhura *et al.*, 2022, Newsham, Shonhe and Bvute, 2021). Over the past decade, decreasing rainfall amounts, rising temperatures,

long dry spells and short wet seasons have been witnessed in the district (Basera, 2020; Chingombe and Siziba, 2021; Newsham *et al.*, 2021). These adversely impacted agricultural activities in the district resulting in adaptation strategies such as shifting to drought resistant crops, practicing irrigation, practicing climate-smart agriculture, water harvesting, practicing Pvumvudza conservation agriculture, planting short-term varieties and practicing agroforestry (Mavhura *et al.*, 2022). According to Basera (2020) and Newsham *et al.* (2021), the decline in maize and tobacco production in Mazowe district over the past two decades has been largely caused by climate change and extreme weather conditions. Besides, there is lack of empirical research on the impacts of climate variation and change as well as the adaptation strategies of farmers in the intensive region of Zimbabwe particularly Mazowe district. Hence, this study aims to bridge the notable research gaps by examining the climate variability and change effects and farmers' adaptation strategies in Zimbabwe using the case study of Mazowe district.

1.3 Research Problem

Climate variability and change is a global concern especially in the developing world. Zimbabwe is among the developing countries experiencing adverse impacts of climate variation and change on agricultural production and productivity (Ndlovu, Prinsloo & le-Roux, 2020). In Zimbabwe, climate variability and change have been found to have adverse effects on the agricultural sector resulting in low agricultural production which ultimately lead to food insecurity and high food prices further leading to poverty (Mugambiwa & Rukema, 2020; Ndlovu *et al.*, 2020). Hence, climate variability and change continue to be a great concern to the Government of Zimbabwe as it has been found as a significant threat to the national objectives stated in the Vision 2030 Agenda for Sustainable Development and the NDS1. In this regard, there have been several efforts to mitigate climate variability and change. Nevertheless, there is lack of empirical evidence on the climate change adaptation strategies being employed by farmers and their

effects on agricultural production in the case of Mazowe district, one of the districts vulnerable to climate variability and change. This therefore indicates existence of a significant gap that necessitates further research. This current study therefore attempts to fill the gaps by examining the climate variability and change effects and explore the farmers' adaptation strategies in Zimbabwe precisely in Mazowe district. Although, the study by Mavhura *et al.* (2022) found established perceived effects of CVC and adaptation strategies of farmers in Zimbabwe's intensive farming region, the quantitative cross-sectional survey research was limited as conclusions were only based on quantitative analyses. This therefore motivated the researcher to carry out an in-depth and comprehensive exploration of the CVC effects and adaptation strategies of the farmers in the same region using the mixed-method research design.

1.4 Objectives of the Study

The study sought to achieve the following objectives:

1. To determine the level of awareness of farmers about climate variability and change effects.
2. To examine the perceived impacts of climate variation and change on farming output;
3. To determine the effect of climate adaptation strategies on agricultural production
4. To recommend alternative sustainable adaptation strategies to climate variability and change

1.5 Research Questions

The following were research questions for this study:

1) What is the level of awareness of farmers about climate change effects and threats?

2) What are the perceived impacts of climate variation and change on farming?

3) What are the effects of climate adaptation strategies of the farmers to agricultural production?

4) What alternative sustainable adaptation strategies may be employed to address climate variability and change?

1.6 Statement of Hypotheses

The study aimed to test the following research hypotheses:

H_1: There is low level of awareness of climate change effects and threats among farmers in Mazowe district

H_2: Climate variability and change has significant negative effects on agricultural production

H_3: Climate change adaptability has significant positive effects on agricultural production

1.7 Contribution of the Study

Completion of this study will make significant contributions to theory. The theoretical contribution of the study will be that new information will be added to the existing theory given lack of empirical studies on the subject. In doing so, the research will contribute to the existing stock of empirical studies on climate variability and change effects and adaptation strategies. From the review of empirical literature, although several studies have examined the impacts of climate variation and change, significant gaps in literature have been noted. For instance, majority of previous studies (Bai *et al.*, 2022, Belloumi,

2018; Mubenga-Tshitaka *et al.*, 2021; Omondi, 2019) have been country-level case studies whilst a few were micro-level case studies (Mavhura *et al.*, 2022; Musetha, 2017). Hence, there is lack of empirical evidence based on first-hand information from the grass-root level such as farmers who directly experience the impacts of climate variation and change.

Besides, majority of the previous studies have been conducted outside Zimbabwe such that the results may not be generalised to the Zimbabwean situation. In addition, previous researches in the context of Zimbabwe such as Jiri (2020), Mavhura *et al.* (2022) and Ndlovu *et al.* (2020) only investigated the impacts of climate variation and change whilst also ignoring the effects of climate change adaptation strategies of the farmers on agricultural production. Hence, this study which also seeks to determine the impact of climate change adaptation on agricultural production will help in addressing the existing knowledge gap. In short, the proposed study will be more comprehensive compared to the previous studies as it investigates the impacts of climate variation and change as well as effects of climate change adaptation strategies.

1.8 Delimitations of the Study

The research focused on information and literature related to the impacts of climate variation and change as well as adaptation strategies of farmers. Geographically, the study was confined to the Zimbabwe's farming region using a case study of Mazowe district. In terms of time period, the research was limited to the period from 2010 to 2022 so as to work with updated and current information. The target population included commercial farmers in Mazowe district, extension officers, district administrators, district representatives from the Agricultural and Rural Development Authority (ARDA), district representatives from the Ministry of Lands, Agriculture and Rural Resettlement as well as district GMB officials in Mazowe district.

1.9 Limitations of the Study

The researcher faced several limitations including the following:

- The researcher was able to collect data from all the commercial farmers in the Mazowe district. This could have influenced validity and generalisability of results. Nevertheless, the researcher made use of a representative sample to enhance validity and generalisability of results. More so, the use of methodological triangulation enhanced validity and reliability of results.

- In addition, the target respondents were not willing to participate in the research due to several reasons. Nevertheless, the researcher sought permission to conduct the research and the respondents were allowed to participate at voluntary will.

1.10 Organisation of the Study

The research was organized into five chapters as follows: Chapter One presented the introduction of the study outlining the background of the study, the research problem, research objectives, research questions, significance of the study, delimitations and limitations of the study as well as definitions of key terms. Thereafter, Chapter Two presented the critical review of theoretical and empirical literature. The theoretical framework is also presented as well as the review of empirical studies. More so, Chapter Three presents the research methodology and research design for the study. The chapter will also present the theoretical model specification, data sources and justification of variables. Chapter Four focuses on presenting, analyzing and interpreting the results of the study. Lastly, Chapter Five presents the summary, conclusions and recommendations for the study.

1.11 Chapter Summary

The chapter presented the introduction of the study outlining the background of the study, the research problem, research objectives, research questions, significance of the study, delimitations and limitations of the study as well as definitions of key terms. The next chapter presents the critical literature review for the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The preceding chapter provided the introduction and background of the research. This chapter presents a critical review of empirical and theoretical literature relevant to the study. The theoretical framework with the main theory guiding the research is presented and discussed as well as the review of empirical studies. The main theories underpinning the study namely the Cobb-Douglas theory, the Sustainable Livelihoods Framework and the Ricardian theory are reviewed in this chapter. In addition, the review of empirical studies starting from the global level (targeting studies from Europe, South America, North America and Asia) down to regional level (studies done in Africa) and lastly local level (studies in the context of Zimbabwe). From the empirical review, research gaps which the study also seeks to fill are identified. The conceptual framework guiding this study is also presented in this chapter.

2.2 Theoretical Framework

The main theories underpinning the research are the Cobb-Douglas theory and the Sustainable Livelihoods Framework (SLF).

2.2.1 Cobb-Douglas theory

The study is theoretically grounded on the Cobb-Douglas theory propounded by Charles Cobb and Paul Douglas in 1927. This theory models the relationship between production output and production inputs and factors (Mubenga-Tshitaka *et al.*, 2021). More specifically, the Cobb-Douglas theory predicts the maximum possible production output given the combination of inputs (Gechert *et al.*, 2019). The theorists developed the equation

to explain the model commonly known as the Cobb-Douglas production function presented as follows:

$$Q = AK^{\alpha}L^{\beta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: Q = production output; A= technical knowledge reflecting technological improvements; K = level of capital, L = amount of labour, α and β represent elasticities of production output to K and L respectively. The theory states that output depends directly on levels of capital (K) and labour (L) and that part of the output which is not explained by K and L inputs is explained by technical change represented by A (Ishikawa, 2021). According to Mahaboob *et al.,* 20*1*9), the Cobb-Douglas theory is regarded a panacea for analysing production processes based on restrictive conditions such as climate variability and change in this study.

This theory is applicable to this study which seeks to examine the impacts of climate variation and change as well as adaptation strategies. This is because apart from labour and capital, climatic conditions such as rainfall, temperature and sunlight are natural input factors that influence agricultural production. In addition, technical knowledge as predicted in the theory represents technical knowledge for climate change adaptation strategies. Hence, the Cobb-Douglas theory aids in explaining the effects of climate variation and change and change as well as adaptation strategies in Mazowe district. Nevertheless, the theory has been severely criticised in existing literature. For instance, the Cobb-Douglas theory considers only two inputs, capital and labour and neglects other important inputs which are key for production such that the theory may not be applicable to estimate output produced using more than two inputs (Gechert *et al.,* 2019). In addition, opponents of the Cobb-Douglas theory argue that the theory is based on constant returns to scale which is not a reality as either decreasing or increasing returns to scale are applicable in production (Ishikawa, 2021). Besides, the theory has been found relevant in this study.

2.2.2 Sustainable Livelihoods Framework

The study also borrows the theoretical lens of the Sustainable Livelihoods Framework advanced by Scoones (1998). The framework has two main aspects, the environmental and social dimensions and these are essential for sustainable livelihoods. The environmental dimension involves the sustainability of the natural resource base which represents sources of livelihoods. According to Scones (2019), the environmental dimension includes the capability of the natural system to sustain productivity when exposed to disturbing external forces or shocks and the social dimension includes aspects such as adaptation, vulnerability and resilience. Vulnerability refers to the degree of susceptibility, exposure and adaptability to external shocks whilst resilience refers to the capacity of responding to, adapting to and recover from external shocks (Thakur & Bajagain, 2019). The major components forming the SLF include the vulnerability context, livelihood resources, transforming institutional and the organisational processes and structures, the livelihood strategies and the sustainable livelihood outcomes (Scoones, 2019). This Sustainable Livelihoods Framework can be diagrammatically presented as shown in Figure 2.1.

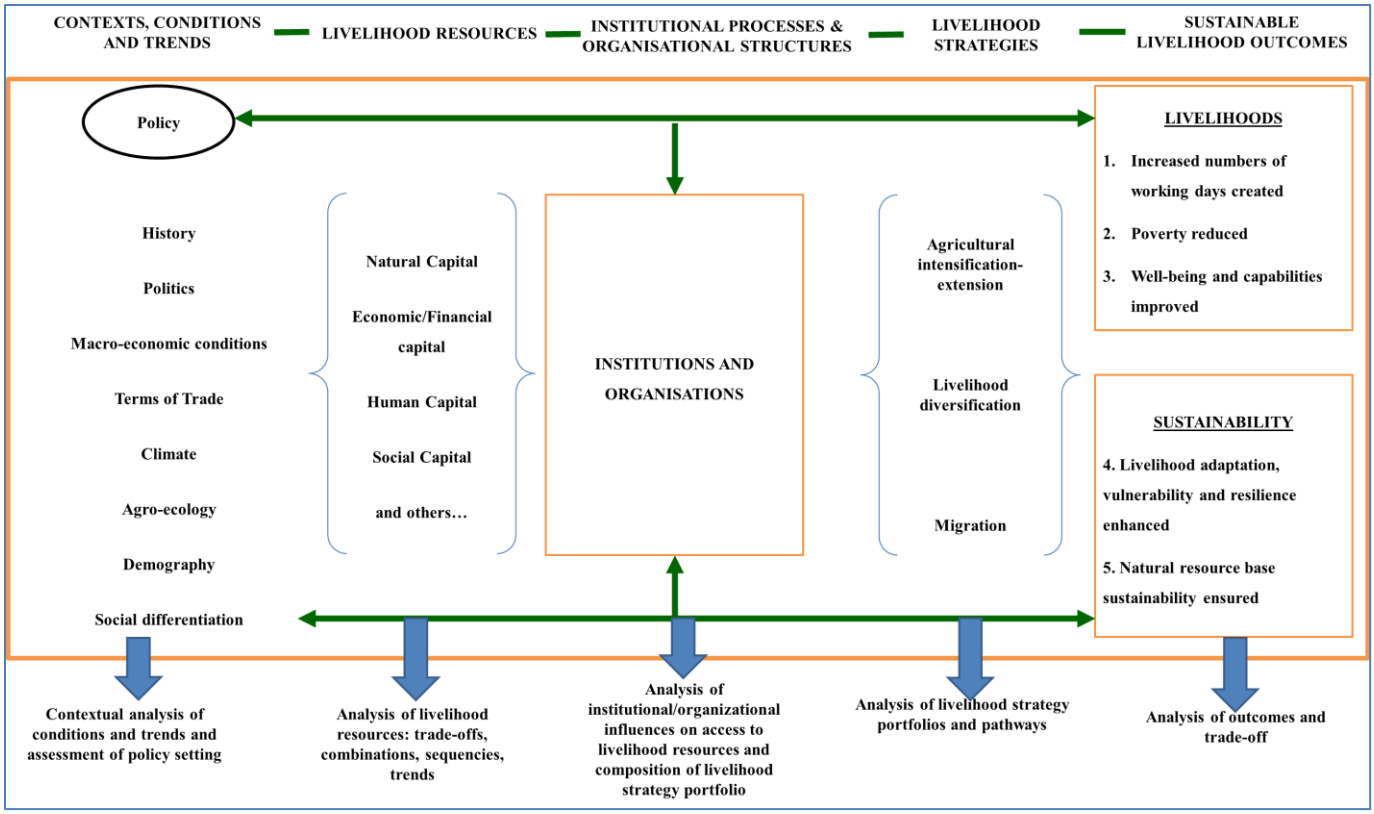

Figure 2.1. The Sustainable Livelihoods Framework

Source: Scoones (2019)

As shown in Figure 2.1, climate change is among the contexts and conditions that influence sustainable livelihoods of communities whilst livelihood adaptation strategies such as agricultural intensification and diversification enhances resilience leading to sustainable livelihoods. In this study, agricultural production represents the source of livelihoods of the farmers in Mazowe district which are impacted by contextual external shocks such as climate variability and change. Hence, this Sustainable Livelihoods Framework has been found relevant to the present study which aims to examine the climate variability and change effects and explore the farmers' adaptation strategies in Zimbabwe. This Sustainable Livelihoods Framework has been widely employed in previous studies on climate change effects and climate change adaptation (Defe & Matsa, 2021; Muringai *et*

al. (20). Nevertheless, SLF has been criticized for being insufficiently dynamic and inflexible in the sense that it fails to capture environmental 'change' (Natarajan *et al.* (22). Besides, the framework has been found the most applicable to this study.

2.2.3 Ricardian theory

The study is also anchored on the Ricardian theory named after the 19th century classical economist, David Ricardo (1772–1823) but firstly introduced by Mendelsohn, Nordhaus and Shaw (1994). The theory was developed to study long-term effects of climate change on agriculture whilst accounting for climate-change adaptation (Bozzola *et al., 201*8). According to Melkamu (2023), the Ricardian theory is applied to measure the sensitivity of agricultural production to climate and other factors. The basic concept of the theory is that agricultural production practices are correlated with climatic variables. The main assumption is that land rents reflect expected agricultural productivity (Van-Passel, Massetti & Mendelsohn, 2018). The theory estimates how much observed cross-sectional variations of land values or revenues can be explained by climatic or other confounding factors (Tun *et al.*, 2020).

The major strength of the Ricardian theory is its ability to measure long-run effects of climate change taking into account the ability to adapt (Bozzola *et al., 201*8). According to the model, climate change results in long-term resource shortages such as worsening soil conditions, water, disease and pest outbreaks which adversely impact on crop and livestock productivity. The theory was found applicable in this study which seeks to examine the perceived effects of climate change as well as climate change adaptation on agricultural production in Mazowe district. The approach has been widely used in existing literature to evaluate the effects of climate change on agriculture for instance it has been applied in previous researches by Omondi (2019), Tun *et al.* (2020) and Van-Passel *et al.* (2018). Nevertheless, the theory has been criticized for not taking into account non-climatic factors such as socio-economic conditions (Huong, Bo and Fahad, 2019).

2.3 Empirical Literature Review

This section presents the review of empirical studies related to the research topic and objectives from the global level (studies outside Africa), to the regional level (studies done in Africa) and lastly the national level (studies done in Zimbabwe):

Empirical evidence in Europe (global level)

A significant number of empirical studies have been carried out across Europe to examine climate change effects. Among these is the study by Van-Passel *et al.* (2018) which employed the Ricardian analysis of the effects of climate change on agricultural production in Europe. Farm level data was gathered using a sample of 41,030 farmers across Western Europe. Data was analysed using the median quantile and the ordinary least square regression (OLS). The results revealed that European agriculture was sensitive to climate change as significant losses in agricultural output occur. Besides using a large sample, the study left out the adaptation strategies of farmers and their effects thereby underestimating their potential effects in agriculture.

A similar study to that of Van-Passel *et al.* (2018) was conducted by Peichl *et al.* (2019) in the context of Germany to determine the climate change effects on maize yield. Secondary data was gathered and analysed using regression analysis. The explanatory variables considered in the study included soil moisture anomalies, rainfall and temperature. The results indicated that climate variation and change results in an average maize yield reduction of 120 to 1050 kilograms per hectare. Nevertheless, other factors such as adaptation were not included in the model thereby affecting validity of the model as accounting for adaptation might have effects on maize yield of Germany.

Furthermore, Maitah *et al.* (2021) analysed the influence of rainfall and temperature variability on maize yield and production in Czech Republic for the period 2002 to 2019. Secondary data was gathered and analysed using t-test and correlation analyses. These

researchers found a significant negative correlation between variability in rainfall and temperature on maize yield in Czech Republic. The present study differs from the study of Maitah *et al.* (2021) as it relies on primary data due to lack of secondary data on climate change variables in Zimbabwe. In addition, Maitah *et al.* (2021) failed to take into account climate change adaptation strategies which moderate the effects of climate change on maize yield.

From the aforementioned review of empirical studies done in the context of Europe, it can be concluded that majority of the studies have found that climate change has adverse effects on agriculture. There is also agreement among scholars and researchers that climate change adaptation has significant positive effects on agriculture in developed European countries.

Empirical evidence in South America (global level)

Similar studies to those conducted in Europe have also been carried out in South America to understand the effects of climate change on agricultural production. One of these studies is the research by Lachaud *et al.* (2022) which examined the economic effects of climate change on agricultural productivity and production across the Latin American and the Caribbean (LAC) countries. Precisely, the researchers estimated the effects of climate change on Total Factor Productivity (TFP) and agricultural production. Secondary data from 28 LAC countries for the period from 1961 to 2014 was gathered. The stochastic production frontier (SPF) model was followed to capture heterogeneities in partial output and technology elasticities across the LAC countries as well as unobserved environmental characteristics. The results showed that climate change induces significant reductions of about 9.03% to 12.7% in productivity resulting in losses ranging from US$14.7 to US$31.4 billion dollars. This study differs from the present study as it was done at regional level whilst the present study is done in the context of Zimbabwe using a case study of Mazowe district.

Gallacher *et al.* (2017) studied the impacts of climate variation on agricultural production in Argentina. The research made use of survey data which was analysed using the Probit model. The results designated that climate variation and change had significant negative effects on agricultural production. The researchers concluded that farmers in Argentina were vulnerable to climate variation and change. Nevertheless, the results and conclusions may not be generalised to other contexts such as the Zimbabwean context.

In a relatively comprehensive research, Cunha, Féres and Braga (2021) studied the effects of climate change on Brazil's agriculture in consideration of irrigation adoption as a climate-change adaptation strategy. Precisely, the study aimed to find out how climate variation and change influences agricultural production and how irrigation adoption reduced farmers' vulnerability to climate change. The researchers employed the matching methods to analyze secondary data gathered. Data on rainfall and temperature projections for the 2010 to 2019 was analysed. The results showed negative impacts of climate variation on agricultural production whilst irrigation was found a very effective tool for counteracting the adverse effects of climate change. The results confirm the important role of climate change adaptation on agricultural production. Similar to this, the present study also aims to determine the impacts of climate variation and change as well as the effects of climate change adaption strategies but in the context of Zimbabwe.

In summary, the preceding review of empirical studies done in South America has shown that most of the studies found similar results regarding the impacts of climate variation and change. Majority of the studies found that climate variability and change negatively impact agricultural production in terms of productivity and output. The results show that climate change has adverse effects on agricultural production among South American countries. The results also confirm the important role of climate change adaptation on counteracting the adverse effects of climate change.

Empirical evidence in North America (global level)

Studies have also been carried out to determine the impacts of climate variation and change in the North American continent. For instance, Estrada *et al.* (2022) examined the economic effects of climate change on agricultural production in Mexico. The study quantified the effects of climate variation and change on the yields of six major crops in Mexico. Secondary data on harvested area, yield and production for the period 2003 to 2012 on the six major crops: maize, sorghum, rice, soybean, wheat and sugarcane were gathered. Data was analysed using multiple-regression analysis. Nevertheless, the present study only focuses on maize which is a major and common crop among farmers in Mazowe district. The results showed that climate variation and change accounts for about 70% of losses and reductions in crop yields resulting in losses amounting to US$37,934 million dollars. This study was secondary based such that the perceived effects of farmers and their adaptation strategies were overlooked. In addition, the present study differs from that of Estrada *et al.* (2022) as the researcher is not interested in quantifying the monetary/economic costs of climate variation and change due to data unavailability but on the general impacts of climate variation and change on crop production.

More so, Eitzinger *et al.* (2019) assessing the effects of climate change on tomato and Cocoa production in Jamaica. Primary data was gathered using survey questionnaires and analysed using descriptive and t-test analyses. The study revealed significant differences between the climate change effects on tomato and cocoa as small reductions in Cocoa production were found due to high resistance of the crop to temperature increases. Climate change was found to have adverse effects on tomato production compared to Cocoa. These results are important to this present study Nevertheless, the major difference is that the present study is not a comparative analysis of the effects of climate change but an analysis of the perceived effects of climate change on maize production.

Joshi *et al.* (2022) studied the impacts of climate variation and change on total agricultural productivity in the Southern part of the United States. The researchers made use of

secondary data to estimate stochastic production frontier models. The Cobb–Douglas functional form was employed as the regression model for the study. Other explanatory variables included were agricultural labour force. The findings revealed that variations in both temperature and rainfall have significant negative effects on production and productivity. Nevertheless, the results may not be applicable to low-income countries such as Zimbabwe as the study was done in a high-income country.

In a nutshell, the above is a review of empirical studies on effects of climate change on agriculture in the context of North America. From the review of the studies, there is agreement among scholars that climate variability and change have significant negative effects on agricultural production and productivity. The results prove that the effects of climate change on agriculture are similar across the North American continent.

Empirical evidence in Asia (global level)

This section reviews some of the empirical researches on the impacts of climate variation and change done in Asia: One of the studies in the context of Asia is that study by Bai *et al.* (2022) which examined the effects of climate change on agricultural productivity in China. The researchers used secondary climatic and agricultural productivity data between 2000 and 2019. The ordinary least square (OLS) technique was employed. The results showed that climate change has significant negative effects on agricultural productivity and food security. Nevertheless, the results may not be generalised to the Zimbabwean context as China is a developed economy whilst Zimbabwe is a developing economy. This means that there could be significant differences in climate change vulnerability as well as climate change adaptation strategies.

Similar to Bai *et al.* (2022), Tun *et al.* (2020) carried a research to measure the economic impacts of climate variation and change on crop production in Myanmar, a country with the highest climate change vulnerability in Southeast Asia. The Ricardian model was employed. Primary quantitative data was gathered using a cross-sectional survey on a

random sample of 425 farmers. A non-linear regression analysis was utilised and the study revealed that between climate change measured by variations in temperature and rainfall negatively impacted crop productivity. Although the study provides empirical-based research findings from the climate change perspective, study did not examine the climate change adaptation strategies of the farmers creating a knowledge gap which the current study aims to address.

Hasan and Kumar (2020) also carried a research to examine the perceived farm-level climate change effects on agricultural productivity in coastal areas of Bangladesh. Primary data was gathered through a household survey conducted on a purposively selected sample of 381 households. Complementary qualitative data was gathered using focus group discussions. The researchers modelled the perceptions using the generalized linear regression logit model. From this study, 64% of the participants perceived that climate change was responsible for the decline in in farm productivity. In addition, the participants perceived dry period salinity, floods and coastal inundations as the major indicators of climate change which adversely affected crop productivity. The logistic regression further revealed that significant variations in agricultural productivity were due to climate change variations. The results have helped the current researcher in having an appreciation of climate change effects, Nevertheless the results may only be applicable to coastal areas and landlocked countries such as Zimbabwe.

In a different perspective, Gorst, Dehlavi and Groom (2018) examined the link between climate change adaptation and crop productivity in Pakistan. Precisely, the researchers examined the effect of climate change on productivity of wheat and rice. Data was gathered using a household survey of 1422 households. The propensity score matching and the endogenous switching regression analyses were employed. The results of the study revealed significant positive effects of climate change adaptation on crop productivity. The results of this study are useful to this current study, Nevertheless, the researchers failed to clearly specify the adaptation strategies employed as a dummy variable was employed.

Basing on this, this current study makes a significant contribution to the existing literature by first establishing the adaptation strategies employed by the farmers and then examine their effects on crop production.

In summary, the abovementioned review of empirical studies done in the context of Asia have shown that climate variability and change have significant adverse effects on agriculture. Most of the studies have found that climate change has negative effects on agricultural productivity whilst climate change adaptation has positive effects on agriculture. From the review, climate change has negative effects on agriculture across the Asian continent.

Empirical evidence in Africa (regional level)

This section presents a critical empirical review of studies on the impacts of climate variation and change done in the African continent exclusive of Zimbabwe: Belloumi (2018) investigated the effects of climate change on agricultural production in Southern and Eastern African (ESA) countries. Panel data between 1961 and 2011 was gathered and analysed using panel regression. The study was a cross-sectional research of 11 countries. Climate change was measured using temperature and rainfall variability data. Other independent variables included land under cultivation and economically active labor in agriculture. The study revealed that temperature and rainfall variability negatively influenced agricultural production among ESA countries. In addition, land under cultivation and agricultural labourforce were found to have significant positive effects on crop production. In this present study, land under cultivation and agricultural labourforce are also included in the model as they represent capital and labour inputs for the farmers in Mazowe district.

In East Africa, Mubenga-Tshitaka *et al.* (2021) examined the short-and long-run impacts of climate variation on agricultural output. The study utilised secondary data from 1961 to 2016. The independent variables included labour, land under cultivation, machinery,

temperature variability, irrigation and rainfall variability. Data was analysed using regression analysis and the results revealed short-term and long-term negative effects of rainfall and temperature variability on agricultural output among East African countries. Land under cultivation was found to have significant positive effects on agricultural output. The results made a significant contribution to body of literature as it quantified both the short-term and long-term impacts of climate variation on agricultural output.

A similar research of Omondi (2019) examined the effect of climate variability and change on agricultural production in Kenya. Precisely, the study aimed to determine the effects of climate change on both livestock and crop production in Kenya. Time series data was employed and data analysed using the Ricardian model. The variables considered were livestock production and crop production as dependent variables whilst temperature, relative humidity and rainfall variability were included as independent variables. The study concluded that climate change negatively impacted livestock and crop production in Kenya. Nevertheless, the present study on focuses on the impacts of climate variation and change on crop production using the major crop (maize) cultivated by majority of the farmers in Zimbabwe specifically Mazowe district.

Musetha (2017) aimed to determine the effects and adaptation options of climate variability and change on agricultural production in South Africa. The study further aimed to determine the level of awareness of farmers about climate change effects and threats. Primary data was gathered using questionnaires over a random sample of 150. Data was analysed using logistic regression. The results of the study revealed high levels of awareness among farmers. The study revealed that climate variability and change resulted in reduction in livestock production and crop yields. Nevertheless, the study also found that adaptation strategies such as planting different varieties, crop diversification, different planting dates and shortening of planting periods have positive effects on agricultural production. Although this study revealed the climate change adaptation strategies, it did not examine the effects of these strategies on agricultural production. To address, the

present study also examines the effects of climate change adaptation on agriculture production.

From the preceding review of empirical studies done in African developing countries, there is agreement among previous researchers that climate variability and change negatively impact agriculture. There is also consensus among researchers that climate change adaptation has significant positive effects on agricultural production among the African countries. The results show that climate variability and change have similar effects across the African content.

Empirical evidence in Zimbabwe (local level)

This section presents a review of some of the empirical studies on the impacts of climate variation and change in the context of Zimbabwe. Recently, Mavhura *et al.* (2022) carried a research on the impacts of climate variation and change as well as farmers' adaptation strategies in Zimbabwe. A cross-sectional quantitative research design was employed. Primary data was gathered using a structured questionnaire using a random sample of 365 farmers. Data was analysed using descriptive statistics. The results showed negative impacts of climate variation and change including soil salinisation and reduced crop yields. The researchers also found that the adaptation strategies such as crop and land use management, use of short-season varieties, crop diversification, mixed-farming, intensified irrigation and drought resistant crops had positive influence on crop yields given climate variability and change. Nevertheless, the results of this study lack validity as only one method of data collection was employed. In this concern, the present study aims to enhance validity of the results by employing a mixed-methods research where multiple data collection and analysis methods are employed. Although, the study by Mavhura *et al.* (2022) found established perceived effects of CVC and adaptation strategies of farmers in Zimbabwe's intensive farming region, the quantitative cross-sectional survey research was limited as conclusions were only based on quantitative analyses. This therefore motivated the researcher to carry out an in-depth and comprehensive exploration of the CVC effects

and adaptation strategies of the farmers in the same region using the mixed-method research design.

Prior the study of Mavhura *et al.* (2022), Jiri (2020) studied the impacts of climate variation and change on crop productivity in Zimbabwe. The main objective was to identify the perceptions of smallholder farmers to climate variability and change as well as the influence of indigenous knowledge systems in deciding adaptation strategies. Primary data was gathered using household surveys, key informant interviews, observations and focus group discussions. A random sample of 100 farmers was selected. Data was analysed using multinomial regression analysis. In addition, linear trend analyses of temperature and rainfall data from 1980 to 2011 was undertaken to corroborate farmers' perceptions. The study found that low rainfall and high temperatures negatively impacted crop production. The results also indicated that farmers in Chiredzi district perceived decrease in annual rainfall. Farmers' adaptation options were found to include adjusting planting dates, drought tolerant crops as well as crop diversification. The study concluded that the perceptions of the farmers help to them to shape climate change adaptation strategies. The other conclusion was that climate variability requires the use of a variety of agricultural strategies and crop selection in order to reduce vulnerability and increase flexibility and capacity to adapt to climate changes and variability. Although this study looked into adaptation strategies of farmers, it was limited as it only focused on indigenous knowledge systems whilst ignoring innovative adaptation strategies which may be more effective compared to traditional adaption strategies. This present study therefore aims to address this by considering both traditional and modern adaptation strategies of farmers but in the context of Mazowe district.

More so, Dhliwayo *et al.* (2022) examined the impacts of climate variation as well as coping strategies in Chiredzi district of Southeast Zimbabwe. Primary quantitative and qualitative data were gathered from 133 participants using questionnaires, focus group discussions and key informant interviews. Purposive and convenient sampling techniques

were employed. Data was analysed using simple linear regression analysis. The study found that climate variation and change resulted in increased livestock mortality Nevertheless no significant changes in crop yields were obtained due to climate variation and change. Further, the research established that farmers have negative perceptions towards climate change adaption strategies. The results of this study contradict those obtained by Jiri (2020) who carried a similar study in the same district. This therefore implies that from the two researches, the effects of climate variation and change are inconclusive. Thus, this present study seeks to contribute to this scholarly debate by examining the climate variability and change effects but in the context of Mazowe district. Besides, the use of methodological triangulation (use of multiple data collection methods) enhanced validity and credibility of the findings. The present study also follows a similar methodology for enhanced validity and credibility of findings.

Kasimba (2018) also carried out a research on the effects of climate change on crop production in Zimbabwe using a case study of Guruve district. Both qualitative and quantitative research methodologies were employed. Structured questionnaires and interviews were employed to collect data from the farmers. Variables considered included rainfall, crop diseases and temperature. The study found that climate variability and change negatively affect crop productivity as a result of high temperatures, insufficient rains and outbreak of crop diseases. Besides being relevant to this present study, the research by Kasimba (2018) failed to consider the adaptation strategies of the farmers which this current study takes into consideration so as to come up with sound recommendations for policy and practice.

In summing up the reviewed empirical studies, there is agreement among scholars and researchers that climate variability and change do negatively impact agricultural production in Zimbabwe. All the reviewed studies found that climate variability and change have found significant negative effects on agriculture precisely on livestock and crop production and productivity. In addition, some of the studies also found that climate change

adaptation strategies have positive effects on agricultural production. Nevertheless, there is dearth of empirical studies in the context of Mazowe district as previous studies have focused on other districts in Zimbabwe. This study therefore aims to fill the existing knowledge gap by examining the perceived impacts of climate variation and change as well as climate change in Mazowe district.

2.4 Conceptual Framework

From the aforementioned theoretical and empirical literature review as well as the research objectives, the conceptual framework for the study shown Figure 2.2 was developed. The conceptual framework shown in Figure 2.2 demonstrates how climate variability and change (independent variable), climate change adaptation strategies (mediating variables) influence agricultural production (dependent variable).

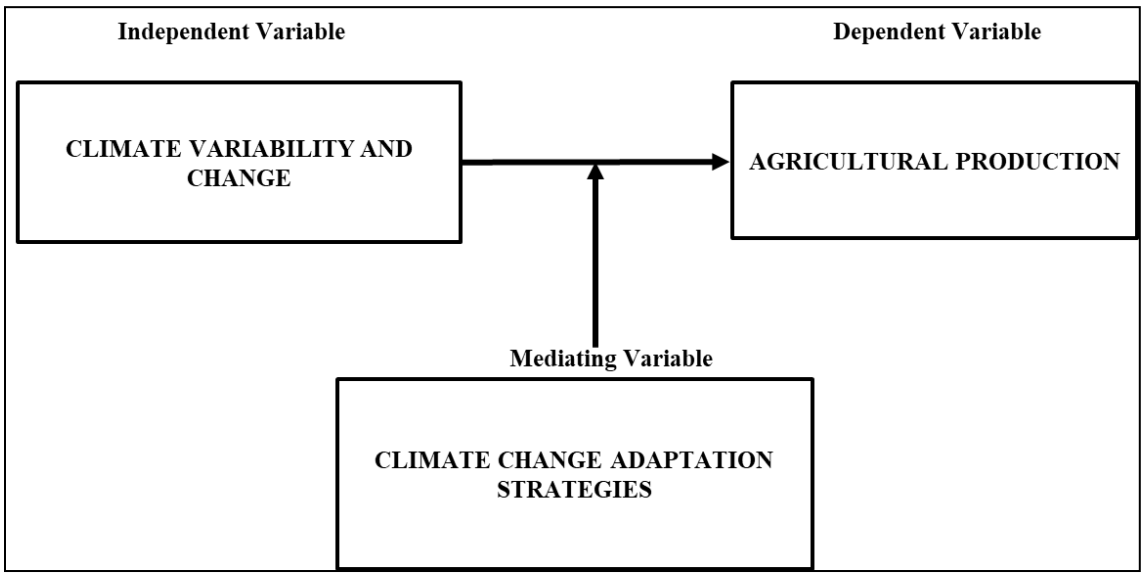

Figure 2.2: Conceptual framework for the study

Source: Researcher's own construction (2023)

2.5 Conclusion

The chapter presented the critical review of theoretical and empirical literature related to climate change effects on agriculture. The theoretical framework with the main theory guiding the research has been presented and discussed as well as the review of empirical studies. Empirical studies from global level to regional level and lastly local level have been reviewed and research gaps which the study aims to fill have been outlined. The conceptual framework for the study has also been presented. The resulting chapter presents the research methods adopted to accomplish the objectives of this research study.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines and describes the research methods, procedures and tools used to achieve the objectives of the study. The study collected primary data using survey questionnaires and key informant interviews. Precisely, the chapter outlines, discusses and justifies the research design and approach, the theoretical model specification, empirical model specification, data sources, definitions and justifications of the variables as well as the estimation procedures. The mixed-method research design was employed to collect both quantitative and qualitative data using survey questionnaires and key-informant interviews. Mazowe district which is one of the districts in region IIa was used as the case study. The target population of the study consisted of commercial farmers or farm managers, extension officers, district administrators, district representatives from the Agricultural and Rural Development Authority (ARDA), district representatives from the Ministry of Lands, Agriculture and Rural Resettlement as well as district GMB officials in Mazowe district. Random sampling and purposive sampling methods were employed. The theoretical model for the study was the log-transformation linear function of the Cobb-Douglas production function. The research made use of primary data sources where primary cross-sectional data gathered using semi-structured questionnaires and key informant interviews. Data were analysed using descriptive and regression analyses through the OLS technique.

3.2 Research Design and Approach

Creswell (2020) defined research design as the blueprint for collecting, measuring and analyzing data. According to Creswell (2020), researchers have to choose between the quantitative, qualitative and mixed-method research designs basing on research questions. Hence, based on the research objectives, this study adopted the mixed-method research design

and approach to guide the data collection and analysis. To achieve the objectives of the study, quantitative primary data were collected using structured questionnaires and primary qualitative data was collected using key informant interviews. This mixed-method research was also a cross-sectional survey research. The other rationale for choosing the mixed-method research approach was that the approach permitted the researcher to carry out both statistical and non-statistical analyses to have an in-depth understanding of the subject.

3.3 Study Area

The study was carried out in Mazowe district. Mazowe district which is one of the districts in region IIa was used as the case study as it has been mostly vulnerable to climate variability and change (Mavhura *et al.*, 2022; Newsham, Shonhe & Bvute, 2021). In addition, over the past decade, decreasing rainfall amounts, rising temperatures, long dry spells and short wet seasons have been witnessed in this district (Basera, 2020; Chingombe & Siziba, 2021; Newsham *et al.* 2021). These adversely impacted agricultural activities in the district resulting in the decline in maize and tobacco production in Mazowe district over the past two decades (Basera, 2020; Newsham *et al.*, 2021). The major crops grown in this district in maize, flue-cured tobacco, wheat, citrus fruits especially oranges, coffee, cotton, sugar beans and other horticultural crops whilst cattle, poultry and pig production are also practiced (FAO, 2022).

The district is located to the southwestern part of the Zimbabwe's Mashonaland Central province. It lies between longitudes 30°36′18″–31°17′32″E and latitudes 16°47′2″–17°44′28″S. The average annual rainfall in the district is 901 mm whilst the average monthly maximum temperatures range from 20.2°C to 31.4°C, whilst the average monthly minimum temperatures range from 5.4°C to 15.9 °C (FAO, 2022). More so, the district is characterized by five main land tenure systems namely A1, communal, A2, institution as well as privately owned farms. Figure 3.1 shows the geographical map of the study area.

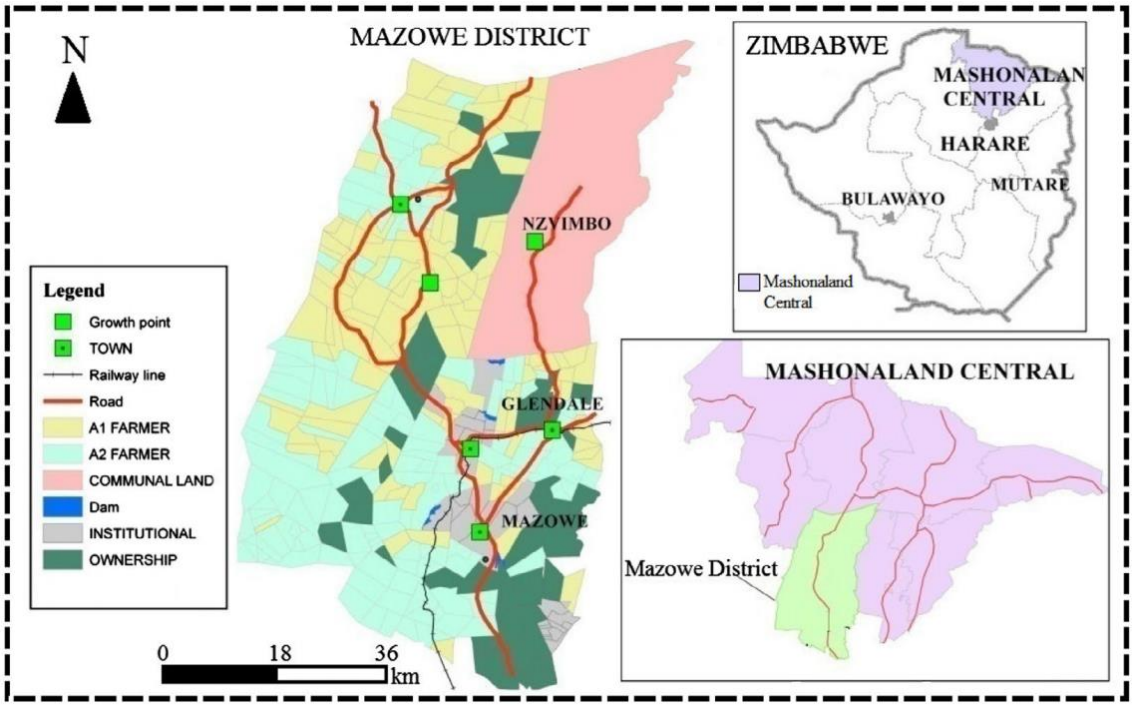

Figure 3.1: Geographical map of Mazowe district

Source: https://www.humanitarianresponse/zimbabwe/infographic/mazowe-district-map

3.4 Target Population

The target population of the study consisted of commercial farmers or farm managers, extension officers, district administrators, district representatives from the Agricultural and Rural Development Authority (ARDA), district representatives from the Ministry of Lands, Agriculture and Rural Resettlement as well as district GMB officials in Mazowe district. According to the recent Department of Agricultural Extension's statistics the commercial farmers' population in Mazowe district stood at 367 in 2022 whilst the district has a total of five Agritex officers, two district representatives from ARDA and three representatives from the Ministry of Lands, Agriculture and Rural Resettlement and one district GMB official.

3.5 Sampling and Sample Size

The study employed both probability and non-probability sampling techniques. The random sampling method was utilised to select the commercial farmers to participate in the survey whilst the purposive sampling technique was adopted to purposively select participants to the key informant interviews. Random sampling was found the most suitable sampling technique as it eliminated sampling bias since each individual commercial farmer had an equal chance of being selected. On the other hand, the purposive sampling technique was found the most applicable sampling technique as it permitted the researcher to use own judgement to select individuals with expert knowledge regarding the subject matter being investigated. The sample size for the interviews was determined using the data saturation concept whilst the sample size for the survey was determined using the Yamane's (1967) formula. The following Yamane's (1967) sample size determination formula was utilized to estimate the representative sample size for the survey using an error margin of 5% and 95% confidence interval:

$$\mathrm{n} = \frac{N}{1 + Ne^2} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (1)$$

Where, e, n and N represent margin of error, sample size and population size respectively. Given the known population estimate of 367 commercial farmers and the sampling error of 5% at 95% confidence level, the representative and ideal sample size for this research study was found to be 192 as shown below:

$$\mathrm{n} = \frac{367}{1 + 367(0.05)^2} = 191.395 \sim 192 \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (2)$$

3.6 Theoretical Model

The theoretical model for the study was the log-transformation linear function of the Cobb-Douglas production function as follows:

$$lnQ = lnA + \alpha lnK + \beta lnL \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where: lnQ = natural logarithm of production output; lnA= natural logarithm of technical knowledge reflecting technological improvements; lnK = natural logarithm of level of capital, lnL = natural logarithm of amount of labour, α and β represent elasticities of production output to K and L respectively. The theory states that output depends directly on levels of capital (K) and labour (L) and that part of the output which is not explained by K and L inputs is explained by technical change represented by A (Ishikawa, 2021).

3.7 Empirical Model

The study's model was further developed basing on the empirical model specification of Omondi (2019) whose regression model as specified as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where: Y = net farm output, X_2= temperature variability, X_1= rainfall variability, X_3= relative humidity variability, X_4= irrigation and μ_i = error term.

3.8 Model Specification

Basing on the Cobb-Douglas production function and empirical model specifications of Bai *et al*. (2022) and Omondi (2019) with some modifications, the model for this study was as follows:

$$Y = \beta_0 + \beta_1 CVC + \beta_2 CCA + \beta_3 LUC + \beta_4 AGL + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Where: Y = farm output, CVC = climate variability and change, CCA = climate change adaptation, LUC = land under cultivation in hectares, AGL = agricultural labourforce measured by economically active population at the farm and μ_i = error term.

3.9 Data Sources

The research made use of primary data sources where primary cross-sectional data gathered using semi-structured questionnaires and key informant interviews targeting farm managers or owners, extension officers, district administrators, district representatives from ARDA, district representatives from the Ministry of Lands, Agriculture and Rural Resettlement as well as district GMB officials in Mazowe district. The semi-structured questionnaire contained open-ended and close-ended Likert scale questions. The following Likert scale was employed: 1 = Strongly disagree, 2 = Disagree, 3 = Not sure, 4 = Agree and 5 = Strongly agree. In addition, the structured questionnaire had four main sections: Section A gathered socio-demographic information of participants, Section B gathered data on the farmers' perceptions on climate variability and change, Section C collected data on the perceived impacts of climate variation and change and Section D collected data on the adaptation strategies of the farmers.

The semi-structured questionnaires were preferred in this research as they were cost-effective and time-saving. More so, the questionnaires permitted the researcher to collect large amounts of data over a large population. Semi-structured questionnaires were also suitable to this mixed-method research as they collected both quantitative and qualitative data. The questionnaires also collected standardized data which was easy to analyse, present and interpret. On the other hand, key informant interview guides with open-ended questions were formulated to gather qualitative data. The key informant interviews were semi-structured in nature such that the research had the opportunity to probe further such that in-depth qualitative data was collected. More so, interview data triangulated data from the semi-structured questionnaires thereby enhancing validity of findings.

3.10 Justification of Variables

The study's dependent variable was farming output whilst the main independent variables were climate variability and change as well as climate change adaption and other independent

variables included in the model include agricultural land under cultivation and agricultural labour force. The justifications for inclusion of these variables are provided as follows:

3.10.1 Maize output (Y)

Farming output was the dependent variable which was proxied by maize output as maize is the major crop in Mazowe (FAO, 2022). Primary data for this variable was collected using a structured questionnaire where respondents indicated the average change of maize output in tonnes between 2021 to 2022. The four-Likert scale (1 = decreased, 2= no change, 3= not sure and 4 =increased) was used where respondents indicated whether on average, maize output decreased, remained constant or increased during the study period. Maize output was considered as maize is the common crop grown by most farmers in Mazowe district.

3.10.2 Climate variability and change (CVC_i)

Climate variability and change was the main independent variable of interest in this research. This variable was measured using indicators such as rainfall and temperature variability. Data was gathered using a structured questionnaire using a five-point Likert scale (1=Strongly disagree, 2=Disagree, 3=Not sure, 4=Agree and 5=Strongly agree) on all the indicators. Thereafter, the weighted mean of the Likert scale responses was therefore estimated as the measure for CVC. For this variable, a negative coefficient was expected as several studies such as Cunha *et al.* (2022), Maitah *et al.* (2022), Omondi (2019) and Peichl *et al.* (2019) have found a significant negative effect.

3.10.3 Climate change adaptation (CCA_i)

The other independent variable of interest for the study was climate change adaptation (CCA) of the farmers. This variable was also measured using various adaptation strategies employed by the farmers to reduce the adverse impacts of climate variation and change. These strategies included crop diversification, irrigation, drought resistant crops, changing planting time, land use management and mixed farming. Weighted mean scores were computed to come up with

an index to measure climate change adaptation. A positive effect was expected as studies such as Gorst *et al.* (2018), Mavhura *et al.* (2022) and Musetha (2017) found positive effects of climate change adaptation strategies such as irrigation on agricultural production.

3.10.4 Land under cultivation (LUC_i)

Land under cultivation (LUC) was also included in the study as one of the predictor variables for agricultural production. Land availability represents a significant capital input for agricultural production based on the Cobb-Douglas model. The priori expectations for this variable were a positive effect. According to the Cobb-Douglas theory, increase in capital lead to increased output. In addition, Belloumi (2018) and Mubenga-Tshitaka *et al.* (2021) found positive effects of land under cultivation on agricultural production. The variable was a continuous variable where data collected using the survey questionnaire.

3.10.5 Agricultural labourforce (AGL_i)

The other independent variable for this study was agricultural labourforce (AGL_i). This variable was measured using the size of labourforce at the farm. Previous studies such as Belloumi (2018) and Mubenga-Tshitaka *et al.* (2021) have found that agricultural labour force has a positive effective on agricultural production. This variable was also considered a continuous variable measured using data from the survey questionnaires.

3.11 Data Presentation and Analysis

Prior to estimation, data editing, sorting and coding was done to spot any errors and inconsistence associated with data collection. Through this process, questionnaires found to be incorrectly completed were discarded for analysis. The researcher used STATA version 15 to analyze the quantitative data were descriptive and regression statistics were estimated. Descriptive statistics such as frequencies, percentages and weighted mean scores were estimated prior the estimation of the model using the ordinary least square regression analysis. Prior estimating the regression model, the researcher checked for the assumptions of the linear

regression namely heteroscedasticity, multicollinearity, normality and model specification. Specifically, the Ramsey's Regression Specification Error Test (RESET) was used to test for model specification whilst the Variance Inflation Factor, Shapiro-Wilk test and the Breusch-Pagan test were employed to test for the assumptions of multicollinearity, normality and heteroscedasticity respectively. Tables and charts were employed in presenting the quantitative findings of the study. On the other hand, the qualitative findings were analyzed using content analysis and presented using verbatim accounts of the participants.

3.11.1 Heteroskedasticity test

Heteroskedasticity is a common problem in regression analysis, where the variance of the errors is not constant across all levels of the independent variables (Gujarati, 2020). This can lead to biased and inefficient estimates of the regression coefficients, as well as incorrect inference about their statistical significance (Wooldridge, 2020). To detect heteroskedasticity, researchers often use a variety of tests such as White's test, Breusch-Pagan test or Goldfeld-Quandt tests. For this research, heteroscedasticity was checked using the Breusch-Pagan test under the null hypothesis that the variances were constant (homoscedastic variance). This null hypothesis would be rejected when the p-value of the Breusch-Pagan test statistic will be less than 0.05 (Gujarati, 2021).

3.11.2 Multicollinearity test

Multicollinearity is a statistical phenomenon that occurs when two or more independent variables in a regression model are highly correlated with each other (Gujarati, 2020). This can lead to problems in the interpretation of the regression coefficients and can result in unreliable estimates of the effects of individual predictors on the outcome variable (Kim, 2019). In this research, multicollinearity was checked using the Variance Inflation Factor (VIF) under the null hypothesis that there is no significant correlation between any of the independent variables in the model. According to Oke, Akinkunmi and Etebefia (2019), VIF values not far from 1

indicate no multicollinearity between independent variables whilst a VIF greater than 5 indicates high levels of multicollinearity and the variable must be removed from the model.

3.11.3 Normality test

Normality test in regression is an important statistical technique used to determine if the residuals of a regression model are normally distributed (Gujarati, 2020). The test in regression analysis is particularly important when conducting hypothesis testing as if residuals are not normally distributed, then estimates may be biased or inaccurate (Khatun, 2021). In this research, the Shapiro-Wilk test was employed to test for the assumptions of normality under the null hypothesis that the residuals of a regression model follow a normal distribution. This null hypothesis would be rejected if the p-value of the Shapiro Wilk statistic is less than the 0.05 level of significance (Khatun, 2021).

3.11.4 Model specification test

Model specification test is an essential tool in econometrics that helps researchers to determine whether their statistical models are correctly specified (Wooldridge, 2020). The purpose of this test is to ensure that the model accurately captures the underlying economic relationships and generates reliable estimates of the parameters of interest (Gujarati, 2020). The Ramsey's Regression Specification Error Test (RESET) was used to test for model specification. The test was carried out under the null hypothesis that the model was correctly specified with no omitted variables or functional form misspecifications. The null hypothesis is rejected when the p-value of the t- or F-statistics are less than 0.05 (Gujarati, 2020). More so, model specification was checked using goodness-of-fit tests using the coefficient of determination (R-squared). According to Gujarati (2020), R-squared values of at least 0.5 indicate goodness-of-fit.

3.12 Ethical Considerations

The research required the researcher to observe ethical issues as it involved human participants. Thus, the researcher adhered to all applicable ethical issues, including confidentiality, anonymity, privacy, informed consent, voluntary participation, and protection from harm. Prior to data collection, the researcher sought ethical approval from the Great Zimbabwe University to conduct this study. Since then, official permission was also obtained from owners or managers of commercial farms, GMB, ARDA and relevant departments such as the Ministry of Lands, Agriculture and Rural Resettlement to conduct the research. After that, before conducting the study, the researcher obtained the informed consent of the participants, explained the only purpose of the study, and emphasized the importance of the study.

During this process, the purpose of the research was determined in advance and an informed consent form was signed, indicating their voluntary participation in the research. Additionally, the researcher assured the participants that no rewards or monetary benefits would be offered to any of the participants. During the study, the researcher also made every effort to ensure that all information was kept as confidential as possible and accurately reported. The researcher also ensured that no physical harm or psychological harm was done to the participants. Participants were also reminded to withdraw their participation at any time without facing any charges.

3.13 Chapter Summary

This chapter outlined and explained the research methods, techniques, procedures and tools used to achieve the objectives of the study. Precisely, the chapter outlined, discussed and justified the research design and approach, the theoretical model specification, empirical model specification, data sources, definitions and justifications of the variables as well as the estimation procedures. The following chapter focuses on presenting and interpreting the findings of the study in order to provide answers to the research questions.

CHAPTER FOUR: PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

4.1 Introduction

The previous chapter presented the methodology employed in this research. This chapter presents and analysis and discussion of findings of the study. The chapter has two main parts which are presentation and discussion of findings. After presentation, the findings of the study are then discussed in line with the literature review presented in Chapter Two. The first section of the chapter presents the response rate of the study, followed by the socio-demographic data of respondents and lastly main findings in accordance to the research objectives and questions.

4.2 Response Rate

The response rates for the survey questionnaire and key informant interviews are presented and discussed in this section. As per the sample size, the researcher distributed a total of 192 questionnaires to selected commercial farmers in Mazowe district. Out these questionnaires, 183 questionnaires were collected back by the researcher whilst nine questionnaires were not answered by the target respondents. Out of the 183 questionnaires collected back, 12 of them were found to be invalid as there were either partially or incorrectly filled-in such that they were discarded for analysis. As a result, only 171 questionnaires were found to be correctly and completely filled and were considered valid for analysis. This therefore represented a successful survey response rate of 89.1%. This response rate was considered good for this research as Babbie and Mouton (2020) proposed that survey response rates of at least 70% are excellent for making any deductions and conclusions from data collected. Bryman and Bell (2020) also regard a survey response rate of at least 60% as good. Also, in the context of survey research, according to Hendra and Hill (2019), a good response rate is often interpreted as one that exceeds 50%.

On the other hand, through the data saturation technique, the researcher successfully interviewed ten key informants and this was found good for the research as Braun and Clarke (2021) recommends that interviews require minimum sample sizes of at least ten to reach data saturation. Hennink and Kaiser (2022) also showed that sample sizes of 10 to 20 are required to attain data saturation. According to Xie and Chen (2021), sample sizes of at least ten are adequate for reaching data saturation in qualitative researches. In doing so, a sample size of ten for the key informant was deemed adequate for the analysis of the interview data.

4.3 Socio-demographic and general information of participants

The study collected socio-demographic and general data from the research participants who included inhabitants of commercial farmers, extension officers, district administrators, district representatives from the ARDA, district representatives from the Ministry of Lands, Agriculture and Rural Resettlement as well as district GMB officials in Mazowe district. The socio-demographic information collected included gender, marital status, age, highest level of education, years of farming experience and marital status. The socio-demographic information for the participants to the survey and key informant interviews are presented in Table 4.1.

In terms of gender distribution as shown in Table 4.1, 106 participants were males representing 58.6% of the sampled individuals and the remainder 75 representing 41.4% were females. These results indicate that most of the commercial farmers in Mazowe district are males. This is also supported by Basera (2020) who concluded that the commercial agriculture sector in Zimbabwe including Mazowe district was male-dominated. Nevertheless, both categories of gender were fairly represented in the study.

Furthermore, the results in Table 4.1 show that 27.1% of the participants were aged between 51 and 60 years followed by 22.1% were over 60 years. Those aged between 41 and 50 years constituted 18.8% of the participants whilst 21.0% were between 31 and 40 years and 11.0% representing the minority were between 18 and 30 years. The results show that most of the commercial farmers in Mazowe district are between 30 and 60 years.

The respondents were further asked to indicate their level of education and 35.9% reported that they have attained tertiary education followed by 35.4% with only secondary education and 28.7% had attained primary education (Table 4.1). These results show that all the participants had at least primary education such that they were literate enough to understand the requirements of the study such that they provided relevant answers.

Table 4.1: Socio-demographic information of participants

Demographic Variable	**Frequency (n)**	**Percentage (%)**
Gender:		
Male	106	58.6
Female	75	41.4
Age:		
18-30 years	20	11.0
31-40 years	38	21.0
41-50 years	34	18.8
51-60 years	49	27.1
Over 60 years	40	22.1
Highest level of education:		
Primary education	52	28.7
Secondary education	64	35.4
Tertiary education	65	35.9
Years of farming/working experience:		
Less than 5 years	10	5.5
5-10 years	43	23.8
11-15 years	25	13.8
16-20 years	53	29.3
Over 20 years	50	27.6
Marital status:		

Demographic Variable	Frequency (n)	Percentage (%)
Single	24	13.3
Married	84	46.4
Widowed	39	21.5
Divorced/Separated	34	18.8

The study further inquired into the participants to the survey and interviews to indicate their farming or working experience. As shown in Table 4.1, 29.3% of the participants had experience of 16 to 20 years followed by 27.6% with over 20 years of farming or working experience and 23.8% with experience of 5 to 10 years. More so, 13.8% of the participants had 11 to 15 years of farming/working experience whilst the minority (5.5%) had less than five years of working/farming experience. This indicate that the respondents had sufficient knowledge regarding climate variability and change effects as well as adaptation strategies of the farmers.

Furthermore, as depicted in Table 4.1, 46.4% of all the participants to the study were married whilst 21.5% were widowed, 18.8% were divorced/separated and lastly 13.3% were singles. The results show that the participants were fairly distributed by marital status implying that no sampling biases were done based on marital status thereby enhancing validity of the findings.

4.4 Presentation of findings

This section presents the findings of the study starting with the qualitative findings from the key informant interviews and lastly the quantitative findings from the survey. The findings are presented as follows:

4.4.1 Qualitative findings

This section presents the findings from the qualitative key informant interviews. The research questions represented the main themes of the study and the findings from the interviews are presented according to the research questions as follows:

4.4.1.1 Level of awareness of farmers about climate change effects and threats

The study aimed to determine the level of awareness of farmers about climate variability and change effects. The participants to the key informant interviews indicated that most of the farmers in Mazowe district were aware of the climate change effects and threats. Precisely, eight key informants indicated high levels of awareness among farmers whilst four key informants indicated low levels of awareness among the farmers. Two of the key informants who indicated high level of awareness among the farmers in Mazowe district were ARDA officials who remarked:

> *Yes, farmers in this district [Mazowe district] are aware of the climate shifts. This is because the farmers have been receiving training and education on climate change from the media, Agritex officers as well as from experiences.* (Participant 2, Key Informant, ARDA official).

> *The majority of Mazowe's farmers are aware of the climatic changes. This is clearly noticeable as most of them are increasingly embracing climate change coping strategies although some farmers are financially crippled to implement some strategies.* (Participant 3, Key Informant, ARDA official).

Similar sentiments were also made by an official from the Ministry of Lands, Agriculture and Rural Resettlement who participated in the key informant interviews. This participant stated:

> *From my own view, most of the commercial farmers have knowledge regarding climate change effects and threats given the increased utilizations of climate change adaptation methods such as smart farming, quarantining cattle from other regions because of January disease and practicing irrigation because of early cutting off of rainfall. On livestock, farmers in the district are now doing artificial insemination (buying bull semen and inject it in a female cow). This is done at the Vet field station.* (Participant 10, Key Informant, Ministry of Lands, Agriculture and Rural Resettlement official)

More so, other key informants who were AGRITEX officers reported that the commercial farmers in Mazowe district were aware of the effects and threats of climate variability and change. This key informant had the following to say:

> *Yes, I can say that the farmers are aware of the impacts and threats of climate change and variability. Farmers are now aware that if there are cyclones or floods reports in the country, rainfall will stop and it become very cold in the region. However, the level of awareness still not to be satisfactory but there is noticeable evidence of awareness. From the previous workshops held on educating the farmers on climate change, the participation by the farmers indicated that most of them are aware of the impacts and threats. Some of the threats mentioned by the farmers in the previous workshop included reduced crop yield, increased deaths of livestock, very low farm output as well as poor quality crops and livestock that face low market value as well as reduced farm labour force which is now resorting to artisanal mining (chikorokoza)* (Participant 4, Key Informant, AGRITEX officer)

> *For the past four years as an Agritex officer in this district, I have noticed improvements in terms of knowledge among the farmers regarding climate variability and change. What I can say is that majority like over 70% of the commercial farmers are now aware of the effects and threats of climate change. Among these threats include reduced crop production, increased crop/livestock disease and pest invasion as well reduced livestock production. The 2022 farming season was similar to 1984, the tillage and crop production was very poor because of climate change and variation. (*Participant 8, Key Informant, Agritex officer)

Nevertheless, a few of the key informants indicated that the level of awareness regarding climate change effects and threats was still low among the farmers in Mazowe district. The following responses were some of the substantiating statements obtained from the key informant interviews:

*Although farmers frequently get training and education on climate change, the level of awareness among them regarding climate change effects and threats is still low as some of the farmers are still using primitive methods of climate change adaptation such as intercropping, mulching and crop rotation whilst there are some innovative and more effective adaptation strategies such as smart agriculture and irrigation farming (*Participant 1, Key Informant, Agritex officer)

*To my observations, farmers are not yet fully aware of the effects and threats of climate variability and change. The low levels of adoption of climate change adaption strategies is a manifestation of lack of awareness of the impacts of climate variation and change. There is still low adoption of innovative climate change adaptation strategies such as smart agriculture and this is attributable to lack of awareness among the farmers and also the issue of lack of finance contribute to low level of adoption. CBZ bank and Agribank are offering loans to farmers but farmers do not have collateral security since these banks want original tittle deeds. Today's farmers only have offer letters to use the farms, not like the Rhodesian era farmers had tittle deeds which enabled them to take loans .(*Participant 6, Key Informant, GMB official)

In conclusion, the presented qualitative findings obtained from the key informant interviews have revealed that majority of the commercial farmers in Mazowe district are aware of the effects and threats and impacts of climate variation and change. However, there is still lack of awareness among a few farmers in the same district.

4.3.1.2 Perceived impacts of climate variation and change on farming

Furthermore, the research pursues to answer the question: "What are the perceived impacts of climate variation and change on farming?" To answer this research question, key informant interviews were carried out and the perceptions of the key informants were obtained. From the findings, most of the participants provided varied responses but with similar perceptions that

climate variability and change negatively impacted farming. One of the longest serving AGRITEX officer in Mazowe district had this to say:

> *Climate variability and change is impacting farmers in the district particularly on maize production to a greater extent. Mazowe district was one of the districts which produced a larger amount of maize in the country, but now maize production has really been affected due to the climatic changes and variability. Precisely, the decline in maize and tobacco production in the district over the past few decades has been largely caused by climate change and extreme weather conditions. Due to heavy rains from mid-December to mid-January farmers could not access the fields and failed to do the spraying activities. This increased completion of nutrients between weeds and crops thereby reducing productivity. Farmers who planted early got good yield but late planters were affected since the plants sunk. (*Participant 4, Key Informant, AGRITEX officer)

Another key informant who was an ARDA official also had similar perceptions to those of the AGRITEX officer. The key informant said:

> *Farmers in the district are feeling the adverse impacts of climate variation and change, particularly on maize production. The Mazowe district used to be one of the districts that produced the most maize quantities in the country; nevertheless, the climatic shifts and variability recently have had a significant negative impact on maize production. This is because Zimbabwe is now importing more grains than it is exporting. The government should provide cheap inputs and electricity so as to provide winter crops* (Participant 3, Key Informant, ARDA official).

Furthermore, one of the interviewed officials from the Ministry of Lands, Agriculture and Rural Resettlement was also quoted stating that climate variability and change has negatively impacted farming in Mazowe district. The key informant remarked:

> *There is no doubt that climate change is posing negative adverse effects on farming activities of the farmers as crop and livestock production have been declining over the past decade. Due to this effect, farmers cannot move their cattle from one region to another unless proven by Vet. This is the reason why there were few cattle at the Agricultural show. On small stocks (rabbits, goats, sheep etc.) farmers are encouraged to vaccine the babies against tetanus unless all will die. If there is no vaccine farmers can simply grind rust and put in water and inject to the animal (*Participant 5, Key Informant, Ministry of Lands, Agriculture and Rural Resettlement official)

Similar perceptions were also provided by other two key informants who pointed out that climate variability and change negatively impacted farming in Mazowe district. The following excerpts are some of the substantiating verbatim evidence of the key informants:

> *Climate shifts have had negative effects on agricultural production in the district as witnessed by the decline in rainfed crops such as maize. This has been evidence by the decline in quantities of maize delivered to GMB by the commercial farmers in Mazowe district.* (Participant 6, Key Informant, GMB official)

> *Mazowe district used to be among the districts that produced large amounts of crops such as maize and tobacco. Nevertheless, we have been witnessing a significant decline in production and this is attributable to climate variability and change, although there are other factors like illegal mining activities. The Mazowe dam is now affected negatively (siltation) affecting irrigation (*Participant 1, Key Informant, AGRITEX officer)

> *Personally, I have observed that the district has become more vulnerable to climate changes witnessed by low rainfalls and high temperatures leading poor agricultural productivity and production. The GDP per capita is now less, due to a decrease in farm labourers some farmers are turning their farms into mines this shows that the farmers are vulnerable* (Participant 8, Key Informant, AGRITEX officer)

> *Climate variability and change have had and continue to have negative effects on the farmers in the district. Although there are other factors contributing to decline in agricultural production in the district such as political environment and lack of financial assistance, climate variability and change are the leading primary factors* (Participant 10, Key Informant, Ministry of Lands, Agriculture and Rural Resettlement official)

The excerpts of the key informants presented above have shown that the participants had similar perceptions regarding the impacts of climate variation and change on farming in Mazowe district. Most of the participants underscored that climate variability and change had negatively impacted agricultural production in the district.

4.3.1.3 Effects of climate change adaptation strategies of the farmers on agricultural production

Moreover, the participants to the key informant interviews were asked to indicate their perceptions regarding the effects of climate adaptation strategies of the farmers in Mazowe district to agricultural production. All the participants to the key informant interviews provided similar viewpoints that adoption of climate change adaptation strategies had positive effects on agricultural production. One of the AGRITEX officers who took part in the key informant interviews averred that:

> *A variety of climate change adaptation strategies, including crop diversification, supplementary irrigation and harvesting, planting drought-resistant crops, and planting short-season varieties have been introduced to Mazowe farmers. Most of the strategies are widely being employed by the farmers leading to the reversal of the declining trend in agricultural production brought about by climate variability and change* (Participant 1, Key Informant, AGRITEX officer)

Another AGRITEX officer who participated in the key informants also indicated that climate change adaptation strategies of the farmers in Mazowe district were attributable to the increase in agricultural crop production in the district: The key informant mentioned that:

> *Through collaborative efforts by ARDA, Agritex, Ministry of Lands, Agriculture and Rural Resettlement , farmers in Mazowe have been introduced to a number of climate change adaptation strategies, namely crop diversification, supplementary irrigation and harvesting, planting of drought resistant crops and planting short season varieties to mention but a few. According to my observations, these strategies are very effective and sustainable. This is because when we compare the crop yields before and after the introduction of these strategies, there is a great improvement. The good part of it is that, most farmers are implementing them* (Participant 7, Key Informant, AGRITEX officer)

More so, the positive effects of climate change adaptation strategies were also highlighted and reiterated by officials from ARDA, Ministry of Lands, Agriculture and Rural Resettlement and GMB. These key informants made the following statements:

> *Farmers in Mazowe district are acquainted with various climate change adaptation strategies, in particular crop diversification, Pvumvudza conservation agriculture, planting short season varieties and establishing agroforestry to specify yet a couple. This has been done in an effort to maintain the previous level of agricultural productivity. As someone who is directly involved in farming, I can attest that these strategies are much more long-lasting and efficient as compared to the seasons they were not introduced. Farmers are now seeing increases in crop yields as a result of implementing these strategies.* (Participant 2, Key Informant, ARDA official).

> *Climate change adaptation strategies have enabled farmers to reduce future losses and damage on crops and livestock and create economic benefits through reducing climatic change and variability shocks, increasing productivity and promoting innovations such*

as adoption of smart agriculture, hybridization, artificial insemination, quarantining and drought tolerant crops among farmers (Participant 9, Key Informant, Ministry of Lands, Agriculture and Rural Resettlement official)

Well, the climate change adaptation strategies being employed by the commercial farmers in Mazowe district have indicated the potential to boost agricultural production of the farmers. Farmers employing innovative strategies such as smart agriculture have been realizing large harvests. The bumber harvests witnessed following the Pvumvudza programme indicate that climate change adaptation strategies positively enhance agricultural production by lessening the negative impacts of climate variation and change (Participant 6, Key Informant, GMB official)

The aforementioned quotations from the key informants demonstrate that the climate change adaptation strategies employed by the farmers in Mazowe district have had positive effects on agricultural production and productivity.

4.3.1.4 Alternative sustainable adaptation strategies to address climate variability and change

Lastly, the study aimed to find out alternative sustainable climate change adaptation strategies that may be employed to address climate variability and change in Mazowe district. From the key informant interviews undertaken, several innovative and sustainable climate change adaption strategies were suggested by the participants. One of the participants to the key informant interviews stated:

In order to lessen the negative impacts of climate variation and change, Mazowe farmers should use hybridization, practicing cross breeding, and intercropping, agroforestry thus planting gum trees for tobacco farmers to use to burn tobacco and avoid deforestation, planting Cyprus trees for furniture and act as wind breaks as well as planting star grass or burner grass to prevent soil erosion and increase feeds for

> *livestock in addition to relying on the strategies previously mentioned. Other farmers in other regions are utilizing these tried-and-true strategies* (Participant 8, Key Informant, AGRITEX officer)

In the same line, two district officials from ARDA who took part in the key informant interviews stated that:

> *Integrating livestock into crop production systems, improving soil quality, and minimizing off-farm flows of nutrients and pesticides are some of the alternative strategies that farmers in Mazowe can use to lessen the negative impacts of climate variation and change.* (Participant 2, Key Informant, ARDA official).

> *These are some of alternative strategies that can be employed by farmers in Mazowe to reduce the adverse impacts of climate variation and change include integrating livestock with crop production systems, improving soil quality and minimize off farm flows of nutrients and pesticides* (Participant 3, Key Informant, ARDA official).

Other sustainable strategies were proposed by other key informants to the study. One of the key informants who as a district official from the Ministry of Lands, Agriculture and Rural Resettlement had this to say:

> *Since farmers now have an appreciation of the advantages of employing climate change adaption strategies, there is need to shift from primitive strategies to innovative and sustainable strategies such as practicing irrigation, practicing climate-smart agriculture, artificial insemination, practicing conservation agriculture, planting short-term varieties and practicing agroforestry just to mention a few* (Participant 10, Key Informant, Ministry of Lands, Agriculture and Rural Resettlement official)

From the presented findings from the key informant interviews, it has been noted that there are various sustainable climate change adaptation strategies that can be employed by the farmers

in Mazowe district to lessen the effects of climate variation and change and improve agricultural production.

4.4.2 Quantitative findings

This section presents the quantitative findings obtained from the survey questionnaire. Descriptive and regression analyses were done to analyse the quantitative survey data. Similar to the qualitative findings, the quantitative findings are presented in according to the research objectives as follows:

4.4.2.1 Level of awareness of farmers about climate change effects and threats

The study aimed to determine the level of awareness of farmers about climate variability and change effects. In doing so, participants to the survey were first asked if they had noted any changes and variability in climatic conditions. The responses to the question are presented in Figure 4.1.

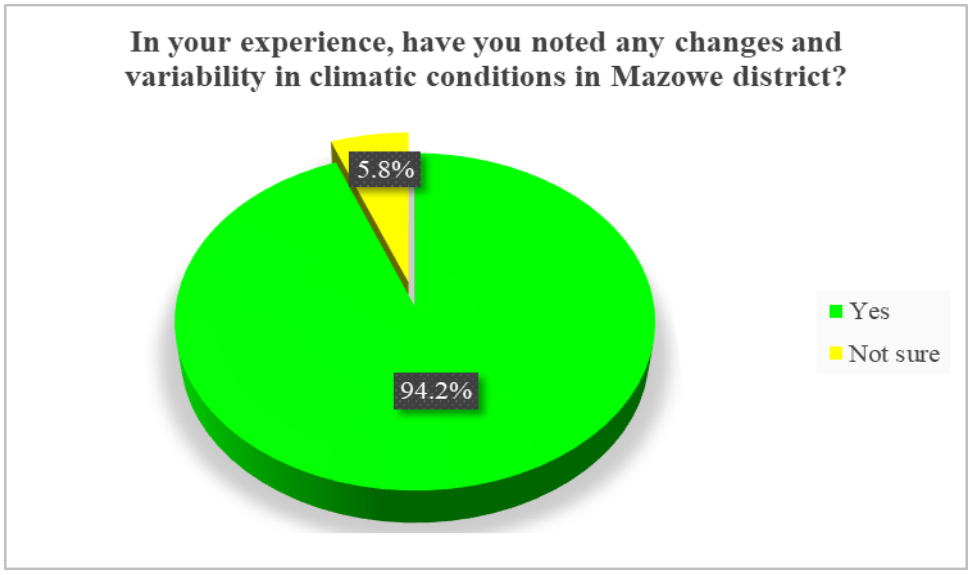

Figure 4.1: Awareness on changes and variability in climatic conditions

Source: Survey data, 2023

From the findings shown in Figure 4.1, majority of the participants (94.2%) highlighted that they had noted any changes and variability in climatic conditions whilst 5.8% were not sure. These findings imply that the farmers in Mazowe district are aware of the climate changes and variability.

Furthermore, those who had noted changes and variability in climatic conditions were required to highlight the main indicators of climate variability and change in Mazowe district. The results in Table 4.2 show some of the indicators of changes and variability in climatic conditions noticeable in Mazowe district.

Table 4.2: Main indicators of climate variability and change in Mazowe district

Indicator	**Mean**	**Std. dev.**
Long dry-spells	4.53	1.113
Low and unpredictable rainfall	4.64	0.851
Rising temperatures	4.53	1.019
Drought	4.05	1.091
Short wet seasons	4.64	0.629
Crop and livestock pests and diseases	4.62	0.783

Source: Survey data, 2023

The results presented in Table 4.2 show that majority of the study participants agreed strongly that they have noted long dry-spells as indicated by the mean statistic of 4.53 and standard deviation of 1.113. In addition, the mean statistic of 4.64 and standard deviation of 0.851 show that the highest number of participants agreed strongly that they had witnessed low and

unpredictable rainfall in Mazowe district. The mean and standard deviation of 4.53 and 1.019 respectively show that majority of the participants agreed that they observed rising temperatures. More so, majority of the study participants agreed strongly that they had noted short rain seasons in Mazowe district as indicated by the mean of 4.64 accompanied a standard deviation of 0.629. As also shown in Table 4.2, majority of the study participants agreed strongly that they had noted crop and livestock pests and diseases as indicated by the mean of 4.62 and standard deviation of 0.783. Other indicators of climate variability and change noted by the commercial farmers in Mazowe district were found to include cyclones, floods, too much humidity, too much wind and very low temperatures. In conclusion, the results indicate that most of the farmers in Mazowe district were aware of climate variability and change.

4.4.2.2 Perceived impacts of climate variation and change on farming

Furthermore, the research aimed to examine the perceived impacts of climate variation and change on farming output. In this regard, the commercial farmers in Mazowe district who participated in the survey were asked to indicate if they agreed or disagreed that climate variability and change have adversely impacted agricultural production in the district. The responses to this question were distributed as illustrated in Figure 4.2.

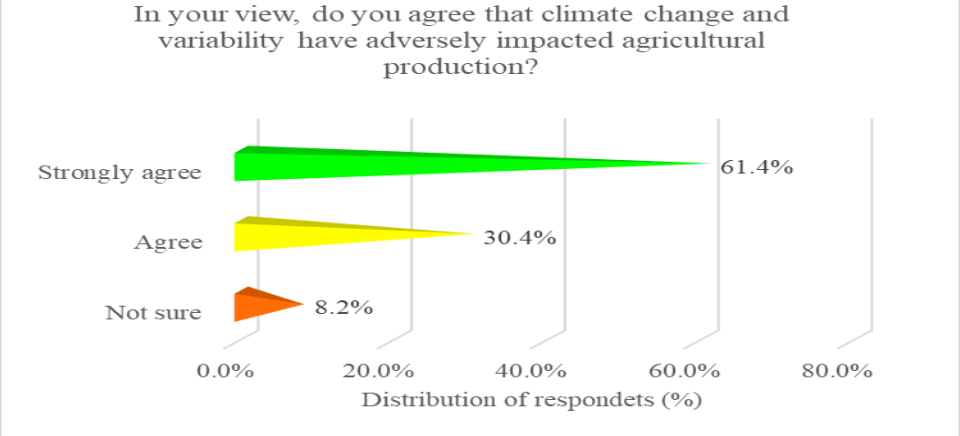

Figure 4.2: Perceived effects of climate change on agricultural production

Source: Survey data, 2023

The findings in Figure 4.2 show that 61.4% of the participants representing the majority agreed strongly that climate variability and change have adversely impacted agricultural production in Mazowe district whilst 30.4% agreed. Nevertheless, only 8.2% of the participants were not sure and none disagreed showing that climate variability and change have had adverse effects on agricultural production in Mazowe district.

Consequently, the participants to the survey were required to indicate the ways in which climate variability and change have impacted agricultural production in Mazowe district. The results are summarized in Table 4.3.

Table 4.3: Impacts of climate variation and change on agricultural production

Impacts of climate variation and change	**N**	**Mean (M)**	**Std. dev. (SD)**
Reduction in maize output	171	4.33	1.227
Loss of arable land	171	4.30	1.047
Reduction in crop yields	171	4.63	0.781
Food insecurity	171	4.65	0.626
Poor livestock health	171	4.14	1.025
Reduction in ground and surface waters	171	4.29	1.140
Loss of grazing pastures	171	4.44	0.812
Decline in land under cultivation	171	4.51	0.863
Decline in agricultural labour force	171	4.49	0.996

Source: Survey data, 2023

The results presented in Table 4.3 show mean scores of at least 4.00 indicating that majority of the participants were in agreement in to the perceived impacts of climate variation and change. As shown majority of the participants agreed that climate variability and change resulted in reduction in maize output (M=4.33; SD=1.227) and loss of arable land (M=4.30; SD=1.047). More so, majority of the study participants agreed strongly that climate variability and change in Mazowe district resulted in reduction in crop yields (M=4.63; SD=0.781) and food insecurity (M=4.65; SD=0.626). On the other side, significant proportions of the study participants agreed that climate variability and change in Mazowe district resulted in poor livestock health (M=4.14; SD=1.025), reduction in ground and surface water (M=4.29; SD=1.140) and loss of grazing pastures (M=4.44; SD=0.812). Additionally, the mean statistic of 4.51 show that majority of the participants agreed strongly that climate variability and change resulted in decline in land under cultivation. A significant proportion of the participants as evidenced by the mean of 4.49 also show that the highest percentage of the participants agreed that climate variability and change in Mazowe district resulted in decline in agricultural labour force. Other impacts of climate variation and change mentioned by the study participants included drowning of crops, wilting of crops, increased death of livestock and low/poor crop quality.

4.4.2.3 Effects of climate change adaptation strategies of the farmers on agricultural production

Moreover, the study aimed to determine the effects of climate change adaptation strategies on agricultural production. The participants to the survey were therefore asked to indicate if they had been introduced to any climate change adaptation strategies. The distribution of the responses to the question are presented in Figure 4.3.

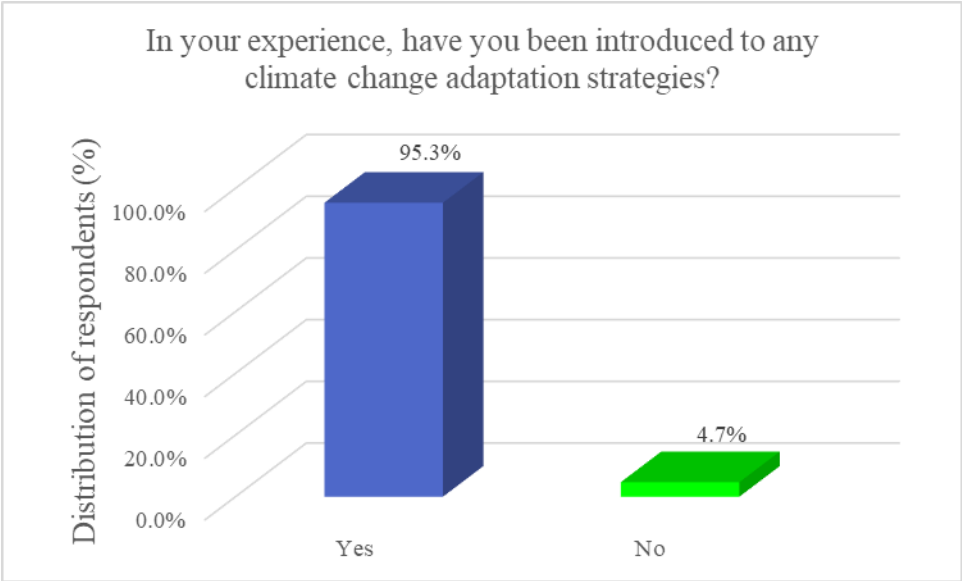

Figure 4.3: Introduction to climate change adaptation strategies

Source: Survey data, 2023

The findings in Figure 4.3 show that 95.3% of the study participants representing the majority have been introduced to climate change adaptation strategies whilst the minority (4.7%) had not been introduced to any climate change adaptation strategies. The results show that most of the farmers in Mazowe district had been introduced to climate change adaptation strategies.

Furthermore, the participants were asked to indicate their level of agreement to climate change adaptation strategies that have been employed by the farmers in Mazowe district. The responses are summarized in Table 4.4.

Table 4.4: Climate change adaptation strategies employed in Mazowe district

Climate change adaptation strategy:	N	Mean (M)	Std. dev. (SD)
Crop diversification	171	4.71	0.539
Supplementary irrigation and water harvesting	171	4.67	0.736
Using drought resistant crops	171	4.82	0.774
Planting short-season varieties	171	4.61	0.929
Practicing climate-smart agriculture	171	2.31	0.769
Pvumvudza conservation agriculture	171	4.63	0.585
Practicing agroforestry	171	4.31	1.053

Source: Survey data, 2023

The descriptive statistics in Table 4.4 show the various climate change adaptation strategies employed by the commercial farmers in Mazowe district. As shown in Table 4.4, majority of the participants agreed strongly that farmers in Mazowe district practiced crop diversification (M=4.71; SD=0.539), supplementary irrigation and water harvesting (M=4.67; SD=0.736), planting drought resistant crops (M=4.82; SD=0.774) and planting short-season varieties (M=4.61; SD=0.929). Nevertheless, the mean statistic of 2.31 and standard deviation of 0.769 show that majority of the participants disagreed that farmers in Mazowe district practiced climate-smart agriculture. This indicates low adoption of climate-smart agriculture among the farmers. More so, significant proportions of the study participants agreed strongly that most of the farmers in Mazowe district practiced Pfumvudza conservation agriculture (M=4.63; SD=0.585). As also shown in Table 4.4, majority of the study participants agreed that the farmers in Mazowe district practiced agroforestry as one of the climate change adaptation

strategies. Other climate change adaptation strategies highlighted by the study participants included crop rotation, winter ploughing, use of greenhouses, intercropping, hybridization, shift cultivation, cross breeding and use of the ridging system.

4.4.2.4 Results of the regression analysis

Lastly, the study conducted the regression analysis to achieve the objectives of the study. Precisely, the study undertook regression analysis to examine the perceived impacts of climate variation and change on farming output and to determine the effect of climate adaptation strategies on agricultural production. The regression analysis was also meant to test the research hypothesis stated in Chapter one. The researcher checked for assumptions of the linear regression analysis. Firstly, the VIF test was undertaken to check for multicollinearity and the results are presented in Table 4.5.

Table 4.5: VIF Test

Variable	**VIF**	**1/VIF**
lnCVC	1.15	0.87
lnCCA	1.02	0.98
lnLUC	1.28	0.78
lnAGL	1.26	0.79

Source: Survey data, 2023

The results presented in Table 4.5 show that all the four independent variables had VIF statistics close to the value 1 indicating absence of multi-collinearity. Hence, the effect of each independent variable could be isolated leading to estimation of robust results.

Furthermore, the results for normality, heteroskedasticity and model specification are summarised in Table 4.6.

Table 4.6: Model diagnostics tests

Test	**Statistic**	**Prob.**
Breusch-Pagan test for heteroskedasticity	Chi2(1) = 32.75	0.0807
Shapiro-Wilk test for normality of residuals	W= 0.98	0.0861
RESET test for model specification	F (3, 163) = 18.30	0.1000

The results presented in Table 4.6 show that the Breusch Pragan test estimated a Chi-square statistic of 32.75 with a probability value (p-value) of 0.0807 which is greater than 0.05 implying absence of heteroskedasticity. More so, the Shapiro-Wilk test estimated a statistic of 0.98 with a p-value of 0.0861 which is greater than 0.05 such that the null hypothesis could not be rejected at 5% level of significance implying normality of residuals. The Ramsey RESET test estimated an F-statistic of 18.30 and a p-value of 0.1000 meaning the model was correctly specified with no omitted variables. From these, the assumptions for the multiple linear regression were satisfied such that the regression model was estimated and the results are presented in Table 4.7.

Table 4.7: OLS regression results

Source	SS	df	MS	Number of obs	=	171
				F(4, 166)	=	53.85
Model	4.91187953	4	1.22796988	Prob > F	=	0.0000
Residual	3.78537217	166	.022803447	R-squared	=	0.5648
				Adj R-squared	=	0.5543
Total	8.6972517	170	.051160304	Root MSE	=	.15101

lnY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnCVC	-.630266	.1131629	-5.57	0.000	-.8536901	-.406842
lnCCA	.2821107	.0714595	3.95	0.000	.1410241	.4231974
lnLUC	.260071	.0483546	5.38	0.000	.1646017	.3555404
lnAGL	.3507141	.0628529	5.58	0.000	.22662	.4748081
_cons	-.3662376	.1267465	-2.89	0.004	-.6164806	-.1159947

The regression results for the estimated model have been presented in Table 4.7. As shown in Table 4.7, the model estimated an R-squared of 0.5648 indicating that approximately 56.48% of the variations in maize output in Mazowe district are explained by climate variability and change, climate change adaptation, land under cultivation and agricultural labour force. The remaining 43.52% of the variations in maize output are explained by other factors not included in the model. These imply goodness of fit of the model. In addition, the F-statistic of 53.85 with a p-value of 0.0000 indicate overall significance of the model.

On the other hand, the four independent variables were found to be statistically significant at 5% level. As shown in Table 4.7, a statistically significant negative coefficient of -0.63 (p=0.000) was found for the climate variability and change (lnCVC) variable the results shows that a 1% change in climate variability is reducing maize output in Mazowe by 0. 63%. On the other hand, a statistically significant positive coefficient of 0.28 (p=0.000) was estimated for the climate change adaptation (lnCCA) variable. More so, statistically significant positive coefficients for land under cultivation (lnLUC) implying a 1% increase in the land under

cultivation would increase maize output by 0.26% and agricultural labour force (lnAGL) inferring that a 1% unit increase in the labour force would increase maize output by 0.35% were found as indicated by the coefficients of 0.26 and 0.35 respectively.

4.5 Discussion of findings

This section provides the discussion of the qualitative and quantitative findings presented in this chapter. The discussion of findings is structured according to the objectives of the study as follows:

4.5.1 Level of awareness of farmers about climate change effects and threats

The study aimed to determine the level of awareness of farmers about climate variability and change effects. Both qualitative and quantitative findings indicated that farmers in Mazowe district were aware of the impacts of climate variation and change on farming. The high levels of awareness could be attributable to the collaborative efforts of stakeholders in educating the farmers in Mazowe district on climate variability and change. This level of awareness may also be attributed to the increasing adoption of climate change adaptation strategies. The results therefore led to the failure to accept the research proposition that there is low level of awareness of climate change effects and threats among farmers in Mazowe district. The results are similar to those of Musetha (2017) who revealed high levels of awareness of South African farmers about climate change effects and threats. Byishimo (2018) also found high level of awareness on climate change among farmers in Rwanda. In their study, Dhliwayo *et al.* (2022) found that most of the farmers in Chiredzi district were aware of climate variability effects and coping strategies. The results also concur with the sustainable livelihoods framework which predicts that human capital in terms of knowledge enhances livelihood adaptation and reduce vulnerability to external shocks such as climate variability and change.

4.5.2 Perceived impacts of climate variation and change on farming

Furthermore, the research aimed to examine the perceived impacts of climate variation and change on farming output. Both qualitative and quantitative findings indicated that climate variability and change negatively impacted farming in Mazowe district. Over 60% of the participants agreed strongly that climate variability and change have adversely impacted agricultural production in Mazowe district. Precisely, the results indicated that climate variability and change has negatively impacted farming by resulting in reduction in maize output, loss of arable land, reduction in crop yields, food insecurity, poor livestock health, reduction in ground and surface waters, loss of grazing pastures, decline in land under cultivation, decline in agricultural labour force, drowning of crops, wilting of crops, increased death of livestock and low/poor crop quality.

More so, the regression analysis revealed that climate variability and change negatively impacted agricultural production in Mazowe district. A statistically significant negative coefficient of -0.63 (p=0.000) was found for the climate variability and change (lnCVC) variable. This means that increased climate variability and change can significantly reduce maize production in Mazowe district. Precisely, the results show that a 1% change in climate variability is reducing maize output in Mazowe by 0. 63%. These results led to the failure to reject the hypothesis that climate variability and change has significant negative effects on agricultural production. The conclusion reached is that climate variability and change negatively impact agricultural production in Mazowe district. The results met the priori expectations and concur with the Ricardian theory which predicts that variations in agricultural production can be explained by changes in climatic factors.

The findings also confirm results of previous related studies. For instance, the findings of this present study corroborate the results of the study by Van-Passel *et al.* (2018) which analysed the effects of climate change on agricultural production in Europe and revealed that European agriculture was negatively impacted by climate change. Similarly, Peichl *et al.* (2019) found that climate variation and change resulted in maize yield reduction in Germany. More so, the

present results are comparable to those of Cunha *et al.* (2021) who studied the effects of climate change on Brazil's agriculture found negative impacts of climate variation on agricultural production, Negative effects of climate change were also confirmed by Estrada *et al.* (2022) who found that climate variation and change accounts for about 70% of losses and reductions in crop yields in Mexico. The results are also in tandem in those of Omondi (2019) who concluded that climate change negatively effects livestock and crop production in Kenya. The results are also comparable to those of Mavhura *et al.* (2022) who negative impacts of climate variation and change on agricultural production in Zimbabwe. Nevertheless, the present findings contradict those of Dhliwayo *et al.* (2022) who found that climate variation and change had no significant changes in crop yields. In conclusion, the present results support results from previous studies.

4.5.3 Effects of climate change adaptation strategies of the farmers on agricultural production

Moreover, the study established the effects of climate adaptation strategies of the farmers in Mazowe district to agricultural production. The qualitative findings demonstrated that the climate change adaptation strategies employed by the farmers in Mazowe district have had positive effects on agricultural production and productivity. The results indicated that over 90% of farmers in Mazowe district had been introduced to climate change adaptation strategies. From the results there are several climate change adaptation strategies employed by farmers in Mazowe district and these included crop diversification, supplementary irrigation and water harvesting, using drought resistant crops, planting short-season varieties, practicing climate-smart agriculture, engaging in Pvumvudza conservation agriculture, practicing agroforestry, crop rotation, winter ploughing, use of greenhouses, intercropping, hybridization, shift cultivation, cross breeding and use of the ridging system.

These strategies have been found to have positive effects on agricultural production in Mazowe district. The regression analysis revealed a statistically significant positive coefficient of 0.28 ($p=0.000$) for the climate change adaptation (lnCCA) variable. The results imply a 1% change

in the climate change adaptation would result in increased maize output by approximately 0.28%. These results led to the acceptance of the research hypothesis that climate change adaptability has significant positive effects on agricultural production. From the results, it can be inferred that adoption of climate change adaptation strategies by the farmers in Mazowe district improved agricultural production in the district by lessening the adverse impacts of climate variation and change.

The present results are in line with the findings of previous related studies. For essence, the study by Cunha *et al.* (2021) confirmed the important role of climate change adaptation on agricultural production by revealing that irrigation effective in counteracting the adverse effects of climate change. The results are also similar to those of Gorst *et al.* (2018) who examined the link between climate change adaptation and crop productivity in Pakistan and revealed significant positive effects of climate change adaptation on crop productivity. The study by Musetha (2017) also found that climate change adaptation strategies such as planting different varieties, crop diversification, different planting dates and shortening of planting periods had positive effects on agricultural production in South Africa. More so, the results of this study support those obtained by Mavhura *et al.* (2022) who found that climate change adaptation strategies such as crop and land use management, use of short-season varieties, crop diversification, mixed-farming, intensified irrigation and drought resistant crops had positive influence on crop yields in Zimbabwe.

4.5.4 Effects of land under cultivation on agricultural production in Mazowe district

Land under cultivation was included as a control variable in the study. In doing so, the regression results revealed significant positive effects on agricultural production in Mazowe district. A positive coefficient 0.26 for land under cultivation was found to be statistically significant at 5% level as indicated by the p-value of 0.000. This infer that a 1% increase in the land under cultivation would increase maize output by about 0.26%. Nevertheless, the descriptive results indicated that climate variability and change resulted in decline in land under cultivation. This therefore implies that decline in land under cultivation due to climate

variability and change leads to decline in agricultural production in Mazowe district. These results concur with the Cobb-Douglas theory which predicts that output depends directly on levels of capital which is land in this context. According to the Cobb-Douglas theory, increase in capital lead to increased output. On the other hand, the results confirm the findings of earlier studies. For example, Belloumi (2018) revealed that land under cultivation had significant positive effects on crop production in Southern and Eastern African (ESA) countries. Among East African countries, Mubenga-Tshitaka *et al.* (2021) also found that land under cultivation had significant positive effects on agricultural output. Similar results were also obtained by Bai *et al.* (2022), land under cultivation has significant positive effects on agricultural productivity. Jiri (2020) also found that land under cultivation as the key input resource it has significant impacts of crop production.

4.5.5 Effects of agricultural labour force on agricultural production in Mazowe district

More so, agricultural labour force was included as the control variable and the regression results indicated a statistically significant positive coefficient for the agricultural labour force (lnAGL). The coefficient of 0.35 for this variable was found to be statistically significant at 5% level as indicated by the p-value of 0.000 which is lesser that 0.05. The results imply a 1% increase in agricultural labourforce would increase maize output by 0.35%. These results show that agricultural labour force positively influences agricultural production. This is further confirmed by the descriptive results which indicate that climate variability and change resulted in decline in labour force on the farms leading to decline in agricultural production. These results also concur with the Cobb-Douglas theory which predicts that output depends directly on levels of labour. Nevertheless, increasing labour force may lead to reduced productivity as predicted by the Cobb-Douglas theory. The results are comparable to those of Belloumi (2018) who found that agricultural labourforce had significant positive effects on crop production in Southern and Eastern African (ESA) countries. Similarly, Mubenga-Tshitaka *et al.* (2021) found that agricultural labour force had positive effects on agricultural production.

4.6 Chapter Summary

The chapter provided the presentation and discussion of the research findings obtained from the survey and key informant interviews. The findings presented, analysed and discussed have answered the research questions of the study and the objectives of the study have been met. The findings presented and discussed in this chapter have demonstrated that climate variability and change has had adverse effects on agricultural production in Mazowe district whilst climate change adaptation has been found to have significant positive effects. More so, the level of awareness regarding climate change effects and threats have been established. The subsequent chapter provides the summary of the study, conclusions and recommendations

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This final chapter provides the research summary including the summary of the entire study and the summary of the key findings. The chapter also presents the major conclusions derived from the research findings as well as the recommendations for policy implications. Lastly, areas for further research are presented in this research.

5.2 Summary of Study

The primary objective of the research was to examine the perceived impacts of climate variation and change: an exploration of farmers' adaptation strategies in Zimbabwe's intensive farming region using the Mazowe district as the case study. The secondary objectives of the study were:

To determine the level of awareness of farmers about climate variability and change effects.

To examine the perceived impacts of climate variation and change on farming output;

To determine the effect of climate adaptation strategies on agricultural production

To recommend alternative sustainable adaptation strategies to climate variability and change

In order to achieve the objectives, the mixed-method approach was adopted. This study was organized into five chapters. The first chapter (Chapter One) provided the introduction and context of the research. Precisely, the introduction included the study's background, the research problem, research questions, research objectives, research hypotheses, contributions of the study, delimitations of the study and limitations of the study. Definitions of key terms

and organization of the research were also presented in this introductory chapter.

The second chapter (Chapter Two) presented and reviewed the relevant literature related to the research topic and objectives. The literature review included the theoretical framework for the study where the Cobb-Douglas theory, the Sustainable Livelihoods Framework and the Ricardian theory were presented and critically discussed as the main theoretical frameworks underpinning the research. In addition, literature review pertaining to the research objectives was presented followed by the review of empirical studies from the global level to regional level and local. Through this, the research gaps were identified.

Thereafter. Chapter Three presented the in detail the techniques, methods, instruments and procedures followed in gathering and analysing data. The presentations included justifications for the choices of the techniques, methods and instruments adopted. In particular, this methodology chapter presented the research design and approach, target population, sampling and sample size, theoretical model, empirical model, model specification, justifications of variables, data analysis techniques and ethical considerations. The mixed-method approach was employed as well the cross-sectional descriptive research design. The target population of the study consisted of commercial farmers, extension officers, district administrators, district representatives from the ARDA, district representatives from the Ministry of Lands, Agriculture and Rural Resettlement as well as district GMB officials in Mazowe district. The sample size of 192 was employed for the survey and for the qualitative study the data saturation technique was employed. Cross-sectional primary data were collected using semi-survey questionnaires and key informant interviews. Data collected were analyzed using descriptive, regression and content analyses.

The fourth chapter (Chapter Four) focused on the presentation, analysis and interpretations of the study's results. The results were presented as per the objectives of the study starting with the qualitative findings followed by the quantitative results. The findings were interpreted and discussed making use of literature reviewed in Chapter Two. The main findings of the study are summarized in the following sections:

5.3 Summary of Major Findings

This section presents the summary of the key findings. The summary of the findings is presented in line with the objectives of the research as follows:

5.3.1 Level of awareness of farmers about climate change effects and threats

The study determined the level of awareness of farmers about climate variability and change effects. The qualitative and quantitative findings of the study indicated that farmers in Mazowe district were aware of the impacts of climate variation and change on farming. The high levels of awareness about climate change effects and threats were attributed to the collaborative efforts of stakeholders in educating the farmers in Mazowe district on climate variability and change. The results therefore led to the failure to accept the research proposition that there was low level of awareness of climate change effects and threats among farmers in Mazowe district.

5.3.2 Perceived impacts of climate variation and change on farming

The results of the study revealed the perceived impacts of climate variation and change on farming output. Both qualitative and quantitative findings indicated that climate variability and change negatively impacted farming in Mazowe district. Over 60% of the participants to the survey agreed strongly that climate variability and change have adversely impacted agricultural production in Mazowe district. Precisely, the survey and interview findings indicated that climate variability and change had negatively impacted farming by resulting in reduction in maize output, loss of arable land, reduction in crop yields, food insecurity, poor livestock health, reduction in ground and surface waters, loss of grazing pastures, decline in land under cultivation, decline in agricultural labour force, drowning of crops, wilting of crops, increased death of livestock and low/poor crop quality. The regression analysis also revealed a statistically significant negative effect of climate variability and change on agricultural production in Mazowe district. These results led to the failure to reject the hypothesis that climate variability and change has significant negative effects on agricultural production.

5.3.3 Effects of climate change adaptation strategies of the farmers on agricultural production

Moreover, the research established the positive effects of climate adaptation strategies of the farmers in Mazowe district to agricultural production. The qualitative findings demonstrated that the climate change adaptation strategies employed by the farmers in Mazowe district have had positive effects on agricultural production and productivity. From the survey, over 90% of the participants indicated that farmers in Mazowe district had been introduced to climate change adaptation strategies. The several climate change adaptation strategies employed by farmers in Mazowe district were found to include crop diversification, supplementary irrigation and water harvesting, using drought resistant crops, planting short-season varieties, practicing climate-smart agriculture, engaging in Pvumvudza conservation agriculture, practicing agroforestry, crop rotation, winter ploughing, use of greenhouses, intercropping, hybridization, shift cultivation, cross breeding and use of the ridging system. These strategies have been found to have positive effects on agricultural production in Mazowe district. The regression analysis revealed a statistically significant positive effect of climate change adaptation on agricultural production. These results led to the acceptance of the research hypothesis that climate change adaptability has significant positive effects on agricultural production.

5.4 Conclusions

Based on the study's findings, the main conclusion derived from this study is that climate variability and change have significant negative effects on agricultural production in the intensive farming region of Zimbabwe particularly in Mazowe district. The other conclusion derived from the findings was that adoption of climate change adaptation strategies by farmers in Mazowe district has the potential to boost agricultural production by minimizing the adverse impacts of climate variation and change. More so, based on the research findings, the study concludes that most of the farmers are aware of the various impacts of climate variation and change which make them implement climate change adaption strategies. The study also

concluded that land under cultivation and labour force are critical input factors for enhanced agricultural production.

5.5 Recommendations from Research Findings

From the research findings, the following recommendations for policy and practice were made:

(i) The study recommends for education and training programmes to farmers regarding the impacts of climate variation and change. This can be done through workshops and seminars targeting the farmers in climate change prone regions such as Mazowe district. These will aid in improving awareness among the farmers regarding climate change and effects.

(ii) Besides, the study recommends the commercial farmers in Mazowe district to adopt innovative and modern climate change adaptation strategies such as climate-smart agriculture, artificial insemination and underground water harvesting.

(iii) The study also recommends the Government of Zimbabwe to ensure maximum support to the commercial farmers through interventions and policies that aim to address climate variability and change. This is because, implementation of climate change adaptation strategies may also require government support.

(iv) The research recommends the commercial farmers in Mazowe district to employ alternative sustainable climate change adaptation strategies such as irrigation, hybridization and agroforestry.

5.6 Research Contributions and Implications

The research made significant contributions to both practice and theory:

a) Firstly, the research findings made a significant contribution to theory as it enriches existing literature climate variability and change. The theoretical contribution of the

study is that new information has been added to the existing theory given lack of empirical studies on the subject. In doing so, the research contributed to the existing stock of empirical studies on climate variability and change effects and adaptation strategies.

b) On the other side, the research findings made significant contributions to policy and practice. The policymakers in the agriculture sector of Zimbabwe would find the findings beneficial to them as they will aid in formulation of policies to address climate variability and change. The results would also be of great value to the commercial farmers in their farming journey as they may be motivated by the results to embrace innovative and sustainable climate change adaptation strategies.

5.7 Recommendations for Further Research

From this research, several limitations were observed such that areas for further research were identified. Firstly, this research was confined a single case study of Mazowe district in the intensive farming region of Zimbabwe thereby affecting generalizability and validity of findings. Therefore, further similar researches need to be conducted using multi-case studies from the region. In addition, similar researches may also be conducted in other farming regions rather than the intensive farming region. Moreover, the research relied on primary data to answer the research questions such that other relevant information from secondary could have been missed out. Hence, future researchers may make use of secondary evidence so that the research subject may be investigated using real-world evidence. Further researches may also be carried using relatively larger sample sizes.

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APPENDICES

Appendix I: Research Questionnaire

PERCEIVED IMPACTS OF CLIMATE VARIATION AND CHANGE: AN EXPLORATION OF FARMERS' ADAPTATION STRATEGIES IN ZIMBABWE'S INTENSIVE FARMING REGION. CASE OF MAZOWE DISTRICT

Dear Prospective Respondent

My name is Janet Tanaka Mupfawi a student at Great Zimbabwe University studying for a Masters in Financial Economics. In partial fulfillment of the requirements of the Masters in Financial Economics, I am carrying out a research entitled: "**PERCEIVED IMPACTS OF CLIMATE VARIATION AND CHANGE: AN EXPLORATION OF FARMERS' ADAPTATION STRATEGIES IN ZIMBABWE'S INTENSIVE FARMING REGION. CASE OF MAZOWE DISTRICT**". The research findings and recommendations will also assist with insights for decision making and policy making. In doing so, you have been selected as one of the participants to the study. I would be very grateful if you would spare some time to answer this questionnaire. In case of any questions, please, do not hesitate to contact the researcher on mobile number: +263 787413553 or mupfawijane@gmail.com. I thank you in advance for your cooperation and your valuable time.

Instructions

This questionnaire is to solicit information to aid the researcher in getting data to achieve the objectives of the study. Strict confidentiality and anonymity will be maintained in the research. Kindly indicate your response by a tick (√) or a cross-mark (**x**) in the appropriate box, representing the most appropriate answer. Thank you in advance for participating!

SECTION A: SOCIO-DEMOGRAPHIC AND GENERAL INFORMATION

1. **Indicate your gender** Male ☐ Female ☐
2. **Age**

18-30 years ☐ 31-40 years ☐ 41-50 years ☐

51-60 years ☐ Over 60 years ☐

3. **Highest level of education**

Primary education ☐ Secondary education ☐ Tertiary education ☐

Other (Specify)_____

4. **Years of farming experience**

Less than 5 years ☐ 5-10 years ☐ 11-15 years ☐

16-20 years ☐ Over 20 years ☐

5. **Marital Status**

Single ☐ Married ☐

Widowed ☐ Divorced/Separated ☐

6. **Land under cultivation in hectares** ☐

7. **Size of labourforce at farm (population of active farm workers)** ☐
8. **Average change in maize output over the past decade**

Decreased ☐ No change ☐

Not sure ☐ Increased ☐

SECTION B: AWARENESS ON CLIMATE VARIABILITY AND CHANGE

9. In your opinion, what do you understand about climate variability and change?

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10. In your experience, have you noted any changes and variability in climatic conditions in Mazowe district?

Yes ☐ No ☐ Not Sure ☐

11. Below are some of the indicators of climate variability and change in Mazowe district over the past decade where you can indicate the extent to which you agree or disagree by ticking or cross-marking the box with the number that corresponds to your answer using the scale: **1=Strongly disagree, 2=Disagree, 3=Not sure, 4=Agree and 5=Strongly agree**

Indicator	**1**	**2**	**3**	**4**	**5**
Long dry-spells					
Low and unpredictable rainfall					
Rising temperatures					
Drought					
Short wet seasons					
Crop and livestock pests and diseases					

12. What are other indicators of climate variability and change in the district?

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SECTION C: PERCEIVED IMPACTS OF CLIMATE VARIATION AND CHANGE

13. In your view, do you agree that climate variability and change have adversely impacted agricultural production?

Strongly disagree **[ ]** Agree **[ ]** Not Sure **[ ]** Agree **[ ]** Strongly agree **[ ]**

14. Below are some of the effects climate variability and change where you can indicate the extent to which you agree or disagree with the statement by ticking or cross-marking the box with the number that corresponds to your answer using the scale: **1= strongly disagree; 2 = disagree; 3 = neutral; 4 = agree and 5 = strongly agree**

Impacts of climate variation and change	**1**	**2**	**3**	**4**	**5**
Reduction in maize output					
Loss of arable land					
Reduction in crop yields					
Food insecurity					
Poor livestock health					
Reduction in ground and surface waters					
Loss of grazing pastures					
Decline in land under cultivation					
Decline in agricultural labourforce					

15. In what other ways have climate variability and change impacted agricultural production?

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SECTION D: CLIMATE CHANGE ADAPTATION STRATEGIES OF FARMERS

16. In your experience, have you been introduced to any climate change adaptation strategies?

Yes ☐ No ☐ Not Sure ☐

17. Below are some of the climate change adaptation strategies being employed by farmers in the district where you can indicate the extent to which you agree or disagree with the statement by ticking or cross-marking the box with the number that corresponds to your answer using the scale: **1= strongly disagree; 2 = disagree; 3 = neutral; 4 = agree and 5 = strongly agree**

Adaptation strategy	**1**	**2**	**3**	**4**	**5**
Crop diversification					
Supplementary irrigation and water harvesting					
Using drought resistant crops					
Planting short-season varieties					
Practicing climate-smart agriculture					
Pvumvudza conservation agriculture					
Practicing agroforestry					

18. What are other climate change adaptation strategies being applied at the farm?

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……..…….

THE END

THANK YOU FOR YOUR TIME!!!!

Appendix II: Interview guide

Dear Participant

My name is Janet Tanaka Mupfawi a student at Great Zimbabwe University studying for a Masters in Financial Economics. In partial fulfilment of the requirements of the Masters in Financial Economics, I am carrying out a research entitled: "**PERCEIVED IMPACTS OF CLIMATE VARIATION AND CHANGE: AN EXPLORATION OF FARMERS' ADAPTATION STRATEGIES IN ZIMBABWE'S INTENSIVE FARMING REGION. CASE OF MAZOWE DISTRICT**". The research findings and recommendations will also assist the management with insights for decision making. In doing so, you have been selected as one of the participants to the study.

The main purpose of this letter is to seek your permission to kindly participate in this interview session. This will take approximately to take not much of your time. Participation is voluntary and participants will not receive any financial or material rewards for participating. You may withdraw your participation at any point for any reason. Your responses will be kept confidential and private. Should you need any clarification or have questions, please feel free to ask.

Thank you in advance for your cooperation.

PART A: DEMOGRAPHIC AND BACKGROUND DATA OF PARTICIPANT

1) Gender…….....
2) Age (range)……..
3) Highest level of education……..
4) Years of working experience……...

PART B: INTERVIEW QUESTIONS

5) In your opinion, are the farmers in Mazowe district aware of any of the changes in climate?

6) In your experience, what the main climatic changes notable in the district?

7) What are some of the indicators of climate variability and change in district?

8) To what extent are climate variability and change impacting farmers in the district particularly on maize production?

9) Based in your observations, what are the main adaptation strategies being employed by the farmers?

10) In your view, do you think the current adaptation strategies are effective and sustainable?

11) In your opinion, what are the contributions of the climate change adaptation strategies on agricultural production?

12) What alternative sustainable climate change adaptation strategies may be employed by the farmers to reduce the adverse impacts of climate change? ?

Appendix III: Turnitin Similarity Index Report