# SMALL-SCALE MAIZE FARMERS' PERCEPTIONS AND ADAPTATION TOWARDS CLIMATE CHANGE IN MAKHUDUTHAMAGA LOCAL MUNICIPALITY, SEKHUKHUNE DISTRICT, LIMPOPO PROVINCE

BY

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Thesis submitted in fulfilment of the requirements for the degree

**MASTERS IN AGRICULTURAL MANAGEMENT (AGRICULTURAL ECONOMICS)**

In

DEPARTMENT OF AGRICULTURAL ECONOMICS AND ANIMAL PRODUCTION

In the

SCHOOL OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

FACULTY OF SCIENCE AND AGRICULTURE

At the

UNIVERSITY OF LIMPOPO

SOUTH AFRICA

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2023

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As the candidate's supervisors, we agree to the submission of this thesis.

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## DECLARATION 2

**The following publication will form part of the research presented in this full dissertation.**

### Publication 1- Chapter Five of this thesis

Kabelo Noko, Mmaphuti A Nkoana and Abenet Belete. Analyses of factors affecting small-scale maize farmer's perceptions and adaptation towards climate change in Makhuduthamaga Local Municipality, Sekhukhune District, Limpopo Province. To be submitted: African Journal of Agricultural and Resource Economics.

## DEDICATION

This thesis is dedicated to the loving memory of my father, Lesetja Samuel Noko and my uncle Vincent Mokwekwe Mphahlele who saw the great potential I have in education. I will always remember you. To my mother Maggie Raesibe Noko who is constantly keeping me in her prayers for this thesis to be done. The thesis is also dedicated to my family and beloved friends for their support and encouragement.

## ACKNOWLEDGEMENTS

I'd like to express my heartfelt appreciation to everyone who helped make this thesis a success. This thesis would not have been possible without the assistance and facilitation of many notable individuals. I greatly appreciate your assistance.

First and foremost, I would like to express my heartfelt gratitude to my supervisors, Doctor M.A Nkoana (Tilu) and Professor A. Belete (Matome). I would like to thank you for your guidance, encouragement, and criticism throughout this study. With your encouragement, support, extensive input, and alternative insights for the improvement of my thesis, you really helped me organize my thoughts; it would have been difficult without your assistance. Be incredibly blessed.

The Department of Agriculture, Land Reform, and Rural Development provided funding for this study, but only for the second and third years (2021 and 2022). I am truly grateful for the financial assistance you provided me during that research period. Thank you for your help; please keep up the good work. In addition, I am grateful to all of the respondents who took the time to complete a detailed questionnaire. Your contribution enabled me to compile this thesis, which would not have been possible without your willingness to collaborate. I'd like to thank my enumerators, Ms T Mphahlele, Ms P.C Mahlake, and Ms T.P Ramoroka, for their hard work in data collection. You did a great job and it must be acknowledged. I also want to thank the Sekhukhune Department of Agriculture for assisting in data collection and the identification as well as location of sampled small-scale maize farmers. Thank you very much.

My family, more especially my mother, your faith in me is the one that pushed me to put in much greater effort to this work. Thank you for your prayers and constant support towards me. My sisters, I would like for you to please accept my heartfelt gratitude for your prayers, love, support and words of encouragement I really appreciate you. Fellow colleagues and friends, I apologize for not naming all of you because there are so many of you, but I would want to thank you for your moral support. In particular I would like to thank M.E Baloyi and M.R Noko for your words of encouragements and constant support. Finally, and clearly not least, I would really like to thank GOD ALMIGHTY for clearing the path for me; you had it all planned. Thank you, Lord, for providing me with the insight, guidance, and power to sail through.

## ABSTRACT

The agricultural sector is a vital component of the South African economy. The industry has the ability to contribute to rural growth, eliminate poverty, improve food security, create jobs, and narrow income disparities. Climate change, on the other hand, poses a threat to South Africa's agricultural sector, water resources, food security, health, infrastructure, and ecosystem services and biodiversity as a result of rising temperatures and less rainfall. Climate change adaptation techniques such as changing or adjusting planting date, use of soil and water as conservation techniques have gained traction as an essential strategy alongside mitigation around the world, and are widely documented in a variety of sources and approaches (such as books, journal articles, reports etc.). Nonetheless, few studies have been conducted in South Africa to prove or analyse if these techniques will be implemented at the farm level, notably in Makhuduthamaga Local Municipality, Sekhukhune District, Limpopo Province. Furthermore, little or no research has been performed to determine whether the small-scale maize farmers from the area have perceived that climate is changing and they are will to adapt to those methods. As a result, this study was carried out to fill the aforementioned research information gap and to draw relevant policy implications to increase the welfare of small-scale maize farmers through the application of perceptions and adaptation towards climate change.

The study's overarching goal was to analyse small-scale maize farmers' perceptions and adaptation towards climate change in Makhuduthamaga Local Municipality, Sekhukhune District, Limpopo Province. The study specifically addressed the following objectives: (i) Identify and describe small-scale maize farmer’s socio-economic characteristics in the study area; (ii) Assess the level of perceptions of small-scale maize farmers towards climate change in the study area; and (iii) Analyse the socio-economic factors influencing perceptions and adaptation of small-scale maize farmers towards climate change in the study area.

A simple random sampling procedure was used to select 110 small-scale maize farmers from a sample frame of 238 based on probability proportional to sample size. The qualitative and quantitative cross-sectional data were collected through group observation and face-to-face interviews using structured questionnaires from Mid-December 2021 to Mid- February 2022. The empirical model that was employed to address the research objectives include; Heckman two stage equation model in chapter five. The data collected was analysed using IBM SPSS Version 27.0 and Microsoft excel 2016, respectively.

To assess the perceptions of sampled small-scale maize farmers in the study area, the Likert-scale method of analysis was used. The majority of small-scale maize farmers interviewed 41 (37 %) strongly agreed that climate change is occurring, followed by those who were doubtful or uncertain 27 (25 %). Twenty four (22%) of the sample small-scale maize farmers agreed that climate change is occurring; however, 6% disagreed and 10% strongly disagreed.

All the null hypotheses of the study are rejected because: the results from the descriptive statistics results shows that a large number of small-scale maize farmers strongly agreed and perceived or rather believed that climate has changed due to rainfall and temperature in the last 30 years. Lastly, the Heckman two stage equation model results revealed that age, educational level, farming experience, number of adult labourers, crop failure, credit access, access to extension services, farm size, perceived changes in temperature and rainfall and they all have a significant impact on the small-scale maize farmers' perceptions and adaptation towards climate change.

On the basis of empirical findings, it is proposed that the government, community members, and other stakeholders (such as NGOs, research institutions, municipalities, and so on) approach climate change adaptation as part of the local development plan. Investments in technologies such as irrigation, drought-resistant plants, and early maturing varieties; institution building; research; training; and promotion of small-scale farmers and animals such as cattle held to mitigate the effects of crop failure or low yields in extreme weather situations are some of the examples. This will also provide additional services required for adaptation, complicating the fulfilment of other development goals for long-term welfare.

**Keywords:** Climate change, Adaptation to climate change, Small-scale maize farmers, Perceptions, probability proportional to sample size.

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## LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AGRA | Alliance for a Green Revolution in Africa |
| CERES-maize | Crop Estimation through Resource and Environment Synthesis |
| DAFF | Department of Agriculture, Forestry, and Fisheries |
| DEAT | Department of Environmental Affairs and Tourism |
| DWAF | Department of Water Affairs and Forestry |
| FANPARN | Food, Agriculture, and National Resources Policy Network |
| FAO | Food and Agriculture Organization |
| FGD | Focus Group Discussion |
| FPP | Food Production Program |
| GDP | Gross Domestic Product |
| IMPACT | International Model for Policy Analysis of Agricultural Commodities and Trade |
| IPCC | International Panel on Climate Change |
| MAFISA | Micro Agricultural Finance Schemes of South Africa |
| MCPP | Municipal Climate Protection Programme |
| MLM | Makhuduthamaga Local Municipality |
| MMEs | Maize Mega Environments |
| SA | South Africa |
| SANCCRS | South African National Climate Change Response Strategy |
| SANNMCCA | South African National Networking Meeting on Climate Change Adaptation |
| SAWS | South African Weather Services |
| SDM | Sekhukhune District Municipality |
| TREC | Turfloop Research Ethics Committee |
| SSA | Sub-Saharan Africa |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WB | World Bank |

# CHAPTER ONE

## INTRODUCTION

### 1.1. Background of the study

Climate change is a real phenomenon that is being observed all over the world (Besada *et al.*, 2009) as indicated by the increase in atmospheric and oceanic temperature, a decrease in snow and ice, and a rise in sea level (Intergovernmental Panel on Climate change, 2014). The earth's surface has been warming for three decades in a row (IPCC, 2014), resulting in a higher average temperature than in previous centuries. Even though the contents are similar in context, the term "climate change" is defined differently by different stakeholders. Climate change is defined by the International Panel on Climate Change (IPCC) (IPCC, 2007) as a change in the state of the climate that can be identified by changes in the mean and/or variability of its properties and that lasts for an extended period, typically decades or longer. Climate change, according to the United Nations Framework Convention on Climate Change (UNFCCC), is defined as a change in climate caused by human activity that alters the composition of the global atmosphere, in addition to natural climate variability observed over comparable time periods (IPCC, 2007).

The effects of climate change differ depending on a region's level of development. According to the IPCC (2013), rising temperatures and changing precipitation rates will most likely hinder the success of rain-fed agriculture in most developing countries. Africa is one of the continents that is expected to experience 1 to 2°C temperature rises and an increase in the likelihood of extreme weather (Mulenga *et al*., 2017; Hamududu and Ngoma, 2019). Thus, the effects of climate change will have a greater direct impact on agriculture because agriculture provides a living for roughly three-quarters of Africa's population, and Africa's agriculture is primarily rain-fed (Kotir, 2011; Tetteh *et al*., 2014; Gemeda and Sima, 2015; Cohn *et al.,* 2017; Amondo and Simtowe, 2018).

Agriculture is important in South Africa (SA) because it employs most people in rural areas and contributes significantly to the Gross Domestic Product (GDP) of most countries. As a result, agriculture employs many people in SA, and increasing agricultural productivity is critical to reducing poverty and food insecurity (Alliance for a Green Revolution in Africa (AGRA, 2014). Temperature rises and increases stochastic rainfall variations, on the other hand, have both direct and indirect negative effects on crop yields and agricultural productivity. Kotir (2011), contends that over the last 50 years, agricultural productivity in SSA has steadily declined and increased at the slowest rate in the world, and that this will only worsen with climate change. Taken together, this evidence suggests that maize production, a vital crop for many millions (Shiferaw *et al.,* 2011), may be threatened by climate change.

Maize, a field crop that is one of the world's most cultivated crops, is a staple crop for the majority of the countries in Africa (Shiferaw *et al.,* 2011). While maize is still an important crop for many millions of people, yields in developing countries (including SA) are lower than in developed countries (Cairns *et al*., 2013; Masasi, 2019 and Ng'ombe *et al.,* 2019). More importantly, maize production is dependent on water availability, and most of the agriculture in SA is rain-fed, making maize production an obvious candidate to be impacted by weather shocks such as droughts one of the negative consequences of climate change. According to Lobell *et al.* (2011), maize is sensitive to daytime high temperatures above 30°C, and with climate change, the projected 2°C increase in temperatures for most of Africa would affect maize production, further lowering maize productivity levels despite rising demand for maize.

Because the effects of climate change appear to be felt, numerous studies have examined the effects of climate change on maize production and productivity, resulting in the promotion of several adaptation strategies to minimize the negative effects of climate change (e.g., Mulenga *et al*., 2017; Cairns *et al*., 2013; Müller *et al.*, 2011; Mulungu and Tembo, 2018; Tesfaye *et al*., 2015 and Amadu *et al.,* 2020). To the best of our knowledge, few studies have been published that provide a comprehensive review of the effects of climate change on maize production and productivity in South Africa. As a result, this project provides a thorough examination of small-scale maize farmer's perceptions of climate change on maize production and productivity.

The agricultural sector is one of the most important sectors of the South African economy, as it provides the majority of rural households and attached urban populations with their primary source of income. The agricultural sector contributes approximately 70% of rural livelihoods, 2.4% of South Africa's GDP, employs an estimated 80% of the population, and generates more than 10.6% of foreign exchange earnings (Department of Agriculture, Forestry, and Fisheries (DAFF), 2015). The agricultural sector's role and significance in South Africa, particularly in the economy of Limpopo province, is critical and viable. The sector is primarily responsible for increased productivity, improved food security, investment impact, labour absorption or employment opportunities, poverty alleviation, reduced rural-urban migration, income distribution, and stability. Given the rise in prominence of food security concerns, the agricultural sector's role as a food provider is particularly relevant at the moment. Food security is generally defined as having consistent access to a sufficient quantity of affordable, nutritious, and safe food for dietary needs. This, however, does not imply food self-sufficiency, as is frequently implied in political debates.

Primary agricultural production in South Africa was valued at R233,2 billion in 2015, with a contribution to GDP estimated at R66,7 billion (DAFF, 2015). Other sectors of the South African economy have grown faster than agriculture, forestry, hunting, and fishing over the years. As a result, agriculture's share of GDP has fallen from more than 6% in the 1970s to 1.9 % in 2015. Primary agriculture is an important sector in the South African economy, despite its small share of total GDP. Agriculture continues to be a significant source of employment, particularly in rural areas, as well as a major source of foreign exchange. Furthermore, agriculture's important, albeit indirect, role in the economy is a result of backward and forward linkages to other sectors. Purchases of goods such as fertilizers, chemicals, and implements establish backward links with the manufacturing sector, while supply of raw materials to the manufacturing industry establishes forward links. Approximately 70% of South Africa's agricultural output is used as intermediate products in the sector (Yirga, 2007). Agriculture is thus a critical sector and an important growth engine for the rest of the South African economy.

The agricultural sector is dualistic, dominated by commercial farmers and a large number of small-scale mixed crop and livestock farmers, with extremely low output and productivity (Bryan *et al*., 2013). The main causes of low productivity are reliance on traditional farming techniques, soil degradation caused by overgrazing and deforestation, inadequate complementary services such as extension, credit, marketing, and infrastructure, as well as climatic factors such as drought and flood (Yirga, 2007). These factors reduce small-scale maize farmers' adaptive capacity or increase their vulnerability to future changes, such as climate change, which has a negative impact on the performance of previously disadvantaged agriculture. It is widely acknowledged that an effective and efficient flow of climate change adaptation strategies through the use of improved agricultural technologies is critical to increased growth and agricultural productivity. Despite the implementation of agricultural policies, technological innovation, changes, and strategies in South Africa, the agricultural sector continues to poorly perform in the face of climate change.

Adaptation is a broad term that encompasses a wide range of behaviours and strategies employed by a wide range of actors. At best, good policy and implementation can result in partial adaptation, which leads to autonomous adaptation. When compared to developed farmers, developing farmers work hard, probably harder than anyone else, owing to their use of physical power and indigenous knowledge. Furthermore, they can make themselves safer even without artificial incentives, insufficient resources, or encouragement, especially if they are given the necessary information and resources. For example, in developing countries, the majority of small-scale maize farmers live in remote areas that are far from markets. Furthermore, such farmers do not have enough arable and grazing land, as well as financial resources. However, this should not be interpreted as a reason to leave adaptation to affected communities or farmers; as previously stated, farmers who are the least resilient are so due to a lack of the resources needed to effectively adapt. Furthermore, there are hard limits to what a community household or farmers can do: they can prepare for flooding by making contingency plans, but they are unlikely to be able to build storm-water infrastructure that would most effectively mitigate the flood's effects. Furthermore, autonomous adaptation is reactive by nature and is unlikely to address the underlying causes of vulnerability. The solution, then, is a combination of autonomous and planned adaptation, with collaboration from government, communities, farmers, and others. When households and communities are organized into community organizations, they are best able to build adaptive capacity. A strong, representative community organization can supplement planned adaptation in the following ways: first, community organizations have direct access to necessary information that government may not have easily available without extensive research, if at all. This includes pinpointing the community's vulnerabilities, as well as variations within it, as well as hands-on monitoring of climate effects and adaptations.

South Africa's current agricultural production decline can be addressed through effective climate change adaptation and mitigation strategies. This has the potential to be a solution for agricultural development and growth. As a result, climate change adaptation strategies in agricultural production are critical for social and economic development, including the maintenance of sustainable livelihoods for small-scale farmers in South African rural communities. Furthermore, it is critical to consider the socioeconomic characteristics of small-scale maize farmers, as well as the self-owned natural resource base, which plays a critical role in boosting agricultural development and growth. Due to an ineffective climate change policy, very low technological and financial capacities, and the current political crisis, South Africa's current level of support for the agricultural sector in terms of climate change adaptation is insufficient (Gbetibouo, 2009). A national integrated policy for adapting the agricultural sector to climate change is required (Erasmus, 2000).

The fact that climate has changed and will continue to change emphasizes the importance of understanding how small-scale farmers perceive and adapt to climate change. Such data is required to guide future adaptation strategies. According to studies (Thomas *et al.,* 2007; Mertz *et al*., 2009), farmers recognize that the climate is changing and are adapting to mitigate the negative effects of climate change. The perception or awareness of climate change, as well as the adoption of adaptive measures, are heavily influenced by various socioeconomic and environmental factors. There are various methods for adapting to climate change in agriculture, and the use of these methods is influenced by a variety of factors. For example, Hassan and Nhemachena (2008) proved that better access to markets, extension and credit services, technology, farm assets (labour, land, and capital), and information about climate change adaptation, including technological and institutional methods, affect climate change adaptation in Africa.

Perceiving climate change and its variability, according to Deressa *et al*. (2011), is the first step in the process of agricultural adaptation strategies. As a result, a better understanding of small-scale farmers' concerns and how they perceive climate change is critical for developing effective policies to support successful agricultural adaptation. Furthermore, precise knowledge of the type and extent of adaptation methods used by small-scale farmers is required. Furthermore, further advancements in the existing adaptation setups in agricultural production are required. Hence, understanding how small-scale farmers perceive climate change and what factors influence their adaptive performance is important for adaptation research (Mertz *et al.*, 2009). Small-scale farmers' adaptation methods are determined by a variety of social, economic, and environmental factors (Deressa, 2007; Cchetri *et al.,* 2012; Bryan *et al.,* 2013). This knowledge ultimately improves the dependability of policies and their ability to meet the challenges posed by climate change to small-scale maize farmers (Deressa *et al.,* 2009).

Agriculture's lack of investment has greatly contributed to the sector's sharp decline in production and growth. Food security and poverty reduction have not been realized as a result of the agricultural sector's subsistence nature, which is most prevalent in rural communities. Rural poverty is caused by a failure to invest in agricultural production, a decline in agricultural production, a lack of income-generating activities, and the depletion and degradation of natural resources. Many young South Africans are turning away from farming as a source of income, but urban areas provide few viable alternatives. Furthermore, other socioeconomic factors such as economic and technological stagnation, high unemployment, inadequate health care, and illiteracy have exacerbated the country's situation. The sector has also failed to grow due to a variety of factors, including erratic climatic and weather conditions, a lack of land, a lack of a land tenure system, a lack of government financial support for agriculture, and a lack of available water for irrigation. Therefore, the study recognized this research process as an important opportunity to improve local perspectives on the critical roles of maize production and the threats to agricultural development posed by climate change. Furthermore, the study would provide motivation for local communities or farmers to use climate change adaptive strategies in their own decisions about future security.

## 1.2. Problem statement and rationale

The Agricultural sector is an important driver of economic growth, mostly in the rural communities of developing countries; however, the production of this sector is exposed to climatic factors (Abid *et al*., 2015; Nhemachena, 2008; Oluwatayo, 2011 and Shongwe, 2014). Climate change has been largely known to have a lot of negative impacts on the agricultural sector and the negative impacts have also been revealed by some studies that have been shown in other parts of the globe (Ziervogel *et al*., 2014; Deressa *et al*., 2009 and Gbetibouo, 2009). Turpie *et al*. (2002) showed that some forecasts that are detrimental to climate change in South Africa indicate that certain species of animals will become extinct because of climate change impact. More importantly, maize production depends on water availability. Moreover, most of South Africa's agricultural sector is rain-fed, which makes maize production an obvious candidate to be affected by weather shocks in Makhuduthamaga Municipality. Drought serves as one of the negative impacts of climate change as most of the farmers produce maize (Houghton, 2001 and Gebreegziabher, 2012).

Various studies have been conducted on farm-level adaptation to climate change across different fields in various countries including South Africa which discovered farmers' perception, adaptive performance as well as their determinants, respectively (Deressa *et al.,* 2009; Gbetibouo, 2009; Mertz *et al*., 2009 and Thomas *et al.,* 2007). According to Deressa (2009) and Mertz *et al*. (2009), despite broad public education campaigns about climate change globally, many South African small-scale maize farmers still do not understand the fundamental drivers of climate change. Additionally, the South African National Networking Meeting on Climate Change Adaptation (SANNMCCA) identified gaps and shortcomings in adaptation in all provinces of South Africa. The prominent gaps and shortcomings identified were rural bias in projects whereby the focus was at the national level, lack of voice from civil society, government failure to integrate activities and minimum contribution from research. Deressa *et al*. (2010) stated that the fact that climate has changed long-ago and will carry on changing even in the yet to come emphasizes the need to comprehend how small-scale maize farmers perceive and adapt to climate change. Furthermore, the study was going to expand on knowledge, literature and information on how small-scale maize farmers perceive and adapt towards climate change.

According to Ziervogel *et al*. (2014), climate change poses a huge threat to South Africa's agricultural sector, water resources, food security, health, infrastructure, as well as its ecosystem services and biodiversity as attributed to higher temperatures and less rainfall. Moreover, currently, climate change has become a serious risk to the sustainable economic growth and development worldwide in general and across developing countries. However, studies have shown certainly that farmers perceive change in climate, and they also try to adapt in order to minimise the negative impacts of climate change (Thomas *et al*., 2007; Ishaya and Abaje, 2008 and Mertz *et al*., 2009). Adaptation is broadly recognized as a crucial constituent of any policy response to climate change. Studies from around the world have shown that without adaptation, climate change is generally harmful to the agricultural sector, but most farmers in Sekhukhune district tend to perceive first before adapting to the climatic conditions (Erasmus, 2000; Kurukulasuriya and Mendelsohn, 2006a; Nhemachena, 2008; Thomas *et al*., 2007). This study, therefore, attempted to investigate small-scale maize farmer's perceptions and adaptation towards climate change in Makhuduthamaga Local municipality Sekhukhune district, Limpopo province.

## 1.3. Research Aim and objectives

### 1.3.1. Aim of the study

The study's aim was to analyse the small-scale maize farmer's perceptions and adaptation towards climate change in Makhuduthamaga Local Municipality, Sekhukhune District, Limpopo Province.

### 1.3.2. Research objectives

Specific objectives of the study were to:

i. Identify and describe small-scale maize farmer's socio-economic characteristics in the study area;
ii. Assess the level of perceptions of small-scale maize farmers towards climate change in the study area;
iii. Analyse the socio-economic factors influencing perceptions and adaptation of small-scale maize farmers towards climate change in the study area.

### 1.3.3. Research Hypotheses

i. There is no difference in the level of perceptions amongst small-scale maize farmers in the study area.
ii. Socio-economic factors do not influence the perceptions and adaptation of small-scale maize farmers towards climate change in the study area.

## 1.4. Organization of the study

The rest of this thesis is organized into six chapters. The second chapter is the study's literature review, and it focuses on the effects of climate change on maize production and on agriculture as a whole and how small-scale maize farmers adapt to those climatic conditions. The third chapter describes the research methodology approaches used in this study, as well as the data collection and analysis methods. This includes the selection of the study area, data collection instruments, sampling methods, and empirical models for data analysis. Before discussing data collection methods and procedures, the study area is briefly described. Following that, the empirical model used in this study is presented. Finally, it describes both the dependent and independent variables used in the model. The descriptive statistics results of the study are reported and discussed in Chapter 4. The fifth chapter contains empirical results and discussions on the perceptions of climate change towards maize farming by small-scale maize farmers the factors influencing small-scale maize farmers to adapt towards climate change. Finally, chapter six presents the study's main conclusions and policy recommendations based on the empirical findings, as well as recommendations for additional research and future research directions.

# CHAPTER TWO

## LITERATURE REVIEW

### 2.1. Introduction

A literature review is the process of recognizing accredited published studies that are relevant to the research topic under consideration. It is the process of assembling academic information to add to the body of knowledge in a specific field. As a result, this chapter reviewed the literature on the effects of climate change on land-use changes (agriculture), biodiversity, maize production, and its relationships with livelihood adaptation strategies. It also provided an overview of climate-driven change throughout the world, as well as in Africa, particularly South Africa.

### 2.2. Definition of terminologies

#### 2.2.1. Climate change

Climate change refers to long-term changes in weather patterns such as temperature, precipitation, and wind (IPCC, 2007b). Climate change is defined by the United Nations Framework Convention on Climate Change (UNFCCC, 2009) as a change in climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, in addition to natural climate variability observed over comparable time periods. As a result, climate change is defined in this study as a variety of general shifts in weather conditions, such as temperature, wind, rainfall, and drought. Climate change is defined by the IPCC (2007a) as any change in climate that is directly or indirectly attributed to human activity and alters the composition of the global atmosphere, in addition to natural climate variability observed over comparable time periods. Drought and flooding are hallmarks of climate change, destroying plants and depleting soil. Droughts have become more common in recent decades, reducing soil moisture and water resources for plants, resulting in severe water stress. Reduced soil moisture reduces water availability for irrigation and prevents plant growth in non-irrigated plants.

### 2.2.2. Small-scale maize farmer's perception about climate change

Clarifying the public's understanding of climate change has been a major focus of research on public perceptions of climate change. Farmers/households must first perceive that changes are occurring to adapt to climate change. Perception, according to Ban and Hawkins (2000), is the process by which individuals receive information or stimuli from their surroundings and transform it into psychological awareness. This project's investigations will be based on perceptions and how rural households and farmers are coping and adapting to past and current effects of climate-driven changes.

### 2.2.3. Adaptation to climate change

When it comes to climate change adaptation in vulnerable areas, research on maize plays a very critical role (Shiferaw *et al.*, 2011). Climate change is expected to have the greatest impact on Africa due to limited institutional, financial, and technological capacity; adaptation to climate change will be difficult and complex (Shiferaw *et al*., 2011). Many of the negative effects are expected to be mitigated by research and plant breeding, but the negative effects of climate change are what farmers can expect if they continue to plant the same varieties in the same ways in the same areas. Shifting planting dates, modifying crop rotations, or adopting pre-existing crop varieties are some autonomous adaptations that will help offset some of the negative effects of climate change (Knox *et al.*, 2012).

It is critical to adapt agricultural systems to climate change in order to ensure food security for SSA's growing population (Tesfaye *et al.*, 2015). Identifying hot spots of climate change and understanding associated socioeconomic impacts at different spatial scales are important steps toward designing and implementing appropriate measures (Tesfaye *et al.,* 2015). Even if there has been success in the past, continued investment in maize productivity remains critical to the growth of agriculture and food security, which includes policies that favour maize production and productivity, as well as the development and adoption of new and improved maize seed and fertilizer (Smale *et al.,* 2011). In Ethiopia, for example, the area covered by improved maize varieties increased from 14 % in 2004 to 40% (Abate *et al.,* 2015). There is a need to invest in research to produce a new generation of improved varieties that are drought tolerant, pest resistant, and nutritionally efficient (Smale *et al.,* 2011). As a result, if appropriate measures to mitigate the negative effects of climate change are not implemented, the risk of food insecurity is expected to rise (Khanal, 2018). To manage current climate change and future adaptation to these variations, maize varieties that are tolerant to drought, heat, and water logging, as well as resistant to diseases, pests, and insects, are needed, and practicing conservation agriculture and precision agriculture would be beneficial (Shiferaw *et al.,* 2011).

### 2.3. Climate change: A global view

Climate change is one of the most serious environmental, social, and economic concerns that the world has ever faced (UNFCCC, 2011). Evidence of recent warming is rising, according to the UN Intergovernmental Panel on Climate Change. The worldwide average surface temperature has risen by 0.6 degrees Celsius since the late 1950s, and snow cover and ice extent have decreased; the sea level has risen by 1020 cm on average during the last century, and ocean temperatures have risen (IPCC, 2007b). By 2100, midrange climate change projections call for a 3°C global mean warming and a 45 cm rise in sea level (IPCC, 2007b).

Climate change is likely to cause more variability in the hydrological cycle (more floods and droughts) (UNFCCC, 2004). Furthermore, climate change is expected to have a considerable impact on the hydrological system, and hence on river flows and water supplies in developing countries, particularly in South Africa (IPCC, 2007b). This is especially significant in South Africa, given the country's semi-arid environment, where water supplies are extremely vulnerable to climate unpredictability and change. Deressa *et al.* (2008) and Nhemachena and Hassan (2008) studies on farmers' adaptation strategies and choice of adaptation strategies and perceptions to climate change suffer from the same limitation as earlier Ricardian studies of agriculture in that they do not include water supplies in their data analysis.

### 2.4. Climate change in South Africa

Climate change is a new issue in South Africa, affecting both urban and rural communities (South African National Climate Change Response Strategy (SANCCRS), 2004). Education, training, research, and public awareness about the effects of climate change continue to lag behind the necessary mitigation standards. Similarly, the government lacks the necessary capacity to deal with climate change effectively, particularly in rural communities. In terms of technical skills, industries are better placed. These skills, however, are not typically available for climate change-related activities. The government promotes public awareness of climate-related issues through the Department of Environmental Affairs and Tourism (DEAT) and the South African Weather Services (SAWS) (SANCCRS, 2004). Presentations and exhibitions are used to raise awareness about climate change, such as during National Atmospheric Week, World Environment Day, and World Meteorological Day. DEAT creates publications that highlight trends on important environmental issues, such as the Environmental Education fact sheet. Climate change, according to the United Nations Framework Convention on Climate Change (2011), poses a serious threat to the South African economy and rural livelihoods. South Africa is especially vulnerable to climate change because a large proportion of the population is unprepared for extreme weather events (e.g poverty; high disease burden; inadequate housing infrastructure and location). Rainfall is already low and variable in many parts of South Africa, particularly in impoverished rural communities. Despite the fact that poor remote communities are minor contributors to climate change, they are the most vulnerable and, as a result, will be the most impacted. Surface water resources are already fully allocated in a significant proportion of rural communities in developing countries, particularly in South Africa; agriculture, natural forests, and fisheries are important for food security and local livelihoods.

However, if nothing is done to address climate change and people continue to burn fossil fuels and cut down forest trees at their current rates, South Africa's coastal regions are expected to warm by 1 - 2°C by 2050 and 3 - 4°C by 2100. (UNFCCC, 2011). Furthermore, South Africa's interior regions will warm by 3 - 4°C by 2050, and by 6 - 7°C by 2100. As a result, there will be significant changes in rainfall patterns, which, when combined with increased evaporation, may result in significant changes in water availability, for example, the western side of the country is likely to experience significant reductions in the flow of streams in the region. South African biodiversity, particularly grasslands, fynbos and succulent karoo that where a high level of extinction is predicted will be severely impacted.

According to Benhin (2006) and NDA (2005), small-scale and homestead farmers in dry lands are the most vulnerable to climate change, and while intensive irrigated agriculture is better off than these farmers, irrigated lands remain vulnerable to water shortages. According to some forecasts, maize production in summer rainfall areas, as well as fruit and cereal production in winter rainfall areas, may be unaffected. In the south-western regions, commercial forestry is vulnerable to increased wildfire frequency and changes in available water, whereas rangelands are vulnerable to bush encroachment, which reduces grazing lands (Fisher *et al*., 2010). Invasive alien plant species are likely to spread further and have a growing negative impact on water resources (Fisher, 2004). Because South African remote areas have a poor health profile, they are particularly vulnerable to new or exacerbated health threats as a result of climate change (Gbetibouo, 2009). Some effects of climate change, for example, may already be occurring as a result of changes in rainfall (droughts and floods) and temperature extremes, such as cholera outbreaks, which have been linked to extreme weather events, particularly in poor, high-density settlements or communities. The frequency and severity of extreme weather events in South Africa will continue to rise. The costs of damage caused by extreme weather events (flooding, fire, storms, and drought) in South Africa have already been conservatively estimated to be around 1 billion rand per year between 2000 and 2009. (UNFCCC, 2011).

Climate change is expected to have the greatest impact on rainfall, temperature, and water availability in South Africa, with western regions expected to have 30% less water availability by 2050. (Hannah *et al.,* 2005). Furthermore, as a result of climate change, South Africa is expected to experience increases in temperature and decreases in rainfall patterns, as well as an increase in the frequency of extreme climate events (such as droughts and floods) (Dale, 1997; Nhemachena, 2008). South Africa has been identified as one of the African countries that will face significant water scarcity by 2025. (UNEP, 2009). The effects of climate change will contribute to increased water scarcity (Richards, 2008). Furthermore, drastic qualitative changes in water supply result in biodiversity and grassland losses, which have an impact on the agricultural sector, as well as possible increases in infectious and respiratory diseases (Kiker, 2000). The interaction of stress and resilience factors produces complex positive and negative livelihood trends, which are heavily influenced by policy environments. In many large developing cities, urban population growth exceeds 4% per year, and rural migrants account for between 35% and 60% of recorded urban population growth (UNEP, 2009). Within developing-country rural areas, there is a shift away from agriculture and toward non-farm economic activities, which already account for 30–50 % of rural income (Adger, 2003).

South Africa will need to adapt to the unavoidable impact of climate change by managing risk and reducing vulnerability. Although there will be costs associated with

South Africa's efforts to reduce greenhouse gas emissions, there will also be significant short and long-term social and economic benefits, including improved international competitiveness as a result of the transition to a low-carbon economy. Furthermore, these costs will be far less than the costs of inaction and delay. Government will continue to participate actively and meaningfully in international climate change negotiations, particularly the United Nations Framework Convention on Climate Change (UNFCCC), in order to secure a binding, multilateral international agreement that effectively limits the average global temperature increase to no more than 2°C above pre-industrial levels. It will, however, be a credible outcome that is equitable, fair, and inclusive, with a balance of adaptation and mitigation responses. South Africa is the world's third most bio-diverse country, trailing only Brazil and Indonesia, and it is the only country with more than one biodiversity hotspot (Aylett, 2011). Durban is located in the Maputaland-Pondoland-Albany Region, which is one of these hotspots. This includes both terrestrial (such as grasslands and forests) and aquatic ecosystems (like rivers, oceans and estuaries). Durban alone has over 2000 plant species, 82 terrestrial mammal species, and 380 bird species. There are also 69 reptile species, 25 endemic invertebrates (such as butterflies, millipedes, and snails), and 37 frog species (Aylett, 2010).

Durban is a representative African city, and as such, it represents a location where climate change poses significant and ongoing challenges to long-term development and human well-being. Climate change is likely to have dramatic consequences for a population that is already vulnerable in terms of poverty, health, water, and food security. Durban's response to these impending threats serves as a model not only for other cities in South Africa and Africa, but also for the rest of the world. Durban exemplifies what is possible in the face of numerous developmental challenges and limited resources, and as such, it is increasingly being recognized as South Africa's climate capital, as well as a global leader in climate protection planning. In response to the challenge of climate change, eThekwini Municipality launched the Municipal Climate Protection Programme (MCPP) in 2004 with the goal of assessing the local impacts of climate change on the municipality; highlighting the key interventions that the municipality would require in order to successfully adapt to climate change; developing tools to assist strategic decision making in the city in the context of climate change; and mainstreaming climate change.

## 2.5. Climate change and maize production

Climate change is caused by anthropogenic greenhouse gas emissions, which have been increasing since the pre-industrial era. This has been largely influenced by economic and population growth, greenhouse gas emissions, and atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have all increased (IPCC, 2014 and Kotir, 2011). Besada and Sewankambo (2009), argue that the IPCC's 4th Assessment Report seemed to ignore Africa's concerns about climate change. They argue that the issue of climate change should not be structured strictly in terms of projected carbon emissions and future environmental damage, but rather in terms of the links between climate change and current disaster events such as droughts, desertification, floods, and coastal storms. They also argue that these climate change-related disaster events endanger lives and livelihoods and hinder Africa's economic growth and social progress. Maize originated in Mesoamerica and is now grown throughout the continent of Africa (Shiferaw *et al.,* 2011). Maize grows best at moderate latitudes between 58°N and 40°S, but it can also be grown below sea level (Leff *et al.,* 2004). Maize accounts for more than 30 % of total calories and protein consumed in Africa, accounting for 13 % of total cereal production (Cairns *et al.,* 2013). The fact that 67 % of total maize production in the developing world comes from low and lower middle-income countries demonstrates the importance of maize in the livelihoods of a good number of farmers. Given its significance, maize productivity in SSA has remained quite low only increasing from about 0.9 to 1.5 tons/ha, with yield remaining highly variable (Cairns *et al.,* 2013; Adhikari *et al.,* 2015). The variation in yields is primarily due to the reliance on rainfall in unfavourable climatic conditions. Maize yields have been negatively impacted by climate change in many regions (IPCC, 2014). Thus, even when compared to the top five maize producing countries in the world, maize yields in SSA have stagnated at less than two tons per hectare, with Western and Southern Africa yielding less than 1.5 tons per hectare (Cairns *et al.*, 2013). Furthermore, when South Africa is excluded, West Africa had the highest growth in maize area, yields, and production from 1961 to 2010, while Southern Africa had the lowest, with yields a little more than 1 ton/ha (Smale *et al.,* 2011).

The primary reason cited for the disparity in maize yields between SSA and other regions is smallholder farmers' limited ability to adapt to the effects of climate change. According to Ng'ombe *et al.* (2017), the success of agriculture in SSA is hampered by the negative effects of climate change, while (Hamududu and Ngoma, 2019) contend that the lower adaptive capacity of smallholder farmers in SSA, combined with their rain-fed farming systems (common in SSA), exposes them to climatic effects. This observation supports the findings of (Smale *et al.,* 2011) who claim that the large yield gap between SSA countries and countries with comparable production conditions is aggravated when rain-fed areas are considered. Drought stress is more responsible for lower maize yields in SSA than other factors such as low soil fertility, weeds, pests, diseases, low input availability, low input use, and inappropriate seeds (Cairns *et al.,* 2013), as well as poor irrigation schemes or a lack of efficient irrigation systems (Ngoma *et al.,* 2017; Masasi and Ng'ombe 2019). While the effects of climate change on maize production may appear to be uniform across SSA, maize production trends in some SSA countries, such as Zimbabwe and Zambia, have changed, possibly as a result of changes in agricultural policy. Zambia has recorded consecutive maize bumper harvests in recent years (Chapoto *et al*., 2015), while access to subsidized farm inputs in Zambia has had a positive effect on technical efficiency of maize production in most of Zambia's provinces (Ng'ombe, 2017). Angola and Mozambique, on the other hand, are in a different situation because prolonged ongoing conflict and wars in the past have somehow depressed maize production and productivity trends (Smale *et al.,* 2011). However, because maize is a highly susceptible crop to droughts, droughts and floods account for roughly 70%–80% of maize losses in SSA (Mulungu and Tembo, 2018).

According to Nelson *et al*. (2009), the negative effects of climate change on crop productivity are more severe in SSA than in other parts of the world. Thus, severe and extended droughts, flooding, and loss of arable land are still possible, leading to lower agricultural yields via pathways such as crop failure and animal loss (Besada and Sewankambo, 2009), which generate draught power and household income. According to the literature, climate change has caused a 10% decrease in maize output, a 15% decrease in rice yield, and a 34% decrease in wheat yield in SSA in past years (IPCC, 2007). Yield forecasts indicate that by 2020, yields from rain-fed agriculture in some African nations could be reduced by up to 50%, affecting food security and worsening the hunger crisis (IPCC, 2007). Mulungu *et al.* (2019), suggest that in the worst-case scenario, maize yields in Zambia will fall by 25%, with temperature rises negating the gains from greater rainfall. According to Hamududu and Ngoma, (2019), climate change would reduce water availability in Zambia by 13% by the end of the century in 2100, posing a far bigger risk to field crops such as maize. Because of Africa's failure to cope with the physical, human, and social implications of climate extremes, it is the most vulnerable to climate change (Besada and Sewankambo, 2009; Hamududu and Ngoma, 2019; Kotir, 2011; Cohn *et al*., 2017; Adhikari *et al.*, 2015). The fact that the bulk of maize agricultural producers in SSA live in rural areas adds weight to the existing situation. According to Mulenga *et al*. (2017), at least 83 % of Zambia's 1.4 million smallholder households produce maize, which is a big quantity. However, the rural poor are more vulnerable to climate change, and as a result, hunger, poverty, and malnutrition levels are more likely to rise, implying that the effect of climate change will increase while other factors remain constant (Masipa, 2017). Because of these findings, there is a need to diversify beyond maize production, as maize production is a concern for food and nutritional security in most SSA nations, especially when alternative supplements for dietary diversity are scarce (Shiferaw *et al.*, 2011). According to the (IPCC, 2007) report, climate change will have a negative impact on agriculture, with the impact varying depending on adaptation and temperature rate. Crop productivity is expected to increase slightly at mid to high latitudes while decreasing at lower latitudes, especially in seasonally dry and tropical regions, in line with temperature variance. Crop productivity will increase with local mean temperature increases of up to 1–3°C in some places, but will decline at temperatures above that magnitude.

Lower latitudes, on the other hand, are expected to see crop yield decline even with moderate local temperature increases of 1–2°C. Cereal productivity, in particular, is projected to decline more at lower latitudes and less at mid to high latitudes, though this may change in some places as temperatures rise (IPCC, 2007). Although maize is commonly thought of as a warm-season crop, it is really more vulnerable to high temperatures than other crops (Tesfaye *et al.,* 2015). Higher temperatures diminish maize yields while encouraging the formation or multiplication of some weeds and pests (Shiferaw *et al.,* 2011). With a one-inch decrease in rainfall and a high temperature of 35°C, maize yield drops by 9% (Adhikari *et al.*, 2015). Furthermore, even though plant breeders have evolved maize varieties that grow well in a variety of biophysical conditions (Banziger and Diallo, 2004), sound maize productivity is still threatened by the consequences of climate change.

## 2.6. Impacts of climate change on maize production/agricultural production

Climate change and agriculture are intimately linked (Bryan *et al.,* 2009; Nelson, 2009). Agriculture productivity is influenced by solar energy, air, and precipitation (Bryan *et al.,* 2009). The agricultural sector faces problems from climatic dangers such as floods, drought, a cold spell, and new illnesses. According to Nelson (2009), agriculture plays a role in climate change, accounting for 13.5% of annual greenhouse gas emissions (with forestry accounting for another 19%), compared to 13.1 % from transportation. However, it is also a part of the solution, providing potential opportunities for carbon sequestration, soil and land use management, and biomass production to reduce emissions (Deressa *et al.,* 2005; Bryan *et al.,* 2009; Mertz *et al.*, 2009; Fisher *et al.,* 2010). The medium- to large-scale farm in South Africa is one of the country's most sophisticated and successful agricultural sectors (Benhin, 2006). These farms, which are commercially oriented, capital-intensive, and generally produce a surplus, account for 90% of value added and 86 % of agricultural land (NDA, 2011). Small-scale farms, on the other hand, are primarily subsistence in nature and rely on traditional methods of production, which are worked by a large proportion of the farming population (86%) (Benhin, 2006). The availability of water is the single most important constraint to agricultural production in South Africa (DWAF, 2010). The country's rainfall is unevenly distributed, with humid, subtropical conditions in the east and dry, desert conditions in the west. The country's average annual rainfall is 450mm, well below the global average of 860mm, and evaporation is relatively high (DWAF, 2010). Only 10% of the country receives more than 750mm of precipitation per year, and more than 50% of South Africa's water resources are used for agricultural purposes. Water scarcity caused by adverse climate change may have an impact on both commercial farming and, in particular, subsistence farming. This is expected to vary across the countries various agro-climatic zones, provinces, and agricultural systems (NDA, 2011).

Climate change, according to Deressa *et al.* (2005) and Mertz *et al.* (2009), threatens agricultural production by increasing and varying temperatures, changing precipitation patterns, and increasing occurrences of extreme events such as droughts and floods. The increase in temperature has both negative and positive effects on agriculture, as the IPCC (2007) predicted that the potential food production would increase with an increase in local average temperature of 1 to 3 $^{0}$C, but that it would decrease above this level. The agricultural sector (crops and livestock), which is the primary source of food and income for the majority of the local people in the area, appears to have improved significantly in recent years, owing primarily to increases in crop area and livestock immigration (Benhin, 2006). This is likely to lead to an underestimation of the true effects of climate change on productivity. Furthermore, while total household production may be increasing due to farm expansion, overall agricultural productivity will be heavily influenced by climate change and variability. The agricultural sector's link to poverty heightens concern about climate change (Adger *et al.,* 2003; Erasmus *et al.,* 2000). It is expected that adverse effects on the agricultural sector, in particular, will exacerbate the incidence of rural poverty, as agriculture is the primary source of income for many of the rural poor. The effects on poverty are likely to be especially severe in developing countries where agriculture is a major source of income for the majority of rural people. Land use and agricultural production continue to be the primary source of income for rural communities in Africa, employing more than 60% of the population and contributing roughly 30% of GDP (Bryan *et al.,* 2009; Nhemachena and Hassan, 2007). Reduced rainfall may necessitate the use of irrigation for agricultural production. Changing temperatures and rainfall patterns can have an impact on which crops are best suited to a particular region. Land managers, on the other hand, can frequently identify replacement varieties or crops that perform equally well in new climatic conditions.

Climate change may also have an impact on South African agricultural livestock production (Erasmus *et al.,* 2000). Higher temperatures benefit small farm animals such as goats and sheep because they are heat tolerant, whereas large farm animals such as cattle are less heat tolerant. Increased precipitation is likely to harm grazing animals because it implies a shift from grasslands to forests, as well as an increase in harmful diseases and a shift from livestock to crops (Adger, 2003). Smallholder, subsistence, and pastoral systems, particularly those in marginal environments, areas with high rainfall variability, or areas at high risk of natural hazards, are frequently characterized by adaptive livelihood strategies that have evolved to reduce overall vulnerability to climate shocks and to manage their ex-post impacts (coping strategies) (Easterling *et al.,* 1993; Adger *et al.,* 2003; Stern, 2007).

Despite uncertainty about the precise effects of climate change on natural forests and agriculture, particularly food production, it is widely agreed that (Erasmus *et al.,* 2000; Giliba *et al.,* 2011):

- Extreme events such as droughts and floods are likely to become more frequent and intense, resulting in lower yield levels and production disruption.
- Temperature increases and changes in precipitation timing, magnitude, and distribution are likely to increase moisture and heat stress on crops and livestock, with the subtropics bearing the brunt of the brunt.
- Soil erosion, runoff, landslides, and pest invasions will pose increasing threats to agricultural systems.
- Pests and diseases are climate-sensitive and are likely to change in unpredictable ways, with some becoming more prevalent in previously unknown unaffected areas.
- Climate change's effects are aggravated in areas where poverty is widespread and social safety nets are weak.

### 2.7. Vulnerability to climate change

Depending on the stakeholders involved, vulnerability can be described from a variety of angles (Adger, 2006; Heltberg et al, 2008). Climate change vulnerability does not exist in isolation from the larger political economy of resource usage. In addition to interacting with biophysical processes, it is frequently driven by unintended or deliberate human action that supports self-interest and power distribution (Ribot, 2010).

Climate risk policy is informed by two polarized views of vulnerability, namely, risk-hazard and social constructivist theory frameworks (Kelly & Adger, 2000; Adger 2006; Fiissel & Klein 2006; O'Brien et al., 2007). The risk-hazard model evaluates numerous outcomes of a single climate event, whereas the constructivist theory framework identifies various causes of single outcomes (Adger, 2006).

The risk-hazard approach views vulnerability as a linear result of climate change impacts and seeks to mitigate those impacts by technology "solutions" (Eriksen & Kelly, 2004; Fussel, 2007; O'Brien et al, 2007). The social constructivist framework, on the other hand, regards vulnerability as a feature of social and ecological systems that are influenced by a variety of variables and processes (Eriksen & Kelly, 2004). In contrast to the risk-hazard paradigm, which places the burden of vulnerability explanation on the biophysical system, the social constructivist framework places the same burden on the social system (Adger, 2006; Ribot, 2010).

Although both vulnerability frameworks are important for policy responses to environmental change, an integrated framework is more useful for planned climate change adaptation. This is due to the fact that it connects the two methods and considers vulnerability to be dependent on both biophysical and human variables. Furthermore, vulnerability is depicted as having "an exterior dimension, which is represented by a system's 'exposure' to climate fluctuations, as well as an internal dimension, which contains its ‘sensitivity and adaptive capability" to these stressors (Fiissel & Klein, 2006).

The degree to which natural and socioeconomic systems are vulnerable to anthropogenic climate change is determined not only by the degree of exposure, but also by a system's sensitivity to the impact and its adaptation potential (Smit & Olga, 2001; IPCC, 2001, 2007). The degree of a perturbation, stress, hazard, or shock that creates a major transformation or change in a system can occur immediately or over a longer period of time (Gallopin, 2006). Sensitivity, on the other hand, is the degree to which a system is influenced or modified by climate change without taking into account adaptation (Easterling et al., 2004). The consequences may be negative or positive, direct or indirect (Gallopin, 2006; IPCC, 2007).

### 2.8. Relative importance of temperature and rainfall

Even though temperature is an important factor in year-to-year production, rainfall is more important in determining agricultural production. In SSA, some countries experienced excessive rainfall, resulting in severe flooding and unfavourable economic consequences. These countries included Burkina Faso in 2007 and 2009, Mozambique in 2000 and 2001, Ethiopia in 2006, and Ghana in 2007 and 2010 (Kotir, 2011), and in 2017, floods destroyed lives and the agricultural sector in Niger, Nigeria, Burkina Faso, Guinea, Mali, Sierra Leone, Ghana, and Central African Republic (UNOCHA, 2019). Some countries experience more of these rain-related disasters than others. Malawi, for example, experienced 40 weather-related disasters between

1976 and 2009 (Pauw *et al.,* 2011). Floods are extremely destructive, and their effects, which include deaths and injuries as well as the exposure of people to toxic substances, are immediate. Flooding occurs all over the world, but the severity of the effects varies according to a country's adaptive capacity. Flooding has a greater impact on poor countries than on developed countries with a high capacity to adapt (Gemeda and Sima, 2015). Temperature increases and variations in rainfall make it less conducive to maize production in nearly three-quarters of the world's countries, resulting in lower yields (Jones and Thornton, 2003). However, the extreme opposite of too little rainfall, drought, is also a reality. Droughts are becoming more common, and grain and other crop yields across the continent may suffer as a result. Drought conditions may prevent maize from being grown in some areas (Ching, 2010) The 2002–2003 drought in southern Africa resulted in a food deficit, with an estimated 14 million people at risk of starvation, and severe droughts struck maize fields in eastern Africa in 2005–2006 and 2009 (Shiferaw *et al.,* 2011). Droughts will be common in most of SSA in the coming decades (Kotir, 2011). Drought affected more than 100 million people in Africa, for example, over the period 1991–2008, Kenya was affected by drought about seven times, and affecting about 35 million people, and Ethiopia was affected by drought about six times in 25 years (1983–2008) (Gemeda and Sima, 2015).

Climate change's impact on crop productivity varies greatly from region to region (Tetteh *et al.,* 2014), and climate change will affect crops differently, such as maize, rice, wheat, beans, and potatoes, while crops like millet may be less affected because they can withstand high temperatures and low water levels (Gemeda and Sima, 2015). However, smallholder farmers in developing countries, on the other hand, are the most vulnerable and disadvantaged people because they rely entirely on rain-fed agriculture (Tetteh *et al.,* 2014). Cohn *et al.* (2017) proved that climate change was responsible for a greater proportion of the variation in maize yields in SSA and Latin America. As a result, climate change has the potential to impede nations' sustainable development by reducing yield, which leads to food insecurity (Gemeda and Sima, 2015). SSA, on the other hand, has massive potential for increasing maize production. Approximately 88 million hectares (88 M ha) of land, excluding protected and forested areas, is suitable for maize production (Smale *et al.,* 2011). Advantages in yield can be significant as long as farmers replace seed every season (Smale *et al.,* 2011). In

2006–2007, the adoption of improved open-pollinated varieties and hybrids was at 44% of maize area in Eastern and Southern Africa (excluding South Africa), and 60% in West and Central Africa. This statistic suggested a significant increase in the adoption of improved varieties, particularly in West and Central Africa (Smale *et al.,* 2011). The global circulation model (GCM) postulated three major types of response of maize crop to climate change in the Jones and Thornton study, which included (1) the crop's productivity decreasing but to an extent that can be easily handled by breeding and agronomy. For example, in eastern Brazil, maize yield changes are expected to be moderate, with some pixels (plots of land) showing a slight yield advantage; (2) climate change benefits the maize crop. For example, in the Ethiopian highlands that surround Addis Abeba, yields are predicted to increase by up to 100 % at times, despite the fact that many of the pixels showing yield increases are adjacent to pixels where yields are predicted to decrease, sometimes dramatically, (3) "maize yields decline drastically, all other things being equal, that major changes to the agricultural system, or even human population, may have to be made" (Ching, 2010)

According to Abate *et al.* (2015), the majority of the results from Africa revealed a projected yield drop of up to 40% across all types of predictions and sub regions, even if the consequences described varied greatly. However, only about 12% of the participants in this survey reported an improvement in maize output in East, West, and Northern Africa. South Asia's results showed a similar negative anticipated impact, but with a wider range of results (Abate *et al.,* 2015). Following Ching (2010), maize production is expected to drop by 4.6 million tons per year from 2025 to 2055, more than doubling to 11.6 million tons per year. The total production impacts of likely future climate change to 2055 on smallholder rain-fed maize production in Latin America and Africa are comparatively minor. However, aggregated results conceal variability, i.e., yields will increase in other areas while yields will decrease in areas where subsistence agriculture is the norm (Jones and Thornton, 2003). Tesfaye *et al.* (2015) discussed the biophysical effects of climate change, as well as the effects of climate change on maize production, consumption, and food security. Climate change's biophysical effects include changes in potential maize cultivation area, changes in maize yields, and yield response to nitrogen levels. Under maize cultivation area, aggregating the change in land area suitable for maize production in SSA by the year 2050 reveals a small change of 0.6 – 0.8 %, which conceals a significant increase. By

2080, the cultivation area for SSA may increase by 1.3–2.5 % due to increased areas suitable for maize cultivation in Eastern and Southern Africa, while suitable maize cultivation areas in Central and Western Africa may decrease by 1.2–1.4 %. And, as a result of climate change, Sub-Saharan African countries bordering the Sahara Desert and Angola's coastal areas are likely to lose agricultural land suitable for maize production. Hence, some countries are likely to see a greater reduction in maize cultivation area by 2050 and 2080, while others are likely to see an increase in maize production areas.

The CERES-maize (crop estimation through resource and environment synthesis) outputs indicated a large spatial difference in maize yields under the projected climate in 2050 and 2080 across Sub-Saharan Africa. By 2050, some parts of SSA may see a 5% increase in yield, while others may see a 5% to 25% decrease in yield, a 25% decrease in yield, or a 25% increase in yield. Yields are expected to fall even further in many areas by 2080, with only a few areas maintaining current maize yields. Even though nitrogen fertilizer application increases maize yield for both the baseline and future climate conditions, the yield response of maize to nitrogen fertilizer application was less under climate conditions than the baseline conditions. However, the impact was less with a high level of nitrogen application than with a low level of nitrogen application. According to IMPACT (International Model for Policy Analysis of Agricultural Commodities and Trade) outputs, global maize production may decrease by 40–140 million tons by 2050, depending on GCM projections. As a result, the decrease in global maize production may result in a decrease in global maize consumption across SSA, which may lead to a decrease in daily caloric intake derived from maize. As a result, the decrease in daily caloric intake is likely to worsen food insecurity across SSA, potentially increasing the number of people at risk of hunger by 17–37 million people.

According to Tetteh *et al*. (2014), the effects of climate change in Ghana are expected to worsen in the near future, particularly if nothing is done to reverse the trend. With global climate change, the combination of abiotic and biotic stresses is likely to increase, causing crop damage (Shiferaw *et al.,* 2011). Climate change has had a greater negative impact on crops than positive impacts (IPCC, 2014), and "climate change will act as a multiplier of existing threats to food security" (Kotir, 2011). The IPCC predicted that annual mean temperature increases in SSA would be greater in the tropics and subtropics than in the mid-latitudes (IPCC, 2014). Furthermore, rainfall will become more intense and frequent over most mid-latitude land masses and wet tropical regions by the end of this century. According to the IPCC's fifth assessment report, climate-related hazards exacerbate other stressors, which has frequently resulted in negative outcomes for poor people's livelihoods. Climate-related hazards have an impact on the lives of poor people both directly and indirectly, through reduced crop yields or the destruction of homes, as well as increased food prices and a reduction in food security (IPCC, 2014). Depending on the level of input supply and GCM projections in SSA, yields will fall by 6–12 % and 9–20 %, respectively, in 2050 and 2080 (Tesfaye *et al.,* 2015). Furthermore, these figures vary by region, with Western and Southern Africa experiencing the greatest reduction in maize yields (Tesfaye *et al.,* 2015). Even if climate change reduces maize yields across Maize Mega Environments (MMEs) by 2050, dry and wet lowland MMEs will experience the greatest reductions (Tesfaye *et al.,* 2015) According to the literature, East Africa will likely lose about 40% of its maize production by the end of the twenty-first century, and there is a general consensus that climate change will affect maize productivity (Adhikari *et al.,* 2015). As a result, "the impact of climate change on global maize production may cause supply shocks in maize markets around the world, affecting food prices and, as a result, causing some adjustments in food production, consumption, and trade patterns worldwide" (Tesfaye *et al.,* 2015).

### 2.9. Small-scale maize farmers’ perceptions about climate change

Clarifying the public's understanding of climate change has been a key focus of study on public perceptions of climate change. Farmers/households must first recognize that changes are occurring in order to adapt to climate change. Perception, according to Ban and Hawkins (2000), is the process by which individuals receive information or stimuli from their surroundings and translate it into psychological awareness. This project's findings will be based on perspectives on how rural households and farmers are coping and adjusting to historical and current effects of climate-driven changes. Furthermore, it is acknowledged that the concept of a coping strategy is more directly tied to short-term survival, whereas the concept of an adaptation strategy pertains to a longer time frame (Bhusal, 2009; Stern, 2007). Claessens *et al.* (2012) investigated smallholder farmers' perceptions of climate change and techniques for coping and adapting in central Senegal's savannah zone. It was discovered that families are aware of climate variability, wind, and the occurrence of excess rainfall. Households' perceptions of climate change were connected to decreased crop output and poor livestock health. Farmers in the Sahel are constantly confronted with climatic variability at the inter-annual, intra-annual, and decadal time scales. Crop and livestock diversification, mobility, and migration were all traditional coping and adaptation tactics. It appears evident that the combination of high climate unpredictability, weak infrastructure, economic destitution, and low productivity will pose significant challenges for Africa, and particularly the Sahelian countries (Adger *et al.,* 2003 as cited by Claessens *et al.,* 2012).

Perceptions of rural households regarding climate change, particularly forest dependency, may differ depending on their socioeconomic and demographic characteristics (Deressa *et al.,* 2011). According to Bryan *et al*. (2009), rural households' perceptions of climate change influence their ability to extract natural forest products and, as a result, their marketing participation level. Climate change components such as rainfall, temperature, wind, floods, and drought are used to collect data as climatic characteristics or variability. Deressa *et al.* (2009) gathered information on farmers' perceptions of climate change by asking farmers if they had noticed any changes in temperature or rainfall over the previous 20 years.

Climate change perceptions are closely linked with knowledge and experience as ascribed to rainfall patterns and temperature changes in rural communities. Because of perceived climate-driven changes, rural communities alter their way of life in terms of generating a living. Because of changes in rainfall patterns and temperature, forest-dependent societies significantly change their visits to the community forest, which has an effect on commercial purposes. Education also improves the powers of conduct in rural communities in terms of social awareness and knowledge about climate change perception. According to Alarima (2011), awareness is a critical determinant of perception. Understanding climate change and its effects on natural forest products, crops, animals, and the environment in general will be difficult with low awareness, making it difficult to achieve sustainable economic activities. This implies that the greater one's level of awareness, the greater one's perception of climatic conditions, and thus the greater one's ability to adapt. Farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making, according to Maddison (2006: page 63). Several studies have found that such farmers' awareness and perceptions of agricultural and soil erosion problems influenced their decisions to implement soil conservation measures in a positive and significant way (Alarima, 2011; Maddison, 2006: page 63; Deressa *et al.,* 2009). According to Deressa *et al.* (2009), farmers who notice and are aware of climate change implement adaptation strategies to reduce losses and capitalize on the opportunities associated with these changes.

### 2.10. Agricultural policies and strategies towards climate change

Climate change is expected to have a negative impact on agricultural production and natural forests in Africa, including South Africa (Bryan *et al.,* 2009). Agricultural production, however, continues to be the primary source of income for the majority of rural communities in the country (NDA, 2005). Adaptation to climate change impacts in the agricultural sector is critical to protecting the poor's livelihoods and ensuring food security. A better understanding of farmers' perceptions of climate change, ongoing coping and adaptation measures, and decision-making processes is critical for informing policies aimed at promoting successful agricultural adaptation strategies (Stern, 2007). However, the presence of climate change impacts is expected to result in both gains and losses for farming systems (Benhin, 2006; Mertz *et al.,* 2009). If policymakers and farmers can identify where the gains and losses are and direct appropriate policies and adaptation strategies to those areas, the expected overall negative effect may be reduced, and it is even possible that climate change will benefit South Africa's agricultural sector.

One critical issue in agricultural adaptation to climate change is how farmers update their climate expectations in response to unusual weather patterns (Adger, 2003). Farmers must adjust to climate change. Knowledge of adaptation methods and factors influencing farmer decisions improves policies aimed at addressing the challenges that climate change imposes on agricultural production (Deressa, 2007). However, it is critical to educate them about the future risks of climate change, particularly the socioeconomic vulnerabilities associated with climate change (Alam *et al.,* 2011). They must be able to respond to adversity. Farms' and individual farmers' production practices must be kept up to date with changes in climate factors.

So apart from that, farmers must understand the significance of timing and must act quickly when forecasted rainfall events occur. They should be educated on crop rotation, crop portfolio management, and crop substitutions in order to address the environmental and economic risks associated with climate change (Deressa, 2007; Alam *et al.,* 2011). Furthermore, they must properly utilize land, knowing which agricultural production practices to implement and, if possible, changing the location of crop production to deal with extreme cases. They must also develop efficient irrigation practices to address moisture deficiencies and drought caused by climate change (McNeely *et al.,* 1990; Yirga, 2007):

- Increasing agricultural land. According to reports, the goal of this strategy is to increase overall production in order to compensate for lost productivity in traditionally small farms due to unfavourable climatic conditions.
- Farming technologies that have been improved, such as the use of improved seeds, fast growing seeds, and agricultural implements such as ploughs. This is intended to improve agricultural productivity even when expanding farmland is no longer feasible. For example, by planting improved seeds, it is possible to harvest more from a given area, whereas fast maturing varieties ensure that some harvest is obtained even after only a short period of rain. Timeliness in farm operations, which can be achieved through mechanization involving the use of ploughs, facilitates the achievement of such goals.
- Another adaptation strategy is the cultivation of drought-tolerant crops such as cassava. Growing drought-tolerant crops improves the area's food security situation when rainfall is unreliable.
- Early crop planting was also mentioned as an important adaptation strategy. Planting on time ensures that crop plants make the best use of early rains. Concerning water scarcity, however, in order to make such an adaptation strategy sustainable, deep well must be dug that can provide sufficient volumes of water to all community members throughout the year.

### 2.11. Factors affecting perceptions and adaptation to climate change

This section discusses the factors influencing small-scale maize farmers' perceptions of agricultural climate change and their adaptive measures. Social capital, institutional factors, age, gender, educational levels, household income, family sizes, employment status, access to credit, access to extension programs, production inputs, and so on are examples. Social capital refers to characteristics of social organizations such as networks, norms, and trust that enable stakeholders (community members and government officials) to work more effectively together to achieve common goals (Putnam, 1993; Adger, 2003). It is controversial in institutional and development economics because it requires significant cooperation, trust, and agreement among groups of individuals. It is based on connections across multiple systems, including the microsystem, ecosystem, and macro system (Putnam, 1993).

Social capital can be increased by organizing individuals into neighbourhood groups, connecting different groups, and eventually connecting these groups with government officials when implementing strategies to prepare for and respond to changing resource use challenges (Nyangena, 2005). The cooperation and active participation of local beneficiaries through their community institutions determines the success of the project. The existence of sustainable outcomes from forest enhancement of sustainable livelihoods in rural communities necessitates the use of social capital by the dependent groups. This is predicated on the existence of trust, norms, and networks that stakeholders and rural communities believe are effective and efficient for achieving sustainable livelihoods (Adger *et al.,* 2003).

The socioeconomic characteristics of groups, such as size and homogeneity, influence some resource users' ability to gain trust that others will not break the rules and significantly over-harvest. It is difficult to establish management of common forest use without the trust of community beneficiaries. As a result, social capital is an important input that influences the collection of forest products and, as a result, their commercial purposes. The number of relatives of a household in the local area also represents social capital, which may imply cheaper labour resources if they are available for the collection of natural products (Dasgupta, 2003). Social capital also encourages market participation through characteristics such as network, norms, and trust among homogeneous groups in order to adapt during economic downturns (Soltani *et al.,* 2012).

Social capital is also important in climate change adaptation because it connects people at various levels of power, such as community members, traditional leaders, and government officials (Reid and Salmen, 2000). According to research, adaptation to climate change risks must occur at the individual, family, community, and government levels (Putnam, 1993; Dasgupta, 2003; Adger, 2003; Soltani *et al.,* 2012). Individuals, groups within society, organizations, and governments make decisions on adaptation to climatic conditions on behalf of society, according to Adger (2003). As a result, adaptation processes involve agent interdependence through their interactions with one another, with the institutions in which they reside, and with the resource base on which they rely. Social capital also gives civil society and collective action a role for both instrumental and democratic reasons, and it attempts to explain different spatial patterns of societal interaction. Dasgupta (2003) argued that multiple institutional forms are derived from the networks and trust that collective action generates. It is expected that rural households with extensive social capital will adapt to changing climatic conditions.

According to the findings of a study conducted by Deressa *et al.* (2009), the Heckman probit model revealed that household size, educational level of the household head, farming experience, wealth, access to credit, and access to water, tenure rights, off-farm activities, and access to extension are the main factors that improve climate change adaptive capacity. The educational level of the household head, for example, increased the likelihood of adapting to climate change. The above-mentioned study discovered that increasing educational level significantly increases soil conservation and changing planting dates as an adaptation method. This implies that a unit increase in the number of years of schooling increased the likelihood of soil conservation and a change in planting dates to adapt to climate change. Furthermore, almost all of the marginal values of education were positive across all adaptation options, indicating a positive relationship between education and climate change adaptation. In short, access to education improves the ability of small-scale maize farmers to perceive and adapt to climate change. Dolisca *et al*. (2006) and Hassan and Nhemachena (2008) discovered that educated individuals have more knowledge and information about climate change and will adapt more quickly. This is consistent with the assumption that the higher one's level of education, the greater one's chances of obtaining more information, formal employment opportunities with higher pay, and adapting to climate change (Hassan and Nhemachena, 2008; Deressa *et al.*, 2009; Chhetri *et al.,* 2012). Most previous studies demonstrated the importance of education in adapting to climate change for long-term welfare (Barrett *et al.,* 2009; Deressa *et al.,* 2009).

### 2.11.1. Awareness, perception, and information on climate components: Temperature and rainfall.

Climate change awareness, education, farming experience, and perceptions of climate change components such as rainfall and temperature all play a role in adoption decisions. Several studies (Benhin, 2006; Bryan *et al.,* 2009; Mertz *et al.,* 2009) have revealed that improving education and knowledge dissemination is an important policy measure for encouraging local participation in various climate change adaptation strategies. Climate change perceptions (such as rainfall and temperature) are linked to education, experience, and awareness (Deressa *et al.,* 2009; Maddison, 2006). Improved education and farming experience raises awareness of potential benefits as well as willingness to participate in and pay for climate change adaptation activities. Farmers with more education and experience are expected to have more knowledge and information about climate change and agronomic practices that they can use to respond (Maddison, 2006; Tazeze *et al.,* 2012). It is economically assumed that increased knowledge and farming experience influence farmers' decisions to implement adaptation measures positively. Another important factor influencing agricultural technology adoption is awareness of the problem and the potential benefits of taking action. Farmers' awareness of changes in climate attributes (rainfall and temperature) is important for adaptation decision making, according to Maddison (2006). Several studies have found that farmers' awareness and perceptions of soil erosion problems influenced their decisions to implement soil conservation measures in a positive and significant way (Deressa *et al.,* 2009, Hannah *et al.,* 2005; Maddison, 2006). Farmers who notice and are aware of climate change are expected to take adaptation measures that help reduce losses or capitalize on opportunities associated with these changes. Agro-ecological setting is also a factor in agricultural adaptation measures; for example, farmers in different agro-ecological settings use different adaptation methods. Farming in the kola zone, for example, may increase the likelihood of soil conservation by small-scale farmers.

### 2.11.2. Household size

Household size is an important factor influencing farmers' ability to respond to climatic conditions. According to Deressa *et al*. (2009), larger households are forced to divert a portion of their labour force to non-farm activities in order to generate more income and influence their consumption pressure. This implies that large families in the studied area face higher opportunity costs when it comes to finding alternative livelihood strategies and thus prefer to stick to local-based strategies. Another possibility for such results was that most forest dependent households in the studied areas reported adapting out of the forest sector, starting their own businesses, engaging in agricultural production, finding informal employment, and home gardening for better welfare outcomes. When adapting to these livelihood adaptation strategies, other factors (such as access to credit, extension services, and access to land) must also be considered. Without access to land, for example, it would be difficult or impossible for the household to engage in crop enterprises. Increasing household size did not necessarily increase the probability of adaptation for most of the adaptation methods, even if the coefficient on the adaptation options had a positive sign. Furthermore, it is not natural to infer that the larger the household size, the better the chances of adapting to climate change. Furthermore, each adult household member may be a source of information or a recipient of an agricultural project. As a result, as household size increases, so does the likelihood of coming into contact with an agricultural project, increasing agricultural productivity and decreasing household food insecurity.

Larger households are more vulnerable to food insecurity than smaller households. One reason for this could be that larger households require more income than smaller households. According to Shongwe (2014), it is assumed that larger households, combined with a greater need for food, should motivate farmers to be more willing to participate in farming in order to ensure food availability for their household members. Farming, on the other hand, is dependent on people's ability to carry out farming activities. According to Nabikolo *et al.* (2012), a farmer with a large household can easily participate in agricultural projects while delegating other important tasks to other household members, and vice versa. Furthermore, each adult household member may be a source of information or a recipient of an agricultural project. As a result, as household size increases, so does the likelihood of coming into contact with an agricultural project, increasing agricultural productivity and decreasing household food insecurity.

### 2.11.3. Age, gender, and marital status of the farmer

One of the factors that may prevent farming households from achieving their goals is age. Because younger people are more likely to adopt new farming methods than older people, age is expected to have a positive effect on long-term household food availability. On the contrary, it appears that as people age, they may become more willing to take risks. They do, however, work fewer hours, which may have an impact on their food security. Younger farmers, who are stronger than older farmers, are expected to work on larger acreages. Several studies (Dolisca *et al.,* 2006; Nhemachena, 2008; Nhemachena and Hassan, 2009) have found that age, gender, and marital status are important factors influencing perception, and adaptive decision-making at the farm level. In their studies, Dolisca *et al.* (2006) and Nhemachena (2008) found that female-headed rural households are more likely to adapt to climatic conditions because they are in charge of much of the agricultural work and have more experience and access to information on farming practices. Most small-scale maize farmers are unique, with a diverse range of men and women, resources, opinions, preferences, and priorities. Given all of this, it stands to reason that when it comes to group–based climate change adaptation strategies, there will be perceivable gender differences in priority setting. Men's and women's adaptation priorities are primarily shaped by existing norms, roles, and responsibilities, as well as how adaptation strategies build or distort these. A large body of evidence from around the world suggests that culturally specific gender norms define the roles of men and women in farm and natural resource management. According to the findings of Deressa's (2007) empirical study, male-headed households adapt more readily to climate change. Male-headed households were 9% more likely to conserve soil, 11.6% more likely to switch crop varieties, and 10% more likely to plant trees. Furthermore, the age of the household head represented experience and influenced adaptation to climate change. For example, as the household head's age increases, so does the likelihood of planting trees and installing an irrigation system.

According to the World Bank (2006), maintaining food security is a serious problem for rural households, particularly women-led households, due to low yields in short crops and production, planting season and supply, as well as price fluctuations. According to the United Nations Food and Agriculture Organization (FAO), the heads of female-headed households have a desire for more activities to be completed. As a result, there is a lack of time and energy for farm or labour activities that will improve household finances. The Food and Agriculture Organization (2013) also identified one of the ways that the gender issue can be expressed in a household's food security status as a change from women-coordination to men-coordination as one of the moves from smallholder farming to commercial farming. Tazeze *et al.* (2012) observed that a younger farmer is more likely to participate in an agricultural project because younger farmers are more likely to be innovative and like to try new things. According to the Food and Agriculture Organization (2013), older farmers are usually more experienced, so they may have experienced or witnessed the benefits of participating in agricultural projects. Gbetibouo (2009), discovered that if men and women participated in agriculture more equally, production would increase, and thus food security would improve. As a result, male-headed households are expected to outperform female-headed households in crop production. This is most likely due to men performing fewer household chores than women. Women have less time to devote to farm labour because they are responsible for other chores. Even if participation in food security programs increases agricultural production, female-headed households may still face food shortages. It is commonly assumed that as farmer's age, farm output decreases, which is why farming requires a strong, healthy person, and older farmers are less willing to change to new farming practices that may increase farming output. Arnold (2002), on the other hand, disagrees with the belief that older farmers are more food secure than younger farmers. However, there is some disagreement about the impact of age on household food availability. As a result, the age of household heads can have a negative or positive effect on climate change adaptation measures.

Males are thought to be better able to withstand the heavy duties of farming practices, according to Stutley (2010). Women, on the other hand, have made strides in agriculture and are now recognized as significant farmers and livestock herders. This is due to the fact that rural households are becoming more focused on agri-business and farming types that cater to women. Female farmers typically have stronger social networks and are thus more likely to be involved in agricultural projects. Male farmers, on the other hand, have access to and control over resources. Males are also the majority of community decision-makers, making them well-suited to participate in agricultural projects.

### 2.11.4. Household or farmer experience in farming

Barrett *et al.* (2009) stated that household farming experience is defined as the length of time that rural households have been involved in farming. An experienced household is more likely to have farming experiences based on agri-business knowledge and skills, minimizing negative effects on his or her food availability. An experienced farmer is defined as one who has knowledge of insecticides, pesticides, disease and fungus control management, as well as a good understanding of local climate conditions. Participation experience can be positive or negative. The justification for this comment is that new technology may be exciting in the beginning and may succeed, but it will become less exciting as farmers grow older and weaker.

### 2.11.5. Farm income, non-farm income and unearned income

Farm, non-farm, and unearned incomes all contribute to the farmer's total household income and are critical factors in agricultural production. These factors influence the small-scale maize farmers' choices of agricultural climate change adaptation methods. Households with more income sources are more capable of owning and purchasing goods and services, and they are better positioned to adapt to climate change for long-term well-being. According to Deressa *et al.* (2009), the availability of sufficient income in rural households alleviates cash constraints and allows households to purchase inputs (such as paraffin, electricity, fertilizer, improved crop varieties, and irrigation facilities). According to the empirical findings of Tazeze *et al.* (2012), the income level of the households surveyed has a positive and significant influence on soil conservation, crop variety use, and planting date changes. Farmers' chances of adapting to climate change increased with each unit increase in income level. Farmers tend to invest in productivity smothering options (adaptation options in this case) such as soil conservation, use of different crop varieties, and changing planting dates instead of planting trees for shading, which compete with the limited land available when farming is the primary source of income. Furthermore, farm and non-farm income increases the likelihood of planting trees, changing planting dates, and using irrigation as adaptation options. A unit increase in nonfarm income increased the likelihood of planting shade trees and changing planting dates by 0.004 and 0.001 %, respectively. Nonfarm income was found to have a negative relationship with the use of different crop varieties and the adoption of soil conservation practices, though this relationship was not statistically significant. These findings suggest that when farmers have nonfarm income options, they can afford to plant trees on limited available land, pay for irrigation, and use fewer agronomic practices such as soil conservation and crop variety diversity.

### 2.11.6. Extension support services and government agricultural programmes

Extension can boost yield by accelerating technology transfer and improving farmers' skills and knowledge of acceptable farm management practices. According to Anaeto *et al.* (2012), extension services provided better technologies, more awareness campaigns, better skills and knowledge coupled with revised information, and training based on demonstration and lecture methods, which would ultimately increase agricultural productivity and thus household food availability. According to Abdu-Reheem and Worth (2013), extension services can act as a bridge between government and the community by transferring new technology that the community needs to adopt quickly, such as water harvesting.

Extension services are a valuable source of information on both agronomic practices and climate. Extension education was discovered to be a key motivator for increased intensity of use of specific soil and water conservation practices (Etwire *et al.,* 2013; Kirsten *et al.,* 2009). Various intervention programs have been implemented in South Africa, according to Kirsten *et al.* (2009). In the Eastern Cape Province, for example, the Green Revolution consisted of two major components: The Siyazondla Homestead Food Production Program, Siyakhula (small-scale), and the massive Food Production Program. Farmers were provided with fencing, stock, water dams, boreholes, deep tanks, tractors and other implements, irrigation schemes, and human resource development under the Green Revolution prospect. These were primarily funded by national government grants. According to Etwire *et al.* (2013), the programs were hampered by a lack of and/or poor quality farm inputs, such as selected seeds, as well as services such as credit and training. As a result, observed overall farm productivity is only about half of the extension program's target. According to Abdu-Reheem and Worth (2013), misunderstandings and a lack of clarity about new technology introduced by extension officers resulted in poor adoption of the technology and hampered progress in government food security interventions. In order for the government to design appropriate packages for rural households, it must first understand why farmers accept a technology. This data will help the government design technology that will meet the needs of rural households while also encouraging the adoption of new methods (Asfaw *et al.,* 2012).

Anaeto *et al.* (2012) described extension officers' roles as critical for a nation's social and economic development, particularly in terms of farmer education. These officers assist farmers in becoming aware of problems and in improving their own farming opinions and decision-making skills. As a result, the job of an extension officer entails significant responsibilities such as information transfer and partnering between the government and farming households.

According to Shongwe (2014), households employ a variety of adaptation strategies to mitigate the negative effects of climate change. Agricultural production in Swaziland continues to decline as a result of climate change, as evidenced by an increase in food relief agencies each year. The extent to which these impacts are felt is determined by the level of adaptation in response to climate change. To investigate the factors influencing the selection of adaptation strategies at the household level, descriptive statistics and multinomial regression model were used. Drought-tolerant varieties, crop rotation, mulching, minimum tillage, early or late planting, and inter-cropping were among the adaptation strategies. The analysis found that the age and occupation of the household head, land category, access to credit, being a member of a social group, access to extension services and training, high input prices, high food prices, high incidences of crop pests and diseases, and household perception of climate change all had a significant impact on the choice of adaptation strategies. Furthermore, the study found that household perceptions of climate change have a significant impact on all adaptation strategies. However, the gender and education of the household head had no effect on the choice of climate change adaptation strategies. The study does, however, recommend that farmers be educated about the negative effects on cropping systems.

Mabe *et al.* (2014) noted that climate change has been a major source of concern for farmers, particularly those in Africa's tropical regions. Farmers in Sub-Saharan Africa are suffering as a result of the current climatic changes. A binary logistic regression model was used to examine the factors influencing farmers' choice of adaptation strategies in Northern Ghana. The empirical results of the binary logistic regression models revealed that various factors influencing the choice of adaptation strategy, such as farm experience, farm income, phone access, mixed farming, farmers' perception of a reduction in rainfall amount, and access to weather information, significantly and positively influenced the choice of at least five climate change adaptation strategies. The study's findings revealed that each explanatory variable influences the adaptation decision of each of the climate change adaptation strategies in a different way. Farmers with higher incomes appeared to be better adapted to climate change. Low-cost climate change adaptation technologies should be developed and made available to poor farmers (Mabe *et al.,* 2014).

Apata (2009), indicated that there has been a widespread interest in the effects of climate change in Sub-Saharan Africa (SSA) and on the most effective investments to assist farmers, which strengthens the factors influencing the choice of adaptation strategies in southwest Nigeria. The Heckman probit model was used in the study to analyse the two-step processes of climate change adaptation measures. It began by assessing farmers' perceptions of climate change, and then examined farmers' responses to this perception in the form of adaptation. According to the results of the study, 53.4 % of the farmers polled noticed an increase in temperature over the last ten years, while 58 % noticed a decrease in rainfall over the same period. Secondly, a Focus Group Discussion (FGD) was held to elicit information; the findings revealed that 64.5 % of farmers have adapted to one or more major adaptation methods. The level of education of the household head, livestock ownership, crop and livestock production extension, credit availability, and temperature are all factors that influence the method of adaptation chosen.

### 2.11.7. Agricultural potential land or land size under cultivation

Several studies have found that having more land is an important factor in increasing the adoption of various technologies (Kurukulasuriya and Mendelsohn, 2006a; Maddison, 2006). Farmers can use all available information to change their management practices in response to changing climatic and other conditions now that they have more financial and other resources at their disposal. Farmers, for example, can buy new crop varieties, new irrigation technologies, and other important inputs they may need to change their practices to accommodate forecasted climate changes if they have financial resources and access to markets and land. South Africa has a scarcity of fertile arable land, which limits the country's ability to increase agricultural output (DAFF, 2012). According to Maddison (2006), urgent attention must be paid to global food security demand in the form of target crops that can withstand environmental conditions and farmers planting the right crops for their local climate and soils. High-yield agriculture allows farmers to make the best use of their land, resulting in year-round food availability. According to DAFF (2012), the greatest challenge in South Africa is water scarcity and rainfall distribution. Irrigation schemes support an estimated 1-3 million hectares, and farming consumes approximately 50% of South Africa's water (DAFF, 2012). With the demand on farming to maximize production per unit of land, it is critical to emphasize the importance of protecting our natural resources for future generations ascribed to the prevention and mitigation of climatic damage.

Empirical adoption studies have found that farm size has a mixed effect on adoption. A study on soil conservation measures in South Africa, for example, found that farm size was not a significant adoption factor (Erasmus *et al.,* 2000; Gbetibouo, 2009). Other studies, on the other hand, discovered that farmers with larger farms had more land to allocate for the construction of soil bunds (embankments) and improved cut-off drains (Kandlinkar and Risbey, 2000; Mabe *et al.,* 2014). Mabe *et al.* (2014), on the other hand, discovered that farmers with a small area of land are more likely to invest in soil conservation than those with a large area. The study hypothesized that farmers with large farms would implement measures that require a large amount of land, such as livestock systems, whereas farmers with small farms would diversify their options. Other studies, on the other hand, discovered that farmers with larger farms had more land to allocate for the construction of soil bunds, irrigation, and drainage systems for agricultural productivity (Yirga, 2007; Nhemachena, 2008; Deressa *et al.,* 2009).

#### 2.11.8. Market, credit, and electricity access

Another important factor influencing agricultural technology adoption is market access. Farmers can use input markets to get the inputs they need, such as different seed varieties, fertilizers, and irrigation technologies. Access to output markets, on the other hand, provides farmers with positive incentives to produce cash crops, which can help improve their resource base and thus their ability to respond to climate change. Madison discovered that farmers in Africa are less likely to adapt due to long distances to markets, and that markets serve as an important platform for farmers to gather and share information. Jari (2009), discovered that access to markets had a significant impact on farmers' use of conservation technologies in the Philippines. Access to electricity was discovered to be a significant factor in crop selection (Kurukulasuriya and Mendelsohn, 2006a) and livestock selection (Seo and Mendelsohn, 2006a). Household access to electricity and ownership of heavy machinery may indicate higher levels of technology, market access, or both. Farmers with greater access to higher levels of technology and market access are expected to be able to implement adaptation measures that necessitate the use of high levels of technology, such as irrigation systems.

Rural farmers require adequate credit, but in most cases, they do not qualify because they lack collateral security. Access to financial assistance is usually important for rural households because unemployment is high and they do not have cash to finance their project (Masuku, 2013). Kandlinkar and Risbey (2000) discovered that if credit assistance is obtained on time, production credit (seeds, fertilizers, and chemicals) could boost production and improve food availability. Masuku (2013) observed that rural households do not receive financial assistance due to a lack of knowledge about lending criteria, and this lack of finance is a symptom of poverty. It is critical for rural families to have access to resources in order for their members to actively participate in community development and upliftment. According to a study conducted by Mahlangu (2006), providing financial assistance to a rural community could be part of a plan to boost food production as well as household food security. In response to this trend, the Department of Agriculture launched a new initiative known as Micro Agricultural Finance Schemes of South Africa (MAFISA), which was aimed at a suitable financial institution market. According to Mahlangu (2006), MAFISA was intended to be a combined venture of public, commercial, and civil society organizations that would provide loan assistance to farmers, agri-businesses, and rural communities. However, the program did not achieve its objectives because its financing did not reach the rural market. When the government became dissatisfied with the investigation into the failure of access for underprivileged rural communities, the program was halted.

## 2.12. Poverty and income inequality amongst small-scale maize farmers

South Africa has one of the world's highest levels of income inequality and performs poorly in most social measures when compared to countries with similar income levels (FAO, 2008; Agrawal, 2003). Most people describe inequality as the disparity between affluent and poor. However, defining exact measurements of poverty and inequality in rural communities is exceedingly challenging. Poverty is defined as the inability to meet a basic standard of living, as measured by basic consumer demands or income (May, 1998). Most emerging countries attribute rural poverty and chronic suffering to a lack of natural resources in erstwhile homeland areas (Fraser, 2003; Mukherjee and Benson, 2003). Furthermore, poverty is linked to a lack of education and a lack of job.

Furthermore, higher wages are associated with better educational levels and a greater understanding of climate-driven change and its negative consequences. Poverty has various characteristics, one of which is poor consumption, which is linked to others such as malnutrition, illiteracy, low life expectancy, insecurity, helplessness, and low self-esteem (Carter and May, 1999). Poverty is also associated with unsatisfied capacities as a result of asset-based deprivation (land, markets, knowledge, credit, and so on), inability to afford adequate health and education, and a lack of authority (Mukherjee and Benson, 2003).

Furthermore, Altman and Ngandu (2010) stated that South Africa has a high level of unemployment. The expense of living is rising, and this, together with greater household sizes, contributes to a higher level of home insecurity. Furthermore, according to Altman *et al.* (2009), KwaZulu-Natal is the province with the highest level of unemployment. Aliber and Hart (2009) expressed similar sentiments, stating that while the unemployment rate has been considered to be addressed, it has had little impact on the reduction of income poverty. As a result, the government continues to have difficulties in reducing unemployment. Musemwa *et al.* (2013) found that work prospects in the Eastern Cape were limited, and that residents in rural regions relied on government assistance for a living. This confluence of circumstances makes food security challenging for people living in rural areas. It usually leads to isolation from the community, food shortages, overcrowding, the use of harmful and inefficient types of energy, a lack of sufficiently paid and secure jobs, and family fragmentation. As a result, poverty has a strong racial dimension, with Africans bearing the brunt of the burden (FAO, 2013).

Food security is a critical issue impacting rural people in developing countries, particularly South Africa (FAO, 2013). Food security is commonly defined as everyone having access to enough food at all times to live active, healthy lifestyles (World Bank, 2006). As a result, food security is determined not just by the amount of food available, but also by people (e.g., individuals, households, and nations) access to food, whether by purchasing it or producing it themselves. Access, in turn, is determined by economic factors such as food costs and household income, as well as agricultural production and natural resource quality (Arnold, 2002a). Food security is also linked to poverty and economic variables in the research region in terms of how rural families get food for their lives. According to preliminary visits to the research region, agricultural output, forest products, and purchasing food are their main sources of food, albeit these sources may be limited by climatic changes and other growing issues.

### 2.13. Summary and conclusions of the review

In conclusion, climate change is not just a global topic of concern, but it also poses significant challenges in developing countries, including South Africa, as this review has demonstrated. Produced agricultural products, natural forests, and the lives of those who rely on these natural resources are all particularly vulnerable to climate change. As a result, it is critical to evaluate adaptation in order to mitigate these vulnerabilities. A useful starting point for addressing adaptation needs in the context of poverty reduction is to consider strategies to deal with current climate variability and variability. Due to the fact that agricultural production is an important component of rural communities' livelihoods systems, it is hoped that the conclusions drawn from the literature review and synthesis will be of assistance to policymakers, agricultural producers, and forest planners in reducing the sectors' vulnerability to climate change.

Agriculture continues to be the primary source of income for rural communities throughout Africa, especially in South Africa. In order to mitigate the effects of climate change on agricultural production, several actions must be taken (for example, switching from crops to livestock or vice versa, adjusting livestock management practices, switching from farming to non-farming or vice versa, increasing the use of irrigation, changing the use of chemicals (fertilizers, pesticides, and herbicides), increasing soil and water conservation, shading and shelter, and using insurance, among others).

South Africa contains important natural resources, such as the agricultural industry and forests, which are vulnerable to environmental difficulties. The agricultural sector and forests in particular are particularly vulnerable (such as climate change, forest degradation, and invasive plant species). These resources are treasured for their biological richness, therapeutic properties, and local or home applications, as well as for their aesthetic and spiritual qualities. Higher-level policy debates over forest resources should take this into account in locations where forest resources are sufficient to support some households. Being able to understand how households respond to shocks (such as those caused by climate change or forest degradation or invasive species or other evolving factors) is critical because it can reveal what rural households can do to help themselves in these circumstances and what policy can do to support their livelihoods in these circumstances. Understanding the responses of rural households can aid in the development of solutions to assist them in coping with their circumstances.

Climate change has the potential to reduce the productivity and output of maize, a field crop that is dependent on water availability. According to the literature, climate change has a major impact on maize output and productivity, and if adequate adaptation methods to the negative effects of climate change are not implemented, these consequences will worsen in the near future. Governments and international organizations must step up efforts to mitigate the effects of droughts and floods, as well as to ensure that the repercussions of climate change are minimized. While we believe these initiatives are underway, a longer-term approach to enhance adaptation may offset these harmful consequences. More capable irrigation technological advances, improved research and development of drought-tolerant maize varieties, increased adoption of climate-smart adaptation strategies, and calls for global leaders to reconsider the negative impact of human activities on ecosystems are all strongly encouraged in the literature.

Based on opinions and observations of how rural households and farmers are coping and adjusting to the past and current impacts of climate-driven change, the investigations were carried out in the field. Aside from that, according to the author's knowledge, none of the research in this emerging literature have looked into small-scale maize farmers' climate change adaptation measures, as stated in the preceding remark. Furthermore, research on the factors that influence small-scale maize farming on climate change adaptation techniques in the context of South Africa is still in its infancy and lacks thorough documentation and understanding. As a result, the presence of this research endeavour is deemed necessary and justifiable. The methodological approaches that were used in this investigation are described in this chapter.

# CHAPTER THREE

## RESEARCH METHODOLOGY AND DATA COLLECTION PROCEDURES

### 3.1. Introduction

The methodological approaches used in this project are described in this chapter. This covers the selection of the study area, data collection tools, sample procedures, and the empirical data analysis model. Before describing methods of collecting data, strategies, and procedures, the study area is briefly described. Furthermore, the chapter provides an overview of the study area (Sekhukhune district), including its municipality (Makhuduthamaga) and two selected villages (Ga-Masemola and Apel Cross), economic activities, agricultural maize production capacity, climatic conditions such as temperature, distribution of rainfall, and general water uses. The conceptual framework and the empirical model that is used to address each objective of the study are described, afterwards, providing the reasons why the model is chosen to undertake data analysis.

### 3.2. Methods of data collection

#### 3.2.1. Study area

This research is conducted in two villages under Makhuduthamaga Local Municipality namely Ga-Masemola and Apel cross in Sekhukhune District based on the characteristics of the villages and that the farmers who are producing maize have available resources, Limpopo Province. Sekhukhune District is one of the five districts of Limpopo province of South Africa. The seat of Sekhukhune is Grobblersdaal where most of its population is 1,076,840 people who speak Sepedi. The Limpopo province is abundant with agricultural resources such as crop and livestock and has rainfall of over 700mm per annum which makes it suitable for agricultural production (Oni *et al*., 2012). Limpopo Province is one of the most fertile agricultural districts in South Africa. It is a big vegetable producer. The province's subtropical environment encourages the development of tea, coffee, and fruits, particularly tropical fruits. Tobacco, sunflower, wheat, cotton, maize, and groundnuts all contribute significantly to the economy.

## Sekhukhune District

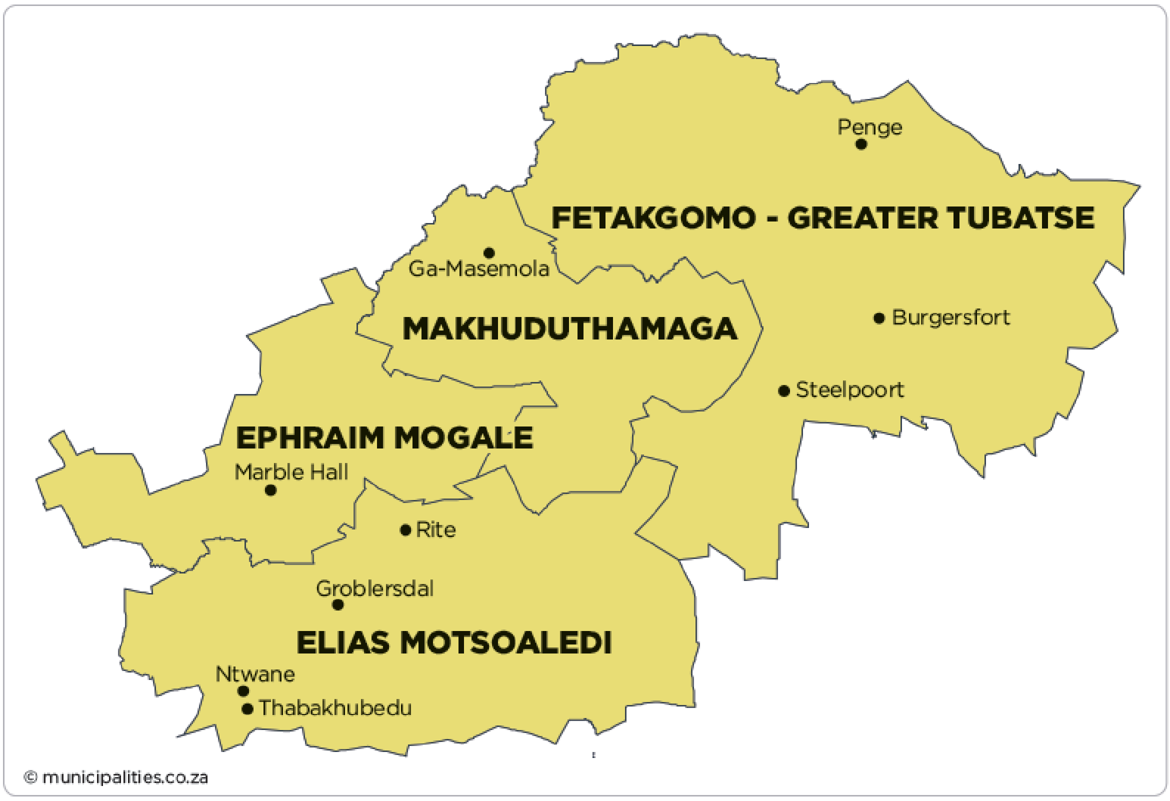


**Figure 3.1: Location of five municipalities under Sekhukhune district of Limpopo Province, South Africa**

Source: www.sekhukhunedistrict.gov.za

Sekhukhune District Municipality is located on the boundary of Limpopo and Mpumalanga Provinces. The district borders Limpopo's Waterberg and Capricorn districts, as well as Mpumalanga's Nkangala, Highveld District Council, and Lowveld Escarpment district. During the transition period, some areas of the Municipality were previously administered by the Northern District Council, Bosveld District Council, Lowveld Escarpment District Council, and Highveld District Council. The Municipality was established as a cross-border District Municipality in accordance with Section 12 of the Municipal Structures Act 117 of 1998. Fetakgomo Municipality, Makhuduthamaga Municipality, Grater Marble Hall Municipality, Greater Groblersdal Municipality, and Greater Tubatse Municipality are its five municipalities.

Agriculture, according to M'Marete (2003), accounts for 8% of the overall value of provincial economic production. Agriculture, forestry, and fishing, on the other hand, account for 11% of the Limpopo Province's GDP (M'Marete, 2003). Subsistence agriculture is practiced by many rural residents. Water is the biggest constraining issue in South African agriculture. Limpopo Province is no exception in this regard. Only arable land is eligible for irrigation when three soil suitability groups are considered: (a) arable, (b) marginal, and (c) non-arable. Despite the fact that the province's total arable land is projected to be 23592147 hectares, M'Marete (2003) reports that only 181 000 ha is irrigated. This is merely a minor %age of the total arable land, accounting for 7.7% of the total arable land.

Limpopo province has five districts, one of which being Sekhukhune. The municipality of Greater Sekhukhune District was founded in December 2000. This region is made up of five local municipalities: Fetakgomo, Makhuduthamaga, Elias Motsoaledi, Ephraim Mogale, and Greater Tubatse (Stats SA, 2011). The vast majority of the district is rural, with 94.7% of the people living in rural regions and 5.3% residing in urban areas. The district is divided into 29 wards and 166 settlements, with the administrative office in Burgersfort. A Councillor represents each ward, which is controlled by a local municipality. Mining, agriculture, government services, and retail services are their primary commercial economic sectors. Following the municipal election in 2006, the municipality was incorporated into Limpopo province. This area is made up of 16 wards and 75 villages. Agriculture, mining, building, trade, transportation, and banking are their main economic activities.

**Makhuduthamaga Local municipality**


**Figure 3.2: Location of Makhuduthamaga Local Municipality**

Source: Drawn by Basil Rabophala, Department of Geography and Environmental Studies

The Makhuduthamaga Local Municipality (MLM) is a category B4 municipality in the Limpopo Province's Sekhukhune District Municipality (SDM). The municipality is entirely rural in nature, dominated by traditional land ownership, and has a total land area of about 2 096.9 square meters. It consists of 189 localities with a total population of 274 358 people and 65 217 homes, accounting for more than 24 % of the District's total population of 1 076 840. (Stats SA, 2011). Makhuduthamaga, like most rural municipalities in the Republic of South Africa, has a weak economic basis, poor infrastructure, large service delivery backlogs, widespread human settlements, and high poverty levels.

### 3.2.2. Data collection instruments

The quantitative and qualitative data were used in this research. The Turfloop Research Ethics Committee (TREC) at the University of Limpopo granted permission to collect data first. Before surveying, questionnaires were explained to the municipality's traditional leaders and farm owners. Data were collected throughout a month, from the middle of December 2021 to the middle of February 2022, by a team of three enumerators who spoke the local Sepedi language. Before going out into the field, the enumerators were given a day of training that focused on the interview and the contents of the questionnaire. The questionnaire was pre-tested on selected farmers before data collection to assess the suitability of the design, clarity, and relevance of the questions. The pre-tested questionnaire was modified appropriately in order to gather the important information linked to the study objectives. Three enumerators were recruited and instructed on the contents of the questionnaire as well as the interviewing procedure. A team of three trained enumerators administered structured questionnaires to 110 small-scale maize producers to obtain primary data.

Before distributing the questionnaires, they were pre-tested. During the pre-testing period, a random sample of 10 small-scale maize farmers from each of the two villages was questioned. Questions that were discovered to overlap during the pre-testing period of the questionnaire were eliminated, and others that were confusing were adjusted to ensure clarity. Pre-testing the questionnaire also helped to refine it in terms of which subtopics to include in the survey questions and allowing the flow of questioning. In this study, the household of a small-scale maize farmer serves as a sampling unit. The household head interviewed is the individual who makes all or most farm management and livelihood decisions affecting the welfare of all household members. In their absence, members of the households who make such decisions were interviewed.

Small-scale maize farmers were interviewed at the study sites between December 2021 and February 2022. The main goal of those inspections was to get to know the research area and plan the empirical data collection procedures that would follow. Community assessment, key informant interviews, group discussions, and observations were used to gain a better understanding of the local context. Members of the community participated in focus group talks to learn more about certain topics such as population demographics, farming dependence, institutional challenges, and so on. Discussions were also held with some key informants (such as ward councillors, chiefs, elders, agricultural extension officers, community members, and members of various gender groups) to obtain context - specific information relevant to the study, such as population dynamics, institutional issues, community level statistics, and farming status over time. Meetings were scheduled with agricultural extension officers, members of (MLM), and representatives of the department of agriculture, and discussions focusing on demographics, administration, infrastructure, occupational structure, socioeconomic conditions, and how individuals use and perceive climate change. Members of the community shared their thoughts on climate change components including temperature and rainfall, which endanger their livelihoods.

To gather information on topics raised in the survey questionnaire, key informant interviews and focus group discussions were done. Key informants were chosen from the community's members of various social groups. An old villager who has resided in the village since his birth, an educator, traditional leader, headmen, and community members were chosen and interviewed. Following the qualitative and quantitative data collection procedures, household surveys were conducted using a thorough questionnaire to create primary data. Basic socioeconomic household variables were collected, such as the relationship between the head of the family and household members, age, gender, marriage status, work status, and educational level. Measures of household socioeconomic factors such as wealth endowments, agricultural production assets, agricultural production activities, and household income sources and amounts were also included in the questionnaire. In addition, questions were developed to gather small-scale maize producers' perceptions of climate change adaptation techniques and obstacles. The questionnaire also asked about perceptions of climate change and its consequences, livelihood strategies and dependent on farming techniques, and adaptation techniques when such reliance is broken. The South African Weather Station provided secondary data on average rainfall and temperature throughout time.

### 3.2.3. Sampling procedures and sample size

Sampling is the process of identifying units from a population of interest in order to study the sample and generalize the results to the population from which the sample was chosen (Greene, 2003). The study did not include all of the small-scale maize farmers in the study area, but a suitable or representative sample of the target participants was drawn. According to Fisher (2004), the characteristics derived from the sample should be similar to those of the population. Because the data from a sample was extended to the entire population, the manner in which the sample units were chosen was critical. A representative sample should have a big enough sample size to conduct credible statistical analysis. According to Gujarati and Porter (2009), a sample size of at least 30 units is required for valid statistics. The target population of the study was the small-scale maize farmers in the selected two villages under

MLM. To choose small-scale maize farmers in each community, a simple random sampling approach based on probability proportion to sample size was applied. The research employed both qualitative and quantitative secondary data, as well as cross-sectional primary data. Face-to-face interviews with structured and semi-structured questionnaires were used to collect qualitative and quantitative cross-sectional data. Secondary data was gathered via reviewing literature in the form of journals, papers, theses, reports, publications, and websites. As demonstrated in Table 3.1 below, a simple random sampling approach based on probability proportional to sample size was considered. The strategy aided by providing a total number of small-scale maize farmers who were eventually interviewed. The sample size in the individual municipalities of Limpopo province's district is shown in Table 3.1 below.

**Table 3.1: Sample size in the respective villages based on probability proportion to sample size.**

| **Villages under Makhuduthamaga Local municipality** | Total number of maize farmers | % ages | Probability Proportional to sample size per Village | Maize farmers interviewed |
|---|---|---|---|---|
| **Apel Cross** | 93 | 39 | 0.39 | 43 |
| **Ga-Masemola** | 145 | 61 | 0.61 | 67 |
| **Total** | 238 | 100 | 1 | 110 |
| Total sampled small scale maize farmers ( 46% of the sampling frame of 238) | | | | 110 |

**Source: Author's own calculations**

Based on probability proportional to sample size, 39 % and 61 % of the total number of small-scale maize farmers were interviewed from Apel cross and Ga-Masemola respectively (for rationale see Table 3.1). This implies that a total number of small-scale maize farmers from each village in the Makhuduthamaga Local municipality differs as depicted in Table 3.1 above. A total of 110 small-scale maize farmers in two villages under MLM in Sekhukhune District, Limpopo Province were surveyed using a structured questionnaire from a sample frame of 238. A total of 43 small-scale maize farmers at Apel Cross and 67 small-scale maize farmers at Ga-Masemola. This was followed to form the targeted sample size of 110 small-scale maize farmers. More than 10 % proportional sample size, data was collected in each village from small-scale maize farmers. This sample on average represents 46 % of the total number of small-scale maize farmers in MLM villages of Sekhukhune district.

### 3.2.4. Data analysis

To ensure consistency, uniformity, and accuracy, field data was edited, coded, and cleaned. The information was entered into computer software for analysis. The data is processed using IBM SPSS version 27.0 computer tools. The acquired data is analysed using two types of analysis: descriptive and econometric.

### 3.2.5. Data integrity

The accuracy and consistency of data captured or preserved is referred to as data integrity (Dosal, 2013). The significance of data integrity is that it reduces data corruption that may occur during the reading, writing, or storing of data (Crespi, 2007:3). The data collection procedure was monitored on a daily basis in order to address any issues that arose. The researcher and enumerators returned to the individual sampled small-scale maize farmers in the study area to compensate for any missing variables. Continuous spot checks were also performed to ensure that all relevant data was gathered.

### 3.2.6. Data processing

The following processes were engaged in the processing of the data from the questionnaires:

- Capturing the data to a processing medium spread sheet
- Data cleaning was the detection and rectification of incorrect data entries from questionnaires. It entailed finding incomplete, erroneous, inaccurate, or irrelevant elements of the data and then replacing, changing, or eliminating the unclean or course data; and data validation, which involves reviewing the data for correctness and meaning.

Descriptive statistics aided in the description of the socioeconomic characteristics of small-scale maize farmers, institutional variables, productive assets, and endowments. Climate change adaptation methods of small-scale maize farmers, as well as their perceptions, are presented in the Limpopo Province district of Sekhukhune.

### 3.2.7. Descriptive analysis

Descriptive statistics such as means, minimum and maximum values, frequencies, percentages, chi-square, and standard deviations are utilized to achieve objective one.

## 3.3. The empirical models and conceptualized variables

### 3.3.1. Factors affecting climate change perceptions and adaptation among small-scale maize farmers

According to a number of studies (Apata *et al*., 2009; Apata *et al*., 2011b; Deressa *et al*., 2009; Nhemachena, 2008; Oluwatayo *et al.*, 2008; Tazeze *et al*., 2012), adaptation to climate change is a two-step process; thus, a small-scale maize farmer must perceive that the climate is changing and that change is affecting their economic activities, and then respond to these changes through coping and adaptation methods. The Heckman probit model was used in the study to examine small-scale maize farmers' perceptions and adaptation to climate change in MLM, Sekhukhune District, Limpopo province. According to Deressa *et al.* (2009), climate change adaptation is a two-stage process that includes perception and adaption stages. The first stage is whether the respondent perceives climate change or not, and the second stage is whether the respondent adapts to climate change based on whether the respondent perceives climate change or not. Because the second stage of adaptation is a sub-sample of the first stage, the second stage sub-sample is likely to be non-random and distinct from those who did not experience climate change, resulting in sample selection bias. To account for this selectivity bias, this study used the well-known maximum likelihood Heckman's two-step approach (Heckman, 1976). Heckman's sample selection model refers to the existence of an underlying relationship consisting of.

The latent equation is given by:

$$Yj^* = j\,\beta + \mu_1 j \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (1)$$

Such that we observe only the binary outcome given by the probit model as:

$$Yj^{\,\textbf{probit}} = (yj^* > 0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The dependent variable is observed only if the observation *j* is presented in the selection equation:

$$Yj^{select} = (Zj\delta + \mu_2 j > 0),$$

$$\mu_1 \sim N(0, 1),$$

$$\mu_2 \sim N(0, 1)$$

$$corr(\mu_1, \mu_2) = \rho \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where $x$ is a $k$-vector of explanatory variables including various elements hypothesized to influence adaptation and $z$ is an $m$ vector of explanatory variables containing various factors hypothesized to affect perception; $u_1$ and $u_2$ are error terms. The perceptions of climate change are the first stage of Heckman's sample selection model, and this is the selection model (equation (3)). The second step, which is the outcome model (equation (1)), is whether the small-scale maize farmer adapts to climate change, based on whether the small-scale maize farmer perceives a change in climate in the first stage. When $\rho \neq 0$, standard probit approaches used to equation (1) produce skewed results. As a result, the Heckman probit (heckprob) yields consistent, asymptotically efficient estimates for all parameters in such models (Apata *et al.*, 2011b).

Natural, socioeconomic, institutional, and physical factors that influence the selection of these measures are referred to as independent variables. Previous research or economic theory, climate change adaptation literature, understanding of the contextual environment, and data availability are used to select the explanatory variables. These variables include: the head of the household's education, household size, the gender of the head of the household, non-farm income, crop production extension, access to credit, farm size, distance to input and output markets, and perceived changes in temperature and rainfall components. Previous research provided a detailed account of the theoretical relationship between these characteristics and adaptation to climate change (Apata *et al.,* 2009; Deressa *et al*., 2009; Oluwatayo *et al.,* 2008; Nhemachena, 2009; Apata *et al.,* 2011b; Tazeze *et al*. 2012). The first stage of the Heckman probit model is the perceptions of changes in climate change, and this is the selection model for this study, while the second stage model is whether the small-scale maize farmer has adapted to climate change, conditional on the first stage that the small-scale maize farmer perceived a change in climate. The outcome model is the second stage. The hypothesized variables influencing perceptions and adaptations to changes in climatic conditions, as well as their respective dependent variables, are listed below (Table 3.2 and 3.3). Tables 3.2 and 3.3 show the variables examined in this analysis for the Heckman probit model's selection and adaptation equation, as well as the expected signs of the computed coefficients based on previous research and economic theory.

**Table 3.2: Description of model variables for the selection equation of the Heckman probit selection model**

| **Dependent Variable** | **Description** | |
|---|---|---|
| Perceptions towards climate change (rainfall and temperature components) | It takes the value 1 if the small-scale maize farmer has perceived any changes in climate change (rainfall and temperature) in the last 30 years and 0 otherwise | |
| **Independent variables or explanatory variables** | | |
| **Variable label** | **Description and units of measurement** | **Expected sign** |
| GENDER | Dummy: 1 if the small-scale maize farmer is a male and 0 otherwise | + |
| AGE | Small-scale maize farmer's age (Years) | +/- |
| EDUC_LEVEL | Number of years the small-scale maize farmer attended school (Years) | + |
| MARIT_STTS | Dummy: 1 if the small-scale maize farmer is married and 0 otherwise | +/- |
| CC_INFN | Dummy: 1 if the small-scale maize farmer has access to information about climate change and 0 otherwise | + |
| FARMER TO FARMER EXTENSION | Dummy: 1 if the small-scale maize farmer has contacted other farmers producing maize and 0 otherwise | + |
| FARM_EXPNC | Number of years the small-scale maize farmer has been farming (Years) | + |
| ACC_CROP_EXT | Dummy: 1 if the small-scale maize farmer has access to extension services and 0 otherwise | + |
| CRP_FAIL | Dummy: 1 if the small-scale maize farmer had experienced crop failure due to climate change in the last 30 years and 0 otherwise | + |

**Table 3.3: Description of model variables for the outcome of the Heckman probit selection model**

| **Dependent Variable** | **Description** | |
|---|---|---|
| Adaptation towards climate change | Takes the value of 1 if the small-scale maize farmer adapted to climate change and 0 otherwise | |
| **Independent variables** | | |
| **Variable label** | **Description and units of measurement** | **Expected sign** |
| GENDER | Dummy: 1 if small-scale maize farmer is male and 0 otherwise | + |
| AGE | Small-scale maize farmer's age (Years) | +/- |
| EDUCATIONAL LEVEL | Number of years the small-scale maize farmer attended school (Years) | + |
| LABOURERS | Number of labourers working on the small-scale maize farm (Number) | + |
| FARM INCOME | The amount of money generated by the small-scale maize farm yearly (Rand) | + |
| ACC_CREDIT | Dummy: 1 if the small-scale maize farmer has gained access to credit and 0 otherwise | + |
| LAND_SIZE_OWND | The small-scale maize farm's size (Hectares) | + |
| DIST_INPUT MARKET | Distance to input market (Kilometres) | - |
| DIST_OUTPUT MARKET | Distance to output market (Kilometres) | - |
| CROP EXTENSION SERVICES | Dummy: 1 if the small-scale maize farmer is visited by extension officers and 0 otherwise | + |
| P_TEMPTRE | Dummy: 1 if small-scale maize farmer has perceived changes in temperature in the last 30 years and 0 otherwise | + |
| P_RAINFALL | Dummy: 1 if small-scale maize farmer has perceived changes in rainfall in the previous 30 years and 0 otherwise | + |

### 3.4. Summary

This chapter described the study area, the sampling method used, the various data collection methods and tools, the research design, data processing, and analysis. The chapter also discussed the empirical model of socio-economic, institutional, and physical elements that influence the choice of climate change adaptation, as well as small-scale maize farmers' perceptions and ability to adapt to climate change. In summary, the survey questionnaire information was based on the five livelihood capital assets (natural, physical, financial, human and social). The results of the descriptive statistics for the sampled small-scale maize farmers are presented in the following chapter.

# CHAPTER FOUR

## DESCRIPTIVE RESULTS AND DISCUSSIONS

### 4.1. Introduction

This chapter descriptively analysis and discusses the results of the field survey that was carried in Sekhukhune District, Limpopo Province. Data was collected from 110 small-scale maize farmers over a period of two months (from Mid-December 2021 to Mid-February 2022) using a team of three enumerators who speak the local Sepedi language. Within the chapter, descriptive statistics such as mean values, frequencies, pie charts, chi-square, percentages, and bar graphs are used. The chapter opens with a brief overview of data collection instruments (such as key informant interviews, group discussions, and participant observation) as well as the demographic characteristics of the sampled small-scale maize farmers. This is followed by a look at farmers' asset ownership and perceived changes in climate change components (rainfall and temperature). It then discusses the socioeconomic characteristics of small-scale maize farmers, with a focus on agricultural production and the factors that influence it (such as climate change). Other sections of the survey questionnaire covered farming operations, such as the amount of land used for farming, the types of farming, access to markets, extension support, financial support (access to credit), access to infrastructure, access to electricity, sources of information on climate change, and related assets. In addition, small-scale maize farmer’s perceptions and adaptation towards climate change and barriers in the study area are also discussed. The reasons of small-scale maize farmers for perceiving and not perceiving climate change and also choosing whether to adapt or not to climate change are subsequently, presented.

### 4.2. Key informant interviews, group discussion and participant observation

The key information interview was crucial for gathering critical information such as the farmer's economic history, traditional livelihood strategies, and informal and formal difficulties related to agricultural production in rural communities. Establishing good relationships with small-scale maize farmers (ward Councillors, extension officers, project steering committees, traditional leaders or headmen) was required to get the farmers to willingly share their opinions and information about their way of life. Key information interview was useful to gather information on farm level statistics in terms of population and the number of homestead in the study area and small-scale maize farmers therein. This was also useful as it gave a light and better understanding on sampling procedures such as sample size and questionnaire design. Although not many farmers attended the group discussions due to

### 4.3. Land tenure system and land size owned by sampled small-scale maize farmers

Land tenure refers to the process of acquiring land as well as the system of rights and institutions that manage access to land use (Adhikari *et al.,* 2004). There is no doubt that the security of the land tenure system is one of the most important factors influencing the development of rural farms. FAO (2008) defined land tenure as the right to own, use, transform, transfer, exclude or include others in the exercise of such rights, as well as the capacity to enforce the foregoing rights. Land tenure influences other farming elements such as disposition and responsibility for resource conservation and land improvement both directly and indirectly (Adhikari, 2001; Dasgupta, 2003; FAO, 2008; Hannah *et al.,* 2005; Narain *et al.*, 2008). Small-scale maize farmers who own their land and have title deeds are eager to learn and implement necessary steps to boost production and productivity for long-term development. Narain *et al.* (2008) discovered that in most developing countries, government ownership of land is the primary source of land insecurity for most small-scale farmers who feel they have the traditional right of ownership. The term "ownership" refers to the registration of a property, which grants the owner exclusive property rights, complete authority, and responsibility over the land and its fixtures. Small-scale farmers find it difficult to develop their land without title deeds or legal ownership, which can lead to neglect of land conservation and sustainability. Land insecurity reaches a tipping point, which can lead to civil conflict. In this study, the land tenure structure and the size of the farm owned by the sampled small-scale maize farmers were used as variables to impact the choice of climate change adaptation techniques, and relative share of farm income.

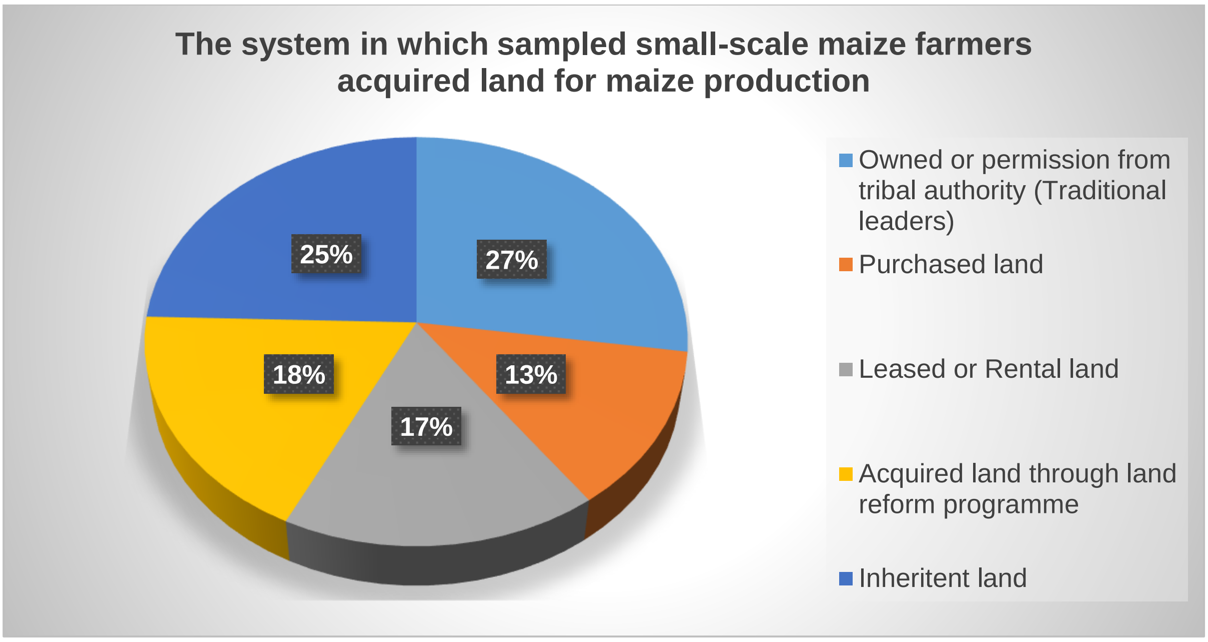


**Figure 4.1: Methods of acquiring land by sampled small-scale maize farmers in Makhuduthamaga Local Municipality, Sekhukhune District 2021/2022 (n=110)**

Source: Survey data (Mid-December to Mid-February 2022)

In this study, land tenure system was divided into five categories as shown in Figure 4.1 and this includes: land owned or get the permission from tribal authorities (traditional leaders), purchasing the land from someone else or certain institution, leasing or renting the land, acquiring land through land reform programme as well as inheriting the land. The percentages in Figure 4.1 shows the distribution of land tenure of sampled small-scale maize farmers and it was dominated by those who acquired land through the permission from tribal authorities (traditional leaders). Out of 110 sampled small-scale maize farmers, 30 (27%) acquired land through the permission from tribal authorities (traditional leaders) followed by 27 (25%) who acquired land via inheriting. Subsequently, 14 (13%), 19 (17%) and 20 (18%) acquired land through purchasing, leasing or renting and land reform programme respectively. The results indicate that the land acquisition method in Sekhukhune district, Limpopo province, differs and simply indicates that land is available for economic activity; nonetheless, the system is rather time consuming, particularly with the land reform initiative. Furthermore, compared to those who do not own the land they grow on, small-scale maize farmers who have security of tenure are less vulnerable because they can access loans, are more likely to invest in their land in terms of infrastructure, and are better equipped to diversify. Land ownership serves as a positive incentive for farmers to make investments on their farms, such as adaptation and appropriate crop and livestock management methods. When farmers are confident in their land ownership, new technologies have a better chance of being adopted. As a result, governments must ensure that tenure arrangements are safe, especially in resettlement projects, to encourage farmers to invest in long-term climate change adaptation solutions. The size of the land owned by the sampled small-scale maize farmers ranged from 9 to 50 hectares. Farmers with larger land size are more likely to have more and better ways to adapt since they have more land area to use and utilize their resources wisely and economically.

## 4.4. Description of the survey data

### 4.4.1 Socio-economic or demographic characteristics

Gender, age, household size, farm experience, marital status, number of adult labourers, farm size, employment status, number of sources of income, and highest educational levels of the sampled small-scale maize farmers are discussed in this section. These variables are critical because the household head coordinates the main household economic operations, and the household head's decisions are most likely to be influenced by such demographic data (Oluwatayo *et al*., 2008; Apata *et al*., 2011b; Cchetri et al., 2012; Bryan *et al*., 2013). When analysing economic data, socio-economic characteristics of small-scale maize farmers are critical since these aspects influence households' economic behaviour and decision-making ability. These kinds of factors, it was expected, will influence small-scale maize farmers' choice of climate change adaptation measures, as well as their proportional share of farm income. The descriptive results of the demographic characteristics of the sampled small-scale maize farmers are summarized in Table 4.1 below.

**Table 4.1: Continuous variables description of the sampled small-scale maize farmers under the villages in Sekhukhune District, Limpopo Province (n=110)**

| Variable definition | Mean | Std. Deviation | Min. | Max. | T-test (Sig. 2-tailed) |
|---|---|---|---|---|---|
| Age (years) | 58.46 | 12.75 | 31 | 85 | 133.6*** |
| Household size | 7.67 | 2.79 | 3 | 16 | 67.8*** |
| Farming experience | 31.2 | 13.43 | 7 | 58 | 53.9*** |
| HH adult members | 5 | 1.671 | 1 | 7 | 56.9*** |
| Total Land size | 28 | 11.556 | 3 | 56 | 114.3*** |
| Number of income sources of the small-scale maize farmer | 3 | 1.126 | 1 | 6 | 53.5*** |
| Total household income of sampled small-scale maize farmers in year 2021 | R139446 | R8672 | R115460 | R448720 | 298.7*** |
| Total Farm income in 2021 | R14754 | R16.115 | R8598 | R179320 | 24.9*** |
| Distant to the output market (Kms) | 51.37 | 25.013 | 7 | 190 | 43.8*** |
| Distance to the input market (Kms) | 49.29 | 23.642 | 6 | 168 | 42.2*** |
| Total Farm labourers | 22 | 1.245 | 7 | 21 | 10.7*** |

Source: Survey data (Mid-December 2021 to Mid-February 2022)

**Notes**: *** means statistically significant at the 1% level

#### 4.4.1.1. Age and farming experience of the sampled small-scale maize farmers

The influence of small-scale maize farmers' age and agricultural experience on climate change adaptation methods has been found to be diverse in the literature. However, the extent to which small-scale maize farmers are ready to pay for those adaptive measures is still unknown. A number of studies (Bryan *et al.,* 2013; Cchetri *et al*., 2012; Deressa *et al*., 2009; Maddison, 2006) identified small-scale maize farmers' age as an important component or aspect impacting their agricultural output and productivity decisions. According to Maddison (2006) and Deressa *et al.* (2009), the age of the small-scale maize farmer represents farming experience; thus, experienced small-scale maize farmers have a higher probability of perceiving climate change because they have been exposed to past and present climatic conditions over the course of their life. Because climate change is the outcome of variations over a relatively long period of time, older farmers are likely to be more familiar with the idea and its impact on agricultural activity. This factor is critical in influencing farming experience and capacity to carry out farming activity. Furthermore, a small-scale maize farmer's age always impacts his or her ability to gain outside knowledge about agricultural production, assessment of climate change components, and adaptation measures. According to Bryan *et al.* (2013), even if older and more experienced farmers are affected by climate change, they can readily adjust to new enhanced technology due to their agricultural experiences. This is consistent with the findings of Tazeze *et al*. (2012), who concluded that older farmers have a better likelihood of adopting a technology due to their accumulated knowledge, capital, and experience. This means that as a farmer ages, he or she accumulates experience in the social, economic, and physical environments associated with farming, making the farmer more productive with greater managerial abilities and accumulated skills.

The survey results in Table 4.1 shows that the mean age and farming experience of the sampled small-scale maize farmers are 58 and 31 years, respectively, with a minimum of 31 and 7 years and a maximum of 85 and 58 years. Highly experienced small-scale maize farmers are more likely to be aware of changes in climatic conditions and crop management practices. Experience paired with knowledge is a driving force for agricultural advancement, allowing some small-scale maize farmers to attain their goals. Experienced farmers are typically leaders and progressive farmers in rural areas, and they can be targeted to promote adaptation management to other farmers who lack such expertise and are not yet adapting to climatic conditions (Apata, 2011; Tazeze *et al.,* 2012).

These finding suggested that agricultural production in Sekhukhune District, Limpopo province, is dominated primarily by elderly small-scale maize farmers, with a few youthful farmers. This could be because the younger generation lacks the financial resources to engage in farming methods. Furthermore, other young people or equivalents are often uninterested in agricultural activities and prefer to stay in cities to pursue other forms of work or economic activities. The two-tailed test results in Table 4.1 are statistically significant at 1%, indicating that there is a highly significant mean difference in the ages and farming experiences of small-scale maize farmers. The statistically significant t-test value indicates that the small-scale maize farmer's age and farming experience influenced his perceptions of climate change components and his choice of coping with climate change adaptation strategies, as well as his relative share of farm income. The results of Table 4.1 also show that the mean total number of labourers employed or utilized by sampled small-scale maize farmers in the study area is 22 with a minimum and maximum of 7 and 21 respectively, but it is not documented whether these workers were employed on a permanent, temporary, casual, or seasonal basis. The two-tailed test result for this variable is highly statistically significant at 1%, indicating that there is a highly significant difference in the number of labourers employed by sampled small-scale maize farmers in the study areas.

#### 4.4.1.2. Household size and number of adult members in the household of the sampled small-scale maize farmers

According to several studies (Apata *et al.*, 2009; Dolisca *et al*., 2006; Gbetibouo, 2009; Mabe *et al.*, 2014; Nhemachena, 2008; Tazeze *et al.,* 2012), household size and the number of adult members in the household are important factors influencing the level or choice of climate change adaptation measures of small-scale maize farmers. According to Mabe *et al.* (2014) and Tazeze *et al*. (2012), the importance of the aforementioned elements on the use of adaptation methods was underlined from two perspectives. The first assumption is that households with more family members may be required to redirect a portion of their labour force to non-farm activities in order to earn cash and alleviate the spending pressures caused by a big family size (Apata *et al*., 2009; Mabe *et al.,* 2014). The other assumption is that a big family size is typically associated with a higher labour endowment, allowing a household to perform a variety of agricultural jobs. Tazeze *et al*. (2012), for example, argue that households with a bigger pool of labour are more likely to adopt and employ agricultural technology more intensively because they have less labour shortages during peak times. According to Shongwe (2014), it is expected that larger households, together with the need for more food, should inspire farmers to be more motivated to participate in farming in order to secure food availability for their family members. Farming, on the other hand, is dependent on people's ability to carry out farming activities. According to Nabikolo *et al.* (2012), a farmer with a large home can readily participate in agricultural production while delegating other critical tasks to other household members, and vice versa. Furthermore, each adult household member may be a source of information or a recipient of an agricultural initiative. According to Deressa *et al.* (2009), larger households are required to devote a portion of their labour force to off-farm activities in order to create more money and affect their consumption pressure. This means that large families in the study have higher opportunity costs when it comes to finding alternative livelihood strategies and are more likely to stick to local-based solutions.

In this study, household size was defined as the number of people who ate and lived together in the respondent's household for six months. Furthermore, adult members are defined as those above the age of 18 in the sampled homes of small-scale maize farmers. Because labour-intensive farming practices are used in small-scale farming, labour is a critical aspect in output. Table 4.1 depicts the distribution of household size and adult members in the study areas. Using household size as a proxy for labour availability, it is possible to conclude that agricultural households in the research areas had little difficulty finding farm labour. A larger family size means that a wider range of labour capacity is accessible in the form of young, middle-aged, and elderly people. Labour, particularly casual labour, is a critical aspect of production for small-scale maize farmers. In most cases, small-scale maize farming is labour-intensive rather than capital-intensive (Dolisca *et al.,* 2006). Furthermore, the majority of small-scale maize farmers rely on unpaid family members for crop production. According to the survey results in Table 4.1, the average household size and number of adult members of sampled small-scale maize farmers are 7.67 and 5, with a minimum of 3 and 1 and a maximum of 16 and 7, respectively. The two-tailed test findings showed that household size and number of adult members were highly statistically significant at 67.8 and 56.9 t-values, respectively, indicating that the household size and number of adult members in each home differs. This means that there is a highly significant mean difference between these variables among the sampled small-scale maize farmers. The statistically significant t-test value indicates that household size and the number of adult members of the small-scale maize farmer's choice of dealing with climate change adaptation techniques and proportional share of farm income, respectively. These findings indicate that farmers in the research areas have access to family labour, which may promote the adoption of labour-intensive climate change technologies and solutions.

#### 4.4.1.3. Distance to the formal market (output and input) of the sampled small-scale maize farmer

The distance between the output and input markets is a key factor determining small-scale maize farmers' ability to select climate change adaptation options (Dolisca et al., 2006; Gbetibouo, 2009; Mabe et al., 2014; Nhemachena, 2008). Table 4.1 illustrates the distances to input and output markets in Sekhukhune district villages. Small-scale maize farmers travelled an average of 49.29km and a maximum distance of 168km to buy inputs such as seed, chemicals, and fertilizer from nearby towns. Lebowakgomo is the nearest large town for the market in the research area. Alternatively, small-scale maize farmers purchased inputs from local businesses, which required them to travel a minimum of 6 kilometres in all areas. However, in most cases, small-scale maize farmers reported having to drive to nearby towns to purchase inputs since they were not always readily and sufficiently available in local shops. In terms of output markets, sampled small-scale maize farmers reported traveling an average of 51.37km with a maximum distance of 190km to sell their produce; however, more than 75% (83 small-scale maize farmers) of the sampled small-scale maize farmers in all communities were marketing their produce locally and did not have to travel due to high transportation costs. In general, the findings in Table 4.1 reveal that the sampled small-scale maize farmers had to travel long distances to formal input and output markets. This is consistent with the findings of Bryan et al. (2013), Cchetri et al. (2012), and Maddison (2006), who believe that small-scale maize farmers face barriers to accessing input and formal markets.

Market accessibility and information are linked to input and formal markets, and they are likely to influence a small-scale maize farmer's crop selection decision. Distance from the market centre, according to Cchetri et al. (2012), is likely to have a detrimental impact on adaption possibilities. Furthermore, Maddison (2006) stated that market proximity is a significant predictor of adaptation since markets offer as a way of exchanging information with other small-scale farmers. As a result, being far from a marketing depot reduces the likelihood of employing climate change adaptation and conservation strategies. The highly statistically significant t-test values show that the small-scale maize farmer's distance to the output (43.8) and input (42.2) markets influenced his or her choice of climate change adaptation strategies and relative share of farm income, respectively. This t-test results of the two above-mentioned variables signifies that there is mean differences in the both variables of the sampled small-scale maize farmers in the studied areas.

#### 4.4.1.4. Household income of sampled small-scale maize farmers

In this study, total household income was defined as the sum of total income obtained by sampled small-scale maize farmers from their various income sources known as household economic activities. It was also defined as money received from unearned income sources (old-grant pension, child-support social grant, remittances, and disability grant), farm (crop sales), and employment income in the form of wages and salary (self-employed, permanent, casual, contract and temporary employment status). According to Nhemachena (2008), household income is a critical variable in rural livelihoods because it represents or measures the relative material of well-being and reflects the degree of reliance on farm and non-farm economic activities of small-scale maize farmers. A unit increase in household income enhances the likelihood of small-scale maize farmers' climate change adaptation measures and their adoption of those measures. Farmers tend to invest on productivity smoothing alternatives (adaptation options in this case) such as soil conservation, usage of diverse crop kinds, and shifting planting dates rather than planting trees, which compete with the limited acreage available when farming is the primary source of revenue. According to Table 4.1, the average total annual income of the sampled small-scale maize farmers is R139446, with a minimum and maximum of R115460 and R448720. This also supports the notion that, in the face of uncertainty, some climate change adaptation strategies, such as adopting new technologies, soil conservation, and other related off-farm economic activities, are cost effective for economic development. This variable's highly statistically significant t-test result of 298.7 in Table 4.1 indicates that there are mean differences in the total income of sampled small-scale maize farmers. As a result, this variable is likely to influence small-scale maize farmers' climate change adaptation measures as well as their selection of those measures.

#### 4.4.1.5. Net farm revenue or income of sampled small-scale maize farmers

Farm income or revenue is one of the key factors thought to influence small-scale maize farmers' climate change adaptation measures as well as their choice of those measures. Several studies have found that farm income is an important factor in increasing the adoption of various technologies (Erasmus, 2000; Kurukulasuriya and Mendelsohn, 2006a; Nhemachena, 2008; Thomas *et al.,* 2007). According to

Nhemachena (2008), small-scale maize farmers can use all available information to change their management practices in response to changing climatic and other conditions because they have more financial and other resources at their disposal. For example, with financial resources, small-scale maize farmers can purchase new crop varieties, irrigation technologies, and other important inputs they may require to change their practices to accommodate predicted climate changes.

In this study, total net farm revenue or income is defined as the difference between total revenues and costs from the sampled small-scale maize farmers' main farming activities. Furthermore, this factor was identified as a component that can be used to assess farm performance (Kurukulasuriya and Mendelsohn, 2006a). Net farm revenue accounts for adaptation costs and benefits (Nhemachena, 2008). Total net farm revenue was calculated from this study as the sum of the net revenue from the main farming activities and was measured by computing gross revenue in Rands (total value of produce consumed, donated, and sold) less total variable costs per year that included expenses such as fertilizer, pesticide, hired labourers, transport, and other post-harvest expenses. According to Table 4.1, the average net farm revenue from the study areas per year was R14754, with a minimum and maximum of R8598 and R179320, respectively. This variable was assumed to influence small-scale maize farmers' choice of climate change adaptation strategies as well as their perceptions towards climate change. The highly statistically significant t-test results of 24.9 imply that there are strong mean differences in farm income of sampled small-scale maize farmers, and the variable is likely to influence small-scale maize farmers' choice of climate change adaptation strategies.

#### 4.4.1.6. Number of income sources of the small-scale maize farmer

The number of revenue sources available to small-scale maize farmers is recognized as a critical factor influencing their choice of agricultural climate change adaptation methods. These factors can be separated into farm, non-farm, and unearned earnings, all of which contribute to total household income and are necessary in agricultural productivity. Households with multiple income sources are more capable of owning and purchasing products and services, and they are better positioned to adapt to climate change for long-term well-being. According to Deressa *et al.* (2009), the presence of sufficient income in rural families alleviates monetary limitations and allows them to acquire inputs (such as electricity, fertilizer, improved crop varieties, and irrigation facilities). According to the empirical findings of Tazeze *et al*. (2012), the income level of the families surveyed has a positive and significant influence on soil conservation, crop variety utilization, and planting date changes. According to Soltani *et al*. (2012), rural livelihoods are built on a variety of non-farm income activities and enterprises rather than primarily on agriculture. Table 4.1 reveals that the average source of income indicated by the small-scale maize farmers is 3, with a minimum of 1 and a maximum of 6. The highly statistically significant t-test result of 53.5 indicates that there are considerable mean variations in revenue sources among the studied small-scale maize farmers. Figure 4.2 depicts the proportion of major sources of income reported by sampled small-scale maize farmers in the study area.

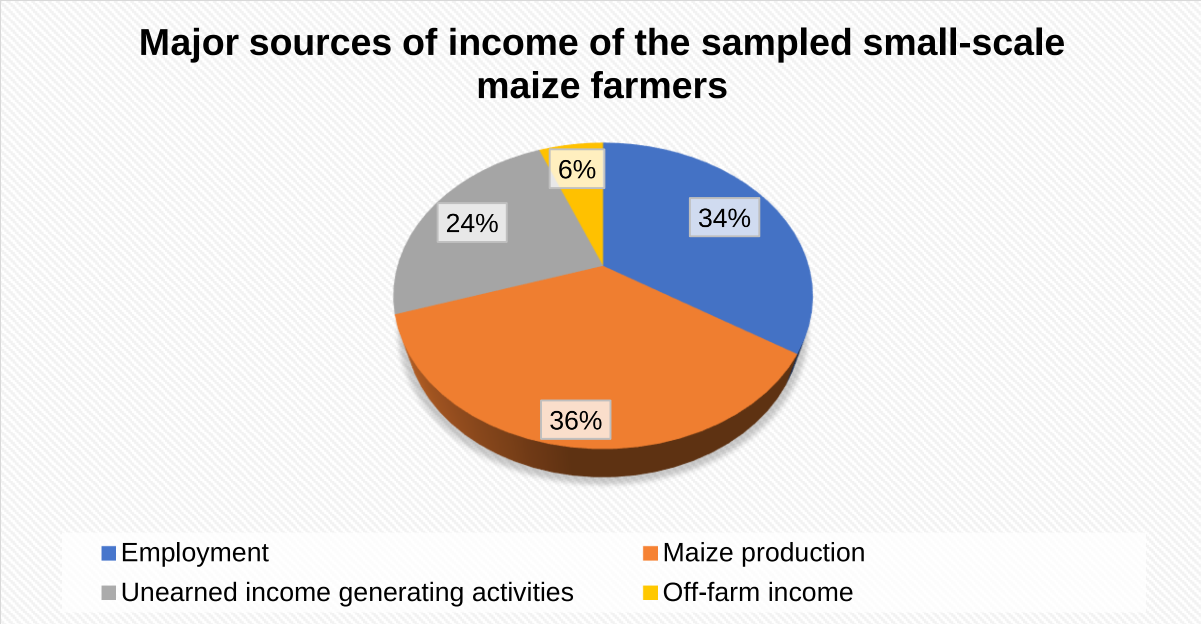


**Figure 4. 2: Major sources of income of the sampled small-scale maize farmers in Makhuduthamaga Local Municipality, Sekhukhune District 2021/2022 (n=110)**

Source: Survey data (Mid-December to Mid-February 2022)

Because respondents were unsure how much they received every month or were unwilling to share the precise amount, the revenue sources were classified; however, they were able to estimate the amounts in respect to these categories. Unearned income, farm income (Maize production), off-farm income (selling wild fruits, vegetables, traditional medicine herbs,) and employment income are all included (self-employed, temporary, contract and permanent). Unearned income refers to revenue for which a small-scale maize farmer did not work or provide any service, such as old age pension grants, child support grants, disability allowances, and remittances from family. Sewing traditional garments and jewellery, crafting mats, catering and decorations, and managing a tuck-shop selling snacks, airtime, and breads were all examples of employment income. More than one-third of the sampled small-scale maize farmers illustrated in Figure 4.2 identified unearned income as their primary source of income in the area of study. Out of 110 sampled small-scale maize farmers, 40 (36 %) identified farm production (maize production) as the primary source, followed by 37 (34 %) as employment, 26 (24 %) unearned income and 7 (6 %) as off-farm income in that order. Furthermore, all of the tested small-scale maize farmers stated that they got farm revenue in the previous year of 2021, however the degree of farm income varied from farm to farm. Furthermore, based on the literature and the current study findings, it cannot be inferred that these farmers commercialized or completely participated in the market.

### 4.5. Categorical variables included in this study

This section of the study provides and examines categorical variables hypothesized to influence small-scale maize farmers' choice of climate change adaptation techniques, and relative share of farm revenue, in that order. These include gender distribution on the type of farming, employment status, educational level, marital status, access to extension services, farmer organization, access to credit from banks and financial institutions, climate change perceptions (based on temperature and rainfall components) among sampled small-scale maize farmers.

#### 4.5.1. Gender distribution on the type of farming

The gender of the small-scale maize farmer is an important component that influences agricultural production as well as the productivity of vulnerable rural livelihoods. Gender is a key variable influencing adoption decisions at the farm level, according to an increasing number of studies (Apata *et al.,* 2011b, Masuku, 2013; Nabikolo *et al*., 2012; Oluwatayo, 2011). Female farmers have been found to be more likely than male farmers to adopt natural resource management and conservation (Deressa *et al*., 2009; Dolisca *et al.,* 2006; Nhemachena, 2008; Nhemachena and Hassan, 2009; Tazeze *et al*., 2012). However, some research revealed that household gender had little effect on farmers' decisions to implement conservation measures (Masuku, 2013; Nabikolo *et al*., 2012; Oluwatayo, 2011). According to Nabikolo *et al.* (2012), female- and male-headed households differ greatly in their ability to adapt to climate change due to considerable variations in access to assets, education, and other important services such as credit, technology, and input supply. The impact of family gender composition on agricultural output and adaptation decisions in the face of climate change can be difficult to predict. The consequences could be related to the type of farming system or availability to resources such as credit or extension. In the study area, however, there were more males producing maize than females. This is due to the fact that most families are headed by men, hence men were the most eligible respondents.

Women, on the other hand, are the pillars of African agriculture, producing more than 90 % of the continent's food, according to the Food, Agriculture, and National Resources Policy Network (FANPARN) (2003). They are regarded as being in charge of cultivating, selling, purchasing, and preparing food for their family. At the same time, women are typically culturally resilient, able to turn their hands to a variety of tasks and overcome hurdles (Tazeze *et al*., 2012). Female-headed households, on the other hand, are thought to have less access to productive resources such as land and credit and to new information than male-headed households (Masuku, 2013). Women continue to be marginalized in company control and have little control over resource availability. As a result, women farmers are reliant on rain-fed agriculture, have limited access to inputs (fertilizers, seeds, and water), extension, financing, and markets for their products, and own small plots of land or none at all. Women also have the duty of providing social protection services to vulnerable members of their immediate family as well as members of their community. This may restrict their ability to produce agricultural products.

### 4.5.2. Marital status of the sampled small-scale maize farmers

Several studies (Alam *et al.,* 2011; Nhemachena, 2008; Nhemachena and Hassan, 2009) have indicated that marital status is a significant variable influencing perception, and adaptive decision making at the farm level. According to Nhemachena (2008), married rural household members are more likely to adapt to climatic conditions because they are responsible for and share or co-join much of their agricultural work or economic activities, have more diverse experiences, and have greater access to information on farming practices. Figure 4.3 depicts the marriage status of the sampled small-scale maize farmers.

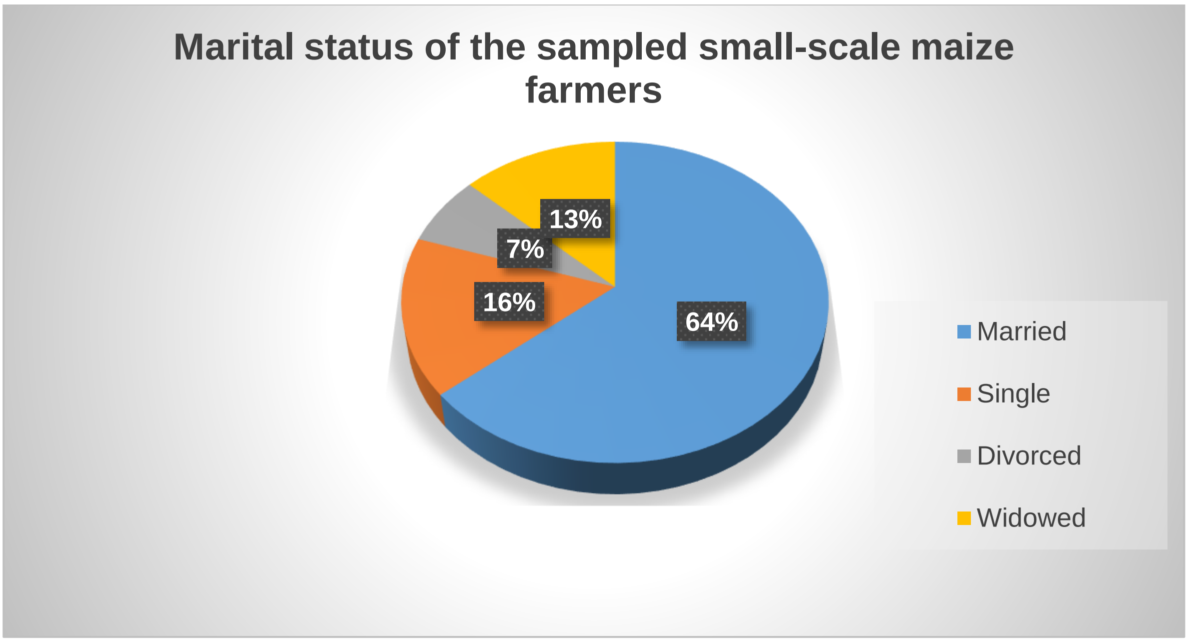


**Figure 4.3: Marital status of sampled small-scale maize farmers in Makhuduthamaga Local Municipality, Sekhukhune District 2021/2022 (n=110)**

Source: Survey data (Mid-December to Mid-February 2022)

According to Deressa *et al.* (2009), marital status is one of the potential factors influencing small-scale maize farmers' variety selection and can also serve as an indicator for variety selection decision-making in the face of climate change. This variable was expected to influence small-scale maize farmers' perceptions towards climate change and adaptation techniques as well as the selection of these adaptive measures in this study. According to the survey results shown in Figure 4.4, the majority (more than half) of the sampled small-scale maize farmers in the research area are married. According to the findings, 70 (64 %) of the 110 sampled small-scale maize farmers are married, with the remaining 40 (36 %) being widowed, single or divorced. As illustrated in Figure 4.3, the sampled small-scale maize farmers were also widowed (13%), single (16%), and divorced (7%). The marital status of the household can influence the extent of farming and the level of climate change awareness through the expertise of small-scale farmers. The better informed and aware the small-scale maize farmer, the better informed and aware the rest of the households. According to Deressa (2007), married small-scale maize farmers share decision-making and are more aware of and adapted to climate change; the possible reason being that they had stayed in the area of study for a reasonable period of time, allowing them to observe climate change and pass it on to the rest of the household.

### 4.5.3. Educational level of the sampled small-scale maize farmers

Small-scale maize farmers' educational level is one of the factors influencing their level and choice of climate change adaptation measures. In our ever-changing technical and economic climate, the value of education cannot be overstated or understated. Education is vital because it increases farm productivity both directly and indirectly by promoting labour equity, allowing farmers to react to adverse situations, and providing farmers with the ability to successfully implement innovations. Education has been identified as one of the aspects that enables farmers to successfully absorb and process essential information. According to Chhetri *et al*. (2012), educational levels influence farmers' acceptance of new technology. Education can influence a household's human capital and ability to process information. A higher educational level indicates that a household can process information more effectively than a household with less education or no education at all (Bryan *et al.,* 2009; Mertz *et al.,* 2009). According to a study conducted by Bryan *et al.* (2009), education levels may affect small-scale maize farmers' interpretation of market information, market involvement, and understanding of both technical and managerial skills. Figure 4.4 exhibits evidence from the survey data indicating the educational levels of the interviewed small-scale maize farmers.

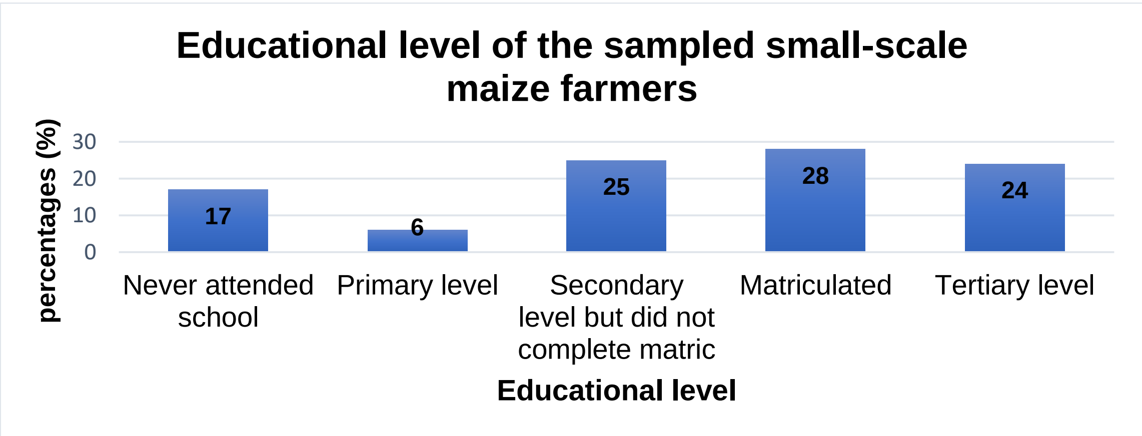


**Figure 4.4: Level of education by sampled small-scale maize farmers in Makhuduthamaga Local Municipality, Sekhukhune District 2021/2022 (n=110)**

Source: Survey data (Mid-December to Mid-February 2022)

The results indicate that the majority (53%) of the sampled small-scale maize farmers (58) attended secondary school; however, some did not complete matric, and those who did complete matric did not continue their studies at a higher institutional level. Surprisingly, the data in Figure 4.4 reveal equal percentages for sampled small-scale maize farmers who went to secondary school but never matriculated 27(25%) and those who matriculated but did not continue their education 31(28%). The number of sampled small-scale maize farmers who never attended school at all is 19 (17%) and those who attended primary school and finished there at grade 7 are 7(6%). Twenty six (24%) of the 110 small-scale maize farmers studied at the tertiary level. Tertiary education includes universities, colleges, and technical schools. According to Figure 4.4, the majority of the small-scale maize farmers interviewed had some type of basic educational background and training. Because the majority of the farmers in the study areas had some formal education, this shows that they can perceive and process information methodically. This could mean that small-scale farmers in the study were able to weigh and choose new technologies and adaptation options in the face of climate change. According to Deressa *et al.* (2011), education increases the likelihood of adapting to climate change because it literates farmers, who are more likely to respond to climate change by choosing the optimal adaptation choice based on their preferences, and it influences individual decision-making.

This demonstrates that the sample small-scale maize farmers understand the changing economic, political, and climatic situations and, as a result, are capable of adopting new or sophisticated agricultural technology and making informed decisions to adjust to changes. According to Mertz *et al*. (2009), a small-scale maize farmer's degree of education not only impacts their way of thinking and their perception of climate variability or created dangers, but it can also alter responsiveness. Furthermore, a more educated small-scale maize farmer may access the internet, which is a vital source of current information on climatic variability and change. Masuku (2013) revealed that the use of the internet and the adoption of new types of technology increased with education level.

### 4.5.4. Employment status of the sampled small-scale maize farmers

Another factor influencing small-scale farmers' selection of climate change adaptation techniques is their employment status. The employment status of a person determines whether they are employed or self-employed and is determined by the terms and conditions of the relevant engagement. The form of small-scale maize farmers' employment determines the amount of their availability related to agricultural production. Other studies, however, discovered that age is strongly and negatively associated to farmers' adaptation decisions (Dolisca *et al.,* 2006; Nkondze *et al*., 2013; Nyangena, 2006). However, Nkondze *et al.* (2013) discovered that a farmer's employment position is positively associated to the implementation of conservation measures. Households with employed people, according to Nkondze *et al.* (2013), are in a more stable condition or position since the household has a continuous flow of revenue. Furthermore, having a consistent source of income in a home is a key feature of financial capital in dealing with climate change-related disasters, because income-empowered households absorb and recover from losses or shocks.

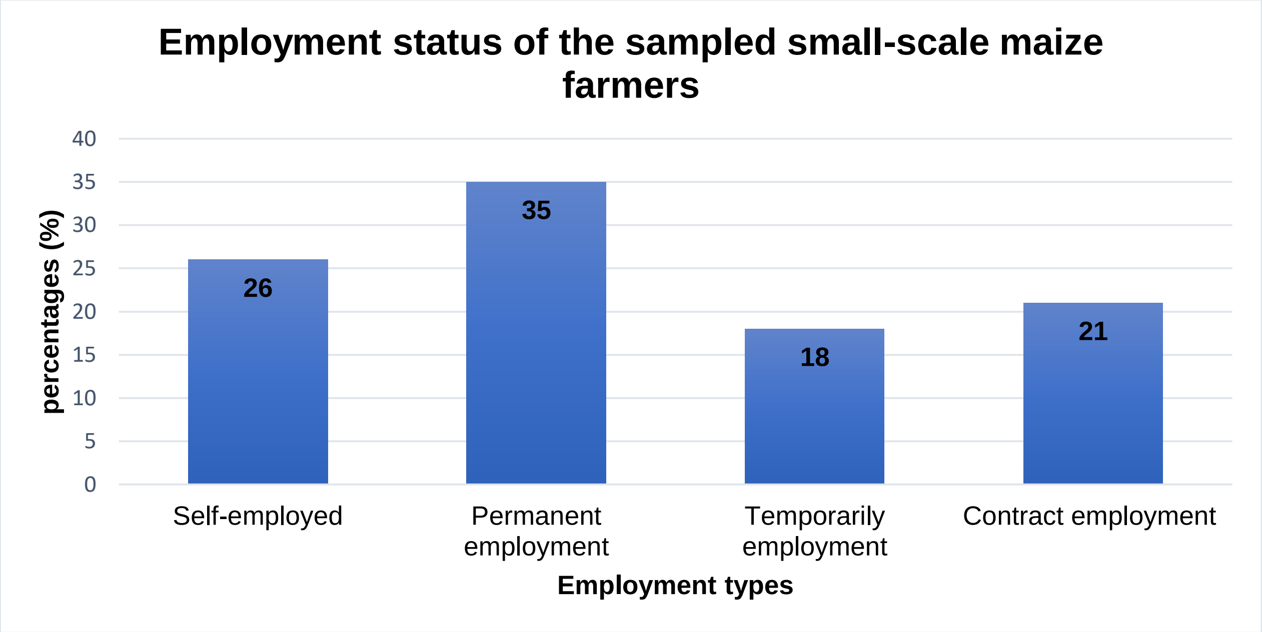


**Figure 4.5: Employment status of sampled small-scale maize farmers in Makhuduthamaga Local Municipality, Sekhukhune District 2021/2022 (n=110)**

Source: Survey data (Mid-December to Mid-February 2022*)*

As shown in Figure 4.5, a high proportion of the sampled small-scale maize farmers are permanently employed, with 35 %, followed by 26 % who are farm employees or self-employed on the farm. Furthermore, 18 % and 21 % of the studied small-scale maize farmers worked on a temporary or contract basis, respectively. In this study, temporary and contract workers include seasonal, casual, and part-time workers. Farming is still a significant source of income for rural households. However, while agriculture has played a significant role in providing employment in rural regions, it has done so at very low salaries. According to Aliber and Hart (2009), rural livelihoods are built on a variety of non-farm income activities and enterprises rather than primarily on agriculture. Sampled small-scale maize farmers in the study area also reported non-farm economic activity. Non-farm work allows farmers to supplement their revenues and so acquire non-agricultural goods and services for their homes. Having non-farm income can assist farmers implement climate change adaptation methods such as acquiring drought-resistant inputs and improved farm equipment, which can boost production in the face of climate change. This explains why people who work in agriculture as their primary career are more inclined to diversify into other activities as a result of the negative effects of climate change. These findings indicate that the small-scale maize farmers studied are particularly sensitive to the effects of climate change. In most cases, the poorest small-scale farmers are those who rely on agriculture rather than non-farm enterprises in rural areas, thus they must adapt.

## 4.6. Access to market, water, electricity, credit and farmer organization and extension services of sampled small-scale maize farmers

### 4.6.1. Access to market

Small-scale maize farmers have the potential for sophisticated returns on land, labour, and money; nevertheless, there is concern about their ability to participate in market-oriented production due to a lack of access to markets, capital, inputs, and technology (Olufonso, 2010). In this study, access to markets was determined by asking the sample small-scale maize farmers whether or not they sold their produce through formal market mechanisms. According to the findings in Table 4.2, only 36 (33 %) of the 110 sampled small-scale maize farmers had access to formal markets, while 74 (67 %) did not. Small-scale maize farmers may be unaware of potential market because they are not educated, are not exposed, and do not have marketing facilities. Farmers that have access to formal markets, according to Nhemachena (2008), have a better chance of adapting to changing climatic conditions. This is due to the fact that they would be exposed in terms of market information such as prices, market demand, and other external information. Better market access also allows farmers to purchase new inputs and conservation technology that they may require if they are to adapt agricultural operations to accommodate expected future climate changes. The results of the variables expected to influence small-scale maize farmers' perceptions and adaptation towards climate change, as well as their ability to choose these adaptive measures, are summarized in Table 4.2 below.

**Table 4.2: Variables of the descriptive results of the sampled small-scale maize farmers under Makhuduthamaga Local Municipality, Sekhukhune District 2022 (n=110)**

| Variable description | Yes/No | Frequencies | Percentages (%) |
|---|---|---|---|
| If a farmer have access to credit | Yes | 26 | 24 |
| | No | 84 | 76 |
| If a farmer have access to formal market | Yes | 36 | 33 |
| | No | 74 | 67 |
| If a farmer have access to extension services | Yes | 96 | 87 |
| | No | 14 | 13 |
| If a farmer has access to climate change information | Yes | 98 | 89 |
| | No | 12 | 11 |
| If a farmer have access to farmer to farmer extension services | Yes | 51 | 46 |
| | No | 59 | 54 |
| If the farmer have access to water and electricity | Yes | 110 | 100 |
| | No | 0 | 0 |
| If a farmer is involved in farmers organization | Yes | 30 | 27 |
| | No | 80 | 73 |
| If a farmer is involved in farmer to farmer extension | Yes | 45 | 41 |
| | No | 65 | 59 |

Source: Survey data (Mid-December to Mid-February 2022)

### 4.6.2. Access to credit, water and electricity

Credit, water, and electricity are recognized as critical elements influencing the availability of production, productivity, and marketing inputs. Several studies have shown that these characteristics are important in agricultural productivity and can help with adaptation techniques in the face of climate change (Bryan et al., 2009; Chhetri *et al*., 2012; Deressa *et al*., 2005; Mertz *et al.,* 2009; Tazeze *et al*., 2012). According to Mertz *et al*. (2009), the literature provides sufficient evidence that a lack of credit and available funding offered to small-scale maize farmers at the right moment constitutes a limitation to sustainable development. Table 4.2 displays the overall number and %age of sampled small-scale maize farmers who had access to credit in the study area. According to the descriptive results presented in Table 4.2, 84 (76 %) of the sampled small-scale maize farmers did not have access to credit, whereas 26 (24 %) did. The overall result in the study area suggests that access to credit remains a significant barrier. This is line with the findings of Deressa *et al*. (2009), who found that a lack of credit is a crucial problem for small-scale farmers in developing-country rural communities. In general, credit is illusive for many small-scale farmers in developing countries, particularly in South Africa, due to the absence or limitation of institutional financial structures to give credit and money to respective small-scale maize farmers. Small-scale maize farmers are frequently discriminated against by financial institutions due to their comparatively low resource base.

Commercial banks, such as land banks, occasionally seek to lend money to creditworthy initiatives and individuals, but are hesitant to do so if small-scale farmers are unsure about enjoying the benefits of such initiatives. It can be inferred that most small-scale maize farmers face significant barriers to credit because of the regulations and processes that must be followed before credit can be awarded. Gbetibouo (2009) and Nhemachena and Hassan (2009) found that access to credit had a beneficial effect on the likelihood of adjusting to changing climatic conditions. Furthermore, access to credit enhances financial resources and a small-scale maize farmer's ability to deal with transaction costs through various adaption mechanisms. Most sampled small-scale maize farmers in the study area who did not have access to credit relied mostly on the amount of money generated through unearned income (remittances, pensions, social handouts) and their work status. Stokvels, government subsidies, bank loans, and farm revenue were among the credit sources revealed by the study's sampled small-scale maize farmers.

### 4.6.3. Access to water and electricity

Table 4.2 also demonstrates that all of the sampled small-scale maize farmers had access to electricity and water (100 %). However, more than 90% of the selected small-scale maize farmers said that water supply is restricted or diminishing, and electricity is prohibitively expensive. It is expected that these variables (availability to water and electricity) will influence small-scale maize farmers' perceptions and adaptation to climate change.

### 4.6.4. Farmers’ organisations

Farmer organization is one of the institutional variables impacting small-scale maize farmers' ability to cope with unmanageable and unpredictable climatic conditions. Collaborative action promotes collective empowerment by enabling small-scale maize farmers to overcome unique barriers to enter the market economy. Farmer organization is a circumstance in which small-scale farmers join together as a group to carry out goals set by them in their agricultural activities. In the aftermath of agricultural market liberalization, collaborative action in the form of co-operatives has lately re-emerged to organize small-scale farmers in developing countries (FAO, 2013). According to Table 4.2, only 30 (27 %) of the 110 sampled small-scale maize farmers reported that they were not active in co-operatives (such as crop marketing co-operatives). A large proportion (73%) of the sampled small-scale maize farmers (80) stated that they had not registered or participated in cooperatives; nevertheless, they stated in passing that they would be willing to engage if given the opportunity.

Agrawal (2010) and Anaeto *et al.* (2012) recommended that small-scale farmers in South Africa take use of the trend of co-operative support to increase their access to input and product markets. The general idea, according to Agrawal (2008), is that collaborative action affects small-scale farmers' marketing strategies and production capacities. Farmers' economies of scale will be obtained if they market their produce jointly. And the bargaining ability to negotiate better market conditions and prices will be lost. However, there is little information available on the various forms of collective action and their functions in facilitating market access for small-scale farmers (Anaeto *et al*., 2012). As a result, there is a critical need to understand the spark of collective participation in order to integrate small-scale maize farmers into mainstream markets. The study's findings, as shown in Table 4.2, also revealed that 45 (41 %) of the sampled small-scale maize farmers were involved in farmer-to-farmer extension programs in order to boost or improve their output through information and resource sharing. However, a bigger proportion (59%) or %age (65) of the surveyed small-scale maize farmers were not active in farmer-to-farmer extension activities to increase production and productivity.

### 4.6.5. Agricultural extension support

The question of extension support was viewed as a factor influencing the choice of climate change adaptation tactics by sampled small-scale maize farmers, as well as their perceptions towards climate change. Extension services can play a critical role in empowering farmers with climate change-related farming methods, information, techniques, and skills. Pest and disease control, water management, crop management, weed control, climate change awareness and information, fertilizer application, record keeping, marketing, advice and knowledge on how to cope with climate change adaptive measures are all provided by extension staff. Furthermore, providing small-scale maize farmers with decision-making authority in order to boost their everyday production activities. Furthermore, extension services can have a favourable impact on net farm revenue and the implementation of various farm level adaptation methods. As a result, there is an urgent need to identify and analyse the availability and capacity of extension workers, as they are likely to impact small-scale maize farmers' decisions on adaptation options in the face of climate change.

Several studies have shown that extension can boost output by hastening technology transfer and enhancing farmers' skills and knowledge based on approved farm management practices (Apata *et al.,* 2011b; Alam *et al*. 2011; Masuku, 2013; Nabikolo *et al.,* 2012; Oluwatayo, 2011; Tazeze *et al.,* 2012). According to Nabikolo *et al.* (2012), extension services provided better technologies, more awareness campaigns, better skills and knowledge coupled with revised information, and training based on demonstration and lecture methods, ultimately increasing agricultural productivity and household food availability. According to Apata *et al.* (2011b), extension services can serve as a bridge between the government and small-scale farmers by conveying new technology that is urgently needed in the face of climate change. A farmer must follow proper agronomic methods from land preparation to harvesting, presentation, and sale of the crop in order to be successful. Failure to obtain the requisite knowledge, as well as lack of sufficient planning and supervision, frequently ends in failure and vulnerability. Social capital promotes economic well-being and security through leveraging networks and relationships between individuals and social groups. Participating in farming organizations reduces the vulnerability of small-scale farmers by boosting their adaptive capability. The assessment of resource management institutions and their performance, efficiency, and legitimacy can demonstrate adaptive potential.

Table 4.2 demonstrates that extension support provided by the Limpopo Department of Agriculture was substantial, as demonstrated by the majority of 87 % (96) of sampled small-scale maize farmers, while 14 (13 %) were never visited by extension officials. Some of the sample small-scale maize farmers claimed that extension officers only visited them once or twice a year. Furthermore, several of the sampled small-scale maize farmers indicated that they were promised seeds and fertilizers, which was not formal. On the contrary, some of the sampled small-scale maize farmers stated that they have acquired more information on cropping practices, optimum input use, high yield varieties, and awareness about the impacts of climate change and other evolving difficulties as a result of extension help.

### 4.6.6. Access to climate change information

Access to climate change knowledge is another major element influencing the perceptions and adaptations of the sampled small-scale maize farmers towards climate change. Because awareness is linked with perception, being aware of the problem and the potential advantages of taking action is another main indicator of agricultural technology adoption. Farmers' understanding of changes in climate features (rainfall and temperature) is vital for adaptation decision making, according to Maddison (2006). Being conscious of climate change and its implications simply implies that a small-scale maize farmer is intelligent and adaptive. Several studies in the literature (Benhin, 2006; Deressa *et al*., 2009; Hannah *et al.,* 2005; Maddison, 2006; Mertz *et al.,* 2009) indicated that small-scale farmers who noticed and were aware of changes in climate took up adaptation measures that helped them reduce losses or take advantage of the opportunities associated with these changes. The results of access to climate change information by sampled small-scale maize farmers in the study area are shown in Figure 4.6 below.

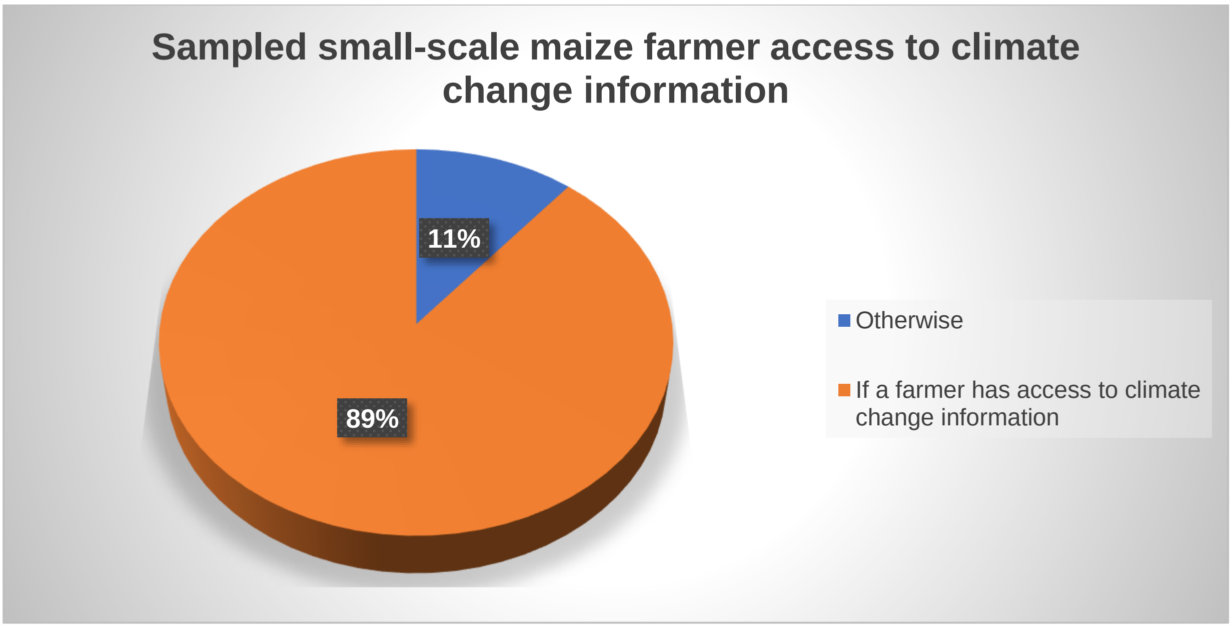


**Figure 4.6: Access to climate change information by sampled small-scale maize farmers in Makhuduthamaga Local Municipality, Sekhukhune District 2021/2022 (n=110)**

Source: Survey data (Mid-December to Mid-February 2022)

Better climate change knowledge makes it easier for small-scale maize farmers to compare alternative adaption techniques (Bryan et al., 2009). Figure 4.6 shows that the majority of the interviewed small-scale maize farmers in the study area are aware of climate change during the last three decades (30 years). Out of 110 selected small-scale maize farmers, 98 (89 %) reported having information on climate change, while 12 (11 %) indicated a lack of or access to climate change information. This finding shows that more small-scale maize farmers in the study area were aware of climate change, and they are more inclined to adapt in order to improve and retain their economic lives. However, sampled small-scale maize farmers stated that they obtain or access climate change information from a variety of sources. Table 4.3 depicts the frequencies and percentages of the descriptive results of sources of climate change information among sampled small-scale maize farmers.

**Table 4. 3: Source of climate change information acquired by small-scale maize farmers**

| The type of source of climate change information acquired by small-scale maize farmers | | |
|---|---|---|
| | **Frequency** | **Percentage (%)** |
| Friends or relatives | 19 | 17 |
| Magazines | 7 | 6 |
| Radio | 20 | 18 |
| Agricultural advisors or extension officer | 30 | 28 |
| Internet | 8 | 7 |
| Newspaper | 14 | 13 |
| None | 12 | 11 |
| **Total** | **110** | **100** |

Source: Survey data (Mid-December to Mid-February 2022)

Numerous researchers (Benhin, 2006; Hannah *et al.,* 2005; Maddison, 2006; Mertz *et al.,* 2009) demonstrated that access to climate change information is a crucial element impacting small-scale maize farmers' choice of adaptive measures. According to the evidence in Table 4.3, the majority of questioned small-scale maize farmers in the study area obtained additional information and understanding about climate change from agricultural consultants or extension workers. According to the findings, 30 (28 %) of the 110 sampled small-scale maize farmers obtained climate change knowledge via extension workers, followed by radio (18 %) and friends or family (17 %). The internet (7 %), magazines (6 %), and newspapers (13 %) were also indicated as sources of information regarding climate change by the sampled small-scale maize producers. Only twelve (7 %) of the surveyed small-scale maize farmers said they did not get knowledge on climate change from any of the sources indicated above. The findings show that the majority of the study's questioned small-scale maize farmers are aware and informed about climate changes and can easily adapt; nevertheless, their adaptation options may differ due to physical, economic, and institutional factors. In addition to this conclusion, sampled small-scale maize farmers mentioned in passing that they have inadequate infrastructure, irrigation infrastructure, and communication networks, resulting in poor marketing mechanisms for their produce. Lack of irrigation infrastructure is caused by a lack of appropriate financial resources, reliance on rainfall for water, dams located distant from farm fields, inability to afford irrigation infrastructure, waiting for government, and problems with generators and the cost of electricity being very high. During interviews with certain farmers, it was revealed that the marketing condition of the sampled small-scale maize farmers was so bad because they received low prices and unsatisfactory payments for their produce, which did not justify greater transportation costs. These previously indicated issues were also seen or believed to have a negative impact on the capacity of sampled small-scale maize farmers to adjust to climate change. The section that follows describes small-scale maize farmers' perceptions of climate change components (rainfall and temperature) over the previous 30 years.

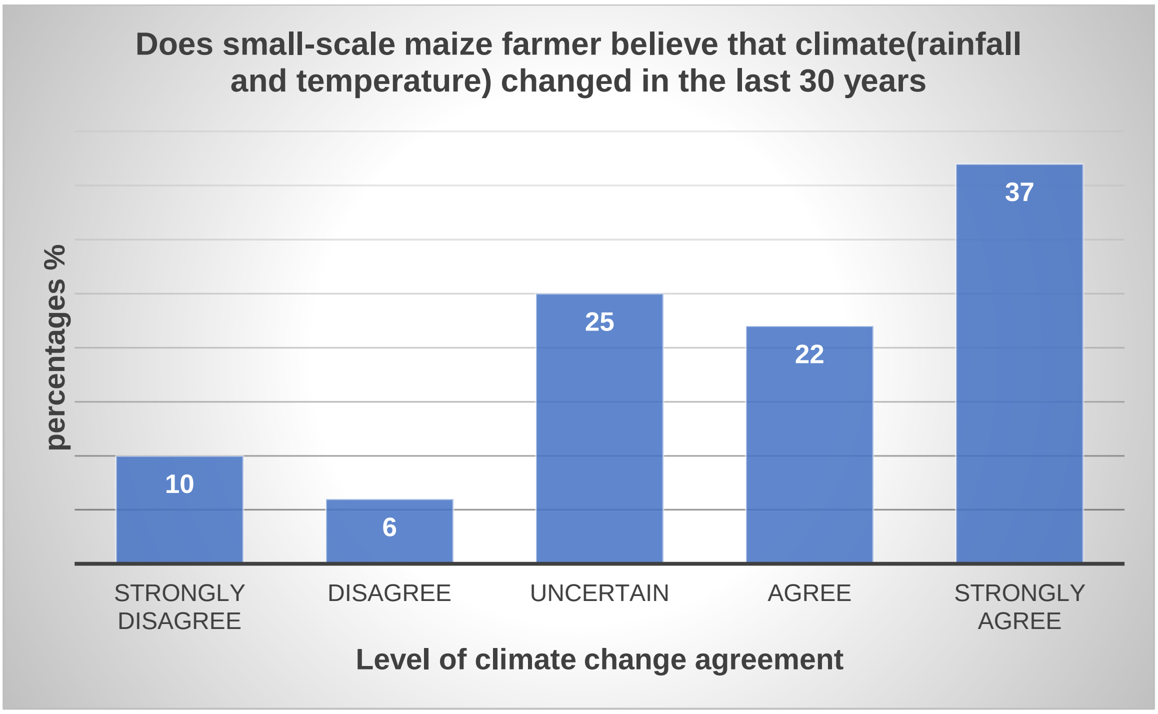


**Figure 4.7: Perception of climate change by sampled small-scale maize farmers in Makhuduthamaga Local Municipality, Sekhukhune District 2021/2022 (n=110)**

Source: Survey data (Mid-December to Mid-February 2022)

Climate has changed in the last 30 years, according to sampled small-scale maize farmers, and will continue to change in the future. Small-scale maize farmers' responses to a series of Likert-scale questions, as shown in Figure 4., to determine whether they truly believe climate change is occurring by the degree to which they agree or disagree. The majority of small-scale maize farmers interviewed 41 (37 %) strongly agreed that climate change is occurring, followed by those who were less certain or doubtful 27 (25 %). 24 (22 %) of the sample small-scale maize farmers agreed that climate change is occurring; however, 6 % (7) disagreed and 10 % (11)

strongly disagreed. Figure 4.9 shows how small-scale maize farmers' perceptions of temperature on the frequency of hot days in the study area have changed over the previous 30 years.

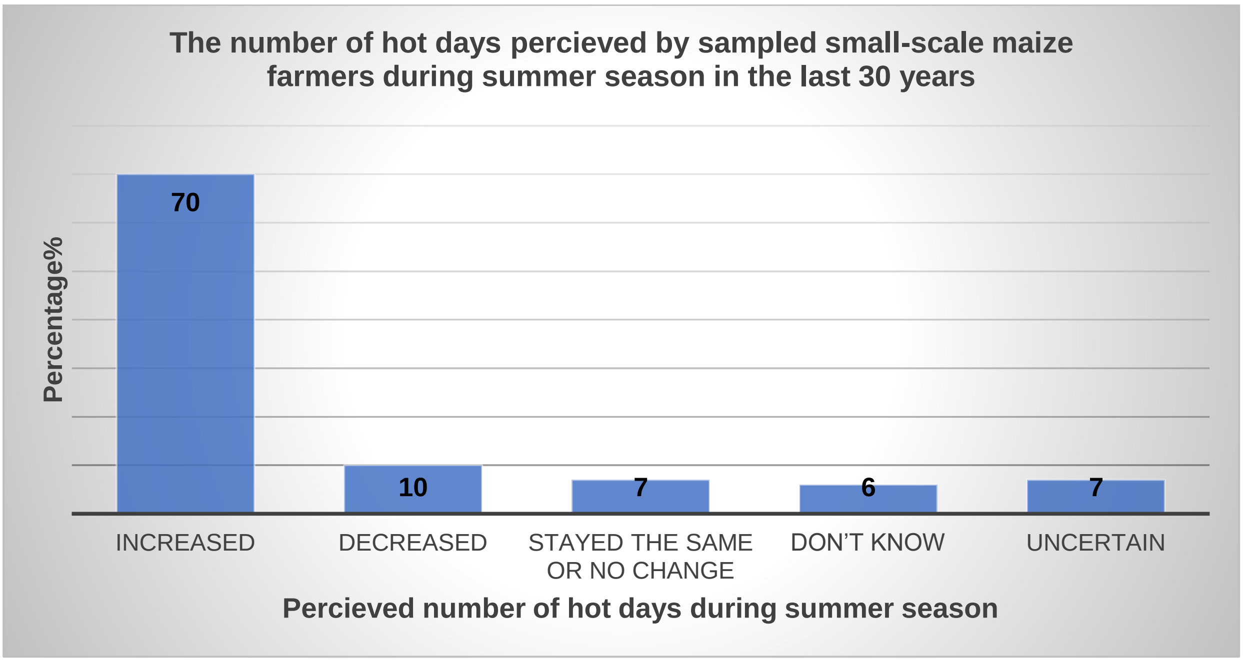


**Figure 4.8: Perception of temperature (number of hot-days during summer) by sampled small-scale maize farmers in Makhuduthamaga Local Municipality, Sekhukhune District 2021/2022 (n=110)**

Source: Survey data (Mid-December to Mid-February 2022)

Small-scale maize farmers were questioned if they had witnessed or noticed any change in temperature or rainfall amount over the last 30 years in order to get information on their perceptions of climate change. To clarify, small-scale maize farmers were interviewed and asked whether the number of hot or rainy days had increased, decreased, or remained constant over the previous 30 years. Small-scale maize farmers were asked about the amount of hot days throughout the summer season over the last three decades. According to the findings presented in Figure 4.8, 79 (70 %) of 110 interviewed small-scale maize farmers perceived an increase in the frequency of hot days during the summer season, whereas 11 (10 %) perceived a decrease. Minority of the small-scale maize farmers indicated no changes 8 (7 %), uncertainty 8 (7 %), and don't know 6 (6 %) in the number of hot days throughout the summer season. Small-scale maize farmers' perceptions of rising temperatures have a direct impact on all cropping decisions in terms of adaptability options. This also means that an increase in temperature resulted in an increase in drought, which led to the adoption of drought-tolerant crops for long-term livelihoods. According to Maddison (2006), farmers' understanding of changes in climate characteristics (temperature) is vital for adaptation decision making, such as changing planting dates. According to Deressa *et al*. (2009), the choice of climate change adaptation measures is influenced by farmers' perceptions regarding climate change. The findings simply indicate that summer seasons have become longer over the last 30 years, necessitating adaptation by the sampled small-scale maize farmers. The responses of the tested small-scale maize farmers are consistent with the South African Weather Service report, which shows an increase in temperature over the last 30 years. Rural farmers must implement a variety of coping and livelihood adaptation techniques in response to long-term perceived changes. Figure 4.9 shows small-scale maize farmers' perceptions on the number of wet days over the last 30 years.

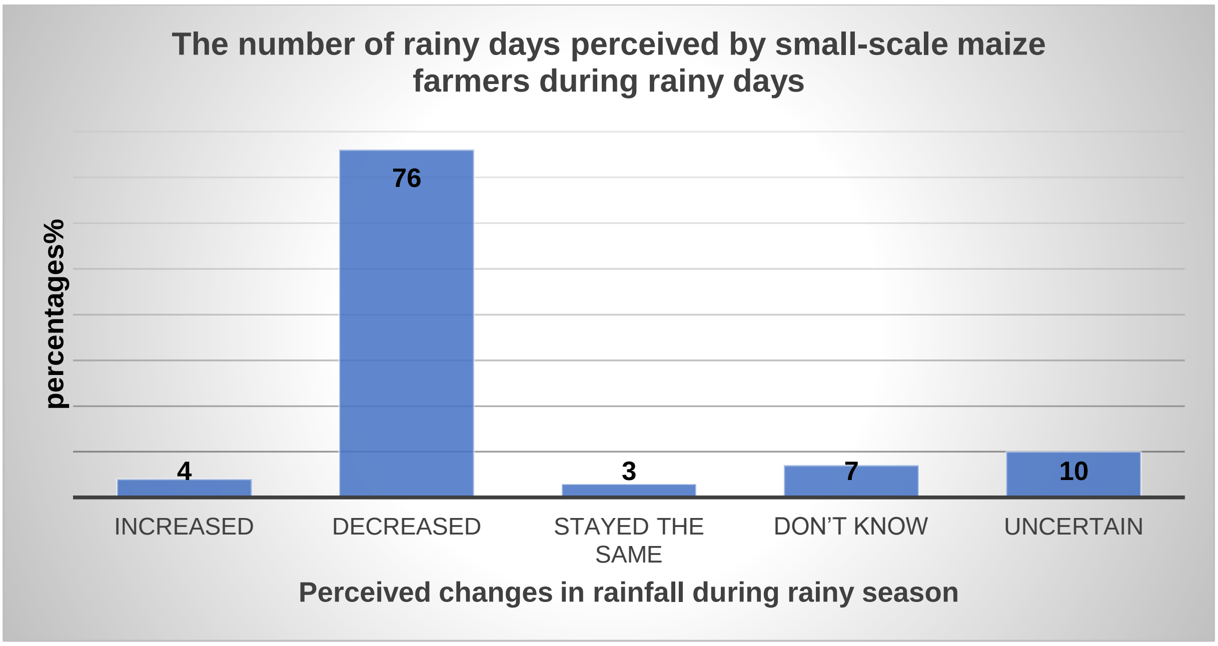


**Figure 4.9: Perception of rainfall (number of rainy days during rainy season) by sampled small-scale maize farmers in Makhuduthamaga Local Municipality, Sekhukhune District 2021/2022 (n=110)**

Source: Survey data (Mid-December to Mid-February 2022)

The majority (79) or (72 %) of surveyed small-scale maize farmers observed a decline in the number of rainy days during the rainy season during the last 30 years. Approximately 6%, 5%, 10%, and 7% of the sampled small-scale maize farmers viewed the number of rainy days during the rainy season as rising, remaining the same, they don't know and are uncertain, or they are not sure. Small-scale maize farmers' expectations of decreased rainfall have a direct impact on all cropping decisions in terms of adaptability alternatives if crop production is rain-fed. Rainfall has been shown in many studies to have a beneficial or negative impact on the adoption of climate change adaptation methods. Similarly, as temperatures rise, rainfall falls, increasing the likelihood of small-scale maize farmers' adaption tactics (such as delaying in planting, adopting irrigation infrastructural systems etc.). Figure 4.10 shows small-scale maize farmers' perceptions of the number of cold days during the last three decades.

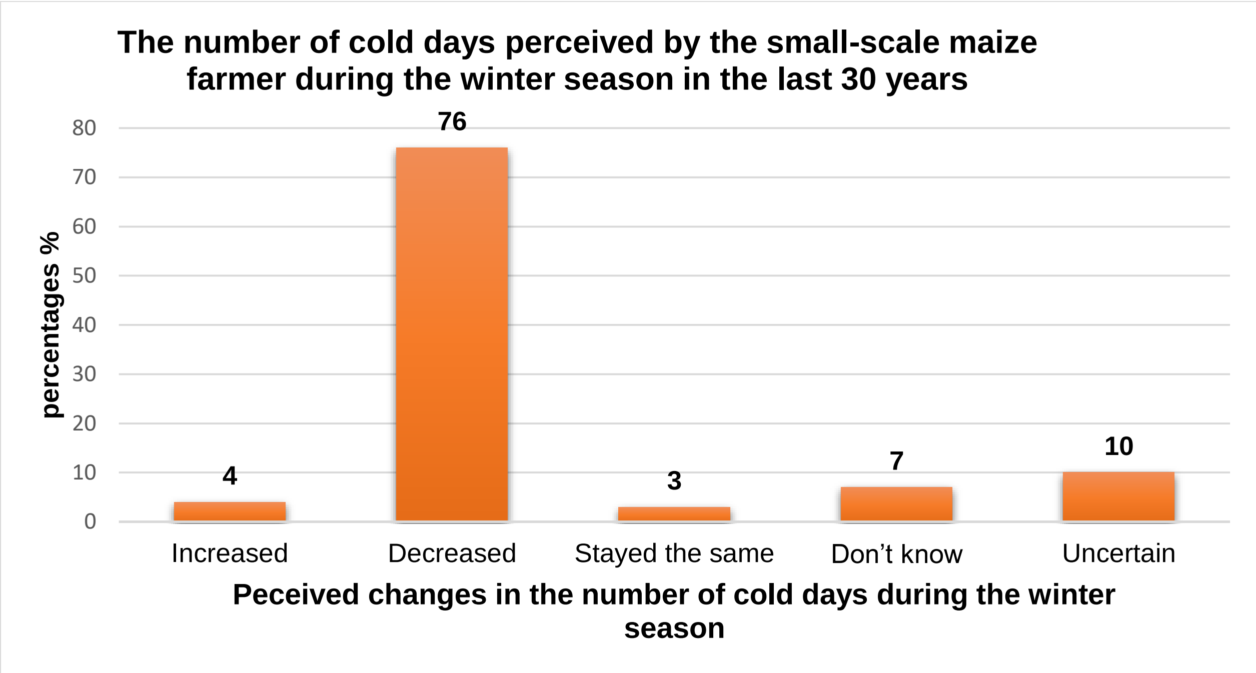


**Figure 4.10: Perception of temperature (number of cold days during winter season) by sampled small-scale maize farmers in Makhuduthamaga Local Municipality, Sekhukhune District 2021/2022 (n=110)**

Source: Survey data (Mid-December to Mid-February 2022)

Figure 4.10 reveals that the majority of small-scale maize farmers, 84 (76 %), saw a decrease in the number of cold days throughout winter seasons during the last three decades. Approximately 4%, 3%, 7%, and 10% of the surveyed small-scale maize farmers perceived the number of cold days during the winter season as rising, remaining the same, they don't know and are uncertain, or they are not sure, respectively. The findings imply that the winter season in the study area has become shorter during the previous 30 years. Figure 4.10 illustrates the perspectives of small-scale maize farmers on the results of climate change impacts.

### 4.7. Summary

The descriptive results for socioeconomic characteristics, household endowments, and perceptions of climate change in connection to its impact on agricultural productivity and adaptability to climate change were reported in this chapter. Males outnumber females in the gender distribution of the sampled small-scale maize farmers. Male and female sampled small-scale maize farmers engage in a variety of farm activities (such as livestock and crop farming). The average age and household size of the sampled small-scale maize farmers in the study area are 58 years and 8 members, respectively. The research also revealed that crop production accounts for a bigger proportion of farming types. The majority of the selected small-scale maize farmers believed that the climate was changing, and that temperatures and rainfall were going up and down. The majority of the small-scale maize farmers questioned, changed their planting dates (either early or late planting practices). A greater proportion of the small-scale maize farmers interviewed in the research area obtained more information and understanding about climate change from agricultural consultants or extension workers. Although all of the studied small-scale maize farmers expressed unfavourable climate change impacts, it cannot be inferred that climate change imposes exclusively negative mainstreams on respective producers.

# CHAPTER FIVE

## EMPIRICAL RESULTS AND DISCUSSIONS

## Analyses of factors affecting small-scale maize farmers' perceptions and adaptation towards climate change in Makhuduthamaga Local Municipality, Sekhukhune District, Limpopo province

### 5.1. Introduction

Similarly, the purpose of this chapter is to give the empirical outcomes of the model developed in chapter three. The Heckman two-stage equation model was used in the study to examine factors that impact small-scale maize farmers' perceptions and adaptation to climate change in the Makhuduthamaga municipality. The Heckman probit model results are provided and analysed. The primary goal is to offer empirical findings that explain small-scale maize farmers' perceptions and adaptation to climate change in the area of study. The model's validity is also tested, and conclusions are drawn based on the results. The important variables are discussed first, followed by a summary. In the empirical estimation, the dependent variables are dichotomous variables (see Tables 3.2 and 3.3) that are influenced by socio-economic and other contextual factors. The explanatory variables were chosen based on the availability of data, economic theory, and literature. The set of explanatory variables varies depending on the contrasts and marginal effects.

Adaptation to climate change is a two-step process that requires small-scale maize farmers to first perceive climate change and then respond to changes through adaptation in the second step. The Heckman probit selection equation model was used to determine the factors influencing the perception and adaptation of sampled small-scale maize farmers to climate change. Age, gender, marital status, educational level, farming experience, number of adult labourers, experienced crop failure loss, access to credit, access to extension services, access to climate change information, farm size, distance to input and output markets, and perceived temperature and rainfall components were among the variables included in the model. To obtain the marginal effects, the data were analysed and the selection equation results were post-estimated. Because the coefficients of selection and outcome equations have no direct interpretation, the marginal effects were used for interpretation. It's because they're simply values that maximize the likelihood function (Heckman, 1976). The empirical results of the Heckman probit model's selection (perception) and outcome (adaptation) equations are presented in Table 5.1.

**Table 5.1: Heckman two stage equation model results of sampled small-scale maize farmers under the villages in Makhuduthamaga municipality, Sekhukhune District, Limpopo Province 2021/2022 (n=110)**

| **Dependent variable** | **Selection stage (small-scale maize farmers' perception towards climate change)** | | | **Outcome stage (small-scale maize farmers' adaptation to climate change)** | | |
|---|---|---|---|---|---|---|
| | **Contrast 1** | | | **Contrast 2** | | |
| **Explanatory variables** | **Coefficient (Std. error)** | **Marginal effects** | | **Coefficient (Std. error)** | **Marginal effects** | |
| | | dy/dx | P-value | | dy/dx | P-value |
| CONSTANT | 4.457*** (1.474) | | 0.0001 | 3.855*** (1.124) | | 0.0001 |
| AGE | 0.712*** (0.224) | 0.012 | 0.001 | 0.608** (0.267) | 0.153 | 0.022 |
| GENDER | 0.450 (0.418) | 0.046 | 0.282 | 0.709** (0.3105) | 0.237 | 0.058 |
| MARIT_STTS | -1.238 (1.502) | 0.030 | 0.023 | -0.8215 (0.533) | 0.047 | 0.217 |
| EDUC_LVEL | 19.863** (8.332) | 0.412 | 0.025 | 76.9535*** (19.494) | 0.530 | 0.000 |
| FARM_EXPNC | 1.179** (0.563) | 0.061 | 0.036 | 0.771*** (0.3145) | 0.014 | 0.021 |
| CC_ INFN | 0.251 (0.175) | 0.089 | 0.152 | | | |
| ACC_CROP EXT | 12.296 (11.378) | 0.0026 | 0.280 | 7.471*** (2.066) | 0.419 | 0.000 |
| CRP_FAIL | 0.396 (0.428) | 0.054 | 0.154 | 4.316*** (1.1485) | 0.192 | 0.0001 |
| ACC_CREDIT | | | | 0.9015** (0.4385) | 0.148 | 0.062 |
| LAND_SIZE_OWND | | | | 0.0805* (0.0485) | 0.433 | 0.091 |
| DIST_ OUTPT MARKET | | | | -1.231 (0.926) | 0.006 | 0.935 |
| DIST_ INPUT MARKET | | | | -2.035 (1.997) | 0.312 | 0.114 |
| P_TEMPTRE | | | | 2.898** (1.4285) | 0.505 | 0.082 |
| P_RAINFALL | | | | 2.142*** (0.448) | 0.342 | 0.011 |

**Diagnostics**
Number of observations= 110
Log likelihood -382.4281***
N unobserved= 91
N observed= 19
Wald chi-square= 381.15***
Probability (Wald chi-square) = 0.000
Rho (p) = 1
dy/dx is for discrete change of dummy variable from 0 to 1
standard errors are in parentheses
Notes:*, **, *** means statistically significant at the 10%, 5% and 1% levels, respectively

Source: Survey data (Mid-December 2021 to Mid-February 2022)

The empirical evidence presented in Table 5.1 shows that parameter (rho) is the correlation coefficient between the residuals of the selection equation and the residuals of the outcome equation. The value of (rho=1), on the other hand, is significantly different from zero, indicating that the residuals of both equations are related, indicating that the model specification has a sample selection problem, and OLS cannot be used as an estimator for climate change adaptation. Because the Wald test indicates that the correlation is highly significant, Heckman's technique is more appropriate to avoid bias than OLS. The variance inflation factor was used in an OLS model to test for multicol vglinearity (VIF). The average variance inflation factors of 4.13 indicated that the degree of multicollinearity among the explanatory variables was far less than the critical value of 10. (Gujarati and Porter, 2009). Ten explanatory variables used in the model were significant with respect to the outcome equation, while three variables were significant with respect to the selection equation (see Table 5.1). The variables in the study area that have a significant impact on small-scale maize farmers' perceptions and adaptation to climate change are discussed below.

## 5.2. Discussion of the significant variables used in Heckman probit two stage equation model

### 5.2.1 Age of the sampled small-scale maize farmers

As prior expectation, age of the small-scale maize famer was found to be positively and highly statistically significant at 1% for the level of perception and statistically significant at 5% associated with adaptation to climate change. This means that a one-year increase in the age of the sampled small-scale maize farmer increases the probability of perceiving changes and adapting to climate change by 1.2 % and 15.3 %, respectively, when all other factors remain constant. This empirical finding is consistent with the findings of Tazeze *et al.* (2012), who found that the small-scale farmer's age, which represented experience, positively and significantly influenced adaptation to climate change. Furthermore, Etwire *et al.* (2013) and Mabe *et al*. (2014) discovered that age is related to the adoption of conservation measures. However, Dolisca *et al.* (2006) state that younger small-scale maize farmers are required to work on larger farmland or hectares because they are stronger than older small-scale maize farmers. Moreover, the literature indicates that as small-scale maize farmer's age, they are more likely to perceive climate change and may be more willing to take the risk through adaptations.

### 5.2.2 Gender of the sampled small-scale maize farmers

The sign coefficient parameter for variable Gender was found to influence climate change adaptation positively and statistically significant at 5% level, as prior expectation in chapter three. This means that for every unit increase in the number of male-headed small-scale maize farmers in the study area, the probability of adapting to climate change increases by 24 % as opposed to female-headed small-scale maize farmers. This finding is consistent with the findings of Apata *et al*. (2011b), who discovered that being a male-headed household may affect a household's ability to cope with various climate extreme events. This result, however, contradicts Apata *et al.* (2009)'s finding that gender has no statistically significant relationship with adaptation towards climate change. This study result could be attributed to the fact that men were more aware of climate change than women. Furthermore, men are likely to be responsible for fewer household chores than women. Women have less time to devote to farm labour because they are responsible for other chores. This is due to the fact that national agricultural policies frequently assume that farmers are mostly men. As a result, women farmers are reliant on rain-fed agriculture, have limited access to inputs (fertilizers, seeds, and water), extension, credit, and markets for their products, and own small plots of land or none at all.

### 5.2.3. Educational level of the sampled small-scale maize farmers (EDUC_LEVEL)

The empirical estimated results for educational level of sampled small-scale maize farmers are positively and significantly associated with their perceived changes in climate and adaptation, respectively, at 5% and 1% level of significance. A positive relationship and marginal effect show that an increase in education increases the probability of perceived changes in climate and adaptation by 41% and 53%, respectively, when all other factors are held constant. This empirical result is consistent with the findings of Abid *et al.* (2015), who discovered that the educational level of the household head increases the probability of adapting to climate change. These findings are also consistent with previous research that demonstrated the importance of educational level in climate change adaptation for long-term welfare (Barrett *et al.*, 2009; Deressa *et al.,* 2011). Various studies, however, contend that the higher the educational level, the better the chances of obtaining formal employment and adapting to climate change (Dolisca *et al.,* 2009; Hassan and Nhemachena, 2008).

### 5.2.4. Farming experience sampled small-scale maize farmers (FARM_EXPNC)

As prior expectation from the table of variables in chapter three, the sign coefficient parameter of farming experience among sampled small-scale maize farmers is positively and significantly associated with their perceived changes in climate and adaptation at the significance level of 5% and highly statistically significant at 1% respectively. This means that increasing the number of years of farming experience among the sampled small-scale maize farmers increases the probability of perceived climate change and adaptation by 6.1 and 1.4 %, respectively. The empirical result is consistent with the findings of Amusa *et al.* (2015), who found that years of farming experience significantly increases the probability of choosing different crop varieties, different planting dates, and different fertilizer as adaptation measures. This could be attributed to experienced farmers having more knowledge and information about changes in climatic conditions and crop management practices.

### 5.2.5. Crop failure (CRP_FAIL)

The empirical evidence shows that crop failure experienced by sampled small-scale maize farmers is positive and highly statistically significant at the 1% level of significance. This means that a one-unit increase in crop failure experienced by sample small-scale maize farmers due to climate change increases their adaptive capacity by 0.192. (19.2 %). The findings are consistent with those of Alam *et al.* (2012), who demonstrated that crop failure due to climatic conditions increases the tendency to adapt with better knowledge and information on crop management practices. This could be because most small-scale maize farmers in rural communities lack assets, and it will be an alarming warning to adapt to the effects of climate change. Agabi (2012) proposed that insurance be targeted as a form of collateral to small-scale maize farmers who are not diverse because diversification acts as an alternate solution risk management strategy, resulting in diversified farmers having a lower probability of participating in insurance.

### 5.2.6. Access to crop extension services (ACC_CROP_EXT)

Access to crop extension has a positive and a highly statistically significant influence on climate change adaptation at 1%, as expected prior in chapter three. The positive relationship suggests that sampled small-scale maize farmers who have access to agricultural extension services are more likely to adapt than those who do not. This means that having access to crop production services increases the probability of climate change adaptation by 41.9 %. This finding is consistent with the findings of Amusa *et al*. (2015), who discovered that increasing the frequency of extension contact by one unit increases the probability of adopting an adaptation strategy in the face of climate change. Abid *et al.* (2015) found that providing extension services for crop production was significantly and positively related to changing crop variety, which supports the current study's findings. Agricultural extension, according to Anaeto *et al.* (2012), improves the efficiency of making adoption decisions in the face of any evolving changes revealed by farming activities. According to Amusa *et al*. (2015), the impact of extension services provided by extension officers may not be optimally related to farmer needs.

### 5.2.7. Access to credit by sampled small-scale maize farmers (ACC_CREDIT)

Credit access by sampled small-scale maize farmers is one factor that leads to climate change adaptation, as it was found to be positive and statistically significant at 5% level. An increase in credit availability increases the probability of climate change adaptation by 14.8%. Apata *et al*. (2011) found that farmers who have access to credit have a better chance of adapting to changing climatic conditions. This finding is consistent with Anaeto *et al*. (2012), who found that small-scale farmers' access to credit had a positive and significant relationship with their perception of climate change and adaptation options. Abid *et al.* (2015) discovered that, although not significantly, access to farm credit is positively related to changing crop variety and increased irrigation and negatively related to changing crop type, changing planting dates, planting shade trees, soil conservation, changing fertilizer, and crop diversification. This is due to the fact that farmers now have more financial and other resources at their disposal, allowing them to use all available information to change their management practices in response to changing climatic conditions. Farmers, for example, can use financial resources to buy new crop varieties, new irrigation technologies, and other important inputs they may need to change their practices to accommodate predicted climate changes.

### 5.2.8. Land size owned by sampled small-scale maize farmers (LAND_SIZE_OWND)

At the 10% level of significance, the coefficient estimates for land size owned by sampled small-scale maize farmers are positive and statistically significant. This implies that there is sufficient evidence to suggest that land size influences adaptation to climate change positively. The marginal effect result indicates that for every unit increase in land size owned by sampled small-scale maize farmers, the probability of adaptation to climate change increases by 0.433 (43.3 %), all other factors being constant. According to studies, farmers with larger farms have more land to allocate for the construction of soil bunds, irrigation, and drainage systems for agricultural productivity (Nhemachena, 2008; Deressa *et al.,* 2011). Apata *et al.* (2009) discovered that farmers with a small area of land were more likely to invest in soil conservation than those with a large area. The fact that adaptation is plot-specific could explain the positive relationship between adaptation and farm size. This means that it is not always the case that the size of the farm influences adaptations, but rather the particular characteristics of the farm that dictate the need for a specific adaptation method to climate change impacts.

### 5.2.9. Perceived changes in temperature and rainfall (P_TEMPTR AND P_RAINFALL)

Temperature and rainfall perceptions were hypothesized to be positively related to climate change adaptation. As expected, the findings of this study show a direct relationship between adaptation to climate change and perception of temperature and rainfall increases. Similarly, the coefficient estimates and marginal effects for perceived changes, as well as the highly statistically significant coefficient result, show that a unit increase in perceived temperature and rainfall increases the probability of adaptation to climate change by 51% and 34%, respectively, when all other factors are held constant. This finding is consistent with the findings of Abid *et al.* (2015), who discovered that households living in regions with high temperatures and low rainfall are more likely to adapt. The current study concludes that the higher the levels of climate change perception of rural dwellers, particularly small-scale maize farmers, the greater their chances of adopting adaptation measures. A decrease in rainfall, for example, is more likely to cause small-scale maize farmers to postpone their planting dates.

### 5.2.10. Discussion of insignificant variables

Furthermore, empirical evidence showed that the marital status of sampled small-scale maize farmers and the number of adult labourers were negatively associated with perceived changes in climate change. Access to climate change information, on the other hand, was positively associated with perceived changes in climate change. Climate change adaptation was found to be negatively related to distance to output and input markets. Because the variables mentioned above were statistically insignificant, there was insufficient evidence to suggest the extent to which they influenced perception or adaptation.

## 5.3. Summary

This chapter empirically investigated factors influencing small-scale maize farmers' perceptions and adaptation towards climate change in Makhuduthamaga local Municipality, Sekhukhune District, Limpopo Province. The Heckman two stage equation models were used in the study to examine the factors influencing perception and climate change adaptation in the study area. The dependent variable in the first stage (selection equation) was perceived changes in climate change by sampled small-scale maize farmers, and the dependent variable in the second stage was adaptation towards climate change (outcome equation). As a result, the Heckman two stage equation model was used in the research. Furthermore, statistical tests revealed that the model fits the data well and that there are no issues with multicollinearity or heteroscedasticity. The marginal analysis in the first selection equation model revealed that age, educational level, and farming experience all have a significant effect on small-scale maize farmers' perceptions of climate change. Furthermore, in the second stage equation model, factors such as age, gender, educational level, number of adult labourers, experienced crop failure, access to credit, access to extension services, farm size, perceived changes in temperature, and rainfall were found to have a significant impact on climate change adaptation. As a result, the null hypothesis that socioeconomic factors do not influence small-scale maize farmers' perceptions and adaptation to climate change is rejected. The conclusions and policy implications derived from these empirical findings are presented in greater detail in Chapter 6.

# CHAPTER SIX

## SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

### 6.1. Summary

### 6.1.1 Introduction

This chapter summarizes the study's research objectives and methodology, as well as its conclusion and policy recommendations. It also emphasizes the extent to which the analysis addressed the objectives and hypotheses posed at the start of the study. The goal of this final chapter is to present the study's key findings, make policy recommendations, and suggest areas for further research.

### 6.1.2. Recap of research objectives and methodology

In developing countries, particularly in South Africa, the agricultural sector has the potential to contribute to rural growth, reduce poverty, improve food security, create jobs, and narrow income disparities. This is a significant contribution to economic growth. However, the sector is vulnerable to climate change and variability, which results in reduced arable land, pastoral agriculture, and forestry, a shorter growing season, and lower yields or productivity. As a result, adaptation was widely recognized as an essential component of any policy response to the impacts and variability of climate change. Despite widespread public education campaigns about climate change around the world, many South African small-scale farmers continue to be unaware of the fundamental drivers of climate change. The current level of support for the agricultural sector in South Africa in response to climate change adaptation is generally poor. This is attributed to ineffective climate change policy, insufficient technological and financial capacity, and the current political crisis. Climate change adaptation methods are well documented in a variety of sources such as books, journal articles, reports, and so on. However, few studies have been conducted to prove or analyse whether these methods will be adopted at the farm level, particularly in South Africa's Limpopo province. Furthermore, little or no research has been conducted to determine whether Makhuduthamaga local municipality small-scale maize farmers perceive that climate is changing and are willing to adapt to these climate change adaptation methods. As a result, this study was carried out to fill the aforementioned research information gap and to draw relevant policy implications to improve the welfare of small-scale maize farmers through the use of climate change adaptive measures.

The overall purpose of the study was to assess small-scale maize farmers' perceptions and adaptation towards climate change in Makhuduthamaga local municipality. Unambiguously, the study pursued the following objectives: (i) Identify and describe small-scale maize farmer's socio-economic characteristics in the study area; (ii) Assess the level of perceptions of small-scale maize farmers towards climate change in the study area; (iii) Analyse the socio-economic factors influencing perceptions and adaptation of small-scale maize farmers towards climate change in the study area.

To meet these objectives, two villages in Makhuduthamaga Municipality (Apel cross and Ga-Masemola) were chosen as case studies. A questionnaire survey was used to collect cross-sectional data from a total sample of 110 small-scale maize farmers using a random sampling procedure based on probability proportional to sample size (for rationale see Table 3.1). Both descriptive statistics and econometric techniques were used in the data analysis. To gather information on issues raised in the survey questionnaire, key informant interviews were conducted. Data from key informant interviews and participant observation were also used to supplement or improve the interpretation of the econometric model results.

In chapter five (5), the Heckman two stage equation model was used to examine the factors influencing perceptions and adaptation to climate change in the study area. This chapter concludes with a discussion of the study's limitations, followed by suggestions for future research. The conclusions derived from these empirical findings are presented in the following section.

## 6.2. Conclusions

According to the empirical findings in Chapter 5, the following factors influenced the choices of clustered climate change adaptation methods of sampled small-scale maize farmers: age, highest level of education, farming experience, total income above average total income, total number of adult members in the household, access to extension services, access to credit, land size owned, access to climate change information, perceived changes in rainfall and temperature in the distance to market, on the other hand, has a negative impact on the sampled small-scale maize farmers. The current study concludes that access to extension services, climate change information, and credit are important in increasing small-scale maize farmers' ability to acquire relevant climate change adaptation methods. Therefore, the above-mentioned factors were prompt to be very imperative to influence the capacity of the small-scale maize farmers' perceptions and adaptation in the study area. In addition, these variables need to be taken into consideration when dealing with perceptions and adaptation towards climate change effects. Moreover, these findings create a platform or highlight the significance of government and non-governmental organizations (NGOs), private and public sectors and support services as to improve the livelihood of the small-scale maize farmers. For example, investing in the educational capacity of the farmers as well as accessibility to credit will improve the capacity of the small-scale maize farmers to adapt to the climate change impacts respectively.

As a result, the government, department, NGOs and other private companies must continue to provide these services and strengthen small-scale maize farmers, possibly by investing in awareness campaigns, workshops, training, and a visit approach in which these small-scale maize farmers are made aware of all the services available to deal with the effects of climate change. In terms of climate change information accessibility, small-scale maize farmers will be able to detect changes in temperature and rainfall and, as a result, act accordingly through adaptive measures.

However, it has been stated in the literature that some climate change adaptation measures (such as soil conservation, changing planting dates, shading, planting trees and shelter, and using insurance, etc.) are not plot specific. The sampled small-scale maize farmers' age, gender, farming experience, and level of education were discovered to promote climate change adaptations. The positive effect of sampled small-scale maize farmers' education level suggests that advancement in education increases ability to obtain climate change adaptation methods. The study's findings indicate that the relative age of the sampled small-scale maize farmers influences increase in climate change adaptations. As a result, the introduction of new technologies should target both younger and older small-scale maize farmers, because young farmers will consider and use an alternative method for a number of years before abandoning it. This emphasizes that raising awareness of the potential benefits of climate change adaptations is an important policy measure that should be considered to improve the welfare of small-scale maize farmers in developing countries. The findings revealed that sampled small-scale maize farmers located far from markets are less likely to adapt to climate change, most likely due to the high transaction costs associated with market access. According to the literature, having access to own means of transport reduces transaction costs, increasing opportunities for small-scale maize farmers to adapt to climate change and fully participate in the market.

To assess the perceptions of sampled small-scale maize farmers in the study area, Likert-scale was employed. The majority of small-scale maize farmers interviewed 41 (37%) strongly agreed that climate change is occurring, followed by those who were doubtful or uncertain 27 (25%). Twenty-four (22%) of the sample small-scale maize farmers agreed that climate change is occurring; however, 6% disagreed and 10% strongly disagreed. According to the findings in Chapter 4, out of 110 interviewed small-scale maize farmers, 77 (70%) perceived an increase in the number of hot days during the summer season, while 11 (10 %) perceived a decrease. Minority of sampled small-scale maize farmers reported no changes (7%), uncertainty (7%), and don't know (6%) in the number of hot days during the summer season. According to the findings, the majority of small-scale maize farmers, 84 (76%), perceived a decrease in the number of cold days during the winter seasons over the last three decades. Approximately 4%, 3%, 7%, and 10% of the sampled small-scale maize farmers perceived the number of cold days during the winter season as increasing, remaining the same, they don't know and are uncertain, or they are not sure, respectively. The majority (84) or %age (76%) of sampled small-scale maize farmers observed a decrease in the number of rainy days during the rainy season over the last 30 years. About 4%, 3%, 7%, and 10% of the sampled small-scale maize farmers perceived the number of rainy days during the rainy season as increasing, remaining the same, they don't know and are uncertain, or they are not sure respectively.

The Heckman two stage equation model was employed in the study to evaluate the factors influencing perceptions and climate change adaptation in the study area. The dependent variable in the first stage (selection equation) was perceived changes in climate change by sampled small-scale maize farmers, while the dependent variable in the second stage was adaptation to climate change (outcome equation). As a result, the Heckman two stage equation model was used in the research. The marginal analysis in the first selection equation model revealed that age, educational level, and farming experience all have a substantial effect on small-scale maize farmers' perceptions towards climate change. Furthermore, in the second stage equation model, factors such as age, gender, educational level, number of adult labourers, experienced crop failure, access to credit, access to extension services, farm size, perceived changes in temperature, and rainfall were proven to have a greater impact on climate change adaptation. As a result, interventions aimed at improving access to agricultural loans, extension, informal social networks facilitating group discussions, better information flows, and so boosting adaptation to climate change are required. For example, providing knowledge, credit, and awareness about the causes and impacts of climate change, as well as the availability of means of production, may motivate small-scale maize farmers to participate in farming management methods.

*Regarding the research hypotheses, the research findings suggest that all the null hypotheses of the study outlined in Section 1.3.3 of Chapter 1 should be rejected.*

*Hypothesis (i):* There is no difference in the level of perceptions amongst small-scale maize farmers in the study area; this hypothesis should be rejected because, the results from the descriptive statistics results show that a large number of small-scale maize farmers strongly agreed and perceived or rather believed that climate has changed due to rainfall and temperature in the last 30 years.

*Hypothesis (ii):* Socio-economic factors do not influence the perceptions and adaptation of small-scale maize farmers towards climate change in the study area; This hypothesis should be rejected because, the Heckman two stage equation model results revealed that age, educational level, farming experience, number of adult labourers, crop failure, access to credit, access to extension services, farm size, perceived changes in temperature and rainfall and they all have a significant impact on the small-scale maize farmers’ perceptions and adaptation towards climate change.

### 6.3. Policy recommendations

Following the identification of the underlying issues affecting sampled small-scale maize farmers' perceptions and adaptation towards climate change, the following policy proposals are thought to help overcome these restrictions. These policy recommendations are based on the study's findings.

**6.3.1** With regards to diversity, the qualitative statistics revealed that the majority of the sampled small-scale maize farmers were above the age of 58. This clearly demonstrates the scarcity of young small-scale maize farmers in the research area. Furthermore, a small-scale maize farmer's age and farming experience always impact his or her ability to learn outside knowledge about agricultural output, perception of climate change components, and adaptation measures. Furthermore, variable age was found to have a significant influence on the choice of climate change adaptation methods, as well as the proportion of farm revenue to total household income of the small-scale maize farmer in the research area. As a result, agricultural training and educational programs should be assessed to guarantee that younger small-scale maize farmers are capable of directly contributing to climate change adaptation options for a sustainable and well-developed agricultural business. As a result, the study suggests that the government work with various stakeholders in both the commercial and public sectors to implement additional incentives and advanced programs that will encourage young small-scale maize farmers to fully participate in climate change adaptation.

In conclusion, the current study suggests that greater emphasis be placed on developing programs that better educate younger small-scale farmers on how to respond to climatic changes through sustainable adaptation practices for acceptable livelihoods and development. For example, the government should urge tertiary institutions that offer agricultural degrees, as well as the Department of Basic Education (DBE), Higher Education and Training (HET), and AgriSETA, to include agriculture as one of the careers that younger counterparts can pursue not only as practitioners but also as farmers.

**6.3.2** In terms of the gender of the sampled small-scale maize farmers in the study area, data collected revealed that males outnumbered females. Gender was discovered to have a substantial influence on small-scale maize farmers' perceptions and adaptation towards climate change. Furthermore, men are known to have greater access to knowledge than women since they frequently visit public areas where agricultural techniques or activities are discussed. As a result of the current study, it can be inferred that there is still a rising attitude in the study area that farming is primarily for men as opposed to women. As a result, it is advised that the government establish rules that eliminate any kind of gender discrimination in property rights and address gender imbalances. There is an urgent need to eliminate the legal structure and customary practices that purposefully deny women property ownership, resulting in lack of credit and, as a result, lack of access to various climate change adaptation options. The government should promote climate change adaption measures that cater to or may be used by both gender participants. Financial institutions, such as the Land bank funding model, should be evaluated in order to support and issue loans empowering both men and women for climate change adaption methods.

**6.3.3** Moreover, the empirical findings demonstrated that educational level affects sampled small-scale maize farmers' ability to adapt to climate change. Furthermore, it has been established in the literature that a higher degree of education is connected with greater knowledge and access to information concerning meteorological conditions. As a result, educational degree is thought to be a key aspect in gaining advanced knowledge on new enhanced agricultural technology and higher agricultural productivity for long-term welfare. According to the study's findings, the degree of education was found to increase climate change adaptations. As a result, the government should encourage and assist the dissemination of more accurate understanding about the causes and effects of climate change to farmers. This can be done so that farmers understand what climate change is, how it affects their farming practices as well as their indigenous ways of farming and how they can best adapt. An appropriate education will raise their level of perception and awareness. Small-scale maize farmers must be educated on climate change, vulnerability, and adaptation measures to assist them in their farm operations. This study suggests that education is a crucial policy tool, and that more investment in education is needed to raise knowledge of the potential benefits of climate change adaptation.

**6.3.4** Access to credit is another major element influencing agricultural technology adoption in the face of climate change. As per the descriptive statistics, the majority of the sampled small-scale maize farmers in the area of study did not have access to finance. According to the literature, rural farmers require access to substantial credit, which they typically do not qualify for due to a lack of collateral security. According to empirical evidence, access to financial resources was a significant factor of adaptation and the share of agricultural income to total household income. There is an urgent need to improve rural farmers' access to credit through financial credit programs. Because most financial institutions, like banks, are headquartered in towns, the government should establish financial institutions in rural communities, specifically for rural small-scale farmers. Furthermore, these types of financial organizations have stringent requirements for lending, such as collateral, which small-scale maize farmers may not have. As a result, the procedures for obtaining loans should be modified in order to adapt to or satisfy the level or ability of rural farmers to obtain them. For example, DAFF launched a new initiative called Micro Agricultural Finance Schemes of South Africa (MAFISA), however the process of obtaining credit through this program is still unclear to the majority of rural farmers. It is, therefore, suggested that many important stakeholders mobilize small-scale maize farmers to form cooperatives, stokvels, or group savings as part of investments. Policymakers should, therefore, ensure that rural small-scale farmers have access to inexpensive loans in order to boost their ability and flexibility in responding to anticipated climate circumstances. This suggests that access to credit will boost rural farmers' resilience to climatic unpredictability as well as the capability of their adjustments. These can be accomplished effectively if information on how small-scale maize farmers can obtain loans or credit is made available. Thus, investment in rural climate change adaptation techniques by the government and other stakeholders, for example, can improve employment prospects, poverty reduction, and food security for long-term rural welfare. Training for the farmers in managing credit perhaps is needed.

**6.3. 5** Empirical findings also revealed that access to the market by the surveyed small-scale maize farmers was a critical factor impacting adaptation to climate change. As a result of the aforementioned facts, increased access to markets helps small-scale maize farmers to purchase new technical inputs if they are to adapt their practices to cope with expected future climate change. As a result, there is a need to improve and sustain small-scale maize farmers' generally low market access. The South African government should invest more in the establishment of depots and markets closer to small-scale maize farmers to solve this problem and encourage more farmers to come to the market and sell their produce. The empirical results show that trying to improve access to market information through appropriate sources and making it easier to access could reduce transaction cost with searching for trading partners, contracting and contract enforcement, and increasing market participation among small-scale maize farmers. If policymakers effectively apply these methods, small-scale maize farmers will undoubtedly see the value of specific adaptation measures, their perceptions will naturally improve, and they will be better equipped to adapt to climate change. Collective action between the public and corporate sectors can make this simple to implement. Furthermore, institutional support from many stakeholders (such as NGOs and government organizations) could boost small-scale maize farmers' market involvement. This can be accomplished by developing suitable institutional support programs, such as public-private partnerships, to better connect small-scale maize farmers to markets. Furthermore, enhancing access to essential services, resources, and market growth can boost productivity, opening up prospects for rural development through climate change adaptation methods.

**6.3. 6** Finally, small-scale maize farmers should be urged to collaborate with extension workers, as empirical evidence suggests that extension services increase the likelihood of adopting to climate change. Government policies should address a need to support extension officer training so that they can provide farmers with relevant information regarding climate change knowledge and skills. They should be provided with the required skills to distribute information in an understandable manner to farmers. The South African government should use a bottom-up approach to identify difficulties faced by extension officers. Extension services must be enhanced to provide small-scale maize farmers with the knowledge they need regarding the causes and effects of climate change. Government policies should address the need to support extension officer training so that they can provide farmers with relevant information regarding climate change knowledge and skills. Extension officers should be trained to distribute information in a clear manner that small-scale maize farmers can understand. The extension officer should consider it worthwhile to support small-scale maize farmers by transmitting knowledge and information that farmers require, such as climate change information, lectures or workshops, participatory rural appraisal, training, and visit model on particular issues on various farm operations. Furthermore, policymakers should recognize the significance of local initiatives (bottom-up method) in achieving greater collective action outcomes. Government agencies must modify their approach to working with communities, becoming more mindful of the importance of strengthening local management institutions and enabling more local decision-making without imposing external regulations. As a result, community education about the various causes and effects of climate change should begin. Extension officers could also organize farmer group meetings to improve confidence, collective demonstration, and involvement. The extension officer and the government should establish and implement a policy that aims to foster and coordinate an effective extension service among small-scale farmers in communities to increase information on climate change awareness and other areas where information is needed. Furthermore, the government should consider hiring more agricultural extension officers in order to reduce the extension worker-to-farmer ratio, as the majority of farmers do not have access to extension services. It may be argued that improved climate information enables small-scale maize farmers to make comparable selections among various adaptation strategies and hence select the ones that allow them to learn to cope with climate change. Farmers who have exposure to climate change information perform significantly better than farmers who have not. In addition, informal social networks among small-scale farmers and rural communities should be encouraged because they have the potential to increase social capital important for adaptation.

**6.3.7** The government should also ensure that future policies emphasize climate change awareness creation or campaigns through various channels such as mass media and extension, encouraging informal social networks, facilitating credit availability, and supporting studies on the effect of climate change adaptation. Empirical findings also revealed that the more the sampled small-scale maize farmers' adaptation to climate change, the higher the contribution of farm revenue to total household income. Government, community members, and various stakeholders (such as NGOs, research institutions, municipalities, and so on) should all consider climate change adaptation as part of the local development agenda. Investments in technologies such as irrigation, drought-resistant plants, and early maturing varieties; institution building; research; training; and promotion of small-scale farmers and animals such as cattle held to mitigate the effects of crop failure or low yields in extreme weather situations are some of the examples. This will also provide additional services required for adaptation, complicating the fulfilment of other development goals for long-term welfare. Research institutions such as the Agricultural Research

Council and non-governmental organizations (NGOs) could aid in the spread of climate change information and impacts.

To summarize, it is also advised that small-scale farmers enhance their access to agricultural land, agricultural extension services, market access, information, loans, and enhanced farming methods in order to effectively adapt to climate change. Policy interventions, however, are essential to assist rural lives and diversify alternative income sources to lessen reliance on the farming sector.

## 6.4. Limitations of the study and suggestions for future research

In the future, a larger sample size should be used to reinforce the study. Future researchers may consider broadening the study to provincial or rather national in order to find if there are other small-scale maize farmers who are having similar responses via perceptions and adaptation towards climate change.

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**APPENDIX A**

## QUESTIONNAIRE SURVEY

## UNIVERSITY OF LIMPOPO

**FACULTY OF SCIENCE AND AGRICULTURE**

**DEPARTMENT OF AGRICULTURAL ECONOMICS AND ANIMAL PRODUCTION**

**PROJECT: SMALL-SCALE MAIZE FARMERS PERCEPTIONS AND ADAPTATION TOWARDS CLIMATE CHANGE IN MAKHUDUTHAMAGA LOCAL MUNICIPALITY, SEKHUKHUNE DISTRICT, LIMPOPO PROVINCE.**

Please read the following statement carefully before signing or completing the questionnaire. This questionnaire is meant to address the preceding project. It is to be completed by the small-scale maize farmer with the help of the enumerator. It is meant to generate information on socio-economic characteristics of the farmers, small-scale maize farmer's perceptions on climate change. Moreover, including section on adaptation used by small-scale maize farmers in Makhuduthamaga Local Municipality. The information provided will be used only for the purposes of this research and will be treated strictly confidentially, with no mention of names in the analysis. Please tick the appropriate boxes when necessary or fill the blank spaces provided.

Please mark with an X if you agree or not to complete the questionnaire. I do not wish to complete the questionnaire ____

I agree to complete the questionnaire and do so in a completely voluntary manner. I understand that my responses will be kept confidential. ______Signature ______________Date __________

**RESPONDENT IDENTIFICATION**

| **QUESTIONNAIRE PARTICULARS** | |
|---|---|
| Enumerator's name | |
| Respondent's name | |
| Date | |
| Village/Area | |
| Questionnaire reference number | |

## SECTION A: SMALL-SCALE MAIZE FARMERS CHARACTERISTICS

1. **What is the name of the farmer………………………………..**
2. **SMALL-SCALE MAIZE FARMER'S KEY SOCIO-ECONOMIC CHARACTERISTICS**

| Marital status | Gender<br>1= male<br>0=female | Age | Highest level of formal education | Employment status |
|---|---|---|---|---|
| | | | | |

**Key: Use the codes mentioned in the table below to answer the table above.**

| Marital status | Highest level of formal education | Employment status |
|---|---|---|
| 1. Married<br>2. Single<br>3. Divorced<br>4. Widowed | 1. Never attended school<br>2. Primary level<br>3. Secondary level but did not complete matric<br>4. Matriculated<br>5. Tertiary level | 1. Self-employed<br>2. Permanent employment<br>3. Temporarily employment<br>4. Contract employment |

3. **How many adult members are there in the household?......................**
4. **What is the household size?.............................**
5. **What are the household's major sources of income? Please rank these according to their importance, where one (1) represents the most important**

| Household income sources | Please tick | Rank |
|---|---|---|
| Maize production | | |
| Unearned income generating activities | | |
| Employment | | |
| Off-farm income | | |

| Other: specify | | |
|---|---|---|

6. **Estimated total farm income per year …………………………………. (R)**
7. **Other income sources per month in the previous year and please tick.**

| **Farm income (R)** | | **Remittances (Gifts) (R)** | | **Child social grants (R)** | | **Employment (wages and salaries) (R)** | | **Pensions (R)** | | **Disability grant** | | **Other specify …………………………..** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| <500 | | <500 | | <300 | | <1000 | | <1000 | | <700 | | <500 | |
| 500-1000 | | 500-700 | | 300-500 | | 1000-1500 | | 1000-2000 | | 700-1200 | | 500-800 | |
| 1001-1500 | | 701-900 | | 501-800 | | 1501-2000 | | 2001-3000 | | 1201-1700 | | 801-1100 | |
| 1501-2000 | | 901-1200 | | 801-1100 | | 2001-2500 | | 3001-4500 | | 1701-2200 | | 1001-1400 | |
| 2501-3000 | | 1201-1500 | | 1101-1400 | | 2501-4000 | | 4501-5500 | | 2201-2700 | | 1401-1700 | |
| >3000 | | >1500 | | >1400 | | >4000 | | >5500 | | >2700 | | >1700 | |

## SECTION B: LAND USE AND MAIZE PRODUCTION

1. **What is the size of the land in hacters?............................**
2. **How did you acquire land?**

| **Land tenure system** | **Please tick** |
|---|---|
| Inheritance land | |
| Leasing or rental | |
| Purchased land | |
| Acquired land through land reform programme | |
| Owned or permission from tribal authority | |

3. **How many years have you been farming? (Farm experience)…………………**
4. **Did you cultivate the land last year?..........................**
5. **What is the distance to the market were you buy your inputs (km)?......................**

6. **What is the distance to the market where you sell your products (km)……………..**
7. **FARM PRODUCTION ASSETS**

| **Assets (Farm implements)** | **Number owned** | **Number hired/borrowed** | **Current value per unit (R)** | **Rental price (if rented or borrowed per day) (value in R)** |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**Suggestions: Planter, Ripper, Tractor, Harrow, Mouldboard plough, Oxen drawn plough**

## SECTION C: CLIMATE CHANGE

1. **Please tick yes or no from the following:**

| | **YES** | **NO** |
|---|---|---|
| **Does the farmer have access to credit?** | | |
| **Does the farmer have access to formal market?** | | |
| **Does the farmer have access to extension services?** | | |
| **Does the farmer have access to climate change information?** | | |
| **Does the farmer have access to water and electricity?** | | |
| **Is the farmer involved in farmer's organisations?** | | |
| **Is the farmer aware that climate is changing?** | | |

2. **Sources of climate change information**

| | **Tick** |
|---|---|
| **Friends or relatives** | |
| **Magazines** | |
| **Radio** | |
| **Agricultural advisors or extension officers** | |
| **Internet** | |
| **News paper** | |
| **None** | |

**SECTION D: SMALL-SCALE MAIZE FARMERS PERCEPTIONS AND ADAPTATION TOWARDS CLIMATE CHANGE**

**NB: In this study climate change is defined as the variety of general shifts in weather conditions (changes in the weather and the seasons) including temperature rainfall, wind, and other factors (such as floods, drought).**

1. **Do you really think climate is changing? Please tick**

| Strongly agree | Agree | Uncertain | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. | 2. | 3. | 4. | 5. |

2. **Do you believe that climate has changed in the last 30 years (Temperature and rainfall)?**

| Strongly agree | Agree | Uncertain | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. | 2. | 3. | 4. | 5. |

3. **The number of hot days perceived by the small-scale maize farmer during summer season in the last 30 years.**

| Increased | Decreased | Stayed the same | Don’t know | Uncertain |
|---|---|---|---|---|
| 1. | 2. | 3. | 4. | 5. |

4. **The number of cold days perceived by the small-scale maize farmer during winter season in the last 30 years.**

| Increased | Decreased | Stayed the same | Don’t know | Uncertain |
|---|---|---|---|---|
| 1. | 2. | 3. | 4. | 5. |

5. **The number of rainy days perceived by the small-scale maize farmer during rainy days in the last 30 years.**

| Increased | Decreased | Stayed the same | Don’t know | Uncertain |
|---|---|---|---|---|
| 1. | 2. | 3. | 4. | 5. |

6. **Perceived effects of heat, cold and rainfall on human health problems/diseases.**
   6.1 **Do you think these changes in temperature, rainfall cause's human health problems? Please explain**
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   …………………………………………………………………………………………….
   6.2 **What do you think are the reasons for these changes to human health problems?**
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   …………………………………………………………………………………………….
7. **Farmers' perceptions of change in temperature and rainfall on farming/ maize production over the last 30 years (see codes below the table).**

| Climate change components | a. How have these changes affected your maize production? | b. What have you done to deal with these changes in your maize production? | c. What were constraints/problems to deal with these changes in your maize production? |
|---|---|---|---|
| Changes in Rainfall | | | |
| Changes in temperature | | | |

**Codes:**

| Codes for 1.1a. | Codes for 1.1b. | Codes for 1.1c. |
|---|---|---|
| 1= Low farm income | 1= Adopting intercropping | 1= Lack of information |
| 2 = Crops dying | 2= Changing the planting dates | 2= Lack of funds |
| 3 = High costs of production | 3= Adopting crops rotation | 3= Shortage of agricultural inputs/seeds |

| | | |
|---|---|---|
| 4 = None | 4= Adopting new crop varieties | 4 = Old fashion of available agricultural inputs |
| 5 = Other specify………… | 5= Diversification of production | 5 = Lack of access to market |
| | 6= partial abandonment | 6 = Lack of enough labour |
| | 7 = No need or No adaptation | 7 = Poor infrastructure |
| | 8= Changing irrigation schedule | 8 = Lack of access to land |
| | 9= Leasing/selling out part of the farmland | 9 = Lack of interest and motivation |
| | 10= Shifting to other crops/plants | 10 = High competition |
| | 11= Leasing/selling out entire landholding | 11 = Lack of time |
| | 12= Land abandonment | 12 = Other specify………… |
| | 13 = Find off-farm job | |
| | 14= Change from crop to livestock | |
| | 15 = Constructing grass strips | |
| | 16= Using more mineral fertilizers/pesticides | |
| | 17= Build a water-harvesting scheme | |
| | 18= Adopting new land preparation practices | |
| | 19= Buy insurance | |
| | 20 = Plant trees for shading | |

| | | |
|---|---|---|
| | 21 = Migration | |
| | 22 = Implement soil conservation techniques | |
| | 23 = Reforestation ………………….. | |
| | 24 = other specify………………….. | |

**Have these changes had any positive impact on your economic activities and how?**

| | |
|---|---|
| 1 Yes | 0 No |

**……....................................................................................................................................**

**.......................................................................................................................................**

8. **How important do you think is to adapt to climate change?**

| | | | | |
|---|---|---|---|---|
| Not very important =1 | Not important = 2 | Uncertain =3 | Important = 4 | Very important=5 |

**What constraints do often face in adapting to new economic activities for a living?**
**..........................................................................................................................................**
**..........................................................................................................................................**

**THANK YOU FOR PARTICIPATING IN THIS STUDY AND KINDLY INFORMING US!**