Farmers' Perception And Adaptation To Climate Change: Case Study Of Vulnerable Areas In uMhlathuze Local Municipality In KwaZulu-Natal, South Africa.

By

Abla Yende
213505648

Submitted in partial fulfilment of the academic requirements for the degree of Master of Agriculture (Food security),
African Centre for Food security.

School of Agricultural, Earth and Environmental Sciences (SAEES)
College of Agriculture, Engineering and Science
University of KwaZulu-Natal
Pietermaritzburg
South Africa

December 2020

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

ABSTRACT

Global climate change has become a crucial concern, with smallholder farmers in developed countries being the most vulnerable In Africa, especially Sub-Saharan Africa, the majority of smallholder farmers cultivate crops and depend on agriculture for food and livelihoods. As a result, smallholder farmers must be mindful of the consequences of climate change and shifting weather conditions in order to implement appropriate adaptation steps. Without adaptation, climate change would have a serious impact on the agricultural development of smallholder farmers.

As a result, however, smallholder farmers from Sub-Saharan Africa and Southern Africa lack the tools such as infrastructure, finance, information, and technology that could help them survive. The study examined smallholder farmers' perceptions of climate change, as well as the types of changes they have made to their agricultural activities in response to climate change, in KwaZulu-Natal, South Africa, more specifically in the rural region of KwaDlangezwa in the Mhlathuze Municipality.

This study employed a mixed-methods approach, which incorporates quantitative and qualitative analysis. The quantitative approach used a standardised questionnaire to elicit responses from 101 smallholder farmers who were purposefully chosen to participate. Qualitative results were gathered by focus group discussions with smallholder farmers in order to delve further into the farmers' views of climate change and their adaptation choices. Additionally, the logit regression model was used to classify determinants (factors affecting farmers') of adaptation to climate change in this analysis.

According to the study's results, the majority of smallholder farmers were female (79.2%) and older (49.5%). The majority of smallholder farmers engaged in crop cultivation for household use (75.2%). Smallholder farmers relied on their indigenous skills when it came to crop selection, planting seasons, and weather forecasting (63.4%). About 56% of smallholder farmers were aware of climate change, 98 percent perceived a rise in temperature, 46.5 percent perceived an increase in rainfall, and 50.5 percent perceived a reduction in rainfall owing to prolonged drought seasons.

The focus group discussions show that smallholder farmers feel climate change is the result of their forefathers' or God's wrath and that they do not understand it. Climate trends have had a significant negative effect on the population of smallholder farmers, including crop loss (99.0% and food insecurity (65.3%). However, 90.1% of smallholder farmers say that they have received no training

on climate change intervention, and 96.0% report that they have made no investment in climate adaptation technology.

Around 94.1% reported receiving no assistance from extension agencies, resulting in just 30.7% adapting to climate change. They have developed mostly by shifting planting dates, crop diversification, and changing planting dates to both temperature and rainfall changes. Although the Logit regression study indicates that four factors are statistically significant for climate change adaptation. These factors are gender (P=0.028), age (0.038), gross hectares of land (P=0.003), and years of cultivation (P=0.018), both of which are statistically important.

Additionally, the study's findings indicated that smallholder farmers faced adaptation challenges such as a lack of knowledge (83.2%) and farm inputs (such as machinery, tractors, and improved seeds) (60.4%). 98% of smallholder farmers confirmed that climate change has impacted their agricultural operations, resulting in a reduction in farm income for 85.1% of smallholder farmers. The majority of female smallholder farmers (95.0%) indicated that their households lacked agricultural-based food products.

Droughts (77.2 percent), price spikes (42.6 percent), and flooding are the primary causes of these food crises (22.8 percent). According to the focus group discussions, while they are adapting to climate change through indigenous expertise, they believe it will help them to learn more cost-effective adaptation approaches that would increase crop production. It is critical, therefore, to conduct awareness-raising and training programmes to teach farmers about climate change, its consequences, and the necessary methods to employ in response to increases in both rainfall and temperature. Additionally, the government would need to provide inputs for climate change adaptation and expand extension programmes to these areas to ensure continued surveillance after farmers have been trained.

PREFACE

The research contained in this thesis was completed by the candidate while based in the School of Agricultural, Earth and Environmental Sciences of the College of Agriculture, Engineering and Science, University of KwaZulu-Natal, Pietermaritzburg Campus, South Africa. Under the supervision of Mr Denver Naidoo and Dr Mjabuliseni Ngidi.

The contents of this work have not been submitted in any form to another university and, except where the work of others is acknowledged in the text, the results reported are due to investigations by the candidate.

Signed: [redacted] Date: 02 December 2020

Abla Yende (Candidate)

As supervisors of the candidate, we agree to the submission of this dissertation.

Signed: [redacted] Date: 02 December 2020

Mr Denver Naidoo (Supervisor)

Signed: [redacted] Date: 02 December 2020

Dr Mjabuliseni Ngidi (Co-supervisor)

DECLARATION 1: PLAGIARISM.

I, Abla Nomfanelo Precious Yende, declare that:

(i) The research reported in this dissertation, except where otherwise indicated or acknowledged, is my original work.

(ii) This dissertation has not been submitted in full or in part for any degree or examination to any other university.

(iii) This dissertation does not contain other persons' data, pictures, graphs or other information unless specifically acknowledged as being sourced from other persons.

(iv) This dissertation does not contain other persons' writing unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:

a) Their words have been re-written, but the general information attributed to them has been referenced.

b) Where their exact words have been used, their writing has been placed inside quotation marks, and reference.

(v) Where I have used material for which publications followed, I have indicated in detail my role in the work.

(vi) This dissertation is primarily a collection of material, prepared by myself, published as journal articles or presented as a poster and oral presentations at conferences. In some cases, additional material has been included.

(vii) This dissertation does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the dissertation and the References sections.

Signed:_____ Date: 02 December 2020

Abla Yende (Candidate)

ACKNOWLEDGEMENTS

This research would have not been possible without the support of the following people to which I would like to express my gratitude:

- My supervisor Mr Denver Naidoo, thank you for your guidance, patience and support, indeed your help is highly appreciated.
- My co-supervisor Dr Mjabuliseni Ngidi for his constructive comments and guidance.
- Thank you to Bright Mukwedeya for his support, guidance and encouragement throughout my research
- Mr Dennis Mngcwango my key informant from the University of Zululand for informing and organizing the smallholder farmers of Kwadlangezwa.
- My enumerators for assisting me with data collection.
- My family particularly my mother and sister thank you for your prayers, love, care and support.
- My Church (Grace Generation Church Pietermaritzburg) and Life group members thank you for your prayers and support.
- My friends Onenkosi Mkize, Samkelisiwe Khumalo and Silindile Mamba thank you for inspiring me to work hard and for your support in challenging times.
- A special thank you to my partner Malusi Zulu thank you for your continuous support, prayer, love, motivation and financial assistance.
- To all the unnamed individuals who assisted me in every other way, it did not go unnoticed.
- Above all to **GOD** my Heavenly Father for giving me the strength to complete this research.

(Philippians 4:13).

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ABBREVIATIONS

DAFF: Department of Agriculture Forestry and Fisheries

DEA: Department of Environmental Affairs

FAO: Food and Agriculture Organization

FDGs: Focus Group Discussions

HIV/AIDS: Human Imunodefiency Virus/ Acquired Imunodefiency Syndrom

IDP: Integrated Development Plan

IFAD: International Fund for Agricultural Development

IKS: Indigenous Knowledge Systems

IPCC: Intergovernmental Panel on Climate Change

KZN: KwaZulu-Natal

LDCs: Less Developed Countries

NGO: Non-governmental Organisation

SDGs: Sustainable Development Goals

SASSA: South African Social Security Agency

SPSS: Statistical Package for Social Sciences

SSA Sub-Saharan Africa

STATS SA: Statistics South Africa

UKZN: University of KwaZulu-Natal

UN: United Nations

UNDP United Nations Development Programme

UNFCCC: United Framework Convention on Climate Change

WFP: World Food Programme

WHO: World Health Organization

CHAPTER 1: THE RESEARCH PROBLEM AND ITS SETTING

1.1 Introduction and Background to the problem.

Food and nutrition security is regarded as a global crisis. As it stands, more than 820 million people around the world are suffering from hunger and about two billion people worldwide are experiencing moderate or severe food insecurity (FAO, 2019). According to FAO et al. (2018) reveals that about 30% out of the 820 million are found in Africa, particularly in rural communities in Sub-Saharan Africa where 33.8% people are food insecure and suffering from hunger. Consequently, South Africa is food secure at the national level but at the household level, there is a high prevalence of food insecurity (Hendricks, 2014). Shisana et al. (2013) highlighted that hunger has a negative effect both socially and physically, in this manner if one is faced with hunger, they are essentially considered to be food insecure. Being food insecure is due to population growth, economic instability and poor use of resources, particularly in developing countries (Grote, 2014).

FAO (2017) reported that food insecurity is also worsened by climate change and climate variability globally. Various studies reveal that climate change is one of the underlying factors of food insecurity as it disturbs the food systems by affecting agricultural productivity, food productivity and natural resources (Grote, 2014; Gemeda and Sima, 2015; FAO et al., 2018). Harvey et al. (2014) argue that climate change does not only affect the food systems, but it also affects the rural livelihoods of people, particularly smallholder farmers thus as a result in a major shift in food that is produced. Africa is most vulnerable to climate change due to its high reliance on rain-fed agriculture and low adaptation (Gameda and Sima, 2015), with women having triple the burden which makes them more vulnerable to climate change. Majority of the main investors and stakeholders in agricultural development in the developing countries such as those found in Africa have agreed that poverty-stricken people will be the most vulnerable to the occurrence of climate variability (Cooper et al., 2008; Leichenko and Silva, 2014). In Africa, temperatures are predicted to increase by 2- 6^{o}C in the next 100 years with a projected increase in changes of rainfall, which will result in flooding and drought (Misra, 2014; Gemeda and Sima, 2015).

Sub-Saharan Africa is reported to be one of the most vulnerable regions to climate change and it is projected to have higher levels of food insecurity in the future (Gemeda and Sima, 2015).

Temperatures are projected to rise above the global average with fluctuating rainfall seasons affecting crop and livestock production (FAO, 2016; Rojas-Downing et al., 2017). In Sub-Saharan Africa (SSA) smallholder farmers are known to be the main agricultural producers and own about 80% of the farms. About 70% of smallholder farmers in SSA are female and they are known to be more vulnerable to the impacts of climate change, due to having limited access to information, farm inputs and extension services compared to their male counterparts (Harris and Consulting, 2014; Jost et al., 2016). Smallholder farmers of this region already lack access to resources such an infrastructure, finance, and technology. This puts their livelihoods at risk since they heavily rely on agriculture for household food security and income (Thornton et al., 2011; Harris and Consulting, 2014). Smallholder farmers of SSA therefore normally rely on indigenous knowledge systems to adapt to climate change (Jiri et al., 2016).

In South Africa, climate change is projected to increase food insecurity and poverty particularly for people living in rural areas (Turpie and Visser, 2013). Like other African countries, South Africa is also vulnerable to climate change as it relies on climate-sensitive economic sectors. Poor rural households normally consist of women, children and elderly people who rely on farming for a living (Pienaar and Traub 2015). Women are more vulnerable to the impacts of climate change since they are more involved in farming due to men migrating in seek of employment. Provinces such as Eastern Cape (30.2%), KwaZulu-Natal (22.3%) and Limpopo (21.8%) have been identified to have higher levels of poverty and more farmers (STATS SA, 2017). The increase in the rate of climate change and the negative effects it has on various agricultural systems leads to a greater and more urgent need for adaption (Mamba et al., 2015). Mudhara (2010) has revealed that smallholder farmers of South Africa find it difficult to cope with and adapt to climate change due to limited resources and institutional support.

During the 2015/16 droughts, KwaZulu-Natal was one of the provinces which was declared as disaster areas that had severely decreased staple foods such as maize and beans (SA Yearbook, 2016). Gbetibouo (2009), states that research has shown that, without adaptation, climate variability is largely harmful to the agricultural division however with adaptation vulnerability can be essentially lessened. The severity of the effects of climate change on the agricultural system depends on its adaptive capacity known as the ability of a system to adjust to climate variability, to moderate possible damage or to cope with the consequences (Gbetiouo, 2009; IPCC, 2014).

Therefore, adaptation requires farmers to be aware that the climate has changed to recognize suitable and sustainable adaptation measures (Gbetiouo, 2009).

According to Gaundure et al. (2013), all farmers irrespective of their age or gender are aware and agree that climate is changing and there is a link between the farmers' awareness (perception) and the collected data on long-term climate changes. Farmers with more farming experience are most likely to perceive climate variability (Juana et al., 2013), hence Gbetiouo (2009) study reports that farmers who have been farming for over 30 years will normally notice a change in temperature or rainfall and having accessibility to extension services increases their chance of noticing climate variability. Globally and nationally several comprehensive studies have been done to understand how farmers perceive and adapt to climate change. However, little information is available on the perceptions of smallholder farmers in South Africa and on climate change adaptation options. Thus, information from this study could inform policymakers to develop a more bottom-up approach in support of smallholder farmers. As they develop more effective strategies that are tailored to the needs of smallholder farmers. The aim of this study is therefore to capture the degree of awareness and perceptions of farmers about climate change and the types of adaptations they have implemented in their farming practices in response to these changes, based on the case study of vulnerable areas in KwaZulu-Natal particularly in the rural area of KwaDlangezwa in Mhlathuze Municipality of South Africa.

1.2 Objectives.

1.2.1 Main objective.

To investigate the perceptions and adaptation of smallholder farmers to climate change, as well as the determinants and barriers of adaptation to climate change, implication on household food security.

1.2.2 Sub-objectives.

1. To determine the farmer's perceptions and awareness on climate change.
2. To evaluate the adaptation options practised by smallholder rural farmers.
3. To identify the determinants and Barriers to adaptation in climate change.
4. To recognise the severity of climate change on farm income and household food security.

1.2.3 Research Questions.

1. What are the perceptions of the rural smallholder farmers on climate change?
2. How are rural farming households adapting to climate change?
3. What are the determinants and barriers to the adaptation of climate variability?
4. What are the impacts of rural farming households' vulnerability to climate change on farm income and household food security?

1.3 Problem Statement

Climate change has adversely challenged the wellbeing of most rural smallholder farmers precisely in developing countries situated in Southern Africa (Morton, 2007; Ubisi et al., 2017). It is predicted that this will have severe environmental, economic and social impacts on South Africa predominantly rural farmers who have livelihoods that rely on the use of natural resources (Gbetibouo, 2009). Climate change negatively impacts smallholder farmers the most as it affects their livelihoods and food security (Ubisi et al., 2017). Stats SA (2017) reports that more than 30.4 million South Africans have been living in poverty, particularly children aged 17 and under, black Africans, women, people living in rural areas such as KwaZulu-Natal, Eastern Cape and Limpopo provinces. As a result of climate variability, smallholder farmers have faced the challenge of small-scale agricultural production, crop loss, human disease epidemics, pest and disease, lacking water for agricultural-based food items at the household level and food insecurities (Ubisi et al., 2017). Furthermore, farmers must perceive climate change to be able to identify and implement the appropriate adaptations (Gbetibouo, 2009). However, there is scarce information on this thus this research seeks to investigate the perceptions of smallholder farmer's and adaption practices as well as the determinants and barriers of climate change.

1.4 Importance of the study

This study is vital, climate change is found to have major negative effects on food availability as it affects crops, thus affecting the farmer's agricultural decision making on what they should grow, where and when to grow it (Mamba et al., 2015). Since South Africa is food secure at the national level, it is also considered to be food insecure at the household level especially in the rural areas (Du Toit, 2011). It is therefore important to understand the link between food insecurity and

climate change amongst the rural communities of South Africa since this matter has not been broadly studied (Shisana, 2013). According to Lewis et al. (2018) seeing that agriculture is the main source of living for most people living in underprivileged rural communities, it is important to protect the lives and livelihoods of farmers to ensure food security. It is, therefore, essential to capture the degree of farmers awareness and perceptions of climate change also the type of adaptation and mitigation measures that they have adopted for their farming practices in response to these changes, for increased household food security. Furthermore, a better understanding of this information could inform policymakers to develop better policies and strategies that directly link to the smallholder farmers, resulting in better adaptation.

1.5 Limitations of the study

The study cannot be generalized as the sample size will only be from Kwadlangezwa in Mhlathuze local municipality it may not be a true picture of the entire province of KwaZulu-Natal thus it is limited to the rural areas of KwaDlangezwa in KwaZulu-Natal, South Africa.

1.6 Definition of terms

Adaptation: Are all the adjustments or adjustments or moderation in natural or human systems in response to actual or expected climate change as well as taking advantage of new/arising opportunities (McCarthy et al., 2001; Adger et al., 2003)

Climate change: A change in the state of the climate that can be identified (for example using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (UNFCCC, 2011). It refers to any change in climate over time, whether due to natural variability or as a result of human activity (UNFCCC, 2011).

Food insecurity: A condition that occurs when people have insufficient access to adequate amounts of safe and nutritious food for normal growth and development also for an active and healthy lifestyle (Napoli et al., 2011).

Food security: According to Food and Agricultural Organisation- FAO (1996) refers to the condition that exists when all people at all times have physical and economic access to sufficient,

safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life

Perceptions: A person's frame of reference emerging from previous experiences, beliefs, likes, dislikes opinions, feelings and other psychological factors of unknown origin (Barrios & Costeil, 2004; Ayal and Filho, 2017).

Smallholder farmers: Also known as small-scale farmers are farmers who own small plots (1ha to 2ha) of land; they normally have limited resources, they grow subsistence crops and a few other cash crops (DAFF, 2014).

1.7 Assumptions

1. The smallholder farmers of KwaDlangezwa perceive and are aware of climate change.
2. The smallholder farmers do have suitable adaptions measures for climate change.
3. The survey participants understood and answered all the questions truthfully.

1.8 Chapter Overview

Chapter 1 represents an introduction and background to the study, research question and objectives, the problem statement, importance of the study, study limits, assumptions and definitions of terms.

Chapter 2 is a review of literature on Smallholder farmers' perceptions, awareness and adaptation strategies, as well as barriers of adaptation and the severity of climate change on farm income and household food security.

Chapter 3 and Chapter 4 are research papers: Chapter 3 represents results on perception, awareness and adaptation options of climate change of Smallholder farmers in Kwadlangezwa, uMhlathuze Municipality. Chapter 4 represents results on barriers of adaption and the severity of climate change on farm income and household food security of Smallholder farmers of Kwadlangezwa, uMhlathuze Municipality in KwaZulu-Natal, South Africa.

Chapter 5 presents conclusions and recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Climate change can be defined as changes in the mean or variability of its properties according to Intergovernmental Panel on Climate Change (IPCC) (2014) lasts for a prolonged period, usually for decades or more. Climate change worsens the hazards associated with hunger and malnutrition due to extreme weather conditions such as droughts, floods as well as storms (WFP, 2019). This has a negative impact on food production and livelihoods since it destroys crops, vital infrastructure and important local assets worsening livelihoods and poverty (WFP, 2019).

The rate of increase in the global average sea level over the 21st century is expected to exceed the rate recorded between 1971-2010 (IPCC, 2014). According to IPCC (2018), global warming is expected to reach 1.5^{o}C between 2030 and 2052 if it continues to rise at the present level. The expected increase in global warming is associated with even higher temperatures mostly in land and sea areas, as well as an increase in rainfall and drought in other areas (IPCC, 2018).

Temperatures on the African continent are projected to increase by 2-6^{o}C over the next 100 years, with an expected increase in rainfall changes leading to more floods and droughts (Misra, 2014; Gemeda and Sima, 2015). Africa is most vulnerable to climate change, as it has many Less Developed Countries (LDCs), that rely heavily on agriculture and have a low adaptive capacity compared to developed countries. Increased temperatures and changes in precipitation will reduce crop production in most African countries with lower incomes and agricultural economies (Gemeda and Sima, 2015).

Sub-Saharan Africa is particularly susceptible to climate change due to various biophysical, political and socio-economic factors affecting the ability to adapt to climate change. Moreover, despite the decline in poverty in most sub-Saharan countries, there are still many people living under the global poverty line (Serdeczny et al., 2017). Thus, in this region climate change affects many poor rural communities that rely heavily on rain-fed agriculture for livelihoods and food security (Connolly-Boutin and Smit, 2016; Serdeczny et al., 2017). Agriculture is a crucial factor for the South African economy, as are most African countries. This also leaves South Africa particularly vulnerable to the effects of climate change. As the effects of water shortages and droughts are most harmful among small-scale farmers and subsistence farmers (Ubisi et al., 2017).

This chapter will review the literature on the concept of food security the pillars of food security and how they link with climate change. As well as the barriers of adaptation and vulnerability, including gender vulnerability to climate change. Lastly, the farmers' awareness and adaptation to climate change and the Policy implication for climate change and food security in South Africa.

2.2 The concept of Food security.

Food security refers to the condition that exists when all people at all times have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO 1996). Food insecurity occurs when people lack sustainable physical or economic access to adequate safe, nutritious, and socially acceptable food for a healthy and productive life. Food insecurity can be chronic, seasonal, or temporary (Barrett, 2010). Nutritional effects of insufficient food or undernutrition include protein-energy malnutrition, anaemia, vitamin A deficiency, iodine deficiency, and iron deficiency (Barrett, 2010). Food insecurity is also increased by various socio-economic and political factors, such as political instability (conflicts), climate change and environmental stressors (shocks), and the use of inadequate agricultural inputs in most African countries (Mamba et al., 2015). Food security is therefore made up of four important dimensions, also known as pillars of food security, namely *food availability, access, utilization and stability.*

2.2.1 Availability

The availability of sufficient quantities of food of appropriate quality addresses the supply side of food security supplied through domestic production or imports, including food aid (FAO, 2006). Napoli (2011) states that the word is usually associated with the availability of food at a regional or national level and may lead to confusion as availability is also used at the micro/household level. Although much progress has been made in reducing world hunger, climate change is likely to hinder progress towards a world without hunger (Wheeler and Braun, 2013; FAO, 2016). There is, therefore, a noticeable global pattern of climate change impacts on crop production that may have implications for food availability (Wheeler and Braun, 2013). Agriculture, forestry and fisheries are fully climate-sensitive, and overall effects are projected to be positive in moderate climate areas (by increasing crop production) and poor in tropical areas (by decreasing crop yields) (FAO, 2008). Wheeler and Braun (2013) suggest that climate change and instability would

exacerbate food insecurity in areas that are increasingly vulnerable to hunger and undernutrition. As a result, there are people in Africa who are vulnerable to food insecurity and malnutrition, with an estimated 23 million people in 11 African countries suffering from severe food insecurity and malnutrition and climate change impacts, which will exacerbate the hunger situation on the continent (Ubisi et al., 2017).

As agriculture is highly susceptible to climate change, high temperatures can, in the long run, reduce the production of desirable crops while increasing pests and weeds (Nelson et al., 2009). Changes in patterns of rainfall increase the possibility of future crop failures and failure in production (Nelson et al., 2009). As a result, changes in rainfall interrupt the agricultural calendar by making precipitation highly erratic (Mamba et al., 2015).

In a crop model study conducted by Rosenzweig and Parry (1994), the results of the study show that more atmospheric Co2 leads to increased crop production through increased leaf photosynthesis measures and improved water quality (Wheeler and Braun, 2013). Nevertheless, based on the broad spatial disparity in crop yields around the world, there has been more crop yields in Northern Europe but fewer yields in Africa and South America. As a result, crop yields are further negatively affected throughout the tropical regions compared to higher latitudes, and the results are further worse with an increased climate (Wheeler and Braun, 2013).

2.2.2 Access

The World Food Programme (WFP) describes food access as "the ability of households to acquire an adequate amount of food regularly through a combination of purchases, barter, borrowing, food assistance or gifts" (WFP, 2009: 170).

Access, therefore, includes three elements which are *physical, economic and socio-cultural* (Napoli, 2011). For example, the physical dimension could be defined as when food is made available in one part of the country, but due to a lack of transport infrastructure, food cannot be transported to people who are vulnerable to hunger living in other parts of the country (Napoli, 2011). The economic aspect is that people have the buying power to buy adequate food. The third dimension of socio-cultural interaction is, for example, that food could be physically and economically available but there is still a lack of food to be part of a certain social group or class (Napoli, 2011).

Access to food is indirectly related to climate change (Wheeler and Braun, 2013) because climate change could affect food costs and therefore impact on the quantity and quality of food people buy and consume (Lake et al., 2010). According to Kubik and May (2018), food prices have a major negative impact on household food security, particularly in poor households. Due to low wages, these households are vulnerable to climate change and price shocks, contributing to a less diverse food basket that sacrifices food that is more nutritious to consuming food that offers fewer essential micronutrients (Kubik and May 2018).

In addition, the most vulnerable are those who rely on agriculture and natural resources for their livelihoods, with around 70% of poverty-stricken people living in rural areas (FAO, 2016). This results in more hidden hunger in families with children being more vulnerable (Kubik and May 2018). There are currently people in Africa who are vulnerable to food insecurity and malnutrition, with an estimated 23 million people in 11 African countries suffering severe food insecurity and malnutrition (Ubisi et al., 2017).

2.2.3 Utilization

The third pillar ‘utilization’ is commonly known or understood as the way the body makes the most of the various nutrients in the food. Sufficient energy and nutrient intake by individuals is the result of good care and dietary practices, food preparation, dietary and food distribution within the household (FAO, 2008). Food eaten by people must provide adequate energy to allow the consumer to carry out their daily physical activities (Napoli, 2011). It is also vital to use aspects such as safe drinking water and adequate sanitation to prevent the spread of disease, as well as awareness of food preparation and storage procedures (Napoli, 2011). As a result, utilization covers a variety of aspects that focus on the consumer's understanding of what types of food to choose and how to prepare and store.

To achieve nutritional security, it rests on the availability of water as well as sanitation, which can be affected by the effects of climate change (Wheeler and Braun, 2013). Food utilization can, therefore, be weakened by a decrease in drinking water resulting in negative health effects (Delpla, 2009). Furthermore, climate change is projected to reduce the quality of drinking water, making more people in poor communities vulnerable to diarrheal infections (WHO, 2014; FAO, 2018). According to FAO (2016), poor households are most likely to reduce the amount of food they eat,

particularly food that is vital to the nutrition of rural indigenous people due to climate shocks such as drought, floods and hurricanes, which damages yields (fruits, vegetables and wild foods), livestock and fish (FAO, 2016). Although most research studies focus on cereals, it is essential to study the dietary consequences of climate change impacts on other foods (vegetables and wild foods) that are at risk and vital to achieving stable nutritional intake (FAO, 2016).

2.2.4 Stability

A population, household or individual need to have access to adequate food at all times to be food secure (FAO, 2006). Adverse weather, political instability, or economic factors (unemployment, rising food prices) may affect the status of food security (FAO, 2008). Therefore, the concept of stability can refer to food security's availability and access dimensions. Napoli (2011) states that, according to the World Food Summit, there must always be stability in terms of availability, access and utilization for food security. The stability of food systems as a whole could be threatened by climate change, as climate can be a vital contributor to future price changes as well as temporary price changes (Wheeler and Braun 2013).

2.3 Climate change and food security.

2.3.1 Global

FAO (2015) describes Food insecurity as a condition that occurs when individuals lack secure access to adequate amounts of safe and nutritious food for normal growth, development and active and healthy life. Progress remains in the combat against hunger yet many people lack sufficient food for active and healthy life (FAO, 2015). Zero hunger is the second sustainable development goal (SDG) to be reached by 2030, and climate change may interrupt improvement towards a world of zero hunger as it puts pressure on vital resources that most people rely on, resulting, in rural to urban migration for better livelihoods (FAO, 2018). Estimates show that 795 million people worldwide – just over one in nine – were malnourished; between 2014–2016 the number of malnourished people decreased from 18.6% in 1990–1992 to 10.9% in 2014–2016 (FAO, 2015). According to FAO (2018), most people suffering from hunger are currently living in developing countries with about 12.9% undernourished and one in four children vulnerable to stunted development. Southern Asia and Sub-Saharan Africa, for example, are still vulnerable to hidden hunger due to lack of micronutrients intake (FAO, 2015).

Globally, agriculture employs most of the people who come from socio-economic deprived households while providing a living for them, since it is usually their biggest source of income (FAO, 2018). Climate change is projected to have a high impact on yield patterns for food, feed and animal welfare while changing the system and stability of trade in food and food products (Wheeler and Braun, 2013). According to FAO et al. (2018), famine is extremely severe in countries that rely on rain-fed agriculture due to their vulnerability to climate change, extreme drought and where much of the population is dependent on agriculture for their livelihoods. Reports on severe droughts were connected to weather events such as Elnino that affected many countries in 2015 and 2016, leading to a global increase in malnutrition and hunger (FAO et al., 2018).

2.3.1 Regional

Rain-fed agriculture continues to be the main source of essential foods produced for most underprivileged rural people living in Sub-Saharan Africa (Cooper, 2008). Since most of the food eaten in Sub-Saharan Africa mainly include cereal or root staple crops (Fanzo, 2012). Regional climates differ greatly depending on location; climate models suggest that Southern Africa and the Mediterranean will experience more dry weather in the near future (FAO, 2016). Research shows that as the climate gets warmer, crop production will be negatively affected by declining staple crops such as wheat, rice and maize (Porter et al., 2014). The most vulnerable to climate change are underprivileged people (Cooper et al., 2008; FAO 2018). Specifically, individuals who are located in Sub-Saharan Africa because they are heavily dependent on rainfed agriculture for food for their livelihoods (Cooper et al., 2008). The IPCC panel's report estimates that about 50% of rainfed agriculture will the decline in various African countries (Turral et al., 2011).

Sub-Saharan Africa is home to some of the world's most nutritionally insecure individuals (Fanzo, 2012). Poor infrastructure and inadequate resources aggravated by conflict, HIV and poor access to health services are the reasons for the regions overwhelming levels of malnutrition and food insecurity (Fanzo, 2012). Eastern Africa is affected by harsh climatic and dry weather conditions that disturb food security and nutrition improvements (FAO, 2015). For example, climate change in Kenya has negatively affected agricultural production, mainly due to severe droughts every 10 years and smaller droughts every 3 to 4 years (Kalungu and Harris, 2013). The study also shows

that yields have decreased over the last 30 years, due to low rainfall associated with extremely high temperatures (Kalungu and Harris, 2013).

Climate change should be included in the common agricultural and risk mitigation agendas, to ensure that the current agricultural and rural development agendas are strengthened (Mann et al., 2009). This is important for alleviating poverty and food security (Mann et al., 2009). According to Muchapondwa and Komba (2018), it is also essential for all sub-Saharan African countries to recognize the degree of climate change and the causes of adaptation, especially among smallholder farmers. The availability of various adaptation approaches may also vary to establish effective policy responses as the insecurity and responsiveness of each nation varies (Muchapondwa and Komba, 2018).

2.3.2 South Africa (local)

South Africa's agriculture faces negative impacts of climate change, affecting most people's livelihoods, especially those vulnerable to food insecurity (SA Yearbook, 2016). In South Africa, it is estimated that about 40% of the poor people live in rural areas and rely indirectly or directly on the land for a living (Turpie and Visser 2014). According to Turpie and Visser (2014), South Africa is most susceptible to climate change since it relies on climate-sensitive economic sectors, high levels of poverty and the interconnected effects of HIV/AIDS (Turpie and Visser, 2014). Climate change is generally known to have serious consequences for food security (DEA, 2016). Climate change is one among a set of interconnected trends and risks facing agriculture and food systems. Although South Africa is known to be food secure at the national level, it is food insecure at the household level (Kubik and May 2018). Furthermore, climate change will have a direct negative impact on the areas that underprivileged people live, such as biodiversity, water supplies and predominantly agriculture, since the country is semi-arid (Turpie and Visser, 2014).

Research shows that climate change in South Africa will lead to higher temperatures, irregular rainfall patterns and frequent droughts (Turpie and Visser, 2014). According to DEA (2016), between 2015 and 2016, the country experienced severe drought ever recorded. From 1904 onwards, rainfall in each province of the country was estimated to be 608 mm per year, but in 2015 the amount of rainfall received decreased to 403 mm by about 66% of the annual average (DEA. 2016). Thus, data from 2016 show that rural underprivileged people have suffered the most from

high food prices due to drought (DEA, 2016). Dube et al. (2013) state that South Africa has adopted several strategies/programs, such as the Integrated Food Security and Nutrition Program, the Household Food Production Program and the Farmers Support Program to enhance food security. However, global climate change is challenging such strategies that are designed to reduce poverty and improve rural development (Turprie and Visser, 2014).

As climate change is predicted to result in more severe weather shocks, policymakers need to incorporate all aspects of food security into their climate action plans (Kubik and May 2018). Particularly, the pillar of utilization since it is mostly not included in the national food security strategies (Kubik and May 2018).

2.4 Barriers to climate change adaptation.

Eisenack et al. (2014) define adaptation barriers as challenges, obstacles, constraints or barriers that hinder adaptation. The IPCC defines it as issues that make it more difficult to plan and implement adaptation measures or restrict options (Eisenack et al., 2014). It is the smallholder farmers who are most vulnerable to climate variability in sub-Saharan Africa, for them to adapt they need to be aware of the changing climate to ensure that they adopt suitable adaptation measures (Komba and Muchapondwa, 2015). Since agriculture is a key source of income for the majority of people living in rural areas, adaptation is vital to improve the resilience of agriculture while protecting the livelihoods of underprivileged people and ensuring food security (Bryan et al., 2013). The most common farming adaptation measures used in Africa have enhanced crop varieties, these included the planting of trees, soil preservation, altering planting dates and irrigation (Komba and Muchapondwa, 2015).

In a study by Komba and Muchapondwa (2015), it is important to note that not every farmer will be able to adapt because of insufficient funding, lack of water, poor planning and lack of seeds. In another study in Kenya, farmers are willing to make vital changes (such as irrigation) to their agricultural practices but are not able to do so due to difficulties such as lack of finance, lack of land and water resources, and lack of information (Bryan et al., 2013). The lack of awareness and information on climate change and adaptation strategies in Jema'a Nigeria has also hindered adaptation (Komba and Muchapondwa, 2015). Research by Bryan et al. (2013) states that,

regardless of other lower-cost adaptation measures, almost 32% of farmers would like to change their crop variety, but access to these enhanced varieties could be a challenge for them.

Most of the regions in sub-Saharan Africa are severely constrained by the lack of social, political and technical resources that currently affect their capability to survive issues such as poverty, which further hinders their ability to survive and adapt to changing environmental conditions (FAO, 2018). To meet the needs of the most vulnerable groups, cross-institutional partnerships, accountability sharing, and information flow need to be at the center of an inclusive climate resilience strategy within and across sectors (FAO, 2018).

2.5 Vulnerability to climate change.

2.5.1 Farm income.

Vulnerability is defined as the probability that a household will fall below a certain income threshold at some future point in time (Shewmake, 2008). Climate shocks such as drought and floods in Sub-Saharan Africa are expected to increase due to climate variability (Deressa et al., 2011; Shewmake, 2008). According to Shewmake (2008), farm households are most vulnerable to climate-related -income shocks, resulting not only in lower expected incomes. However, to greater income change which leads to taking upon pricey risk coping strategies as well as being under the poverty trap threshold (Shewmake, 2008). Such shocks may, for example, affect physical capital when assets are damaged or when farmers have no choice but to trade livestock (productive capital) such as cattle to absorb income shocks (FAO, 2016). In South Africa with the expected increase in temperature and lower rainfall leading to local water endowments plus soil moisture, harvesting land will be negatively affected (Calzadila, 2014). With many underprivileged people relying on agriculture precisely food- insecure rural individuals the potential impact on farm incomes with the economy will have many consequences in low-income countries that rely on agriculture (FAO, 2016). The consequences of climate change on production will generally lead to economic and social impacts, affecting all four pillars of food security, which reduces income at both household and national levels (FAO, 2016). Therefore, it is important to understand the impact of climate change on farm income as most smallholder farmers earn their monthly income from selling crops, which is vital for their livelihoods (Ubisi et al., 2017).

2.5.2 Household Food security.

Globally, it is estimated that the number of people susceptible to starvation will rise to 321 million in 2050 and 391 million in 2080 without climate change alleviation, with South Asia and Africa most vulnerable to more hunger due to climate change (FAO, 2016). The number of undernourished children will also increase as a result of climate variability by 1 million in 2030 and 0.6 million in 2050 (Ringler et al., 2015).

Sub-Saharan Africa (SSA) maintains the highest percentage of undernourished people globally, with one in three chronically suffering from hunger and an economy that enormously relies on agriculture (FAO, 2016). Majority of the people who are poor and hungry globally are from rural areas who earn an inadequate livelihood from farming (FAO, 2016). The increase in cereal production for a variety of yields in SSA was projected to decrease by a net of 3.2% in 2050 due to climate change (Ringler et al., 2010). According to FAO (2016), there are currently hostile effects in tropical areas that are disturbing the livelihoods and food security of vulnerable families and societies. As a result, the greatest harvesting effects are estimated for wheat, since not much of it is grown in SSA as well as sweet potatoes (Ringler et al., 2010). Global food prices are the main sign of the impacts of climate change on agriculture in terms of food affordability and food security (Ringler et al., 2010). Furthermore, food security is diminished when food systems are stressed, which are affected by a range of factors which include climate change and vulnerability.

When responding to higher food prices, families change the way they eat by saving, for example, in South Africa households reduce their caloric intake by reducing the amount and types of food they eat switching to more cheap food (Ubisi et al., 2017; Kubik and May 2018). Many South Africans suffer from household food insecurity, with one in a quarter of children suffering from extreme undernutrition, the largest of whom is hidden hunger due to inadequate food consumption for their nutritional needs (Kubik and May 2018). There is an increase in food prices for each one of the essential produces due to climate change, as there is an increase in pressure on the tightening price perspective (Ringler et al., 2010). For example, according to Ringler et al. (2015), the cost of maize, rice and wheat was estimated to be 4.7% and 15 % higher, which will reduce food demand.

2.5.3 Gender vulnerability to impacts of climate change on agriculture.

Agriculture is the backbone of many developing countries, and women play a major role in the agricultural labour force, and agricultural activities, making their contribution to agricultural output extremely important (Raney et al., 2011). Rural women also play various roles in the agricultural system, such as wage labour, agricultural processes, and the market as agricultural producers (Tegegne, 2012). However, they are also particularly vulnerable to climate variability as they have to work on their gender determined household duties, such as collecting water and wood, while working for longer hours on farming due to males migrating for employment opportunities (FAO, 2016 and Jost et al., 2016). As a result of the lack of access to resources and decision-making, restricted mobility puts women in rural areas at a place where they are most affected by climate variability (Watch, 2009).

As droughts and water shortages increase, this disrupts farm productivity and household well-being (FAO, 2016). Women are known to be more susceptible to climate variability compared to men because women make up most of the underprivileged population in the world, also since they are more dependent on natural resources (which are vulnerable to climate change) to make a living (Watch, 2009). They are also vulnerable to social economic and political barriers that hinder their ability to cope, such as the lack of economic growth, improvements in agriculture and food insecurity (Watch, 2009; FAO et al., 2012).

The irregularities in ownership of and control of livelihood assets (such as land, water, energy, credit, knowledge, and labour) negatively affect women's food production (IFAD, 2009) and Connolly-Boutin, 2016). Limited access to land leads women to make minimal decisions on crop choices and to obtain lower yields compared to when they would have more access to productive resources (IFAD, 2009). These gender-based inequalities can hinder women's access to the assets needed for adaptation (FAO & UNDP, 2017), for example, the advancement of the capacity of African countries to meet their demand and the role of women in agriculture must be seen (Tegegne, 2012). In addition, the migration of young men also exacerbates the problems faced by women working in agriculture and, when linked to climate variability, results in less sustainable agricultural practices due to labour restrictions (FAO, 2015).

Mostly, women are less likely to own their land and can usually get it through, a relative of men. Studies show that women who had land in only 10 % of Ghanaian households while men held land

in 16–23 % of Ghana; women account for 5 % of registered landholders in Kenya. Normally, men's land holdings were almost three times more than women's land holdings (Tegegne, 2012). This lack of access to land tenure and other productive resources for women results in lower investment and is vulnerable to environmental degradation, which reduces future production potential and increases food insecurity (Tegegne, 2012 and Jost et al., 2016). Yet, given a better role in agriculture, this could empower women if they are involved in decision-making and they are able to control and manage natural resources at household and community levels (FAO, 2015). It is also predicted that crop production would increase by 20 to 30% if rural female farmers had equal access to agricultural resources as male rural farmers (Jost et al., 2016).

2.6 Farmers Awareness and Adaptation to climate change

Awareness and adaptation to climate change become critical components in improving farmers' understanding. It is thus vital for smallholder farmers to be aware and perceive climate change in order to adopt the appropriate adaptation measures.

2.6.1 Farmers perceptions and awareness of climate change.

Agriculture is extremely vulnerable to climate change, which hinders the development of agriculture in Africa and around the world. In addition, food security and livelihoods of people living in Africa who depend on agriculture are affected by poverty and lack of proper infrastructure and technological development (Issa et al., 2015; Ayanlade et al., 2017; Elum et al., 2017). According to Li (2015), farmers need to be aware of and respond to climate change to ensure sustainable agriculture. Ayanlade (2017) points out that regardless of the improvement that has been made in understanding and addressing the issue of climate change in agriculture at a global level; awareness of the issue at a regional level remains critical, especially among rural underprivileged farmers in Africa.

Research notes that farmers in various parts of the world can cope with climate change because of their perceptions of climate change (Li et al., 2013; Ayalande et al., 2017). Farmers also recognize the changes that are centered on their observation of the occurrence and the number of highs and lows of climate data. Thus, the ability of farmers to cope with and adapt to the methods they use depends on the importance of their awareness (Ayal and Filho, 2017). This has resulted in understanding the smallholder farmers awareness and perception of climate, which is also vital for

informing policymakers on the responses of adaptation at the local level (Gandure et al., 2013).

2.6.2 Adaptation to climate change

According to Carmin (2015) and Fankhasuer (2017), adaptation to climate change in human systems can be referred to as the pattern of change in response to current or projected climate effects, to reduce negative effects or to increase the favourable outcome of climate change. UNFCCC (2007) points out that in the years to come it has been anticipated that many people, mainly from less developed countries, are vulnerable to water shortages, and that they are also susceptible to health problems due to climate change. There is, therefore, a serious need for global action to encourage less developed countries to adapt to current climate effects that may worsen in the near future (UNFCCC, 2007).

With regards to the social aspects of vulnerability to climate change, some people are vulnerable to poverty compared to others and lack access to basic amenities to handle pressures (Carmin, 2015). Adger (2013) argued that climate change impact models are often unsuccessful in clarifying the diverse cultural groups of individuals who are vulnerable to similar changes but respond differently. Thus, cultural perspectives help to clarify the different ways in which people respond to similar environmental changes (Adger, 2013). Furthermore, the IPCC (2014) states that the susceptibility to climate change, greenhouse gasses and the ability to adapt is strongly affected by people's way of life, the standard of living, behaviour and culture. Various adaptation measures can help to address climate change, although one option is not sufficient on its own, an integrated approach from all levels of society is needed (IPCC, 2014).

2.6.2.1 Indigenous Knowledge and climate change

Indigenous knowledge is that which has been acquired over decades of life in a given ecosystem and has been critical in addressing environmental problems such as floods, droughts, disease, and insect infestations, as well as their associated consequences (UNEP 2008). The transmission of this understanding and related rituals has been ingrained in the society through a variety of rites of passage, including birth, adult initiation, marriage, death, and social gatherings. Thus, such understanding was embedded in their belief structures and formed their spiritual beliefs.

The indigenous communities' phenological knowledge is extremely valuable (Lantz et al. 2003; Lefale & Stormy 2009; Green & Raygorodetsky 2010). Numerous traditional cultures have

amassed extensive knowledge about environmental change over time and evolved elaborate mechanisms for recognizing and coping with these changes. However, implementations of traditional knowledge systems to climate change mitigation and adaptation have long been overlooked in the development and implementation of climate change policies and have only recently become a part of the climate change debate.

Traditional and indigenous cultures will impart invaluable knowledge about effective and ineffective adaptations to change, knowledge that may be critical in the sense of global climate change (Macchi 2008). For example, in the Sahel, indigenous information networks have allowed local communities to establish and adopt comprehensive mitigation and adaptation strategies that have reduced their vulnerability to past climate fluctuations and change.

2.6.3 Farmers (smallholder) adaptation to climate change

Climate change in sub-Saharan Africa (SSA) is expected to increase extreme weather scenarios such as droughts that are likely to affect crop production and stability (Cairns et al., 2013). Most smallholder farming households in SSA rely heavily on agriculture for their livelihoods, however, with inadequate resources to manage climate variability, they are more vulnerable (de Jalon, 2018). Successful adaptation requires not only awareness but also other aspects such as the level of education, gender, age, household capital, climate information, social capital and agro-ecological location (Li, 2015). Many farmers in SSA countries are susceptible to both climate and non-climate related threats, such as market shocks, pests, and outbreaks of disease, making it difficult to reduce poverty and ensure food security (Shikuku et al., 2017). Adaptation is therefore essential

not only for the prevention of climate threats but also for the achievement of food security (Shikuku et al., 2017).

African smallholder farmers employ a variety of similar adaptation methods, such as crop diversification, change in harvesting and planting dates, increased use of irrigation and soil conservation practices (Hassan and Nhemachea, 2008; Falaki, 2011). Interchanging from farming to non-farming activities, such as the Falaki study (2011), found that about 95.7 % of farmers used prayer and other spiritual exercises, 84.8 % changed their house construction (with improved ventilation and reduced amount of heat-conducting material), 76.1 % engaged in insect management (mosquito) and non-farm subsistence (petty) activities. In a study conducted in South Africa by Calzadilla et al. (2014) using the CSIRO-B1 scenario predictions for the evaluation of irrigated areas and enhanced crops. The study discussed that the increased use of irrigation systems will not be an effective adaptation method as a result of the predicted immense effects of climate change. However, with enhanced crops, the findings show that it is a more effective adaptation method which will require improved agronomic practices and extension services specifically for the development of smallholder farmers in the county.

According to FAO (2018), adaptation must be a key component of sustainable development in terms of climate change impacts, ensuring that it is included in all development planning, decision-making and implementation. Thus, to ensure the efficiency of climate change adaptation methods for smallholder farmers, they should be inexpensive, providing smallholder farmers with essential resources and providing climate forecasting services so that they can be aware of the changes (Falaki, 2011; Pettengell, 2015). The government also needs to ensure that smallholder farmer, particularly women who are most vulnerable to climate change, are considered when providing effective adaptation (Pettengel, 2015).

2.7 Summary

Agriculture plays a vital role in rural smallholder holder farmers who depend on farming for food security and income. However, agriculture is highly affected by climate change and smallholder farmers are unable to sufficiently adapt due to having limited resources, this threatens their livelihoods and household food security. With rainfed agriculture being the main source of essential foods for most rural communities' smallholder farmers are susceptible to both climate

and non-climate related threats. Such as drought, floods, market shocks, pests, and outbreaks of diseases. Adaption is essential to the lower risks associated with the impacts of climate change. There is, therefore, a need for government institutions to provide more sufficient and less expensive adaption methods which can be adopted by smallholder farmers. Gender-based inequalities and the lack of knowledge and extension services also hinders the development of smallholder farmers. So, there is a need for extension services and training to educate smallholder farmers about climate change.

Chapter 3: Smallholder farmers' awareness, perceptions, adaptation options of climate change and the determinants of adaptation: A case study of Mhlathuze Municipality, in South Africa.

3.1 Abstract

Climate change on a global scale has become an incredibly serious problem. Smallholder farmers in developing countries are the most vulnerable to climate and rainfall changes. South African farmers are also confronted with climate change-related problems, such as yield reduction and revenue loss, which have a direct impact on their livelihoods and household food security. Climate change awareness and perceptions among farmers are investigated in this study. Additionally, it is essential to recognise existing adaptation methods and the determinants of farmer adaptation to climate change. This study was performed in the uMhlathuze municipality of KwaZulu-uThungulu Natal's district, which is home to a large number of poor smallholder farmers. The research sampled 101 farmers using a purposive sampling technique and interviewed them through questionnaires and focus group discussions. Additionally, logit regression was used to examine the factors influencing smallholder farmers' selection of climate change adaptation strategies. Farmers are mindful of climate change in 45.5% of cases, and 98.0% experience a rise in temperature, while 46.5% perceive an increase in rainfall. Crop diversity and diversification, shifting planting times, and mixed cropping are the primary adaptation techniques. The logit regression study revealed that gender (P=0.028), age (P=0.038), years of farming (P=0.08), and land size (P=0.003) are all significant factors in climate adaptation. As a result of the study's conclusions, policymakers should consider using these considerations in prospective programmes. Additionally, to conduct climate change mitigation and education programmes and to provide extension facilities for resilience-building.

3.2 Introduction and Background of the study

Globally climate change is a crucial issue. Climate change effects are unparalleled in scales ranging from fluctuating weather patterns to rising sea levels, potentially raising the likelihood of significant flooding and impacting food production and food systems (United Nations, 2019). Changing rainfall patterns and increasing occurrence of extreme weather events such as floods and droughts due to climate change are affecting agricultural production (FAO, 2016). This directly

affects the world's ability to achieve the first two sustainable development goals (SDG's), which are to end world hunger and eradicate poverty (FAO, 2016; FAO, 2019). Globally smallholder farmers are most vulnerable to climate change increasing the risks of the challenges they already facing (Harvey et al., 2014; Lewis et al., 2018). Challenges such as owning small land sizes, limited credit, not being able to manage natural resources (land and water), having limited access to markets and technology (Lewis et al., 2018).

In African countries, the majority of the smallholder farmers are engaged in crop farming since they rely on agriculture for food and income (FAO, 2016). Climate models predict that this region will be drier in most land areas with small increases of rainfall in tropical areas (FAO, 2016; Ayanlade et al., 2017). Thus, agricultural production will be most affected by the continent's high reliance on rain-fed agriculture (Amare and Simane, 2017). This makes the African region more vulnerable to climate change due to the lack of infrastructure, poverty and poor governance (FAO, 2009).

The key agricultural producers in Sub-Saharan Africa (SSA) are smallholder farmers, who own about 80% of the farms, employing about 175 million people, of whom approximately 70% are female (Harris and Consulting, 2014). Agriculture is also one of the most crucial sectors and particularly susceptible to climate change (Harris and Consulting, 2014; Pereira, 2017). Since the agricultural system is heavily depended on rainfall and is underdeveloped (Cooper, 2008; Harris and Consulting, 2014; Pereira, 2017). According to Serdeczny (2017) in SSA temperatures are projected to rise above the global average with fluctuating rainfalls and seasons. Temperatures are also expected to rise above the tolerance rate for crops and livestock that threatens food production (Thorton et al., 2011 and Serdeczny, 2017). This increases food prices, rural poverty and the vulnerability of smallholder farmers (Thorton et al., 2011). With most of the smallholder farmers of this region already lacking access to resources such as infrastructure, finances, information and technology. As a result, their livelihoods are threatened as they depend heavily on agriculture for sustainable living (Thornton et al., 2011; Harris and Consulting, 2014; Pereria, 2017).

Agriculture is one of the main sectors that play a vital role in the socio-economic development and growth of South Africa. However, the potential development of this sector is influenced by key issues, including climate change, population growth and skills shortages (SA Yearbook, 2016). According to Stats SA (2017), about 15.6% of households participate in farming and the majority

of the households' farmed for food production. It is estimated that about 40% of the poor in South Africa live in rural areas and rely indirectly or directly on the land for a living (Turpie and Visser 2014). Like other African countries, climate change is a major concern in South Africa, with average annual temperatures rising to about 1.5 times the predicted global average of about 0.65^{o}C over the past five decades and rising high rainfall (Ziervogel et al., 2014).

Therefore, South Africa is highly susceptible to climate change because it relies on climate-sensitive economic sectors; there are high levels of poverty and the interconnected HIV/AIDS effects (Turpie and Visser, 2013). While South Africa is known to be food secure at the national level, it is considered to be food insecure at the household level (Kubik and May 2018). Consequently, climate change is also widely considered to have significant implications for food security in South Africa (DAFF, 2016). Given that climate change is expected to result in more extreme weather shocks, policymakers need to integrate each food security factor into their climate action plans (Kubik and May 2018).

Gbetibouo (2009), argues research has shown that, without adaptation, climate variability is largely harmful to agriculture, but with adaptation, the vulnerability can be significantly reduced. Adaptation requires farmers to see or to be aware of the fact that the climate has changed to recognize and implement appropriate adaptation measures (Gbetiouo, 2009; Arbuckle et al., 2015; Elum et al., 2017; Tripathi and Mishra, 2017). Knowing the opinions, attitudes and beliefs of farmers on climate issues is key to adaptation behaviours (Akhtar et al., 2018). However, there are scarce information exits on this particular issue. This study, therefore, seeks to investigate the attitudes, knowledge and adaptation of climate change among smallholder farmers. Finally, to identify the key determinants of adaptation to climate change for smallholder farmers. As this information will be helpful for policymakers, government agencies as well as agricultural extension officers to inform and achieve suitable strategies for smallholder farmers.

3.3 Materials and Methods

3.3.1 Study site

The study was conducted in uMhlathuze the local municipality of uThungulu district, KwaZulu-Natal province, South Africa. uMhlathuze municipality consists of several villages and the study was primarily conducted in KwaDlangezwa, where the majority of the smallholder farmers are located. The area is characterised by shallow soil and is located on the north-eastern coast of

KwaZulu-Natal (KZN). The municipality is one of six local municipalities within the uThungulu district, covering an area of approximately 79 334 ha to 123 325 ha. Many rural residents also practice subsistence farming. With an increase in the number of households from 86 609 in 2011 to 110503 and population from 334 459 to 410 465 according to the Community Survey of 2016 (IDP, 2018/2019). Hence the increase in the population size of 22% between 2011 and 2016 is due to the addition of 3 wards from the former Ntambanana post the 2016 Local Government Elections (IDP, 2018/2019). About 58% of the people live in tribal areas, 39% in urban areas and 3% in farmland (IDP, 2018/2019). Most of the farmers are involved in crop farming and the common crops produced in the area are sugarcane, maize, and vegetables. The municipality has been plagued by droughts and floods in different areas with average annual rainfall ranging from about 800 mm in the upper and middle regions to about 1400 mm near the coast.

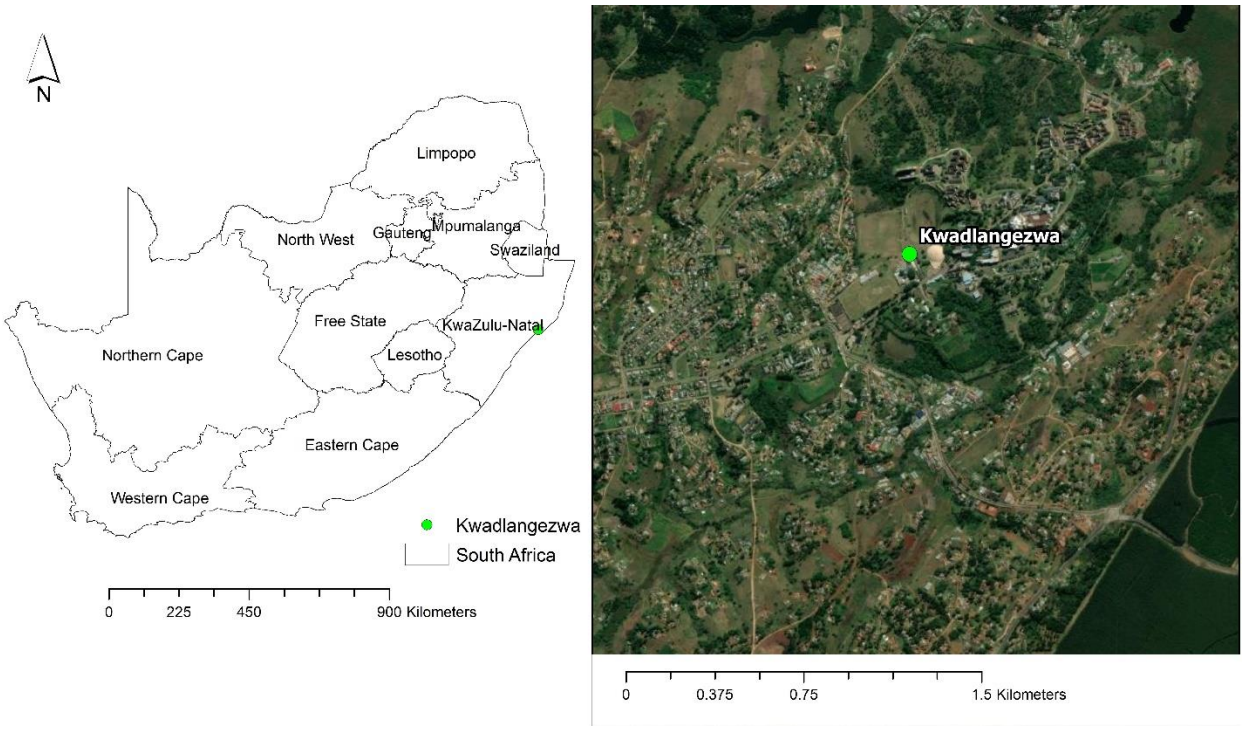

Figure 1: Map indicating study area.

3.3.2 Research design and Methodology

The convergent parallel mixed research design was used for this study. This type of research design allows for quantitative and qualitative data to be collected in parallel, analyzed separately and the results are to be combined (Creswell, 2013).

This study was conducted using the mixed research method, that combines both quantitative

(involve collection and analysis numerical data) and qualitative research (involve narrative or experiential data). For this research, a mixed-method approach was chosen to draw useful information on the perceptions of smallholder farmers and their knowledge of climate change as well as their adaptation strategies and determinants of adaptation. Qualitative data was collected through focus group discussions with smallholder farmers to further interrogate the information on the farmers' perceptions, awareness and adaption options. Quantitative data were collected through a structured questionnaire from individual farmers; all questionnaires had the same questions to compare the responses of the participants. The structured questionnaire was used to gather information on community demographics, crop and animal production, source of water for crop irrigation, the weather changes observed over the pasted 15years, farmers' perceptions, awareness and data on adaptation options practised by smallholder farmers.

3.3.3 Sampling technique and sample size

In this study, 101 participants were purposively selected to participate. Farmers were found with the help of a key informant, who had first-hand knowledge of where farmers could be found and affected by climate change, and who were active in both crop and livestock farming. The focus groups consisted of 6 to 12 individuals who were selected using a random sample selection that was selected after the structured questionnaires were carried out. In total, three focus groups (one in each of the three villages) were performed. Every group had a professional facilitator to chair the discussion and clarify some questions; the discussions took about an hour to an hour and a half, and videos and photos were taken for all sessions.

3.4 Data analysis

The Statistical Package for Social Sciences (IBM SPSS), version 25, was used in this analysis to generate descriptive statistics. Data from the survey were subject to descriptive analysis, coding questions while the information from focus group discussion was synthesized through content, theme and frequencies analyses.

3.4.1 Logit regression model

For this study, the logit regression model was used to identify determinants of adaptation to climate change. Previous findings have shown that the logit model is the most appropriate econometric models/ analysis tool to be used as it considers the relationship between a binary dependent

variable and set of independent variables whether binary or continuous (Nabikolo et al., 2012). The equation can be written as:

$$\text{Li} = \frac{Pi}{1 - Pi} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_{12} X_{12} + \varepsilon_i \qquad (1)$$

where βs are the vectors of binary regression coefficients, $\varepsilon_i \cong (N\ 0, \sigma^2)$ is the error term, which is homoscedastic and normally distributed such as zero mean and constant variance, and X's are the variables as defined in Table 1.

3.4.1.1 Variables used in the logit model

Table 3.1 describes the independent variables used in the logit model. These include age, gender, education level, land size, family size, farming experience, extension services, awareness, mass media exposure, perceived temperature and perceived rainfall.

Table 3.1: Variables used in the model

Variables	Description	Expected sign
Age	Age of head of household	+
Gender	Gender of the head of household	+/-
Education	Level of education of the head of household	+
Land size	Total hectare of the farmers land	+/-
Family size	Total number of individuals in the households	+
Farming experience	How long have you been farming?	+
Extension services	Do extension officers provide climate change support?	+
Awareness	Have you ever heard about climate change?	+
Mass media exposure	How were you made aware of climate change?	+
Perceived temperature	Perceived change in temperature?	+
Perceived rainfall	Perceived change in rainfall?	+

3.5 Ethical consideration

The permission to conduct the study in Kwadlangezwa was granted by Chief Mkhwanazi with the help of IziNduna from all rural villages of the Kwadlangezwa area.

Each farmer had to sign a consent form agreeing to participate in the study and to take pictures when appropriate.

Ethical clearance was also granted by the University of KwaZulu-Natal (UKZN), Humanities and Social Sciences Research Ethics Committee, **Protocol reference number: HSS/0355/019M**. The findings and recommendations of the study will be reported back to the communities once the study has been

completed.

3.6 Results and discussions

3.6.1 Demographic characteristics

The results of the study (see Table 3.2) show that the majority of farmers were female (79.2%), the findings are consistent with the study by Thamaga-Chitja and Morejele (2014) which confirms this trend of more female farmers participating in smallholder farming compared to male farmers. This may be because, in rural areas, woman tend to stay at home and take care of the family while men migrate for employment. The highest number of individuals/respondents is over the age of 55 (49.5%) followed by those between the ages of 46-55 (25.7%), another trend confirmed by this study, as more elderly people are involved in agriculture than the youth. This is due to the fact that majority of the youth population tends to migrate to urban areas for job opportunities in non-farming sectors. Most of the farmers interviewed were single (58.4%) followed by married individuals (40.6%). As reported by the IDP (2018/2019) since the number of female-headed households increased from 36.29 % in 2007 to 40.70 % in 2011 due to a high divorce rate and the number of women becoming independent.

The results show that most of the respondents completed their secondary education (42%) followed by those who have completed their primary education (36.6%). Eighteen percent (18%) of respondents did not attend formal education and 3% have obtained tertiary education. This indicates that most farmers are literate. Several studies suggest that higher educated farmers are more likely to embrace new knowledge and implement new technologies for improved crop production (Uaiene et al., 2009; Varadan et al., 2014 Manda et al., 2016;). As a result, more literate smallholder farmers are more likely to respond to climate change (Fosu-Mensah et al., 2012; Belay et al., 2017).

The findings show that the majority of farmers (94.1%) participate in crop farming and 15.5% are participating in livestock. The most common income for respondents was government Pension (29.7%), Farming (20.8%), Government grants (14.9%), and Wages (14.9%). The findings show that the majority of farmers depend not only on old age grant as a source of income, but also on agriculture. Thus, any vulnerability to climate change risks will adversely affect their livelihoods and household food security.

Table 3.2: Respondents demographics

Variable description	Frequency	Percentage (%)
Gender		
Male	21	20.8
Female	80	79.2
Age		
25-35	6	5.9
36-45	19	18.8
46-55	26	25.7
>55	50	49.5
Marital status		
Single	59	58.4
Married	41	40.6
Divorced	1	1.0
Level of education		
No schooling	19	18.8
Primary	37	36.6
Secondary	42	41.6
Tertiary	3	3.0
Source of income		
Wages	15	14.9
Salary	14	13.9
Pension	30	29.7
Government	15	14.9
Farming	21	20.8
Other	6	5.9
Type of farming		
Livestock		
Yes	16	15.8
No	85	84.2
Crop		
Yes	95	94.1
No	6	5.9
Mixed		
Yes	4	4.0
No	97	96.0
Other		
Yes	1	1.0
No	100	99.0

3.6.2 Smallholder farmer's description of production systems

Most of the subsistence farmers from this area lack resources and farm inputs such as tractors for farming, seeds, fertilizers and water. They also have limited or no access to the extension officer, it partially, for this reason, smallholder farmers lack knowledge about climate change. From the Focus group discussions (FDGs) one of the farmers mentioned that they are helped by a Farm manager from the University of Zululand who comes at least once or twice a month to share new farming skills and knowledge with them. Despite this, most farmers expressed a lack of training,

which is one of the main reasons why they are unable to adapt to climate change.

Farmers also pointed out from the FGDs that they lack the information to differentiate the various types of soil. Since different soil types require different fertilizers for crops to thrive. Land owned by smallholder farmers varies in size from 1 hectare to 2 hectares (41.6 %) and approximately 24.8% owns more than 2.5 hectares. The results agree with the findings of Rapsomanikis (2015) and Altieri (2012) land sizes between 1ha and 2ha are the normal sizes of land owned by smallholder farmers, especially in African countries.

Irrigation (52%) is the main source of water for agricultural purposes followed by river water (24%) and dam water (11%). Only a few respondents relied mainly on rain-harvested water (9%) due to increased droughts, especially during winter. The smallholder farmers have pointed out that they suffer from water shortage during winter and during summer months, they receive heavy rains that destroy and flood their crops. The majority of the smallholder farmer's farm for own-consumption (100%) and selling (78.2%). About 41.6% sell a quarter of their produce and 39.6% sell half of their produce (see Table 3.3). The results of this study show that the majority of the respondents rely on farming for their livelihoods and household food security. Therefore, it is important for smallholder farmers to be aware of climate change and to provide them with knowledge and training so that they will be able to adapt to these weather changes for increased crop production and household food security.

Table 3.3: Production systems of smallholder farmers

Variable description	Frequency	Percentage (%)
Land sizes		
>1 ha and <2.5 ha	42	41.6
< 1 ha	34	33.7
>2.5 ha	25	24.8
Source of water		
1. Rainfed		
Yes	6	5.9
No	95	94.1
2. Tank		
Yes	13	12.9
No	88	87.1
3. Taps		
Yes	52	51.5
No	49	48.5
4. Rain harvest		
Yes	9	8.9
No	92	91.1
5. River		
Yes	24	23.8
No	77	76.2
6. Dam		
Yes	11	10.9
No	90	89.1
Purpose of smallholder farming		
1. Consumption		
Yes	101	100.0
No	0	0
2. Selling purpose		
Yes	79	78.2
No	22	21.8
3. Supplementary		
Yes	0	0
No	101	100.0
The estimated proportion of produce sold		
1. Quarter of produce	42	41.6
2. Half of the produce	40	39.6
3. All of the produce	1	1.0
4. Don't sell	18	17.8

3.6.3 Crop selection

This study consists of two different types of smallholder farmers who are subsistence farmers producing for their own consumption and those producing for both sales and household consumption see Table 3 4. The majority (75.2%) of the farmers select crops because the household will consume them. As a result, most farmers plant spinach, cabbage, onions, potatoes,

sweet potatoes, *capsicum annuum* (chilli) and maize, which are the staples of most rural households in the area. Most respondents also indicated that they preferred crops for production due to their early maturity (54 %), easy-to-manage crops (67 %), high potential crops (40 %) and easy market access (33 %) see Table 3.4 below. According to the FGDs, the smallholder farmers mention as much as they do not have the market access, they still want to try to make the most of their lives from the little access they have. The farmers also mentioned that they sell produce amongst each other and neighbours, which boost their income.

The farmers often use their knowledge (70.3%) specifically indigenous knowledge (63.4%) to select crops to plant in particular seasons and to forecast weather. The results support the findings of Seleti and Tlhompho (2014) that the majority of subsistence women farmers in South Africa rely on Indigenous Knowledge Systems (IKS) for increased crop production and better livelihoods. In addition, a study by Mapfumo et al. (2016) shows that IKS has been used by smallholder farmers from eastern Zimbabwe to identify rainy seasons that have historically been named according to the different times they occur and how they impact the community, but have become highly unpredictable due to climate change, which has affected their livelihood calendar. In addition, Table 3.3 shows that Farmer-to - Farmer advice (58.4%) is still very useful because they have been able to help each other by exchanging relevant knowledge that another farmer might not be aware of. As mentioned in the focus group discussions, for example, as to which crops are good to be planted in dry seasons and which plants have a higher yield potential compared to others and what type of pesticides to use for certain crops.

Table 3.4: Crop selection

Variable description	Frequency	Percentage (%)
How do you select a crop for production?		
Early maturity		
Yes	54	53.5
No	47	46.5
Resistance to disease		
Yes	6	5.9
No	95	94.1
Resistance to drought		
Yes	4	4.0
No	97	96.0
High yield potential		
Yes	40	39.6
No	61	60.4
Easy market access		
Yes	33	32.7
No	68	67.3
Easy management of crop		
Yes	67	66.3
No	34	33.7
Human consumption		
Yes	76	75.2
No	25	24.8
Other		
Yes	2	2.0
No	99	98.0
Who mainly influences your crop selection?		
Extension officer advise		
Yes	5	5.0
No	96	95.0
Farmer to farmer advises		
Yes	59	58.4
No	42	41.6
NGOs advise		
Yes	7	6.9
No	94	93.1
Myself		
Yes	71	70.3
No	29	28.7
Indigenous knowledge		
Yes	64	63.4
No	37	36.6
Other specify		
Yes	1	1.
No	100	99.0

3.6.4 Farmers awareness, perceptions and adaptation strategies

3.6.4.1 Farmers awareness

Table 3.5 below shows that about 56% of smallholder farmers are aware of the climate, while 45 % are not aware of the climate. The results show that most of the farmers were made aware of climate change through television (39.6%), radio (5.9%), friends and neighbours (5.9%). Similar findings by Tambo and Abdoulaye (2013) reported that about 51% of the smallholder farmers interviewed for their study stated that they heard or were made aware of climate change through the media. Smallholder farmers stated in the FGDs that as much as they are now aware, they are not well informed about climate change and its challenges. Farmers have not attended any awareness-raising workshops and training courses, so they only get information from televisions, radio and newspapers. "*Most of us recently heard about climate change because of the recent floods that happened in Durban this year in April 2019"*. There is therefore a need for government workers (extension officers) and Non-governmental organizations (NGO's) to help smallholder farmers to join forces and train farmers on the overall concept of climate change.

Table 3.5: Awareness of climate change.

Variable description	Frequency	Percentage (%)
Climate change awareness		
Yes	56	55.4
No	45	44.6
How were they made aware?		
TV	40	39.6
Radio	6	5.9
Farmers union	1	1.0
Friends and neighbours	6	5.9
Others	3	3.0
Not aware	45	44.6

3.6.4.2 Farmers Perceptions about climate change

Approximately 98 % of farmers in all study areas perceived an increase in temperature, 46.5 % perceived an increase in rainfall, while 50.5 % perceived a decrease in rainfall due to increased drought seasons (see Table 3.6). Similar results have been documented by Fosu-Mensah (2012), who found that about 88 % of farmers in his study observed a rise in temperature and 87 % observed a decrease in rainfall. The FGDs reveal that farmers believe it is a punishment from God

or ancestors, and they do not understand what is going on with regards to climate change and its impacts.

In this study, most smallholder farmers understand that climate change is associated with droughts (75.2%), flood or intense rains (56.4%), High temperatures (53.5%) in summer, erratic temperature (34.7%) and an unusual change in nature (34.7%). The findings of this study are similar to Ansari et al. (2018), where it was also discovered that majority of farmers (83%) had agreed to notice an increasing temperature whilst having more sunny days in summer. Furthermore, 68% of smallholder farmers noticed that there had been an increase in rainfall particularly heavy rainfall (80%), which occurs either early or later than the expected time of the rainy season, (Ansari et al., 2018; Shukla et al., 2016).

Table 3.6: Perceptions about climate change.

Variable description	Frequency	Percentage (%)
What is climate change for them?		
Flood or intense rain		
Yes	57	56.4
No	44	43.6
Drought		
Yes	76	75.2
No	25	24.8
Unusual change in nature		
Yes	35	34.7
No	66	65.3
Irregular temperature		
Yes	35	34.7
No	66	65.3
High temperature		
Yes	54	53.5
No	47	46.5
Low rainfall		
Yes	7	6.9
No	94	93.1
Perceived change in Temperature and Rainfall.		
Increase	99	98.0
Decrease	2	2.0
No change	0	0
Rainfall		
Increase	47	46.5
Decrease	51	50.5
No change	3	3.0

3.6.4.3 Farmer's perceptions about the causes of climate change

The findings of the study reveal that about 49.5% of the farmers do not know the causes of climate changes, 38.6% believed its nature or evil (bad given) and only 11.9% believe it is man-made (see Table 3.7 below). Farmers assume that it is a punishment from God or an angry ancestor because of all the bad things that have happened in the universe. Farmers have said that they do not understand what is going on and what the causes of climate change are. These results are consistent with the study by Daninga et al. (2011), which stated that 50.3 % of male and 46.2 % of female respondents claimed that climate change was triggered by God's punishment and angry ancestors against humans because of all the evil taken place in the world, such as deforestation and humans not appeasing the ancestors.

Table 3.7: Perceived causes of climate change

Variable description	Frequency	Percentage (%)
What are the causes?		
Nature or bad given	39	38.6
Manmade causes	12	11.9
Do not know	50	49.5

3.6.4.4 Farmers' perceptions of climate change-related events and their impacts.

Over the past 15 years, the majority of the farmers have observed changes in weather, such as prolonged droughts (67.3%), very hot seasons (66.3%) precisely in summer, while 47.5% confirm a rise in floods, 21.8% experience very wet seasons and 2% have observed no changes (see Table 3.8 below). The findings are consistent with the study by Akhtar et al. (2018) in which 73 % of respondents indicated that they had observed a rise in temperature in the last 10-15 years, 8.5 % of farmers observed no improvement, 78.4 % observed more droughts and 95 % observed more floods in the last 10 years. As a result of these changes in weather conditions, there have been substantial negative impacts on smallholder farmers' community, such as crop failure (99.0%), food insecurity (65.3%) and livestock deaths (11%). In addition, for the last 15 years, the majority of farmers (99.0 %) recorded low crop yields, 83.2 % suggested that this loss was very significant and the majority of respondents claimed that the loss of yield was due to natural causes (77.2 %) such as drought and floods, insect damage (64.4 %), lack of farm inputs (33.7 %), lack of water (13.9 %). The results are consistent with Wolka and Zeleke, (2017) and Fosu-Mensah, (2012) which confirm that weather changes negatively affect farmers' crop production by reducing crop

yields that directly affect their livelihoods and food security as they are highly dependent on agriculture.

Table 3.8: Perceptions of climate change-related events and their impacts

Variable description	Frequency	Percentage (%)
Main changes of weather observed in the past 15 yrs.		
1. Floods		
Yes	48	47.5
No	53	52.5
2. Prolonged drought		
Yes	68	67.3
No	33	32.7
3. Very hot seasons		
Yes	67	66.3
No	34	33.7
4. Very wet seasons		
Yes	22	21.8
No	79	78.2
5. No changes have been observed		
Yes	2	2
No	99	99
Main impacts of these changes in the community?		
1. Crops failure		
Yes	100	99.0
No	1	1.0
2. Death of livestock		
Yes	11	10.9
No	90	89.1
3. Food insecurity		
Yes	66	65.3
No	35	34.7
4. Human disease outbreak		
Yes	1	1.0
No	100	99.0
Have you experienced low? crop yields in the past 15 years?		
Yes	99	98.0
No	2	2.0
How severe has the loss been?		
Very severe	84	83.2
Moderately severe	16	15.8
Not severe	1	1.0

What do you think are the causes of yield loss?		
1.Natural causes		
Yes	78	77.2
No	23	22.8
2.Pest damage		
Yes	65	64.4
No	36	35.6
3.Disease outbreak		
Yes	12	11.9
No	88	88.1
4.Lack of farm inputs		
Yes	34	33.7
No	67	66.3
5.Lack of water		
Yes	14	13.9
No	87	86.1

3.6.4.5 Farmers adaptation to climate change

This study examined the existing adaptation methods (see Table 3.9) used to resolve rainfall and temperature variability and to find out if training or support has been given to farmers. Approximately 90.1% of smallholder farmers reported that they did not receive training on climate change intervention with only 9.9% who have received some training. Farmers (96.0%) do not invest their money in adaptation technologies due to their limited monthly incomes. This threatens the well-being of smallholder farmers, as they find it difficult to deal with the impacts of not adapting to climate change.

In addition, about 94.1% reported that they did not receive any form of support from extension officers and organizations. From FGDs farmers also mentioned, "they are not well informed about climate change and its challenges and have not received extension and advisory services". As a result, 30.7% of farmers have adapted to climate change and 69.3% have not adapted. These findings indicate that there is a need for the Government of South Africa, NGO's and trained agricultural government employees (extension officers) to increase their presence in these vulnerable communities and provide the necessary information dissemination on climate change.

Thirty-one per cent (31%) of farmers have made adjustments, to deal with temperature changes, 25% were practising crop diversification, 20% were engaged in mixed cropping 17% by changing dates of planting and 8% built water harvesting schemes. The same practices were adopted for dealing with rainfall changes 25% for crop diversification, 17% for changing planting dates, 23%

practised mixed cropping and 9% built water harvest schemes. These findings are consistent with the studies conducted by Bryan et al. (2013); Akhtar et al. (2018); Daninga et al. (2018) which indicated that the main adaptation measures adopted by the smallholder farmers were also crop diversification, changing planting dates and selecting a new variety of crops for produce. Smallholder farmers cannot use other suitable adaptation methods for this study due to lack of expertise and agricultural inputs. Climate change support programs should also educate farmers about climate-smart agricultural practices, as this strategy improves resilience while ensuring effective use of resources.

Table 3.9: Adaptation strategies

Variable description	Frequency	Percentage (%)
Trained in climate change intervention?		
Yes	10	9.9
No	91	90.1
Made adjustments in farming practices to climate change?		
Yes	31	30.7
No	70	69.3
Adaptations used to deal with temperature changes?		
1. Crop variety and diversification		
Yes	25	24.8
No	76	75.2
2. Changing dates of planting		
Yes	17	16.8
No	84	83.2
3. Build a water harvest scheme		
Yes	8	7.9
No	93	92.1
4. Mixed cropping		
Yes	20	19.8
No	81	80.2
Adaptations used to deal with the changes in rainfall?		
1. Crop variety and diversification		
Yes	25	24.8
No	76	75.2
2. Changing dates of planting		
Yes	17	16.8
No	84	83.2
3. Build a water harvest scheme		
Yes	9	8.9
No	92	92.1

4.Mixed cropping		
Yes	23	22.8
No	78	77.2
Do extension officers provide climate change support?		
Yes	6	5.9
No	95	94.1
Do you receive climate change support from institutions/organisations?		
Yes	6	5.9
No	95	94.1
In a month how much is spent towards climate change?		
R0	97	96.0
R20	1	1.0
R50	1	1.0
R300	2	2.0

3.6.4.6 Determinants of adaptation

The binary logit regression was used to analyze factors influencing farmers' decision to adapt to climate change.

Logit regression analysis shows that four variables were statistically significant for adaptation to climate change. These variables are *Gender (P=0.028)*, *Age (0.038)*, and *a total hectare of land (P=0.003)* which is negatively significant and *Years of farming (P=0.018)* which is positively significant. Whereas Education, Family size, Extension services, Awareness, Mass media exposure, Perceived temperature and Perceived rainfall were insignificant.

The findings (see Table 3.10) show that the total hectare of land (P=0,003) is negatively significant. This means that it is not easy for smallholder farmers to sustain large land sizes due to limited agricultural resources. Previous studies have shown that the greater the size of the land, the less likely it would be for smallholder farmers to adapt (Regmi et al., 2017; Ndamani and Watanabe, 2015). Large farms, therefore, need more investment and farm inputs such as seeds, irrigation systems, pesticides and fertilizers to adapt (Regmi et al., 2017). For this research, smallholder farmers may not be able to afford these inputs.

As expected by the results of this study, the overall years of farming (P=0.018) have provided positive significance to adaptation, as more experienced farmers are likely to respond to climate

change than less experienced farmers are. This finding is consistent with Trinh et al. (2018) study, which shows that farmers who have more farming experience are most likely to adapt to climate specifically by changing crop varieties and to be able to monitor climate changes. In this study, based on the analyses of the structured questionnaires' and FGDs farmers who have farmed for many years use their own IKS to farm and adapt to climate change compared to less experienced farmers who lack indigenous knowledge.

Age (P=0.038) has a negative effect on adaptation, which may be attributed to the fact that the majority of farmers in this study are older (49% are over the age of 55) and thus lack awareness of the value of adaptation. This finding is consistent with the previous study by Ndamani and Watanabe (2015) which showed that older farmers are less likely to adapt to climate change because older farmers lack confidence and motivation to adapt to climate change. Moreover, most farmers feel afraid, 35.6 %, and 29.7 % unable to respond to climate change. These results also suggest that younger family members need to be involved and provided with training on climate change and adaptation. From the FGDs respondents mentioned that one of the other main reasons why they are less likely to adopt is that they lack knowledge of appropriate climate change strategies.

Gender *(P=0.028)* also has a negative significance on adaptation. This may be because most female-headed households are unable to adapt due to a lack of education and minimal income for women taking on domestic responsibilities. This finding is consistent with previous findings, which suggest that female farmers are less likely to adopt adaptation strategies compared to male farmers. In Sub-Saharan Africa, most female heads of households lack access to markets, inputs, are less educated, and are likely to be consumed with households chores and other off-farm activities to diversify income (Ndamani and Watanabe 2015; Fadina and Barjolle, 2018). For this study majority of the farmers are female (79.2%) and from the FGDs smallholder farmers mentioned that they do not have access to larger markets to sell their produce to have money to invest in farm inputs that will assist in adapting to climate change and to provide the extra income.

Table 3.10: Determinants of farmers' adaptation to climate change

Variable	B (value)	Significance	Exp (B)
Gender of the household head	-2.806	.028**	.060
Age of household head	-.993	.038**	.370
Level of Education	.051	.913	1.053
Total number of individuals in the Household	.662	.136	1.939
Years of Farming	.832	.018**	2.299
Total hectare of land	-1.519	.003***	.219
Have you ever heard about climate change?	-.257	.866	.773
How were you made aware of Climate Change	.089	.689	1.093
Perceived change in temperature	-.492	.546	.611
Perceived change in rainfall	-.018	.975	.982
Do extension officers provide climate change support?	24.169	.999	31371730270.203
Constant	-38.091	.999	.000

***=values statistically significant at 0.01probability level, ** =values statistically significant at 0.05 probability level, *=values statistically significant at 0.1 probability level. Number of observations 101.

3.7 Conclusion and Recommendations

The objective of this study was to determine the awareness and perceptions of climate change among smallholder farmers. As well as identifying key factors or determinants of climate change among smallholder farmers. This research has shown that more people are aware of climate change; many have also seen and correlated climate change with increased temperatures and rainfall, increased incidence of floods and droughts. Yet many of the farmers lack knowledge and training to adapt to climate change. This has a negative effect on the smallholder farmers' crop production, as they have experienced a significant decline in yields. Factors such as limited access to extension services, gender, age, and not being able to manage large farm sizes and not having enough access to markets and farm inputs, have a significant impact on climate change adaptation. Government and policymakers need to consider these factors, which prevent smallholder farmers from adapting, to ensure better crop production, which will lead to improved livelihoods, as they

are highly dependent on agriculture. It is therefore important to have awareness-raising and training campaigns to educate farmers about climate change and the appropriate strategies to adopt for both rainfall and temperature changes. These campaigns should target young farmers and, for the most part, the older generation. It will also be very necessary for the government to increase the extension services to these areas for further monitoring after the farmers have been educated.

Chapter 4: Smallholder farmers' barriers to adaptation and the severity of climate change on farm income and household food security: Case of uMhlathuze Municipality, in South Africa.

4.1 Abstract

Climate change has a significant negative impact, particularly on countries that depend on rain-fed agriculture. Without adaptation, climate change is projected to adversely affect the livelihoods and well-being of rural smallholder farmers. The study, therefore, investigated barriers to adaptation and the severity of climate change in farm income and food security. The study was conducted in the uMhlathuze municipality of uThungulu district in KwaZulu-Natal, which has several villages. One hundred and one (101) farmers were purposively selected to participate in the study. Quantitative data were collected via a standardized questionnaire and qualitative data was collected via focus group discussions. The main barriers to adaptation were lack of information (83.2%) and input (60.4%). Ninety-eight percent (98%) of farmers recorded that climate change had impacted their farming activities and 85 % had lost farm income. Ninety-five per cent (95%) of respondents experienced food shortages, the key reason being droughts (77.2 %) and food price increases (42.6 %). To cope with food shortages, most households are forced to change their diets (52.5%) and consume less food. It is therefore important for the government to consider how to resolve climate change challenges in the Food and nutrition security policy and to provide farmers with training and farm inputs that will enable them to adapt to climate change.

Keywords: Smallholder farmers, climate change, barriers, livelihoods,

4.2 Introduction and Background of the study

Climate change has already had profound effects on people's lives and the diversity of life on the planet (FAO, 2018). Increased temperatures and rainfall variability affect crop yields and food security in low-income and agricultural economies (FAO 2016; UN 2019; FAO 2019). Temperatures across Africa are expected to rise by 2-6^{o}C over the next 100 years and rainfall variability is projected to increase, leading to frequent floods and droughts (Gemeda and Sima, 2015). Africa is susceptible to climate change because it relies heavily on rain-fed farming and has inadequate economic and institutional capability (Deressa et al., 2011; Antwi-Agyei et al., 2015; Dube et al., 2016).

Countries in Sub-Saharan Africa (SSA) are expected to get hotter and drier in the coming years. Rainfall will also become more unpredictable affecting the farming season, leading to an increase in pest diseases and attacks (Dube et al., 2016 and Banerjee, 2015). Harvey et al. (2014), reported that smallholder farmers make up a large part of the world's population, with an estimated 450-500 million smallholder farmers making up 85% of the world's farms. Smallholder farmers are also projected to account for half of the world's poor population and possibly three-quarters of Africa's poor population (Harvey et al., 2014). Climate change will have catastrophic effects on the lives and livelihoods of these vulnerable people, as there would be major yield losses (Altieri and Nicholls, 2017). Smallholder farmers will be affected because both food safety and income rely on crop production (Altieri and Nicholls, 2017; Mashizha, 2019).

The agricultural sector plays an important role in the development and economy of South Africa; thus, by 2050, climate change could lead to a decrease of about 1.5% of GDP in the country (Turpie and Visser, 2019). Smallholder farmers in South Africa are most vulnerable and, if proper adaptation methods and policies are not implemented, there will be significant negative effects on farm produce. This would further increase food poverty and deprivation in rural households in South Africa (DAFF, 2018 and Turpie and Visser, 2019).

According to Shackleton et al. (2015), human adaptation is defined as the process of adjustment to the current or anticipated climate, as well as its effects to reduce damage or to utilize helpful opportunities. Adaptation is critical to addressing the adverse impacts of climate change and can improve food security (Shikuku et al., 2017). Climate change adaptation needs to be understood by farmers, as to the extent to which climate has already changed and to identify useful strategies for implementing the adaptation measures that are needed (Akhtar et al., 2018). Agricultural practices such as crop technology, soil, land management and water management are important adaptation methods, but implementation remains poor, mainly in the SSA. This could be due to various barriers, such as economic and social barriers (Akhtar et al., 2018).

Barriers are climatic and non-climatic obstacles, factors and circumstances that may interfere with or hinder adaptation (Shackleton et al., 2015). Poor and vulnerable people in less developed countries such as South Africa are more likely to face additional barriers to adaptation (Shackleton et al., 2015). In a study by Amare et al. (2018), most rural households have not adapted to climate change for various reasons. These reasons include limited or no access to water sources, limited

knowledge and skills, labour shortages, lack of agricultural land; finances; information; agricultural extension services and additional institutional factors. This study aims to identify the adaptation barriers of smallholder farmers' and the effects of climate change on farm income and household food security in the vulnerable rural areas of KwaDlangezwa in uMhlathuze municipality. Information from this study will be able to inform policymakers and relevant stakeholders to develop suitable policies and support systems for smallholder farmers.

4.3 Materials and Methods

4.3.1 Study site

Data was collected in uMhlathuze the local municipality of uThungulu district, located in the north-east coast of the province of KwaZulu- Natal province, South Africa. uMhlathuze municipality consists of central business districts such as Richards bay, urban areas, townships and rural areas. The study was primarily conducted in the rural are of KwaDlangezwa which is under the authority of Chief Mkhwanazi, where the majority of the smallholder farmers are located. The uMhlathuze area is characterised by shallow soil and covers an area of about 1195 km² with a population of 384 449. The municipality is one of six local municipalities within the uThungulu district, and has four key economic sectors such as mining, manufacturing, agriculture, commercial farming and tourism. Most rural residents are also involved in subsistence farming. With many of the smallholder farmers being involved in livestock and crop farming and the common crops produced in the area are sugarcane, maize, and vegetables. Droughts and floods have plagued the municipality with average annual rainfall ranging from about 800 mm in the upper and middle regions to about 1400 mm near the coast.

4.3.2 Research design and Methodology

To gain an in-depth understanding of the topic the convergent parallel mixed research design was used for this study. This type of research design allows quantitative and qualitative data to be collected in parallel, analyzed separately and the results to be combined (Creswell, 2013). This research design was found to be appropriate for the study, to gain more meaningful information and the experiences of the smallholder farmers barriers to adaptation and the severity of climate change on farm income and household food security.

This study was carried out using the mixed research method, incorporating both quantitative

(involves collection and analysis numerical data) and qualitative (involves narrative or experiential data) research. Qualitative data was collected through focus group discussions with smallholder farmers. The main purpose of focus group discussions is to draw upon attitudes, feelings, beliefs, experiences and reactions of the respondents in a way in that would not be feasible by using other methods, for example, observation, one-to-one interviews, or questionnaire surveys. The focus group discussions for this study were especially appropriate because they helped to gain a variety of perspectives on adaptation barriers, the effect of climate change on household food security and incomes. In addition, it helped to gain insight into the mutual understanding of the research topic among respondents. Quantitative data were obtained through a standardized questionnaire; all questionnaires had the same questions to be able to compare the answers of the participants. The structured questionnaire for individual farmers was formulated to gather information on demographics, on barriers to adaptation, and the effect of climate change in farm income and food security.

4.3.3 Sampling technique and Sample size

Hundred and one (101) participants were purposively selected to participate in this study. Farmers were identified with the help of a key informant, who had first-hand knowledge of where farmers were located and affected by climate change, and who were active in both crop and livestock farming. The focus groups consisted of 6 to 12 individuals who were selected using a random sample selection during the administration of the structured questionnaires. In total, three focus groups (one in each of the three villages) were conducted. Each group had a professional facilitator to chair the discussion and clarify any questions; the discussions took about an hour to an hour and a half, and videos and photographs were taken for all sessions.

4.4 Data analysis

In this study, the Statistical Package for Social Sciences (IBM SPSS), version 25, was used to analyse and generate descriptive statistics. Data from the survey were subject to descriptive analysis, coding questions, while the information from focus group discussions were synthesized through content, theme and frequency analyses.

4.5 Ethical consideration

The permission to conduct the study in Kwadlangezwa was granted by Chief Mkhwanazi, with the help of IziNduna, from all rural villages of the Kwadlangezwa area.

Each farmer had to sign a consent form agreeing to participate in the study and, where necessary, take pictures.

The University of KwaZulu-Natal (UKZN), Humanities and Social Sciences Research Ethics Committee, Protocol reference number, also granted ethical clearance: HSS/0355/019M.

The findings and recommendations of the study will be reported back to the communities once the study has been completed.

4.6 Results and discussions

4.6.1 Demographic description

The majority of the smallholder farmers interviewed were female (79.2%) (see Table 4.1), because most of the households in the study area are female-headed households and therefore perform most of the farming activities. Research by Apata et al. (2010) and Oluwatayo, (2014) has shown that more women are engaged in agriculture in Africa, yet they have limited access to agricultural inputs and credit markets that makes them vulnerable to poverty.

The largest number of individuals over 55 years of age (49.5%). The findings are consistent with those of Heide-Ottosen (2014) which confirms this trend in the participation of older women smallholder farmers in agriculture. Heide-Ottosen (2014) also stated that policymakers do not have to see older farmers as unable to adopt new technologies and as unproductive due to their age. The current study and previous research show that there are active and older smallholder farmers engaged in agriculture. Therefore, policymakers need to review and make provision for these smallholder farmers to have access to the necessary support to enhance and improve food production and livelihoods.

The sample consisted more of single individuals (58.4%) followed by a significant number of married individuals (40.6%). This is supported by the IDP (2018/2019) as the number of female-headed households increased from 36.29% in 2007 to 40.70% in 2011 due to high divorce rate, even with the majority of females left at home as husbands have migrated for work purposes. The

results show that most of the respondents completed their secondary education (42%) followed by those who have completed their primary education (36.6%). The findings show that majority of the respondents have formal education and were not illiterate.

Table 4.1: Respondents demographics

Variable description	Frequency	Percentage (%)
Gender		
Male	21	20.8
Female	80	79.2
Age		
25-35	6	5.9
36-45	19	18.8
46-55	26	25.7
>55	50	49.5
Marital status		
Single	59	58.4
Married	41	40.6
Divorced	1	1.0
Level of education		
No schooling	19	18.8
Primary	37	36.6
Secondary	42	41.6
Tertiary	3	3.0

The results show that many of the smallholder farmers interviewed were unemployed (56.4%) and rely mostly on Old Age grant (29.7%) and Farming (20.8%) as the major source of income, while only 14.9% depend on wages and other government grants (see Table 4.2). This is attributed to the fact that the majority of the smallholder farmers are over the age of 55 years and are unemployed, most of them rely on farming for both household consumption and sales. Research by Pienaar and Traub (2015) has shown that women, children and elderly people reside in most rural households in South Africa and are highly dependent on agriculture for their livelihoods and food security. They also depend on off-farm livelihood strategies such as remittance and petty trading for extra income (Oluwatayo, 2014; Pienaar; Traub, 2015; Lewis et al., 2018). Furthermore, the majority of respondents (39.6%) earned monthly income between R801.00- R1500 and 37.6% between R1501.00-R3500.00. According to the South African Social Security Agency (SASSA) report (2019), it is only those 60 years of age or older who are eligible for an old-age grant who receive R1780 per month and R1800 if they are over 75 years of age and R425 in child grants.

Table 4.2: Smallholder farmers' sources of income

Variable description	Frequency	Percentage (%)
Monthly income		
Below R800.00	16	15.8
R801.00-R1500.00	40	39.6
R1501.00-R3500.00	38	37.6
Above R3500.00	7	6.9
Source of income		
Wages	15	14.9
Salary	14	13.9
Pension	30	29.7
Government	15	14.9
Farming	21	20.8
Other	6	5.9
Employment status		
Employed full-time	16	15.8
Employed part-time	23	22.8
Unemployed	57	56.4
Self-employed	5	5.0

4.6.2 Barriers to climate change adaptations

Smallholder farmers rely on season rainfall arriving at a specific time and bringing with it a certain amount of water to ensure their food security for the next few months. Climate change cannot purely be labelled as drought or increased rainfall; rather it signifies a massive change or exacerbation in weather patterns that we have all come to know. Since the 1980's SSA has been experiencing a major drought with only increasing in severity.

The smallholder farmers in this study do adopt crop management strategies to address the impacts of climate change. Such as crop diversification, change in harvesting and planting dates. However, the findings of this research have shown that smallholder farmers are faced with various adaptation challenges. The key barriers identified in the study were lack of information (83.2%), and lack of farm inputs (such as equipment, tractors and improved seeds) (60.4%). Approximately 13.9% did not adapt due to drought which reduces their crops which leads to the smallholder farmers not having enough money to invest adaptation. Only 4.0% did not see the need (see Table 4.3), which may be due to the fact that some smallholder farmers were not aware of climate change and its impact on crop production. For example, previous findings (Akhtar et al., 2018; Ndamani and Watanabe, 2015) have indicated that farmers could not implement adaptation measures due to costly farm inputs, erratic weather conditions, lack of weather information, insufficient water, lack of credit facilities and extension officers. Access to knowledge on weather and climate change is

therefore an important tool that can be used to enhance the adaptation and implementation of adaptation measures in the study area. Access to information may also improve crop production and household food security.

Table 4.3: Adaptation barriers.

Variable description	Frequency	Percentage (%)
What made you not to adapt?		
1. Lack of information		
Yes	84	83.2
No	17	16.8
2. Lack of inputs		
Yes	61	60.4
No	40	39.6
3.Drought		
Yes	14	13.9
No	87	86.1
4. Do not see the need		
Yes	4	4.0
No	97	96.0
5.Poor health		
Yes	2	2.0
No	99	98.0

4.6.3 Vulnerability to climate change

According to the IPCC (2007) definition, vulnerability in the context of climate change is "the degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity"

4.6.3.1 Impact of climate change on farm income

Agriculture plays a vital role for rural households who depend on farming for their livelihoods most (98.0%) of the smallholder farmers reported that climate change has affected their farming activities and, as a result, 85.1% smallholder farmers experienced a decline in farm income (see Table 4.4). From the FGD's, the smallholder farmers have stated that climate change is affecting their crops since it decreases crop production as drought seasons have increased in recent years, and they are selling less produce that decreases their farm income.

The findings are consistent with the study done by Mashizha (2019) who stated that smallholder farmers in Zimbabwe experienced a decrease in their main cash crop, maize due to droughts.

Despite the NGO training of smallholder farmers on mulching, which reduces water losses while growing maize, they have still suffered losses in recent years due to soil infertility and droughts (Mashizha, 2019). Turpie and Visser (2013) have discovered that the negative impacts of climate change in South Africa will depend on whether or not the farmland is irrigated, rendering smallholder farmers more vulnerable because they will earn less income. Smallholder farmers in this study are poor in resources they lack agricultural inputs such as irrigation systems and have limited government and NGO (non-governmental organization), support, which have negatively affected their farm income.

Table 4.4: Impacts of climate change on agricultural activities and farm income

Variable description	Frequency	Percentage (%)
Has climate change affected your agricultural activities?		
Yes	99	98.0
No	1	1.0
Not sure	1	1.0
Has climate change affected your farm income?		
Increase	2	2.0
Decrease	86	85.1
No change	13	12.9

4.6.3.2 Impact of climate on household food security

As the majority of the participants were female farmers, 95.0 % of the respondents experienced shortages of agricultural-based food items in their households. The major reasons for these food shortages are droughts (77.2%), price increases (42.6%) followed by floods (22.8%) and lack of farm inputs (such as equipment and improved seeds) (21.8%), (see Table 4.5). The results are consistent with the research conducted by Mashizha (2019), where farmers in the research also reported a decrease in crop production of approximately 33 smallholder farmers who indicated that the cause in decrease was due to abnormal weather patterns. In addition, Turpie and Visser (2013) pointed out that climate change is expected to increase food insecurity leading to increased poverty in households. This is evident in this study, as smallholder farmers are vulnerable to both climatic and non-climatic shocks, which lead to more crop losses, which means less income and less food is available and accessible for consumption.

Table 4.11: Reasons for food shortages in households.

Variable description	Frequency	Percentage (%)
If yes, what were the reasons for food shortages?		
1.Price increase		
Yes	43	42.6
No	58	57.4
2.Droughts		
Yes	78	77.2
No	23	22.8
3.Floods		
Yes	23	22.8
No	78	77.2
4.Lack of farm inputs		
Yes	22	21.8
No	79	78.2

To deal with food shortages, 52.2% of the respondents changed the households' diet, 39.6% ate less food, 27.7% borrowed money, 12.9% only received food from relatives and 5.9% sent older children to work (see Table 4.6). The results of this study are consistent to Oluwatayo (2014) who also found that smallholder farmers had various coping strategies to cope with food shortages, and among the most common were eating less diversified food (10.5%), eating in smaller quantities to share with the whole family (10.2%) and consuming fewer meals a day. Such results indicate a negative effect on the food security status of smallholder farmers, as food was not always accessible nor affordable so that they could not consume their desired meals. This is why policymakers need to include climate change in Food and Nutrition policies and support programmes.

Table 4.12: Coping strategies for food shortages.

Variable description	Frequency	Percentage (%)
How did you cope with these shortages?		
1. Eat less food		
Yes	40	39.6
No	61	60.4
2.Change diet		
Yes	53	52.5
No	48	47.5
3.Borrowed money		
Yes	28	27.7
No	73	72.3
4.Received food from relatives		
Yes	13	12.9
No	88	87.1
5.Sent older children to work		
Yes	6	5.9
No	95	94.1

4.6.3.2 Focus group discussions on Barriers of adaptation and effects of climate change on the smallholder farmers livelihoods.

This section presents results from focus group discussions (FGDs) (see Table 4.7 below) on barriers of climate change and the impact of climate change on farm income and food security.

The respondents expressed that as much as they adapt to climate change by using their indigenous knowledge, they feel that it would benefit them if they knew better and cost-effective adaptation methods that could improve crop production. Smallholder farmers explained that a lack of money and lack of access to information and training are the greatest barriers to adaptation. The respondents also reported that they do not have access to larger markets to sell their produce to make enough money for a living and also to invest in farm inputs that will assist in adapting to climate change.

The FGDs showed that smallholder farmers do not receive support from the government or government workers (extension officers). For example, being supplied with improved seed varieties, fertilizers and pesticides. They also have restricted access to extension officers, information and training on effective adaptation methods plus enhanced alternative farming practices for better crop production in the light of climate change. Farmers, instead, have to purchase seeds with their own money and cannot afford improved seeds because they are costly

compared to regular seeds. As a result, the livelihoods of smallholder farmers and the source of income are adversely affected and face numerous obstacles to climate change adaptation. Smallholder farmers have also indicated that, as climate change decreases their crops, they end up not having enough food to eat in the households and not making enough money from the sale of limited produce. This forces smallholder farmers to buy inexpensive and less nutritious food from the supermarkets, and if they cannot afford to buy food, they are forced to eat fewer meals a day and change their diets. The findings show that climate change has negatively affected all four dimensions of food security (food: availability, accessibility, utilization and stability) and the welfare of smallholder farmers in this study.

Table 4.13: Focus group discussions: Barriers of adaptation and effects of climate change on farmers livelihoods.

Themes	Focus group questions	Direct quotes
Adaptation methods and Barriers	▪ What (other) adaptation methods have you put in place to protect crops and livestock from climate change? ▪ There are many reasons (barriers) that stop farmers from adapting to climate change, what are your reasons for that? ▪ Do you think enough is being done for climate change by the National and local governments' authorities?	" We don't have other ways to adapt or protect our crops from climate change due to the lack of understanding and resources, we just use our own indigenous knowledge and if we knew other better ways of adaptation that we could afford it would be better for our crops" "the main reason is just lack of knowledge of other better strategies that we can use "we breed good chickens and crops, but we don't have access to bigger markets to sell our produce in order to have money for investing in farm inputs that will assist in adapting to climate change" "government does not help with anything we have nothing we use our own pension money to buy seeds, if you don't have pensions money or any other source of income it's a struggle" "we also cannot afford to buy improved seeds which are drought resistant, produce bigger yields are resistant to pests and diseases nor does the government assist us with that" "we are struggling from dealing with issues of moles they really destroy our crops and all our hard work we don't have money to buy pesticides that are able to kill moles" "our children are stuck at home unemployed government should be helping our kids with

		employment at least so they can help us at home the only thing they survive on is a child and pension grant most of the time"
Food security and livelihoods	▪ What are the main livelihoods in the community? ▪ Do you think climate change causes a decrease in crop (and livestock) productivity how has that affected your household food security and farm income?	" We make our livelihoods from farming we sell to each other and neighbours but last year our cabbages got rotten since we did not have enough people to sell to, we also make beads and sell snacks at schools to have an extra income" "climate really does affect our crops as it decreases them which affects household food security and decreases the money we earn from selling our produce, as a result,we end up not having enough to eat we end up buying food from shops with the little money that we have"

4.7 Conclusion

The objective of this study was to identify the barriers of adaptation and the impacts of climate change on farm income and household food security. The result of this study indicates that agriculture plays a crucial role in the lives of smallholder farmers in the municipality of uMhlathuze. Since farming is a source of income for rural communities in the study and adaptation to climate change is crucial. With the majority of smallholder farmers being single female farmers, this makes them more vulnerable to climate change as they have restricted access to capital relative to male farmers, they also have to take on additional income from other off-farm activities. The lack of knowledge, training and financial resources for smallholder farmers in this area does not allow them to invest in new farming practices and adaptation methods. Their quality of living is also influenced bylower incomes due to crop losses resulting in a lack of household diet as a way to cope with household food insecurity challenges. Government and policymakers, therefore, need to include climate change in the next Food and Nutrition Security Strategy, which will solve all the problems of household food shortages due to climate change. To lessen the barriers of adaptation amongst the smallholder farmers the government also needs to provide smallholder farmers with training and farm inputs to help them to adapt to climate change.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

This chapter presents the main conclusions and recommendations of the study. The study aimed to investigate the perceptions and adaptation of smallholder farmers to climate change, as well as the determinants and barriers of adaptation to climate change and the implication on household food security. The specific objectives of the study were: (i) to determine the farmer's perceptions (and awareness) on climate change, (ii) to evaluate the adaptation options practised by smallholder rural farmers, (iii) To identify the determinants and barriers to adaptation in climate change, (iv) to recognize the severity of climate change on farm income and household food security.

5.1 Conclusion

It has been noted in the literature that climate change and variability adversely affect agriculture, which is the main means of livelihoods of smallholder farmers in the study area. The results of the study revealed that farmers of Kwadlangezwa rely on farming for consumption and sale of produce. Majority of the farmers are single female farmers, making them more vulnerable to climate change as they have limited access to resources, and they have to take on other off-farm activities for extra income. These farmers have limited or no access to extension services, most of which use indigenous knowledge for their farming practices.

5.2 Conclusion for:

Sub problem 1: What are the perceptions of the rural smallholder farmers on climate change? And Sub problem 2: How are rural farming households adapting to climate change?

The objective under **Sub problem 1** was to determine the farmers awareness and perceptions of climate change. And the objective under **Sub problem 2** was to evaluate the adaptation options practised by smallholder rural farmers? The study found that farmers are aware of climate change, however, farmers lack knowledge and training to adapt to climate change. Farmers have revealed that they do not know the causes of climate change; they believe it is caused by nature or bad given by God. Smallholder farmers have seen an increase in temperature and a decrease in rainfall due to floods and droughts in recent years. As a result of the increased occurrence of climate change-

related events, smallholder farmers reported low crop yields. To combat the impacts of climate change, smallholder farmers have adopted mixed cropping, crop diversification, changing planting dates and built water harvesting schemes. Therefore, interventions should focus on informing farmers about climate change and to encourage smallholder farmers to adopt cost effective and climate smart adaptation strategies.

Sub problem 3: What are the determinants and barriers to the adaptation of climate variability? And Sub problem 4: What are the impacts of rural farming households' vulnerability to climate change on farm income and household food security?

The objective of **Sub problem 3** was to identify the determinants and Barriers to adaptation. Followed by the objective of **Sub problem 4** it was to recognize the severity of climate change on farm income and household food security. The results of the study revealed that determinants such as age and gender hinder female smallholder farmers to adapt to climate change. Since most of the female farmers of this study are older in age and tend to take on most of the household roles, they lack education and do not have enough help from younger family members to assist in farming. Although both male and female smallholder of the study adopted crop management strategies to combat the impacts of climate change, they faced various challenges and hindrances to better adaptation methods, such as lack of information and finances to funding these adaptation methods. Since farmers rely on rain-fed agriculture for consumption and income climate change has affected farmers' wellbeing and household food security.

To address food shortages, smallholder farmers were forced to compromise their diet by eating fewer meals a day and consuming less diversified meals. Government and policymakers must therefore consider climate change in the next Food and Nutrition Security Plan, which will address the challenges of household food shortages caused by climate change. There is also a need to consider factors that prevent smallholder farmers from adapting to the development of policies. In addition, to awareness-raising and training campaigns to educate farmers about the appropriate adaptation strategies for both rainfall and temperature changes. Lastly, it is vital for relevant government stakeholder to assist smallholder farmers with inputs such as financial assistance and drought resistance crops to hinder barriers of adaptation while increasing crop production for improved livelihoods.

5.3 Policy Recommendations

Inc conclusion, the study showed that the smallholder farmers of Kwadlangezwa are aware of climate change but most of the farmers do not have the knowledge and means or inputs to better adapt to climate change. If they do not know how to adapt this will affect their crops thus affecting the farmers' socio-economic status and household food security. Hence, government policies should improve the existing rural smallholder farmers adaptation strategies and encourage the implementation of climate-smart agricultural practices to enhance crop production in midst of climate change.

There is also an urgent need for the smallholder farmers to be informed about climate change and its impacts, through awareness campaigns. Moreover, training smallholder farmers on adaptation to climate change through workshops and training sessions. The government should also offer extension services to the farmers of Kwadlangezwa as they need support and more knowledge about climate change and better adaptation and farming methods. Agricultural decision-makers can use the knowledge produced from this study to develop new policies that can minimize the climatic and non-climatic shocks experienced by smallholder farmers.

It would also be vital for the government and policymakers to ensure that the smallholder farmers of the study area do have access to existing support services created for smallholder farmers in South Africa that these farmers do not know of and do not have access to. For example, services provided by the Department of Agriculture, Forestry and Fisheries such as Ilima/Letsema (which provides production inputs to subsistence and smallholder farmers).

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APPENDIX A: Survey Consent form and Questionnaire

Translated consent form (IsiZulu)

Topic: Farmers' perception and adaptation to climate change: case study of vulnerable areas in Mhlathuze local municipality (KwaDlangezwa) in KwaZulu-Natal, South Africa.

Igama lami uAbla Yende ngenza izifundo zami zeMasters kwi Agriculture noma kwezolimo (Food Security) eNyuvesi yaKwaZulu- Natali. Ngenza ucwaningo ngesihloko esibhalwe phezulu, bengingathanda niphendule imibuzo yalolu ncwaningo.

Nakhu ekumele nikwazi ngaphambi kokuphendula:

Ukuze ube ingxenye yalolucwaningo ngenxa yokuvolontiya kwakho, uvumelekile ukuthi uyeke phakathi kocwaningo uma ufisa, akukho lutho olubi oluzokwenziwa kuwe.

- Ayikho imali ezoyithola uma uba yingxenye yalolucwaningo.
- Imininingwane ezotholakala izosebenziswa kulolucwaningo kuphela. Futhi izogodlwa ngokuphephile esikhungweni seNyuvesi.
- Yonke imininingwane yalolucwaningo izolahlwa uma ingasadingeki
- Ngiyavuma futh ukuthi:

Ningirekode mangiphendula YEBO/CHA
Ningathwebula nezithombe zomhlangano YEBO/CHA

- Ngenxa yeRekhodi, kufanele nivume ngokusayina ideclaration ngezansi ngaphambi kokuphendula imibuzo (**Abangaphansi kweminyaka ewu 18 kuzofanele basayinelwe abazali babo).**
- Uma unemibuzo noma ufuna ukwazi eminye imininingwane mayelana nocwaningo ungangithola kule nombolo: 073 829 8728 noma kuEmail ablayende@gmail.com

Mina…… (Amagama aphelele nesibongo) ngiyaqiniseka ukuthi ngichazelekile kahle ngalemibuzo engizobuzwa yona futhi ngiyasiqonda isizathu salolucwaningo nokuthi yonke imininingwane etholakele izohlolwa. Ngiyavuma ukuba ingxenye yalolu cwaningo, ngiyaqonda ukuthi kuyavolontiywa ukuba ingxenye yalolucwaningo nanokuthi ngingashiya phakathi uma ngifisa

Sayina……
Usuku……..

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban, 4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557 - Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

Questionnaires for Research. (IsiZulu)

Topic: Farmers' perception and adaptation to climate change: case study of vulnerable areas in Mhlathuze local municipality (KwaDlangezwa) in KwaZulu-Natal, South Africa.

Name of Interviewer: _____
Date: _____
Time: _____
Farm/Village name: _____
Contact details: _____
Name of Enumerator:

SECTION A: SOCIO-ECONOMIC DEMOGRAPHIC DATA

1. Gender/ *Ubili*

1.	Male/ *Ngingowesilisa*	
2.	Female/ *Ngingowesifazane*	

2. Age of head of household/ *iminyaka*

1.	Below 25 years	
2.	25-35 years	
3.	36-45 years	
4.	46-55	
5.	Over 55	

3. Marital Status of household head/ *Isimo somshado*

1.	Single/ *angishadile*	
2.	Married/ *ngishadile*	
3	Divorced/ *ngihlukanisile*	
4.	Widow/Widower/ *umfelwa- umfelwakazi*	

4. Level of Education/ *Izinga lemfundo*

1.	No schooling completed/ *angifundile*	
2.	Primary Schooling/ *amazinga aphansi*	
3.	Secondary Schooling/ *amazinga aphakathi nendawo*	

4.	Tertiary/ *amazinga aphezulu*	

5. What is your major source of income?/ *Iholo olitholayo liphuma kuphi*?

1	Wages/part-time/ *Etohweni*	
2	Salary/ *Iholo elivela emsebenzini njalo ngenyanga*	
3	Pension/ *Imali yempesheni*	
4	Government Grant/ *imali kahulumeni*	
5	Farming/ *imali yokulima*	
6	Other/ *okunye*	

6. Total income per month/ *Ingakanani imali engena njalo ngenyanga ekhaya?*

1	Below R800.00	
2	R801.00- R1,500.00	
3	R1,501.00- R3,500.00	
4	Above R3, 500.00	

7. Employment Status/ *umsebenzi*

1.	Employed full-time/ *umqhashwa ophelele*	
2.	Employed Part time/ *umqhashwa wesikhashana*	
3.	Unemployed/ *angiqashiwe*	
4.	Self-employed/ *ngiziqashile*	

8. Total number of individuals in household/ *Nibangaki enihlala endlini noma ebaleni elilodwa*?
……

9. How long have you been farming?/ *singakanani isikhathi ulima?*

……. (Years)/ *Iminyaka*

10. Which type of farming activity are you involved in?/ *uhlobo lokulima olenzayo?*

Please **Tick** the appropriate answer

1.	Livestock farming / *imfuyo*	
2.	Crop farming/ izitshalo	
3.	Mixed farming/ *uxubile*	
4.	Other/ okunye	

11.11.

	a) What are the main crops grown/animals kept?/ *iziphi itshalo noma imfuyo onayo*	b) What are the main products sold?/ *ikuphi okudayisayo*
1.		
2.		
3.		
4.		

12. How do you select crops for produce?/ *uyikhetha kanjani imfuyo etshalwayo* ?

(Rank the top 3)

1.	Early maturity/ *isheshe ikhule*	
2.	Resistance to disease/ *ngokuvikeleka kumagcikwane*	
3.	Resistance to drought/ *ngokuvikelea kusimo sesomiso*	
4.	High yield potential/ *isivuno esiningi*	
5.	Easy market access/ *iyashesha ukuthengeka/ukutholakala*	
6.	Easy management of crop/ *kulula ukunakekela izitshalo*	
7.	Human consumption/ *udliwa abantu*	
8.	Other/ *okunye*	

13. Who mainly influences your crop selection?/ *ubani okwenza ukhethe imfuyo yakho*

1.	Extension officers advise/ *abasebenzi bakahulumeni abasiza abalimi*	
2.	Farmer to farmer advise/ *ukuboniswana phakathi kwabalimi*	
3.	NGOs advises/ *ukuboniswana kwama organisation*	
4.	Myself/ *uwena*	
5.	Indigenous Knowledge/ *ulwazi enakhula nilwazi*	
6.	Other specify/ *okunye cacisa*	

14. What is your source of water for crop irrigation?/ *amanzi okuthelela imfuyo*

1.	Rain fed/ *imvula*	
2.	Tank/ *itagi*	
3.	Taps/ *upopi*	
4.	Rain harvest/ *ukukhomgozela kwamanzi emvula*	
5.	River/ *umfula*	
6.	Dam/ *idamu*	

15. What is the purpose of smallholder farming to your family?/ *siyini isizathu sokulima emdeninini wakho?*

1.	Consumption/ *ukudla*	
2.	Selling purpose/ *ukudayisa*	

3.	Supplementary/ *ukwenzela nje*	
4.	Other Specify/ *okunye*	

16. What is the estimated proportion of the produce that is sold?/ *ingakanani imfuyo/izitshalo enidayisayo?*

1.	Quarter of produce/ *ikota*	
2.	Half of the produce/ *uhafu*	
3.	All of the produce/ *konke*	
4.	Don't sell/ *anidayisi*	

17. Total income received from selling agricultural your agricultural products (monthly)?/

Imali eniyenza manidayisa ngenyanga?

18. What is the total hectare of your land? *ubukhulu bomhlaba wakho?*

1.	Less than 1 ha/ *kunzane ne 1ha*	
2.	greater than 1 and less 2.5ha/ *kukhuku ne 1 kuphinde kube kucane ne 2.5 ha*	
3.	Greater than 2.5/ *bukhulu ne 2.5 ha*	

19. What is the location of your land?

1.	Upper land	
2.	Low land	
3.	Plain	
4.	River valley	

SECTION B: INFORMATION ON FARMERS PERCEPTIONS AND AWARENESS

20. Have you ever heard about climate change?/ *suke wezwa ngokujikajika kwesimo zezulu?*

1.	Yes/ *yebo*	
2.	No/ *cha*	

21. What do you know about it?/ *wazini ngaso ?*

_____

_____

_____

_____

_____

22. How were you made aware of climate change?/ *wezwa kanjani ngokujikajika kwesimo sezulu?*

1.	TV	
2.	Radio/*umsakazo*	
3.	Newspaper/ *iphephandaba*	
4.	Farmers' union / *inyunyana yabalimi*	
5.	Friends and neighbours / *abangani Kanye nomakhelwane*	
6.	Extension workers / *abasebenzi bakwa hulumeni abasiza abalimi*	
7.	Others/ *abanye*	

23. What is climate change for you?/ *Ngokucabanga kwakho ngabe yini ukujikajika kwesimo sezulu?*

1.	Flood or intense rain	
2.	Drought	
3.	Unusual change of nature	
4.	Irregular temperature	
5.	High temperature	
6.	Low rainfall	

25. What are the causes of climate change?

1.	Nature or bad given (bad luck)	
2.	Manmade causes	
3.	Do not know	

26. Perceived change in temperature?

1	Increase	
2.	Decrease	
3.	No change	

27. Perceived change in rainfall?

1.	Increase	
2.	Decrease	
3.	No change	

28. What are main the changes in the weather have you observed in your community over the past 15 years?/ *uluphu ushitsho osulubonile eminyakeni ewu 15 ngesimo sezulu?*

1.	Floods/ *isikhukhula*	
2.	Prolonged drought/ *isimo eside sesomiso*	
3.	Very hot seasons/ *inkathi ende yokushisa*	
4.	Very wet seasons/ *inkathi ende yokunetha*	

5.	No changes have been observed/ *alukho ushitsho olibonile*	

29. Please specify if it's a combination/ *cela ucacise uma kukhona okunye*

_____
_____
_____
_____
_____

30. What are the main impacts of these changes in the community?/ *umuphi umthelelo owenze ushitsho kakhulu emphakathini?*

1.	Crops failure/ *ukwehluleka kwezitshalo*	
2.	Death of livestock/ *ukufa kwemfuyo*	
3.	Food insecurity/ *ukungabi nokudla okwanele*	
4.	Human disease outbreak/ *izifo*	

31. Have you experienced low crop yields in the past 15 years?/ *uku waba nezithelo esincane eminyakane ewu 15?*

1.	Yes	
2.	No	

32. How severe has the loss been in the past 15 years?/ *ubunzima bokulahlekelwa imfiyo eminyakeni ewu 15?*

1.	Very severe/ *bunzima kakhulu*	
2.	Moderately severe/ *bunzima kancane*	
3.	Not severe/ *abukho nzima*	

33. What do you think are the causes of yield loss?/ Ngabe yini eyenza niphelelwe Imfuyo/izitshalo?

1.	Natural causes (droughts, hails, floods)/ *izimo zemvelo*	
2.	Pest damage/ *izinambuzane*	
3.	Disease outbreak/ *Ukuqubuka kwesifo*	
4.	Lack of farm inputs/ *ukungabi nezinto zokulima*	
5.	Lack of water/ *ukungabi namanzi*	

34. Please specify if it's a combination/ *cacisa uma kuhlangene*

_____
_____
_____
_____

SECTION C: INFORMATION ON ADAPTATION OPTIONS PRACTICED BY SMALL HOLDER FARMERS

35. Have you been trained on climate change intervention?/ *Uke waqeqeshwa ngokuzivikela kulesimo sokujikaka kwesimo sezulu?*

1.	Yes/ *yebo*	
2.	No/ *cha*	

36. Have you made any adjustments in your farming practices to climate change? Khona ukulungiswa okwenzile ngendlela olima ngayo ?

1.	Yes/ yebo	
2.	No/ cha	

37. If yes please specify what adaptations did you use to deal with temperature changes? / *uma uthi yebo ikuphi ukulungiswa okwenzile?*

1.	Crop variety and diversification/ *ukutshala izitshalo ezihlukahlukene*	
2.	Changing dates of planting/ ukushitsha izinsuku zokutshala	
3.	Build water harvest scheme*/ ukukwakha izinto zokukhongozela amanzi*	
4.	Mixed Cropping/ *ukutshala okuxubile*	

38. Please specify if there's any other/ *cacisa uma kukhona okunye*

_____
_____
_____
_____
_____

39. What adaptations did you use to deal with the changes in rainfall?/ *ikuphi ukulungiswa enikwenzile mayelana nokushitsha kwesimo zemvula?*

1.	Crop variety and diversification / *ukutshala izitshalo ezihlukahlukene*	
2.	Changing dates of planting/ *ukushitsha izinsuku zokutshala*	
3.	Build water harvest scheme*/ ukukwakha izinto zokukhongozela amanzi*	
4.	Intercropping Cropping/ *ukutshala okuxubile*	

40. Do Extension officers provide climate change support? *Ngabe kukhona ukweseka enikuthola kwabasebenzi bakwahulumeni mayelena nokujikajika kwesimo sezulu?*

1.	Yes/ *yebo*	
2.	No/ *cha*	

41. In a month approximately how much money is spent towards adapting to climate change?/ *ngenyanga ngabe malini eniyisebenzisa ngokuzivikela kusimo sokujikajika kwesimo sezlu?*

_____

42. Do you receive climate change support from institutions/organisation?

1.	Yes	
2.	No	

43. If yes please provide the name of the institution/organisation and support they provide

Institution/organisation	Support provided

SECTION D: INFORMATION ON BARRIERS TO ADAPTION OF CLIMATE CHANGE

44. If you have not adopted any of the adaptation measures what made you not to adapt?

Uma ungakaze uzivikele ngabe yini isizathu salokho?

1.	Lack of information/ *ukungabi nemininigwane*	
2.	Lack of inputs/ *ukungabi nezinto zokwenza*	
3.	Drought/Water shortage/ *isomiso/ ukungabi namanzi anele*	
4.	Do not see the need/ *anisiboni isidingo*	
5.	Poor health/ *ukungaphili kahle empilweni*	

45. How do you feel about climate change adaptation?/ *uzizwa kanjani ngokulungiswa ngokujikajika kwesimo sezulu?*

1.	Fearful/*ukwesaba*	
2.	Helpless/ *ukungasizeki*	

3.	Assured/ *unethamba*	
4.	Powerless/ awanamandla	
5.	Encouraged/ *ukhuthazekile*	

SECTION E: INFORMATION ON THE SEVERITY OF CLIMATE CHANGE ON FARM INCOME AND FOOD SECURITY.

46. Do you think the change in climate has affected your agricultural activities?/ *ngoku cabanga kwakho ngabe ukujikijika kwesimo sezulu kuyilimazile indlela olima nagyo?*

1.	Yes/ *yebo*	
2.	No/*cha*	
3.	Not sure/ *angazi kahle*	

47. How has climate change affected your farm income?

1.	Increase	
2.	Decrease	
3.	No change	

48. Have you ever experienced shortages of agricultural-based food items at your household?/ *seke nangaba nakho ukudla okunganele endlini?*

1.	Yes/ *yebo*	
2.	No/ *cha*	

49. If yes, what were the reasons for the food shortages?/ *uma uthi yebo yini eyenze ukuthi ukudla kunganeli?*

1.	Price increase/ *ukunyuka kwamanani*	
2.	Droughts/ *isomiso*	
3.	Floods/ *izikhukhula*	
4.	Lack of farm inputs/ *ukungabi nezinto zokulima*	

50. Which months did you experience shortages of agricultural-based foods the most?/ *iziphi inyanga la nanshodelwa ukudla okutshaliwe kakhulu?*

1.	Dec-Feb	
2.	March-May	
3.	June-Aug	
4.	Sep-Nov	

51. How did you cope with these shortages?/ *naziphilisa kanjani ngenkathi kushoda?*

1.	Eat less food / *nadla kancane*	
2.	Change diet/ *nashitsha ukudla enikudlayo*	
3.	Borrowed money/ *naboleka imali*	
4.	Received food from relatives/ *nathola ukudla kuyihlobo*	
5.	Sent older children to work / *nathumela ingane endala ukuthi iyosebenza*	

Thank you

Ngiyabonga

APPENDIX B: Focus group discussion guide.

Focus group discussion guide

Consent Process

Consent forms for focus group participants are completed in advance by all those seeking to participate. Below is a summary of the information in the consent form that focus group organizers and facilitators should use to make sure participants understand the information in the consent form.

Thank you for agreeing to participate. We are very interested to hear your valuable opinion on your perceptions and adaptation to climate change, as well as the factordand barriers of adaptation to climate change and how these impact household food security.

- The information you give us is completely confidential, and we will not associate your name with anything you say in the focus group.
- We would like to tape the focus groups so that we can make sure to capture the thoughts, opinions, and ideas we hear from the group. No names will be attached to the focus groups and the tapes will be destroyed as soon as they are transcribed.
- You may refuse to answer any question or withdraw from the study at any time.
- We understand how important it is that this information is kept private and confidential. We will ask participants to respect each other's confidentiality.

Introduction:

1. Welcome

Introduce yourself and the note-taker, and send the Sign-In Sheet with a few quick demographic questions (age, gender) around to the group while you are introducing the focus group.

Review the following:

- Who we are and what we're trying to do
- What will be done with this information?
- Why we asked you to participate

2. Explanation of the process

Ask the group if anyone has participated in a focus group before. Explain that focus groups are being used more and more often in research.

About focus groups:

- We learn from you (positive and negative)
- Not trying to achieve consensus, we're gathering information
- In this project, we are doing both questionnaires and FDG's. The reason for using both of these tools is that we can get more in-depth information from a smaller group of people in focus groups. This allows us to understand the context behind the answers given in the written survey and helps us explore topics in more detail than we can do in a written survey.

Logistics

- Focus group will last about one hour
- Feel free to move around
- Where is the bathroom? Exit?
- Help yourself to refreshments

3. Ground Rules

Ask the group to suggest some ground rules. After they brainstorm some, make sure the following are on the list.

- Everyone should participate.
- Information provided in the focus group must be kept confidential
- Stay with the group and please do not have side conversations
- Turn off cell phones if possible
- Have fun

4. Turn on Tape Recorder

5. Ask the group if there are any questions before we get started, and address those questions.

6. Introductions

- Go around the table: where you were born etc.

The discussion begins, make sure to give people time to think before answering the questions and do not move too quickly. Use the probes to make sure that all issues are addressed, but move on when you feel you are starting to hear repetitive information

Climate Change related questions

1. What is your understanding and experience of climate change impacts in your farming community?
2. Are you well informed about issues related to climate change?

Adaptation Methods and Barriers.

3. What (other) adaptation methods have you put in place to protect crops and livestock from climate change? Why have you used those particular methods to protect your crops and livestock?
    - *Other Methods such as: seeking government aid, off-farm employment,reduction of consumption, use of credit service*
4. There are many reasons (barriers) that stop farmers from adapting to climate change, what are your reasons for that?
    - *Barriers such as: lack of farm labour poor soil fertility, Limited access to agricultural extension officers, Unpredictable weather, Less access to agricultural markets*
5. Do you think enough is being done for climate change by the National and local governments' authorities?

Food security and livelihoods

6. What are the main livelihoods in the community? (Ranked according to importance).
7. If you sell your produce to whom do you sell?
8. Do you think climate change causes a decrease in crop (and livestock) productivity how has that affected your household food security?

APPENDIX C: Approval letter.

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

19 February 2019

A LETTER OF PERMISSION TO CONDUCT RESEACRH.

Dear Tribal Council

I am Abla Nomfanelo Yende currently a student at the University of KwaZulu Natal, under the College of Agriculture, Engineering and Sciences. I am currently doing a Master of Agriculture Research under the Supervision of Mr. Denver Naidoo. The Title of my study is **Farmers' perception and adaptation to climate change: case study of vulnerable areas,** the main Objective of my study is: To investigate the smallholder farmer's perceptions and adaptation to climate change as well as the determinants and barriers of climate change adaptation: implication on household food security. I am writing to request permission to conduct my research in your area and to work with the smallholder farmers of Kwadlangezwa.

Kind Regards

AblaYende.

Signature [redacted] Date 19 February 2019

Tribal council

Stamp for approval:

KWAZULU NATAL DEPT OF LOCAL GOVERNMENT & TRADITIONAL AFFAIRS
2019 -02- 19
MKHWANAZI TRADITIONAL COUNCIL
P.O. BOX 14, KWA-DLANGEZWA 3868
UTHUNGULU DISTRICT
TEL: 035 7936 169

APPENDIX D: Ethical clearance

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

01 August 2019

Ms Abla Nomfanelo Precious Yende (213505648)
School of Agriculture, Earth & Environmental Sciences
Pietermaritzburg Campus

Dear Ms Yende,

Protocol reference number: HSS/0355/019M
Project title: Farmers' perception and adaptation to climate change: A case study of vulnerable areas in Mhlathuze Local Municipality (KwaDlangezwa) in KwaZulu-Natal, South Africa

Approval Notification – Expedited Application

In response to your application received on 04 April 2019, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 1 year from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

Dr Rosemary Sibanda (Chair)

/ms

Cc Supervisor: KD Naidoo
cc Academic Leader Research: Professor Trevor Hill
cc School Administrator: Ms Marsha Manjoo

Humanities & Social Sciences Research Ethics Committee
Dr Rosemary Sibanda (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 Facsimile: +27 (0) 31 260 4609 Email: [illegible]
Website: [illegible]

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