AN ANALYSIS OF CROP FARMERS' RESILIENCE TO CLIMATE CHANGE IN THE THULAMELA LOCAL MUNICIPALITY OF VHEMBE DISTRICT, LIMPOPO PROVINCE, SOUTH AFRICA

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DECLARATION

I Gwebu Mashoma Pusheletjo Nairobi (11640897) hereby declare that this research dissertation for Master of Science: in Agricultural Economics (MSCAEN) at the University of Venda hereby submitted by me to the Department of Agricultural Economics and Agribusiness, Faculty of Science, Engineering and Agriculture, has not previously been submitted for a degree at this or any other university and is my own work in design and in execution and that all reference materials contained herein has been duly acknowledged.

..... 04/05/2022

Signature: Miss Gwebu M.P.N Date:

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DEDICATION

I would like to dedicate this work to my family: my parents, Mr. M.J. and the late Mrs. C.S. Gwebu; my older sister, Kgaugelo; my younger brothers, Kabelo and Tshepiso; my niece and nephew, Khanyisa and Mpho. Last but not least, I would also like to dedicate this work to my daughter, Vhugala and husband, Nyiko Mashila.

ABSTRACT

Climate change is a well-known phenomenon, and it affects agriculture negatively. Due to the rising impacts of climate change, this study sought to assess resilience strategies that have been adopted by farmers to mitigate against the effects of climate change in the Thulamela Local Municipality. A mixed research design was used in this study. The simple random sampling techniques was used to select a sample of 180 farmers from a population of 300 registered farmers that used resilient strategies to mitigate the effects of climate change in Thulamela Municipality. Data was collected using structured questionnaires. The Statistical Package for Social Sciences (SPSS version 27) was used to analyse the data. The study used descriptive statistics, to analyse the socio-economic characteristics of farmers that have adopted resilience strategies and challenges faced by farmers when adopting the resilience strategies. Furthermore, the principal component analysis model was used to analyse the resilient strategies adopted by farmers and multinomial regression analysis was used to analyse the factors influencing the choice of resilient strategies by farmers. The study found that there are more females than male farmers that use resilient strategies to mitigate the effects of climate change and that farmers with more farming experience adopt better these strategies than those with fewer experience. It was also found that most farmers that participate in using resilient strategies have formal education. The resilient strategies used by farmers were crop diversification, soil conservation practice and crop management, cover crops and rainwater harvesting, fertilizer application and the use of resilient crop varieties. Again, the study revealed that the most common factors influencing the adoption of resilience strategies were educational level, extension support, farming under irrigation, having an income. The result on the challenges that farmers faced while adopting to the resilience strategies indicate that farmers are unable to access credit, they do not have enough agricultural information, they have no proper guidance in using some resilient strategies, they do not have enough water on their farms. The study recommends that extension officers should facilitate networking among farmers, wherein farmers with more farming experience could assist farmers with less experience on the best adoption of resilient strategies Also, there should be mechanisms to assist farmers to adopt resilience strategies even if they are expensive to adopt within their practices.

Keywords: Climate change, Resilience, Emerging farmers, smallholder farmers

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ABBREVIATIONS AND ACRONYMS

CSA	Climate Smart Agriculture
DAFF	Department of Agriculture Forestry and Fisheries
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GWP	Global Warming Potential
ICE system	Immersion Cooling Equipment
IPCC	Intergovernmental Panel on Climate Change
TLEDS	Thulamela Local Economic Development Strategy
UNEC-ACPC	United National Economic Commission of African Climate Policy Centre
UNFCC	United Nations Framework Convention on ClimateChange

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND

Climate change is a well-known phenomenon, and it affects agriculture negatively (Okonya, Syndikus and Kroschel, 2013). According to Food and Agriculture Organization (FAO) (2013) climate change results in loss of income, loss of agricultural production and loss of livestock. Furthermore, the relationship between agriculture and climate change is weakly understood given the limited progress made on mainstreaming climate change in the agriculture sector (FAO, 2010). In 2010 Climate Smart Agriculture was considered an ideal way forward to practice for minimising greenhouse gas emissions and improving food security (FAO, 2010).

As noted by Lipper et al. (2014) CSA is an effort to enhance agriculture development yet mitigating the impacts of climate change. Climate smart agriculture promotes the development of agricultural practices that enhance food security and increased farmers' resilience to climate change and minimise the emissions of Greenhouse Gases (GHGs) (FAO, 2010). According to Neufeldt et al. (2013) CSA can be a relevant tool for farmers to thrive in the face of climate change, increasing farmer's income as well as promoting agricultural productivity (FAO, 2013).

Literature attests that CSA promotes environmentally friendly farming systems by so doing it combines the improvements of social and ecological resilience (Nwajiuba, Emmanuel and Bangali Solomon, 2015). While some farmers have been trying to adapt to climate change, others have been developing resilience strategies to this phenomenon (Smit and Wandel, 2006). Farmers are faced with challenges of changing their choice of produce for products that are likely to survive the climatic changes to maintain their income (Warner, Kuzdas, Yglesias, and Childers, 2015). A study conducted by Maponya, Mpandeli and Oduniyi (2013) discovered that impacts of climate change within agriculture resulted to low production, similar findings that climate variability negatively affects crop productivity (Mugi-Ngenga, 2016). Resilience towards climate change will enable farmers to survive the impact of climate change

with ease (Mijatovic, Van Oudenhoven, Eyzaguirre and Hodgkin, 2013). Ford, Berrang-Ford, Bunce, McKay, Irwin and Pearce (2015) stated that resilience to climate change is gradually becoming an important aspect to mitigate the effects of climate change. Resilience has been identified to be a way of doing things for groups of people or communities to be ready for disasters which will eliminate recovery costs (Manyena, 2006). According to Mijatovic et al. (2013) resilience towards climate change will enable farmers to survive the impact of climate change with ease. The rate of CSA implementation has relatively been low, more especially in developing countries like South Africa (Ford et al., 2015).

Smallholder farmers are the most vulnerable group to climate change as they are not well informed with resilient strategies (Chandra, McNamara and Dargusch, 2018). Smallholder farmers ought to adjust their farming practices to suit climatic changes that are taking place around the world (Jost et al., 2016). There is a need to improve agricultural productivity and reduction of yield inconsistency over time in areas where the impacts of climate change are expected to be severe (FAO, 2010). Developing countries are considering CSA due to its potential to increase food security and implement farming systems that promote reductions of greenhouse gases emissions (FAO, 2013).

CSA promotes coordinated actions by farmers, researchers, private sector, civil society and policymakers towards climate-resilient pathways through four main action areas which are building evidence, increasing local institutional effectiveness, fostering coherence between climate and agricultural policies and linking climate and agricultural financing (Chandra et al., 2018). Resilience to climate change requires different characteristics. On the other hand, adaptation to climate change need different changes to successfully implement different adaptive measures and such changes may include infrastructure. Information processes and technologies (IPCC, 2011). With communities and households continually experiencing changes in social, economic, and environmental conditions, building resilience to mitigate and adapt to shocks and stresses associated with these inherent changes has become an urgent matter.

The recent emergence of concern over global food security amplified by anticipation challenges of climate change, according to Meye and Kirwan (2013) led to new

debates over the nature of future agricultural change. Developing countries are said to be the most vulnerable to climate change as they possess minimum financial and technical resources to successfully mitigate the challenge (Wheeler and Von Braun, 2013). Farmers are more likely to adopt to resilience strategies that they are aware of (Hyland et al., 2016). Farmers from rural areas have recognized the changes in rainfall patterns and extended dry spells which they link greatly with climate change (Belay, Recha, Woldeamanuel and Morton, 2017).

Developing policy that incentivizes the diversification of agricultural crops and landscapes may be a more rational strategy for developing resilient agricultural systems and protecting food production in the future under climate change (Lin, 2011). There is a need to develop an implementable climate change framework that reflects different needs of affected farmers (Phillipo, Bushesha and Mvena, 2015).

Policy plays a vital role in decision making of selecting resilience strategies and it may also pose some difficulties during the implementation process of adaptation response (Madzwamuse, 2010). In its endeavour to inculcate resilience, the South African government is introducing carbon tax, moreover to those that are major contributors to the emission of greenhouse gases (Van Heerden et al., 2016). Agricultural activities should be practiced in different ways that seek to reduce the cause of climate change and for that to be done; there is a need to develop clear institutional policy frameworks (Collier and Dercon, 2014).

1.2 STATEMENT OF THE RESEARCH PROBLEM

Climate change negatively affect agriculture around the globe (Cline, 2008). Limpopo province has been identified as one of the regions that is vulnerable to climate change reason being that it is a rural based province dominated by rural crop farmers (Rankoana, 2016). Literature attests to the existence of climate change challenges in the country, especially Limpopo province and according to Mudinda (2010), Thulamela Municipality in particular experiences periodic droughts and sometimes heavy flooding, climate change imperatives that have devastating effects on both livestock and crop farming. Emerging farmers are amongst those who are likely to be vulnerable to climate change, due to not having enough information on climate change (Chandra et al., 2018). Some climate change impacts result in loss of agricultural production, loss

of income, food insecurity and a decrease in the livelihood of the society (FAO, 2010). Climate smart agriculture has been identified as a tool to tackle the impacts of climate change, it aims at increasing agricultural productivity, improving farmers' resilience to climate change as well as reducing the emissions of GHGs (FAO, 2013). Resilience to climate change is gradually becoming an important aspect, though its implementation is relatively low more especially in developing countries (Ford et al., 2015). Farmers' adaptive capacity in developing countries seems to be relatively low, due to various factors (Harvey, 2014). This study therefore sought to respond to the question "how crop farmers in the Thulamela Municipality cope with the effects of climate change". Responses to this question was useful not only to the affected farmers but also to policy makers and implementers. The study will endeavour to contribute to the rapidly advancing body of climate change research in the social sciences through exploration of potential impacts and responses to the impeding climate change upon farmers in Thulamela Local Municipality of Vhembe District Municipality of Limpopo Province.

This allowed farmers' resilience to be investigated and in addition it will place the views and knowledge of farmers who live and work in the land at the centre of analysis.

1.3 JUSTIFICATION/RATIONALE OF THE STUDY

Since climate has been contributing towards food insecurity, this study will be of great importance as it addressed issues of how farmers may cope with the effects of climate change and how they can improve their resistance towards it. In the long run the study will also assist farmers to ensure food security through improved productivity.

1.4 RESEARCH OBJECTIVES, QUESTIONS

1.4.1 Main objective

The main objective of this study was to assess the resilience strategies that have been adopted by crop farmers in the Thulamela Local Municipality to mitigate against the effects of climate change.

1.4.2 Specific objectives

The above main objective was informed by the following specific objectives:

i. Identify and describe socioeconomic characteristics of the crop farmers that have adopted resilient strategies of climate change.
ii. Investigate climate change resilient strategies adopted by the crop farmers.
iii. Examine factors influencing climate change resilient strategies adopted by crop farmers in the Thulamela Local Municipality.
iv. Identify the challenges faced by the crop farmers in adopting the resilient strategies.

1.4.3 Research Questions

i. What are the socio-economic characteristics of crop farmers' that influence the adoption of resilience strategies to climate change?
ii. Which strategies have been adopted by crop farmers to mitigate the effects of climate change?
iii. What are the determinants of climate change resilient strategies adopted by crop farmers in the Thulamela Local Municipality?
iv. What are the challenges faced by crop farmers as they adopt resilience strategies?

1.5 CONCEPTUAL FRAMEWORK OF THE STUDY

To achieve the above objectives the suitable conceptual framework in relation to the research aim was devised. Conceptual shifts in agricultural geography will be considered with a particular focus on the behavioural approach combined with Cultural-behavioural approaches (Burton, 2004). Climate change affects agriculture negatively and it is a very well-known aspect (Okonya, Syndikus and Kroschel, 2013). Climate changed is caused by the following factors in the agricultural sector which are deforestation and the emission of greenhouse gases. FAO (2013) highlighted that climate change results in loss of income, loss of agricultural production and loss of livestock, since farmers are suffering from the impacts of climate change, they are finding ways to mitigate climate change conditions. Socio-economic characteristics of farmers play an important role in farmers trying to cope with climate change (Debela, Mohammed, Bridle, Corkrey and McNeil, 2015). Mehar, Mittal and Prasad (2016) stated that farmers who are likely to be more resilient to climate change are those who get extension services, have an agricultural educational background and male farmers are likely to make decision on which adaptive strategy to take as compared to female farmers. Bryan, Deressa, Gbetibouo and Ringler (2009) observed the following challenges faced by farmers while trying to mitigate climate change, which are lack of credit, lack of access to land, lack of water, lack of access to information, lack of extension services and lack of finances. Some of the coping strategies that have been considered useful for crop farmers to be resilient to climate change crops diversification, substitution, calendar redefinition and an increase in fertilizer application. The expected outcomes from the study which are improved resilience to climate change by farmers, enhanced awareness of resilient strategies that farmers can adopt and lastly enhanced farmers adaptation to climate change. The aim is to assess resilience strategies adopted by crop farmers to cope with climate change.

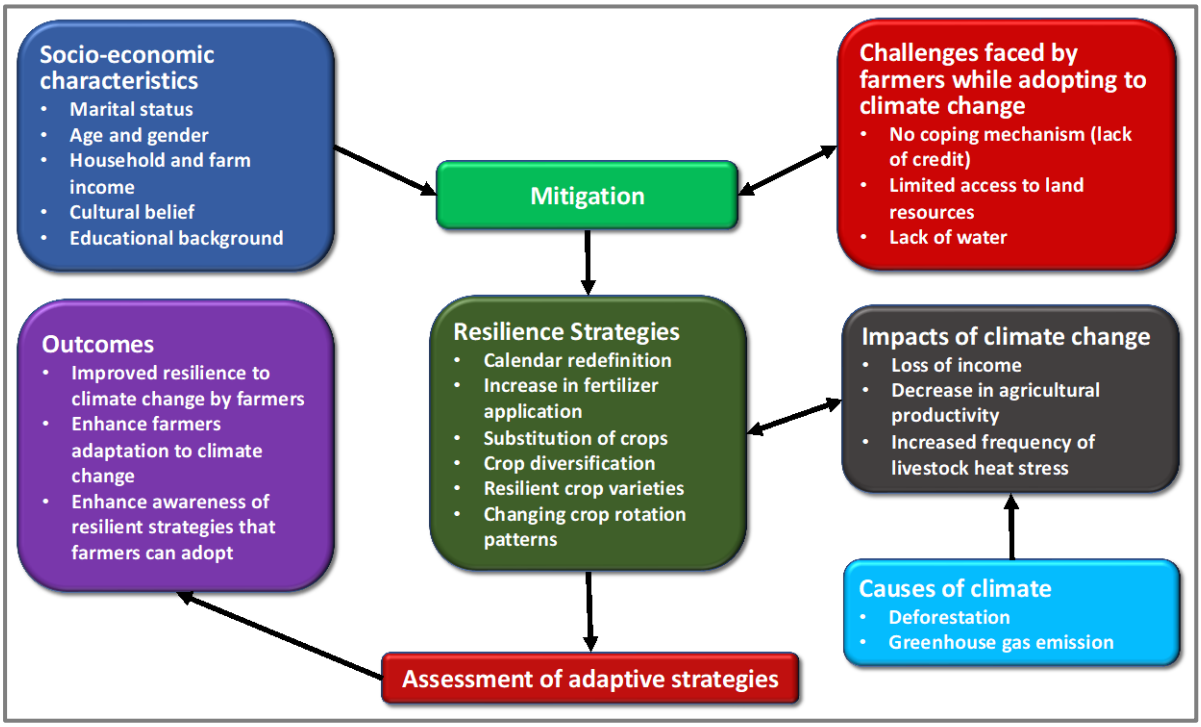

Figure 1.1: Conceptual framework of functional model

Adapted from Burton (2004).

1.6 OPERATIONAL DEFINITIONS OF KEY TERMS AND CONCEPTS

1.6.1 Resilience

Resilience can be defined as" the ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change" (Adger, 2000). The study will be adopting this definition, resilience is closely related to adaptation. I.e., a process at which the system (community) is able to adjust to changing conditions (FAO, 2010).

Resilience can be defined as "as a way to improve the livelihood of the human society through the maintenance of natural resources in the long-term" (Brand and Jax, 2007).

Resilience can be used as a way to enhance people's life through coping to external situations that are unfavourable from social or public related aspects (Ungar, Ghazinour and Richter, 2013). Resilience has been identified to be a way of doing things for groups of people or communities to be ready for disasters which will eliminate recovery costs (Manyena, 2006).

1.6.2 Smallholder farmers

Literature reviewed reveals several words referring to smallholder farmers and its characteristics, it is closely related to an emerging farmer. According to Department of Agriculture Forestry and Fisheries (2012), a smallholder farmer is a farmer owning small-based plots of land on which they grow subsistence crops and one or two cash crops, relying almost exclusively on family labour. A group of farms with inadequate resource endowment, in comparison to their respective counterparts in the farming sector (Barlow and Van Dijk, 2013). Most smallholder farmers, especially in developing countries, have limited capacity to adapt to climate change, given their low education levels, low income, limited land areas, and poor access to technical assistance, market and credits, and often chronic dependence on external support or government support, hence they face adverse climatic conditions (Vignola et al., 2015). This study adopts the definition of the term smallholder farmer" is alternatively used to refer to "communal farmer", "emerging farmer" and "black farmer" (Chikazunga and Paradza, 2012), according to Wiggins and Keats (2013) the term smallholder farmer has also been used to describe "the rural poor" and "emerging commercial farmers".

1.6.3 Emerging farmers

From subsistence, micro-scale, small-scale, emerging and established commercial farmers, the government has been investing towards commercialization of emerging farmers and despite such efforts, majority of emerging farmers are vulnerable to climate change (DAFF, 2012). The National Department of Agriculture defines emerging farmers as farmers who are the beneficiaries of one of governments land reform programmes (DAFF, 2012). According to Aliber and Hall (2012) Farmers who are mainly dependent on state and semi state organisations for support and finance, they consume and sell some portion of their harvest. This study defines emerging farmers as farmers that have the intention to produce and sell more and have the intention to expand.

1.6.4 Climate Change

Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (Bours, McGinn and Pringle, 2014). Climate change is caused by global warming due to the rising temperatures throughout the globe. Global warming on the other hand is a warming of the earth as a result of increased emission of Greenhouse Gases (GHGs) (Tol, 2006). According to FAO (2010) climate change is on-going changes in climatic system caused by anthropogenic global warming due to the increased GHGs emissions). It can also be regarded as a gradual change in climate standards and weather extremes (FAO, 2013).

1.6.5 Climate Smart Agriculture

Climate smart agriculture is an effort to enhance agriculture development yet mitigating the impacts of climate change (Lipper et al., 2014). Climate smart agriculture aims at increasing agricultural productivity, improving farmers' resilience to climate change as well as reducing the emissions of GHGs (FAO, 2013), therefore the study will adopt the previously mentioned definition. According to FAO (2010), "climate-smart agriculture is the agriculture that sustainably increases productivity, reduces climate change vulnerability (enhance adaptation), reduces emissions that cause climate change (mitigation), while protecting the environment against degradation and enhancing food security and improved livelihood of a given society". CSA combines the improvement of social resilience with the improvement of ecological resilience and promotes environment friendly intensification of farming systems, herding systems and the efficiency of sustainable gathering systems (Nwajiuba et al., 2015).

1.6.6 Mitigation

According to IPCC (2007) “mitigation is an intervention to reduce human-caused net emissions of greenhouse gases.” The study defines mitigation as the technological change and substitution that reduce energy resource inputs and emissions per unit of output. Climate change mitigation is a planned process that seeks to stabilise the pace and scale of climate change through reduction of emissions of GHGs (FAO, 2009). Although several social, economic and technological policies would produce an emission reduction, with respect to climate change, mitigation means implementing policies to reduce GHG emissions and enhance sinks (IPCC, 2007).

1.6.7 Livelihood

According to FAO (2010), for the developing countries like India, where a majority of families, in both the farm and non-farm sectors, derive their livelihoods from agriculture, sustainability of agriculture cannot be discussed or even defined in isolation of the issue of livelihoods. The study will adopt this definition of livelihood is defined as adequate stock and flow of food and cash with an individual or a family to meet its basic needs (Sharma, Rao, Vittal and Amarasinghe, 2006). It can also be defined as securing ownership of, or access to, resources and income-earning activities, including reserves and assets to offset risks, ease shocks and meet contingencies. According to Jonah, Maitho and Omware (2015) a farmer’s sustainable livelihood is determined by looking at assets that may be tangible, such as food stores and cash savings, as well as trees, land, livestock, tools, and other resources and assets may also be intangible such as claims one can make for food, work, and assistance as well as access to materials, information, education, health services and employment opportunities.

1.6.8 Greenhouse gases (GHGs)

Greenhouse gases vary in their ability to absorb and hold heat in the atmosphere. Emissions are expressed in terms of carbon dioxide equivalents (Ramachandra, Aithal and Sreejith, 2015). All greenhouse gases have what is called a global warming potential (GWP). These potentials relate to the heat-absorbing ability of each gas relative to that of carbon dioxide, as well as the decay rate of each gas (Montzka, Dlugokencky and Butler, 2011). The potential effect of methane and nitrous oxide is

considerably higher than carbon dioxide (Bessou, Ferchaud, Gabrielle and Mary, 2011). Agricultural emission of greenhouse gases does not include those from fossil fuels combustions arising from agricultural related processes such as transport, greenhouse heating or grain drying (Popp, Lotze-Campen and Bodirsky, 2010).

1.6.9 Food security

According to FAO (2010) food security is defined as the availability of food and one's access to it, a household is considered food secure when its occupants do not live in hunger or fear of starvation. Food security exists when all people, at times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an inactive and healthy life (FAO, 2009). According to Kabunga, Ghosh and Griffiths (2014) It is considered equivalent to the reliable availability of food towards the contemporary notion in which food is one of the elements of a complex social context that determines livelihoods. According to Meye et al. (2013) Food security is generally understood to incorporate four main components: food availability, food access, food utilisation and stability. Originally the term "food security" was used to describe whether a country had access to enough food to meet dietary energy requirements, the study will adopt the definition above. Food security at the national and global level tends to focus on the supply side of the food equation (Meye et al., 2013).

1.6.10 Adaptation

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities (Richardson, Steffen and Schellnhuber, 2009). Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC, 2001). Adaptation as a response to change must be appropriate to specific hazards or threats in a given period of time; in the same way, an effective adaptation to a real or perceived change in local climate could, over time, become inappropriate as circumstances changes (FAO, 2014). The study defines adaptation to climate change as the most practical strategy to control the impacts of climate change.

According to Pettengell (2010) it is important to determine farmers' awareness to climate change as well as factors that affect their respective adaptive choices. Adaptation is an adjustment through natural and human systems in response to climatic stimuli which might be harmful or beneficial to the climate system (IPCC, 2001).

1.6.11 Attitude

It can be defined as a predisposition or a tendency to respond positively or negatively towards a certain idea, object, person, or situation. Attitude influences an individual's choice of action, and responses to challenges, incentives, and rewards together called stimuli (Vaughan and Hogg, 2005).

1.6.12 Carbon tax

It can be defined as a tax levied on the carbon content of fuels. Carbon tax can also be referred to as a carbon dioxide equivalent tax. It effectively reduces greenhouse gas emissions (Department of Energy, 2013). It is argued that carbon taxes are the most efficient and effective way to curb climate change. Carbon tax has been introduced in South Africa in order to reduce carbon dioxide emission (Narayan and Narayan, 2010).

1.7 LIMITATIONS AND DELIMITATION

The major limitation of the study was lack of finances, since farmers are located at diverse locations, the travelling cost was high, and this negatively influenced the duration and time each farmer was visited for the purpose of the interview. The study focused on farmers within the Thulamela Local Municipality, with the sample size kept small to have enough time for the study.

1.8 OUTLINE OF THE RESEARCH STUDY

This research is organized into three chapters. Chapter 1 introduces the research topic and articulates the background for the study, problem statement, research objectives, hypothesis, questions and significance of the study and the operational key words and concepts. Chapter 2 presents the literature reviewed for the study. Chapter 3

discussed the research methodology adopted for the study, the description of the study area, research design, population and sampling procedure, data collection, data analysis, ethical consideration and expected outcome. Chapter 4 comprised presentation of results and discussion of the research results. Chapter 5 comprised the summary of the study, recommendations and conclusion of the study.

CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents the review of literature on resilience strategies that have been adopted by farmers to mitigate against the effects of climate change. It consists of literature where a review of previous studies related to this study are reviewed. This review is of a global, regional, and local context (South African and international studies). The chapter starts by the definition of climate change and resilience to climate change. The chapter further delve into the various strategies that have been adopted by emerging and smallholder farmers to mitigate the effects of climate change. Finally, the challenges faced by farmers as they adopt resilience strategies to mitigate climate change are discussed.

2.2 DEFINITION OF CLIMATE CHANGE AND RESILIENCE TO CLIMATE CHANGE

2.2.1 Definition of climate change

Climate change is caused by global warming due to the rising temperatures throughout the globe. Global warming on the other hand is a warming of the earth as a result of increased emission of Greenhouse Gases (GHGs) (Stern, 2006). Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCC, 2011). According to FAO (2010) climate change is on-going changes in climatic system caused by anthropogenic global warming due to the increased GHGs emissions). It can also be regarded as a gradual change in climate standards and weather extremes (FAO, 2008).

2.2.2 Definition of resilience to climate change

Resilience to climate change requires different characteristics. Information processes and technologies (IPCC, 2011). Resilience towards climate change will enable farmers to survive the impact of climate change with ease (Mijatovic et al., 2013). Resilience in agricultural regions can be derived from functional reinforcement across and within scales (Allison and Hobbs, 2004).

Resilience can be used as a way to enhance people's life through coping to external situations that are unfavourable from social or public related aspects (Ungar et al., 2013).

2.3 THE GLOBAL CHALLENGE OF CLIMATE CHANGE

Agricultural activities contribute about 10-12% of human generated greenhouse gas emissions (Pye-Smith, 2011). Climate change plays a part in the agricultural markets of different crops which tend to reduce the global GDP, when trade and production patterns can adjust (Costinot, Donaldson and Smith, 2016). Climate change is caused by failure reduction of greenhouse gas emissions from agricultural activities will increase future food risk (Pye-Smith, 2011). Climate change is likely to cause an increase of areas categorised as water-stressed, with agricultural productivity likely to reduce time after time (Debela et al*.,* 2015). Touch et al. (2016) attests that climate change is known to pose serious impacts on agricultural production worldwide and thus promoted implementation of different adaptation measures those farmers can apply to build resilience on climatic changing condition, resilience to climate change needs different characteristics. On the other hand, adaptation to climate change need different changes to successfully implement different adaptive measures and such changes may include infrastructure, information processes and technologies (IPCC, 2011). Developing countries are vulnerable to climate change though they are not affected equally, crop failures from natural disasters and soil loss caused by climatic changes impacted the livelihoods of small-scale farmers (Am, Cuccillato, Nkem and Chevillard, 2013). Climate change will also have a great impact on farmers in many ways, such as changes in crop yields due to variations in climate, thus affecting feed costs to farmers and of course reducing the amount of nutrients being fed to the animals (Moreki and Tsopito, 2013).

South Africa has been listed to be the largest CO_2 emitter in Africa. Though South Africa has been listed as a developing country with no obligation to reduce its GHG emission in Kyoto protocol; in 2009 South Africa has therefore committed itself to reduce its GHG emissions (UNFCC, 2011). Introduction of carbon tax is considered to be useful in internalising external costs induced by climate-related damages as well as introduction of carbon budgeting (Winkler et al*.,* 2012). Introduction of carbon tax is appropriate in GHG reductions, whereby GHG are significant emitters and will have to incorporate with the mitigation measures (National Treasury, 2013). While on the other hand some believe that the introduction of carbon tax is controversial with the opinion that the effectiveness of carbon tax is most likely dependent on the level of taxation (Department of Energy, 2013).

According to Oxfam International (2010) there was introduction of an adaptation finance which plans to support those who are severely affected by climate change by those who are capable to pay for such damages. In developing countries, smallholder farmers are the identified group most deserving for such support as they are the most vulnerable to climate change (Biagini, Bierbaum, Stults, Dobardzic and McNeeley*,* 2011).

2.4 THE GLOBAL FARMERS' RESILIENCE TO CLIMATE CHANGE

Adaptation in the context of climate change is viewed as a means of strengthening resilience of individuals and systems to climate change and climate variability. Resilience to climate change is planned when the actions that are taken are meant to reduce risk and utilise new opportunities that are brought about by global climate change (Saito, Boafo and Jasaw, 2018). Farmers' perception on resilience to climate change seems to shape their behaviour to adapt as well as influencing the choice of adaptation to climate change (Nguyen, Bonetti, Rogers and Woodroffe, 2016). According to Ampaire, Happy, Van Asten and Radeny (2015) most farmers are operating in degraded natural resource base and though majority of them intend to cope with the impact of climate change, they lack sound knowledge about adaptation to climate change options relevant to their production systems due to limited access to assets, technologies and financial services.

2.4.1 Farmers resilience to climate change in developed and developing countries

Smallholder farmers in developing countries are mostly affected by climate change. Climate smart agriculture needs supportive frameworks and public investments for successful implementation (Williams et al., 2015). Successful climate smart agriculture requires an in-depth understanding of association between farming and livelihoods practices as well as effects on farm performance. For every group of farmers, specific interventions should be designed to meet different needs. Interaction between the characteristics of the farm household and farm strategy clearly determines climate smartness of different farm strategies. There should also be a development of clear strategies used to assess climate smart interventions (Notenbaert, Pfeifer, Silvestri and Herrero, 2017). Successful promotion of climate smartness on small farms needs off-farm income to be placed in order before the interventions whereas for large farms, the focus should be on labours (Hammond et al., 2017). Farmers' perception to climate change influences their behaviour to cope with climate change (Nguyen et al., 2016). Farmers have a traditional way of adapting to their farming practices to different weather conditions and should therefore familiarise themselves with newly developed practices in order to reduce the negative impacts of climate change (Okonya, 2013). For farmers to execute such newly developed adaptive measures, they should be supported by policies and strategies (Stringer et al., 2009). Government policies need to support research and development that develops and diffuses the climate-smart technologies to help farmers respond changes in climatic conditions. Adaptations driven by policies tend to improve the resilience to environmental change (Stringer et al., 2009). In India, farmers frequently mentioned changing cropping patterns as well as resilient crop varieties as the most desirable adaptive measures in the face of climate change (Jost et al., 2016).

According to Mandleni (2011) it was predicted that certain animal species in South Africa will be extinct due to climate change. Farmers will endure more negative effects than the positive effects. Though there is massive research on effects of climate change there is less information about perceptions of rural farmers (Jokastah, Leahl Filho and Harris, 2013). United Nation Economic Commission of African Climate Policy Centre (Olutola, 2020) reported that crops will fail too often for maintaining current

livelihood strategies and that the temperature rise might be beyond capabilities for agriculture in Africa, making adaptation in some regions impossible. The major threat that climate change poses will be on food security and extended drought in Africa (Manyeruke, 2013).

2.5 CLIMATE CHANGE AND FOOD SECURITY

The climate is changing, which negatively impacts natural resources and food security (IPCC, 2007). Global warming has become one of the major challenges in maintaining global food security (Agili, 2012). The impact of climate change on crop yields is largely negative. For other grain crops, such as maize and soybean, up to 45% yield reductions are expected by the end of this century (Bita and Gerats, 2013). Developing countries are said to be the most vulnerable to climate change as they possess minimum financial and technical resources to successfully mitigate the challenge (Wheeler et al., 2013). Heat stress during flowering and grain filling stages results in decreased grain count and weight, resulting in low crop yield and quality, which in turn results in food insecurity (Bita et al., 2013). Frost is also a problem for crops, some crops need medium climate in order for them to grow and smallholder farmers have minimal finances to use resilient strategies to prevent crops from frost (Bimpong, Manneh, Sander, Futakuchi and Kumashiro, 2011). Soil and water conservation measure are important in maintaining crop productivity and building resilience against climate change (Burney and Naylor, 2012). The population is rapidly increasing in developing countries and food security is still an issue in most of the countries. Climate change has put a strain on food security, with countries unable to produce enough thus there is a need to improve productivity (Bita et al., 2013). Grasslands are important for global food supply. However, due to the rising population, extra food will need to come from the world's existing agricultural land base (O'Mara, 2012). Cattles are efficient converters of forages and poor-quality feeds into humanly edible energy and protein, and pasture-based food production can produce food with a comparable carbon footprint (Bauman and Collier, 2010). Pastures are a good storage of carbon. Grazing land management can also improve productivity (Thornton and Herrero, 2010). The application of different resilience techniques in Countries should aim to improve several critical components including soil health, water conservation, livelihood diversification and the capacity of local institutions (FAO, 2014), most of the cropped

area is rainfed, development of small-scale irrigation would be the most crucial step in ensuring future food security (FAO, 2014).

2.6 FARMERS' KNOWLEDGE AND UNDERSTANDING OF CLIMATE CHANGE

Farmers' views of climate change and their farming practices will provide information of ideal interventions for successful adaptation to climate change. Farmers are aware of climatic changes and have subsequently adjusted their farming practices to adapt. Smallholder farmers are likely not to take adaptive measures due to their lack of information regarding climate change as well as lack of credit to adapt (Harmer and Rahman, 2014). According to Touch et al. (2016) famers' knowledge to climate change is vital. Crop farmers who are aware of climate change use resilience strategies so that they could minimize risks and cope with the impacts of climate change. Farmers' perception on climate change seems to shape farmers' behaviour to adapt as well as influencing the choice of adaptation to climate change (Nguyen et al., 2016). Farmers' perception and their interpretation of climate change influence their decision to adapt to climate change (Burnham and Ma, 2017).

2.7 SOCIO-ECONOMIC CHARACTERISTICS OF FARMERS AND PERCEPTION OF RESILIENCE STRATEGIES TO CLIMATE CHANGE

Socio-economic characteristics of farmers play a vital role on farmers' perception of climate change (Debela, Mohammed, Bridle, Corkrey and McNeil, 2015). Socio-economic characteristics of farmers such as age, education level and access to climate information as well as extension services do considerably influence the perception of farmers on climate change adaptation (Mehar et al., 2016). Since farmers who have access to extension services are likely to get adaptive measures based on the information and advice, they are receiving from extension workers (Debela et al., 2015). According to Murphy, Tembo, Phiri, Yerokun and Grummell (2016) farmers who are likely to be more resilient to climate change are those who get extension services, have an agricultural educational background.

According to Mehar et al. (2016) male farmers are likely to make decisions on which adaptive strategy to take as compared to female farmers. Access to agricultural support services improves farmers' awareness of climate change and their willingness

to adapt to climate change systems (Debela et al., 2015). There are various elements hindering farmers to adopt climate-smart agriculture more particularly smallholder farmers (Ampaire et al., 2015). Farmers' religious beliefs play a vital role on the willingness of farmers to adapt to climate change and it is also believed to shape the adaptive capacity of communities in response to climate change (Murphy et al., 2016).

Social-cultural belief is also an influencer of farmers' decision to mitigate the impacts of climate change through resilience (Nguyen et al., 2016). Study conducted by Bzugu, Egbeadumah and Ibrahim (2019) showed farmers' socio-economic characteristics that significantly influence farmers to select various resilient strategies towards deforestation were found to be age, farming experience and education status (Bzugu et al., 2019).

A study conducted in Nigeria revealed that the determinants of climate smart agriculture include education, income, credit, extension, livestock ownership, farming experience, land area cultivated, distance to the market and water resources, leadership position, risk orientation, gender, land ownership, household size (Onyeneke, Igberi, Uwadoka and Aligbe, 2018). Socio-economic factors are key elements for climate-smart adoption by farmers. Socio-economic characteristics of farmers such as education level, age group and gender status positively influence farmers' decision to adapt various climate change adaptive strategies (Bedeke, Vanhove, Gezahegn, Natarajan and Van Damme, 2019). There is a need to prioritise the identified climate smart interventions so that farmers may familiarise themselves with them (Makhubele, Shokane and Mabasa, 2016).

Socio-economic factors are key elements for climate-smart adoption by farmers (Long, Blok and Coninx, 2016). For every group of farmers, specific interventions should be designed to meet different needs. Interaction between the characteristics of the farm household and farm strategy clearly determines different farming strategies. Successful promotion of climate change adaptation on small farms needs off-farm income to be in place before the interventions, whereas for large farms, the focus should be on labour (Hammond et al., 2017).

A study conducted by Fadina and Barjolle (2018) revealed that the more experienced or literate farmers are, the better they adopt climate change adaptation strategies. The

results of factors influencing the choice of a specific adaptation strategy suggest that farming experience, educational level, gender and farm size are the most significant factors affecting the adaptation choice of farmers. Farming experience facilitates the identification and implementation of any adaptation strategy. A study conducted by Bedeke et al. (2019) revealed that adaptive strategies like the use of crop varieties and chemical fertilizers is commonly preferred by young and highly educated farmers whereas crop diversification and conservation tillage is preferredby farmers with large household size. The educational level has significantly influenced the choice of resilient strategies. A study conducted by Jost et al. (2016), it revealed that women appear to be less adaptive due to different contributing elements such as financial or resource constraints and other adaptive strategies which may create higher labour loads for women.

2.8 STRATEGIES ADOPTED BY SMALL HOLDER FARMERS TO MITIGATE THE EFFECTS OF CLIMATE CHANGE

According to Yéo, Goula, Diekkrüger and Afouda (2016) Crops diversification, substitution, calendar redefinition and an increase in fertilizer application are considered to be useful strategies which farmers have adopted in order for them to be resilient to climate change. There is also a need to support adaptation strategies such as development of new crop varieties that may be used to inform adaptation policies, strategies and measures (Sonwa et al*.,* 2017; Akinyi et al., 2021). Farmers found soil and crop management as effective strategies to reduce the effects of climate change. In India, farmers frequently mentioned changing cropping patterns as well as resilient crop varieties as the most desirable adaptive measures in the face of climate change (Jost et al*.,* 2016). Farmers with high level of education were found to have an enhanced level of adaptation, particularly using drought tolerant varieties, calendar redefinition and substitution of crops as their adaptive strategies.

Maddison (2007) observed that crop farmers focused more on changing planting dates when precipitation and times of rains varied. Likewise, in a study involving 1800 farming households in South Africa and Ethiopia, it was observed that commonly adopted resilience strategies among the farmers included, the planting of different crops and crops varieties, tree cultivation, soil conservation practice, irrigation and change of planting dates (Phuong, Biesbroek, Sen and Wals, 2018.). These associated

farm activities helped to reduce the production risk faced by the farmers. The increasing focus on adaptation of agriculture to climate change indicates the need for climate smart agricultural practices which could see to the reduction of GHG emissions and their adverse effects. By adopting to climate-smart agricultural practices it will help in reducing emissions such as nitrous oxide from applied fertilizers and methane from livestock operations (Alemu and Mengistu, 2019). The study identified various resilience strategies such as crop diversification, resilient crop varieties, substitution of crops, calendar redefinition, fertilizer application and changing crop rotation patterns. Crop diversification can be explained as the addition of new crops or cropping systems to agricultural production on a particular farm taking into account the different returns from value added crops with complementary marketing opportunities (Khanam, Bhaduri and Nayak, 2018).

2.9 THE CHALLENGES FACED BY FARMERS AS THEY ADOPT RESILIENCE STRATEGIES

Limited access to land resources and lack of water are challenges that affect farmers to adopt resilient strategies, particularly small-holder farmers (Onyango, 2014). It was however, observed that farmers who did not engage in any coping mechanisms cited lack of credit, lack of access to land and information for their inability to adapt to perceived climate change (Bryan et al*.,* 2009). Choy et al. (2016) identified the main factors constituting the adaptive capacity of a country to include, economic wellbeing and stability, demographic structure, global interconnectivity, institutional stability and wellbeing, and natural resource dependence.

Believably, most African farmers would easily adapt to changed climate if they had unfettered access to markets and new technologies (Nanjappan and Parameswaranaik, 2018). Though farmers are aware of adaptive measures, they seem hindered to take such adaptive measures into practice due to limited enforcement of policies and regulations (Ampaire et al*.,* 2017). There is no or limited well-structured functional operational structures outlined by policies to help farmers with such adaptation strategies.

Benhin (2006) reported that lack of access to credit or saving and lack of adequate information about climate change are some of the major constraints encountered by

farmers in adapting to climate change in Africa. Kassahun (2009) further confirmed that lack of access to credit and lack of information as major constraints on adapting to climate change in Ethiopia.

2.10 SUMMARY OF LITERATURE REVIEW

As observed from the above literature review, it was found that most farmers have challenges in adopting to resilient methods in order for them to cope with observed changes in the climatic conditions. It has also been observed that farmers who did not engage in any coping mechanism cited lack of credit, lack of access to land and information for their inability to adapt to perceived climate change. Farmers are aware of the adaptive measures, but adoption is hindered by limited intervention and introduction of policies surrounding farmers resilient to climate change. A study in South Africa showed that socioeconomic characteristics are also playing a huge role in farmers in the adoption to resilient strategies.

CHAPTER THREE
METHODOLOGY

3.1 INTRODUCTION

In this chapter, mixed method research approach was used. The description of the study areas was outlined. It was followed by the presentation of research aspects such as research design, population and sampling procedures, data collection, data analysis, ethical considerations, expected outcomes, feedback and dissemination plan.

3.2 DESCRIPTION OF THE STUDY AREA

The study was undertaken in Thulamela Local Municipality in the Limpopo Province of South Africa. The Thulamela Local Municipality is a Category B municipality. It shares municipal executive and legislative authority in its area with a category C municipality. It is situated within the Vhembe District Municipality in the far north of the Limpopo Province (Thulamela Local Economic Development Strategy, 2013). Agriculture is the main economic sector and most dominant in vegetable and subtropical fruits. Agriculture within the area is diverse in the sense that it is made up of commercial, emerging or smallholder and subsistence farming (TLEDS, 2013). Farming activities include crop-production, livestock production, agroprocessing, forestry, and aquaculture. Figure 3.1 below is a map of Limpopo Province showing the study area.

The Municipality has a strong tradition of livestock production, particularly cattle and goats. There are also varied cropping systems including horticulture. The municipality is situated in the eastern subtropical region of the province, and it is generally hot and humid. Considerable diversity in agricultural production has evolved over time with contrasting land scape of cropping and livestock.

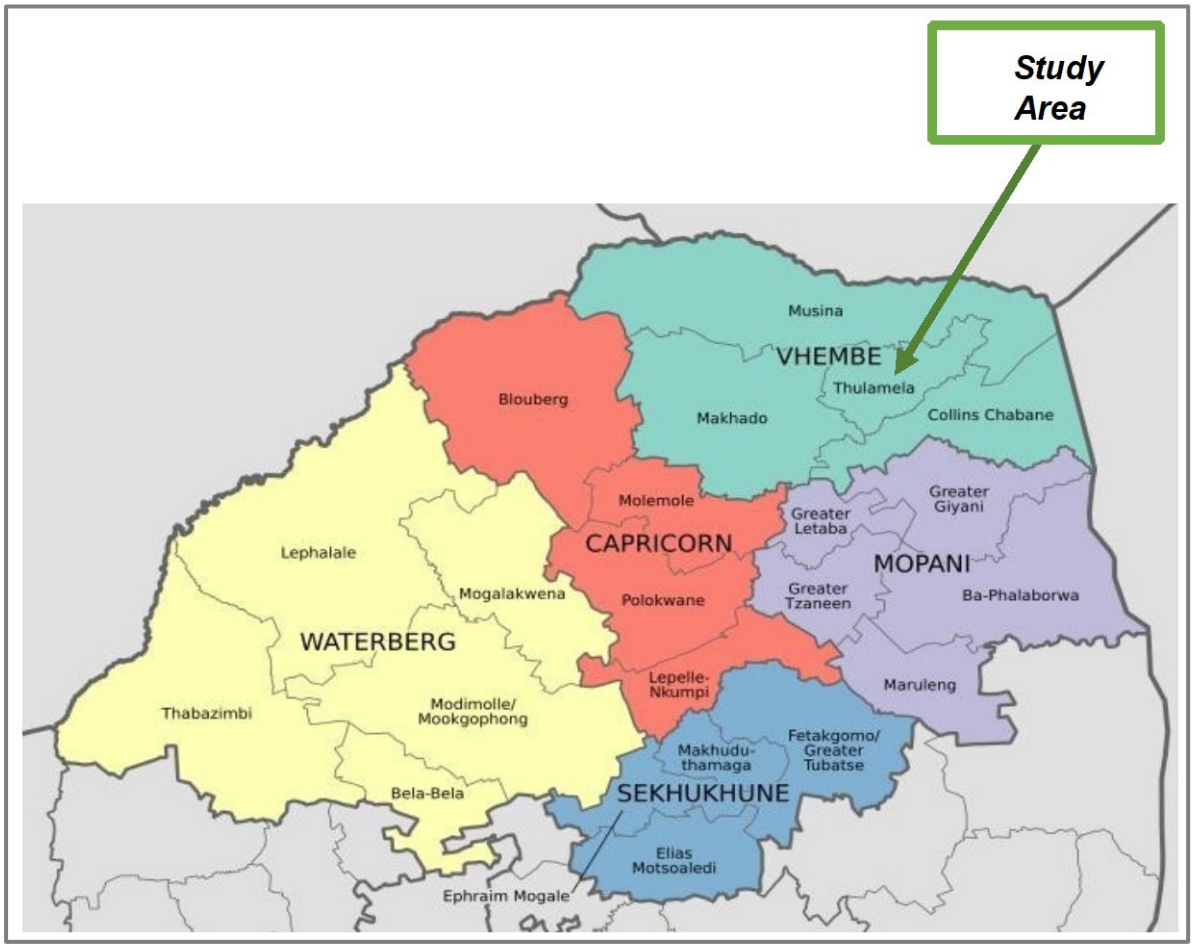

Figure 3.1: The Map of Limpopo Province showing the study area

Source: https://oursouthafrica.wikispaces.com/The+Nine+Provinces

The study focused on villages around Thulamela local municipality. The villages were selected as study areas due to their agricultural diversity, known experiences of extreme weather events and farmers that use resilient strategies to cope with the changing climatic conditions. The targeted groups are summer crop farmers, and cash crop farmers. When there are extreme weather patterns for example if there is extreme heat for subtropical farmers, there is a high possibility of outbreaks of pests and diseases. Each commodity has its stresses when it comes to climatic conditions. According to a study conducted in Limpopo by Ubisi, Mafongoya, Kolanisi and Jiri (2017), farmers in rural areas have been experiencing low agricultural productivity, crop failure, human disease outbreak, pests and diseases affecting both livestock and crop production.

3.3 RESEARCH DESIGN

A research design is a systematic plan to study a scientific problem. It is also referred to as the overall strategy that one chooses to integrate the different components of the study in a coherent and logical way. Saunders, Lewis and Thornhill (2016) emphasised that the nature of the study together with the research questions of the study guide a research design to be employed. A research design ensures the effective address of the research investigation and constitutes the blueprint for the collection, measurement, and analysis of data (De Vaus, 2006).

Mixed methods research design was used in this study. According to Johnson, Onwuegbuzie and Turner (2007), a mixed method research design is a procedure for collecting, analysing and mixing both qualitative and quantitative research approaches in a single study to understand the research problem. Its central premise is that the use of quantitative and qualitative approaches provides a better understanding of research problems than either approach alone. The objective of using both methods is to draw upon the strength and minimise the weakness associated with a single research method (Terrell, 2011). The descriptive survey design and the cross-sectional research design were employed in the conduction of this study. The descriptive research design is chosen because it helps to describe, record, analyse and interpret the conclusions that exist in the study (Salaria, 2012). The descriptive research design can answer the questions of how? And why. The study also adopted the cross-sectional research design, which the researcher collects data from many different individuals at a single point in time (Busk, 2014). Qualitative data was used at one face of the study and the quantitative data was used to determine the socio-economic characteristics of farmers.

3.4 POPULATION AND SAMPLING PROCEDURE

The population consisted of 300 farmers that use resilient strategies to cope with climate change in the Thulamela Local Municipality. Simple random sampling was used for this study to get a sample size of 180 farmers in the Thulamela Municipality.

3.5 DATA COLLECTION

Both primary and secondary data were collected. Quantitative and quantitative data was collected with the aid of a structured questionnaire completed by personal interviews, key informant interviews. Focus group discussion per area was not feasible due to the strict covid-19 lockdown regulations which prohibited gatherings. Secondary data was collected from textbooks, journals, internet and other relevant literature sources.

3.6 DATA ANALYSIS

Data capturing was done using Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS version 27). In the study the following methods of data analysis were employed: Descriptive Statistics, Multinomial Linear Regression and Principal Component Analysis.

3.6.1 Objective 1: Identify and describe socioeconomic characteristics of the farmers

Descriptive statistics such as frequencies, tables and percentages were used analyse and presents information on farmers' socioeconomic characteristics (objective 1) in the study area.

Descriptive statistics of data limits generalization to a particular group of individuals observed. No conclusions extend beyond this group and any similarity to those outside the group cannot be assumed. The data describe one group and that group only. Much simple action research involves descriptive analysis and provides valuable information about the nature of the particular group of individuals (Best and Kahn, 2003).

3.6.2 Objective 2: Investigate climate change resilient strategies adopted by the farmers

The aim of Principal Component Analysis was to reveal any latent variables that cause the patent variables to covary. During factor extraction the shared variance of a variable is partitioned from its unique variance and error variance to reveal the underlying factor structure; only shared variance appears in the solution. PCA was used to visualise correlations amongst the original variable components by reducing

original variables into non-correlated variables (Fabrigar, Wegener, MacCallum and Strahan, 1999). PCA was used to define variables for each factor of latent variables.

According to Wold, Esbensen and Geladi (1987) Principal component analysis (PCA) is a multivariate technique that analyses a data table in which observations are described by several inter-correlated quantitative dependent variables. Its goal is to extract the important information from the table, to represent it as a set of new orthogonal variables called principal components, and to display the pattern of similarity of the observations and of the variables as points in maps (Abdi and Williams, 2010).

The estimated model

The empirical model was specified in the following format below:

$R_i = f\ (X_{1i,}\ X_{2i,}\ X_{3i,}\ X_{4i,}\ X_{ki,})$,

Where R= factor categories *I*= is the measured value of variables

$X_{1i,}\ X_{2i,}X_{ki}$ = explanatory variables

The following variables will be fitted to the Principal Component Analysis model as:

$R_i = f\ (Divers_{1i,}\ Sub_{2i,}\ Redef_{3i,}\ Ferti_{4i,}\ Varie_{5i,}\ Conserv_{6i,}\ Culti_{7i},\ Manage_{8i})$

Description of variables

Table 3.1: Description of objective 2 variables

Independent Variables	Description	Expected outcomes on how it affects adoption of resilient strategies
X_1 –DIVERS	Crop diversification	+
X_2 –SUB	Substitution	+
X_3 -REDEF	Calendar redefinition	+
X_4 -FERTI	fertilizer application	-
X_5 –VARIE	Resilient crop varieties	+
X_6 -CONSERV	Soil conservation practice	-

Independent Variables	Description	Expected outcomes on how it affects adoption of resilient strategies
$X_{7\text{- CULTI}}$	Crop rotation	-
$X_{8\text{- MANAGE}}$	Crop management	+

3.6.3 Objective 3: Examine factors influencing the climate change resilient strategies adopted by crop farmers in the Thulamela Local Municipality

Multinomial Linear Regression Model was used to analyse the determinants of climate change resilient strategies adopted by farmers. The relationship between two or more variables were analysed. Dependent variables are all the resilience strategies listed and the independent variables are the factors influencing selection of resilience strategies.

The estimated model

The empirical model can be specified in the following format below:

$$Y = \beta 0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_k X_k + Ut \quad (1)$$

Where: • Y = select the resilience strategies that you have adopted • $\beta 0$= Intercept

• K + 1= parameters

• $X_1, X_2 X_k$,= explanatory variables

• Ut = disturbance or error term

The following variables will be fitted to the model as:

Fitted model

$$Y = \beta 0 + \beta 1 X_{1\text{gen}} + \beta 2 X_{2\text{funds}} + \beta 3 X_{3\text{edu}} + \beta 4 X_{4marit} + \beta 5 X_{5\text{ownership}} + \beta 6 X_{6\text{marketaccess}} + \beta 7 X_{7\text{information}} +$$

$$\beta 8 X_{8\text{exten}} + \beta 9 X_{9\text{credit}} + \beta 10 X_{10\text{inc}} + \beta 11 X_{11\text{occupation}} + \beta 12_{12\text{method}} + \beta 13 X_{13\text{irrigation}} + Ut \quad (2)$$

Y= β0 + β1 farmers gender + β2 access to funds + β3 educational level + β4 marital status + β5 land ownership + β6 market access + β7 access to agricultural information + β8 extension support + β9 credit access + β10 source of income + β11 occupation + β12 method used + β13 farming under irrigation

Description of variables

Table 3.2: Description of objective 3 variables

Independent Variables	Description	Expected outcomes
X1- GEN	Farmer's gender	-
X2-FUNDS	Access to funds	+
X3-EDU	Educational level	+
X4-MARIT	Marital status of farmer	-
X5-OWNERSHIP	Land ownership	-
X6-MARKET	Market access	-
X7-INFORMATION	Access to agricultural information	+
X8-EXTEN	Extension support	+
X9-CREDIT	Credit access	-
X10-INC	Source of income	-
X11-OCCUPATION	Occupation	+
X_{12}-METHOD	Method used	+
X13-IRRIGATION	Farming under irrigation	+

3.6.4 Objective 4: Identify the challenges faced by the farmers in adopting the resilient strategies

Descriptive statistics was used to analyse the data collected for this objective 4, which are challenges those farmers are facing when adopting resilience strategies. Frequencies, percentages, and tables on demographic information such as no coping mechanism (lack of credit), Limited access to land resources, no proper guidance, lack of funds, limited enforcement policies and Lack of water.

3.7 ETHICAL CONSIDERATIONS

Ethical clearance was sought from the University of Venda Research Ethics Committee. Thereafter, written permission to conduct the study was sought from the Thulamela Local Municipality. This was achieved through holding meetings with community leaders, the local extension officer, Ward Councillor and Traditional leaders. These meetings helped gain community entry.

After written permission was secured to conduct the study, public meetings were held with the farmers with the aim of clarifying the nature of the study and how the results will be used. This cleared the way towards securing informed consent of the farmers to participate in the study. The consent form that explained to the farmers what the study focused on as well as their obligations and rights (Appendix D) were given to them. In order to ensure that participation was voluntary, all the data collection tools were accompanied by a written consent form which summarizes the study and its objectives. The form contained a clause that informed the participants that they can choose to discontinue their participation at any time. A confidentiality and secrecy declaration were also included in the form. Besides informed consent, the participants were made aware of what the data was used for. Upon completing the study, a feedback workshop will be held with the farmers. Information sheets that summarise the study objectives, approach, results, implications, conclusions and recommendations for policy and practice will be distributed to the farmers.

Table 3.3: Summary of research objectives, hypothesis, variables, data source, and data collection methods

Research Objectives	Research Questions	Research Hypotheses	Variables or Measurements	Data source	Data Collection Methods, Techniques and Tools
a) Identify and describe socioeconomic characteristics of the farmers that have adopted to resilient strategies of climate change.	i) What are the socioeconomic characteristics of farmers' that influence the adoption to resilience strategies to climate change?	i) Socio-economic Characteristics has a positive impact on farmers adoption to resilience strategies.		From participants	**Data tool:** Questionnaire **Data method:** Interview **Data analysis**: Descriptive Statistic Analysis
b) Investigate climate change resilient strategies adopted by the farmers.	ii) Which strategies have been adopted by emerging and smallholder farmers to mitigate the effects of climate change?	ii) The adoption of Resilient strategies is positively **influenced** by the type of crop the farmer plants.	**Dependent:** categories of resilient strategies **Independent:** Crop diversification, Substitution, Calendar redefinition, Increase in fertilizer application, Resilient crop varieties, Soil conservation practice, Tree cultivation, Crop management	From participants	**Data tool:** Questionnaire **Data method:** Interview **Data analysis:** Principal Component Analysis
c) Examine factors influencing or the determinants of climate change resilient strategies	ii) What are the determinants of climate change resilient strategies adopted by farmers	iii) The adoption of resilient strategies by farmers in the Thulamela Local Municipality is positively influenced	**Dependent:** Resilient strategies **Independent**: gender, access to funds, educational level, marital status, land ownership, market	From participants	**Data tool:** Questionnaire **Data method:** Focus group **Data analysis:** Multinomial linear regression

Research Objectives	Research Questions	Research Hypotheses	Variables or Measurements	Data source	Data Collection Methods, Techniques and Tools
adopted by farmers in the Thulamela Local Municipality.	in the Thulamela Local Municipality?	by determinant factors.	access, access to agricultural information, extension support, credit access, source of income, occupation, method used, farming under irrigation		
d) Identify the challenges faced by the farmers in adopting the resilient strategies.	iv) What are the challenges faced by farmers as they adopt resilience strategies?	iv) The adoption of resilience strategies of climate change is negatively affected by challenges that farmers are facing.		From participants	**Data tool:** Questionnaire **Data method:** Focus group **Data analysis:** Descriptive Statistic Analysis

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 INTRODUCTION

The results of each objective of this study are presented in this chapter. Resilient strategies that have been adopted by crop farmers to mitigate against the effects of climate change as well as the hypotheses are discussed in this chapter.

4.2 PRESENTATION AND DISCUSSION OF DESCRIPTIVE RESULTS ON SOCIOECONOMIC CHARACTERISTICS OF CROP FARMERS

Table 4.1: Socio-economic characteristics

Characteristics	Minimum	Maximum	Mean
Age	18	77	48.11
Income	1000	504000	32272.22
Farming experience	1	58	18.14
Land size	1	9	1.80

Source: Survey results (2021/2022)

Table 4.1 above shows the socio-economic characteristics of the respondents. The results from the study sample above showed the socio-economic characteristics of crop farmers that have adopted to resilience strategies of climate change. According to Debela et al. (2015) socio-economic characteristics play a vital role on farmers perception of climate change. Regarding the age of farmers, the study found that the youngest farmer was 18 years old, and the oldest farmer was found to be 77 years of age. Farming experience can be associated with age, the study found that the youngest farmer could have 1 year farming experience and the oldest farmer could have maximum farming experience of 58 years, these finding is supported by a study that states that older farmers have good farming experience or are more experienced in decision making of which resilient strategies to use (Alam et al., 2016). Whereas Income of the farmer can be associated with the experience of the farmers, the study found that in a good year a farmers can make a minimum of R1000 and a maximum

of R504 000, land size goes hand in hand with income, since farmers with 1ha make less money than farmers with 9ha.

Table 3.2: Gender

Gender	Frequency	Percentage
Female	97	53.9%
Male	83	46.1%
Total	**180**	**100%**

Table 4.2 above shows the gender of the respondents, the results from the study sample shows that in terms of gender equality, the study found that the majority of the interviewed farmers were female, though it contradicts with a study conducted by Mehar et al. (2016) which stated that male farmers are likely to make decisions on which adaptive strategy to take as compared to female farmers, though the narrative has changed , a study in Ghana revealed that female farmers are more likely to adapt to resilient strategies (Addaney et al., 2021) and in this study female farmers are the dominating group with percentage of 53.9%, whereas male farmers are taking up to 46.1% in the Thulamela Local Municipality.

Table 4.3: Marital status

Marital Status	Frequency	Percentage
Married	99	55%
Divorced	14	7.8%
Single	43	23.9%
Widowed	24	13.3%
Total	**180**	**100%**

Table 4.3 above shows the marital status of the respondents, The study found that the majority of the farmers were married at 55%, which helps them make decisions better and can choose resilient strategies that need manpower like crop rotation and crop management.

Table 4.4: Educational level

Educational level	Frequency	Percentage
No formal education	35	19.4%
Primary education	43	23.9%
Secondary education	66	36.7%
Tertiary education	36	20%
Total	**180**	**100%**

Table 4.4 shows the educational level of respondents, the study found that the educational level of the majority of farmers was secondary education which represented by 36.7% of the respondents, followed by those with primary education at 23.9% then tertiary education at 20% and lastly was the respondents who have no formal education with 19.4%, farmers with more education are more likely to use resilience strategies, this statement is supported by a study conducted by Mutandwa, Hanyani-Mlambo and Manzvera (2019) where it states that farmers that have formal education are more likely to use resilience strategies when trying to cope with the effects of climate change, crop farmers with high educational level adapt to climate change (Alam et al., 2016). Farmers who achieved primary and secondary level education had great chances of adopting multiple resilience strategies (Mutandwa et al., 2019).

4.3 PRESENTATION OF PRINCIPAL COMPONENT RESULTS ON RESILIENCE STRATEGIES ADOPTED BY CROP FARMERS

4.3.1 Scree plot

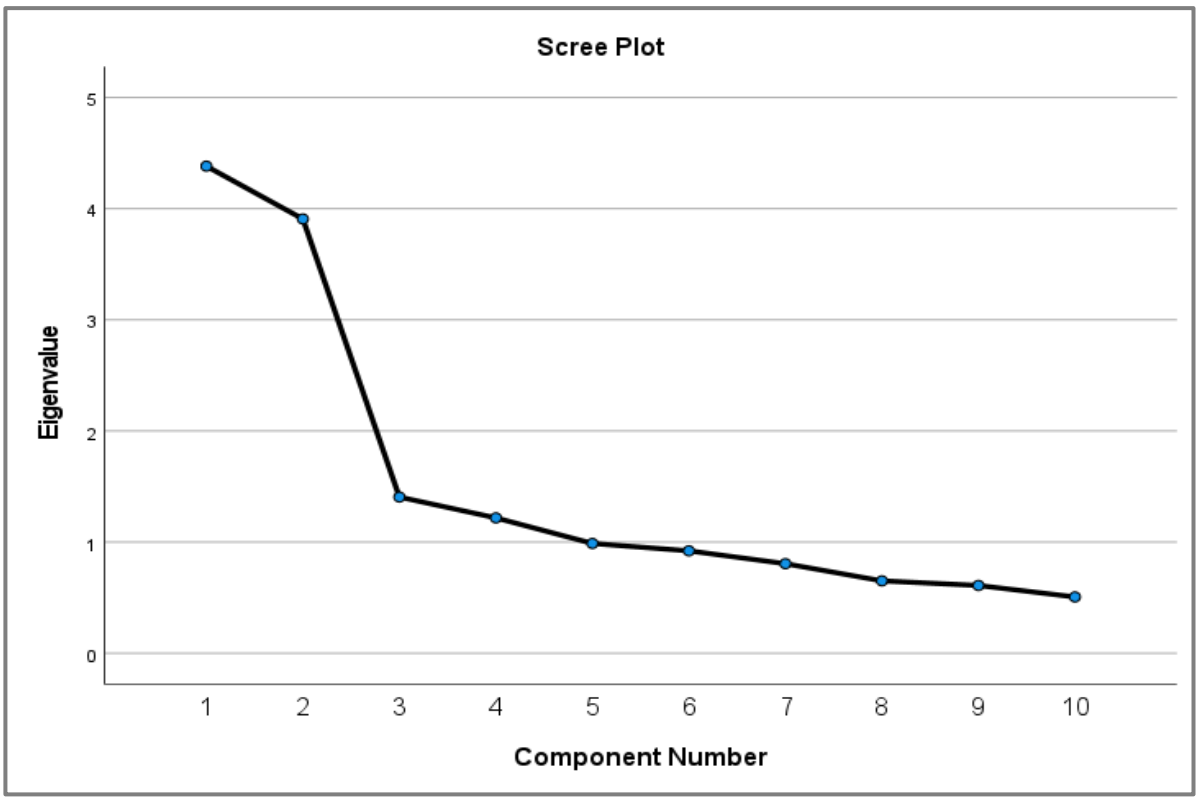

Figure 1.1: Scree Plot

The Scree Plot test above gave the four principal components. The adoption of resilience strategies was mainly influenced by factors which could be categorised into four components. The results indicated that the number of components of users was ranging between 1 and 4, for which PC_1 is environmental factors. PC_2 is biological factors, PC_3 is chemical factors and lastly PC_4 is technological factors. The results of the study were best interpreted using eigen values, as eigen values help to reduce a linear operation to separate, simpler problems. Pearson correlation matrix was used to single out the resilient strategies that were commonly adopted under various factors.

Table 4.5: Principal component (PC) retained, and percentage of variance explained

variables	Factor loadings			
	PC_1	**PC_2**	**PC_3**	**PC_4**
crop diversification	**.929**	.521	.477	-.119
fertilizer application	-.065	.143	**-.762**	.017
resilient crop varieties	-.409	.186	**.616**	**.696**
soil conservation practice	**.520**	-.095	.372	.040
crop management	**.841**	.029	-.052	-.023
crop rotation	-.459	-.024	.184	.184
no tillage/ minimum tillage	.138	.009	.207	.019
cover crops	.102	**.654**	.162	-.121
rainwater harvest	.020	**.974**	-.104	.016
mixed landscapes	-.079	-.169	-.071	**.750**
Eigen value	**25.781**	**48.769**	**57.040**	**64.208**
% Variance	**25.781**	**22.988**	**8.271**	**7.168**
Cumulative %	**25.781**	**48.769**	**57.040**	**64.208**

N=180

Source: study survey (2021/2022)

Principal component 1 (PC_1) contributed to 25.781 of the variations with an eigen value of 25.781 in the variables included and represented resilience strategies which were adopted by crop farmers and fall under environmental factors. All coefficients were positive indicating a positive correlation among the variables. The environmental factors PC equation could be represented as follows: Environmental factors: (PC_1) = 0.929X1 +0.520X4 +0.841X6

Principal component 2 (PC_2) contributed to 22.988 percent of variations with an eigen value of 48.769 in the variables included and represented resilient strategies which were adopted by crop farmers and fall under biological factors. All coefficients were positive indicating a positive correlation among the variables. The biological factors PC equation could be represented as follows: Biological factors: (PC_2) = 0.654X8 + 0.974X9

Principal component 3 (PC_3) contributed to 8.271 percent of variations with an eigen value of 57.040 in the variables included and represented resilient strategies which were adopted by crop farmers and fall under chemical factors. The chemical factors PC equation could be represented as follows: Chemical factors: (PC_3) = -0.762X2 + 0.616X3

Principal component 4 (PC_4) contributed to 7.168 percent of the variation with an eigen value of 64.208 in the variables included and represented resilient strategies which were adopted by crop farmers and fall under technological factors. All coefficients were positive indicating a positive correlation among the variables. The technological factors PC equation could be represented as follows: Technological factors: (PC_4) = 0.696X3 + 0.750X10

4.4 DISCUSSION OF RESILIENT STRATEGIES ADOPTED BY CROP FARMERS

According to the results from the principal component analysis, the resilient strategies adopted by crop farmers were therefore measured by factors that influenced crop farmers to use the resilient strategies chosen. The results indicated that the number of components of users was ranging between 1 and 4. For which PC_1 is environmental factors. PC_2 is biological factors, PC_3 is chemical factors and lastly PC_4 is technological factors.

The study showed the resilience strategies that are mostly or commonly used by farmers in the Thulamela Local Municipality, which were crop diversification, soil conservation practice and crop management, they were classified under environmental strategies, wherein farmers adopted the strategies mainly because they were concerned about environmental factors. A decision to use a certain adaptive strategy as a way to mitigate the impact of climate change depends on both personal and environmental factors (Meijer, Catacutan, Ajayi, Sileshi and Nieuwenhuis, 2015). The study found that other farmers adopted the biological strategies which were cover crops and rainwater harvesting, the farmers were concerned about biological factors that were affected by the effects of climate change and opted to use the biological resilient strategies. The study revealed that other farmers were more concerned with chemical factors and adopted resilient strategies that were classified under chemical

factors which were fertilizer application and the use of resilient crop varieties on their farms, furthermore the study showed that some farmers preferred looking at technological factors and took a decision to adopt technological strategies which were resilient crop varieties and mixed landscapes to be able to cope with the effects of climate change. A study conducted by Bedeke et al. (2019) discovered that resilience strategies like the use of crop varieties and chemical fertilizers is commonly preferred.

4.5 MULTINOMIAL LOGISTIC REGRESSION RESULTS ON FACTORS INFLUENCING CLIMATE CHANGE RESILIENT STRATEGIES ADOPTED BY CROP FARMERS

Table 4.6: Parameter estimates of multinomial logistic

Explanatory variables	Fertilizer application		Resilient crop varieties		Crop management		Crop rotation		No/mini tillage		Cover crops		more than 2	
	Coefficient	P-level	Coefficient	P-level	Coefficient	P-level	Coefficient	P-level	Coefficient	P-level	Coefficient	P-level	Coefficient	P-level
Gender	.251	.764	-.244	.610	-1.503	.956	-.064	.892	-1.210	.220	-.340	.719	.641	.052**
Marital status	.158	.645	.364	.070*	.856	.064*	.212	.003***	.197	.622	-.035	.939	.003	.990
Educational level	1.858	.051**	-.244	.011**	.837	.635	.116	.659	.556	.340	-.728	.084*	.197	.468
Land ownership	-.378	.116	1.284	.257	1.423	.016**	-1.309	.023**	17.127	.520	-.902	.433	.443	.021**
Extension support	.866	.013**	.149	.045**	-1.825	.996	.411	.418	-.201	.044**	-.746	.016**	-.639	.223
Method used	.321	.589	.635	.426	-23.650	.970	-.198	.515	.134	.034**	.697	.045**	-.092	.773
Farming under irrigation	.922	.074*	-.271	.607	-8.314	.640	-.855	.018**	-18.360	.997	-1.997	.009***	.892	.011**
Source of income	-.417	.015**	2.083	.149	-23.360	.987	-.184	.509	.132	.837	-1.962	.141	1.263	.364
Market access	.243	.651	.658	.036**	-.589	.333	.225	.016**	.105	.234	-.879	.556	.970	.345
Access to information	1.285	.005**	.323	.015**	-1.845	.025**	.118	.445	2.523	.234	.980	.022**	1.850	.024**
Access of funds	.332	.521	.158	.007***	.737	.641	.056	.256	.897	.356	.139	.123	.950	.094*
Credit access	.825	.025**	.189	.325	-.898	.243	-1.567	.532	.723	.111	-.254	.690	.872	.294
Off-Farm Occupation	-.312	.649	-.106	.783	-23.777	.966	-.358	.342	-1.000	.211	-.192	.789	1.780	.182
Constant	1.981	0.564	0.562	0.615	36.370	0.983	1.427	0.188	2.067	0.000	2.704	0.220	1.632	0.134

Diagnostics	
Base category	Crop diversification
Number of observations	180
LR chi-square	14.404
-2 Log likelihood	538.658
Pseudo-R2	.835

Cox and Snell (0.429), Nagelkerke (0.447), McFadden (0.174); Note ***, **, * Significant at 1%,5% and at 10% probability level, respectively

Source: Survey results (2021/2022)

4.5.1 Fertilizer application

Results from table 4.6 educational level, extension support, farming under irrigation, access to information, credit access and source of income are statistically significant. When farmers educational level increases, educational level has a (1.858 chance) of increasing on fertilizer application. Farmers that get extension support are more likely to use more fertilizers on the farms, hence the two are strongly significant. Farming under irrigation increases the chance of farmers to use more fertilizers on their crops. Income is strongly significant to increasing fertilizer application reason being when farmers have an income of some sort that are able to purchase more fertilizers and apply them on their farms.

4.5.2 Resilient crop varieties

Marital status, educational level, extension support, market access, access to information and access to funds are statistically significant with resilient crop varieties. Educational level is highly significant and has a negative relationship with choosing resilient crop varieties as a strategy. Agriculture extension support also increases the chances with 0.149 chances of a farmer to use resilient crop varieties to cope with the effects of climate change.

4.5.3 Crop management

Marital status, land ownership and access to information are statistically significant with crop management. When a farmer is married, they are more likely to use crop management as a resilient strategy, crop management is more effective when there is manpower on the farm. Land ownership is significant and has a positive relationship with the adoption of crop management, since farmers would invest more when they know the farm belongs to them. When a farmer has enough information then they will be able to select crop management as a resilient strategy.

4.5.4 Crop rotation

Marital status, land ownership, farming under irrigation and market access are statistically significant and have a positive relationship with farmers adopting to crop rotation as a resilient strategy. The system allows for the variations in the crop choice from every season or year (Agula et al., 2019), most farmers choose leguminous crops

in the rotations, which can make better use of organic fertilizers, reduce N2O emissions, and enhance nitrogen fixation in soil. Married farmers are more likely to adopt crop rotation, as they will be helping each other on the farm in terms of maintenance and will increase the adoption of the strategy by (0.212 chances). Farming under irrigation contributes to the adoption of crop rotation as a strategy, as when a farmer has water on the farm, they are able to practice crop rotation.

4.5.5 No tillage to minimum tillage

Extension support and method a farmer uses are statistically significand and have a negative and positive relationship with the adoption of no tillage/minimum tillage. Farmers are likely to use this strategy, since extension services encourage farmers to apply for support of tractors come and till the farm. The method that the farmer uses increases the chance of farmers to adopt to the resilient strategy, the less the farmers want to damage their soils by tilling.

4.5.6 Cover crops

Educational level, extension support, method used, farming under irrigation and access to information are statistically significant. Educational level has a negative relationship with the adoption of cover crops, the more education a farmer has the less likely for them to think of using cover crops as a resilient strategy. Extension support has a negative relationship with the adoption of cover crops. Farmers getting extension support are less likely to adopt to cover crops. Method used has a positive relationship with the adoption of cover crops, it increases the chances of adoption by (0.697 times).

4.5.7 Adopting more than two strategies simultaneously

Gender, land ownership, farming under irrigation, access to information and access to funds are statistically significant with adopting more than 2 resilient strategies. They all have a positive relationship with adopting more than two strategies. The study revealed that more females participate in farming practices, hence the use of more strategies on their farms, for them to provide for their families. Land ownership helps farmers adopt to more strategies, so they are guaranteed farm operations goes on. Farming under irrigation helped farmers adopted to more strategies at a go, as when they have

water, they can interchange the strategies to be able to identify which one works for them on the farm and helps them cope with the effects of climate change.

4.6 DISCUSSION OF THE SIGNIFICANT VARIABLES INCLUDED IN THE MULTINOMIAL LOGISTIC REGRESSION RESULTS

4.6.1 Fertilizer application

The study shows that educational level is statistically significant and had a positive relationship with the selection of fertilizer application. When farmers educational level increases the more the chances of selecting fertilizer application as a resilient strategy by 1.858 chances. Farmers who can read and write are more likely to use fertilizers to mitigate the effects of climate change. Farmers that get extension support are more likely to use more fertilizers on the farms (Alam et al., 2016), hence the two are strongly significant and have a positive relationship. The study is supported by findings from Debela (2015) stated that farmers who have access to extension services are likely to get resilient strategies based on the information and advice they are receiving from extension officers. Farming under irrigation and source of income are statistically significant. Farming under irrigation increases the chance of farmers to use more fertilizers on their crops, since when you have enough water, you are able to use fertilizers since most of them need a farmer to water their crops after the application. According to Yadav et al. (2018) access to information is also very helpful to farmers in making decisions on which strategy to choose. Income is strongly significant to increasing fertilizer application reason being when farmers have an income of some sort and access to credit that are able to purchase more fertilizers and apply them on their farms.

4.6.2 Resilient crop varieties

Marital status is statistically significant with resilient crop varieties and has a negative relationship, which implies when a farmer is married their chances of selecting resilient crop as a strategy decreases with 0.244 chances. Educational level is highly significant and has a negative relationship with choosing resilient crop varieties as a strategy, which implies that the higher the educational level of the farmer the less chances of them choosing resilient crop as a resilient strategy, The findings of this study contradict

the findings of Tesfahunegn, Mekonen and Tekle (2016) which found that chances of educated farmers to adopt resilience strategies are high compared to farmers no formal education. This could be because farmers with high level of education end up investing more in formal employment or other off-farm activities. Agriculture extension support and access to information are statistically significant with the selection of resilient crop varieties and also increases the chances of a farmer to use resilient crop varieties to cope with the effects of climate change. Having market access also helps in making proper decision in taking resilient crop varieties as a strategy, since a farmer has a place to sell his produce, so they need to produce to their maximum capacity regardless of the effects of climate change. According to Nazir et al. (2022) access to funds is also beneficial to farmers, since getting resilient crops is expensive, so having funds will give farmers a chance of selecting resilient crop varieties as a resilient strategy.

4.6.3 Crop management

Marital status and land ownership are statistically significant with crop management. When a farmer is married, they are more likely to use crop management as a resilient strategy, crop management is more effective when there is manpower on the farm. male farmers are usually considering crop rotation practice more openly than any other adaptive strategies. Married farmers are unlikely to consider possible ways to adapt to climate change, largely due to Making decisions with partners rather than making decisions on their own (Yadav and Lal, 2018). Land ownership is significant and has a positive relationship with the adoption of crop management, since farmers would invest more when they know the farm belongs to them, this study is supported by Diencere (2019) which shows that farmers with land security are more involved in climate change adaptation than their counterparts.

4.6.4 Crop rotation

Marital status, land ownership, farming under irrigation is statistically significant and have a positive relationship with farmers adopting to crop rotation as a resilient strategy. Married farmers are more likely to adopt crop rotation, as they will be helping each other on the farm in terms of maintenance and will increase the adoption of the strategy by (0.212 chances). A study conducted by Alih, Abu and Asogwa (2019)

agrees with the above statement, that marital status of farmers positively influences their adoption of crop varieties as their adaptive strategy. Van Aelst and Holvoet (2016) concluded that marital status plays an important role in consideration of resilience strategies by farmers. Farming under irrigation contributes to the adoption of crop rotation as a strategy, as when a farmer has water on the farm, they are able to practice crop rotation.

4.6.5 No tillage/minimum tillage

The study found that extension support and method a farmer uses are statistically significand and have a negative and positive relationship with the adoption of no tillage/minimum tillage. Farmers are likely to use this strategy, it helps to maintain and restore soil fertility, prevent soil erosion, increase soil water holding capacity (Lankoski et al., 2018; Agula et al., 2019), and enhance soil carbon storage, ultimately improving the agricultural soil structure and fertility though the more advice you get from extension officer then the less of the chances of a farmer using no tillage to minimum tillage, since extension services encourage farmers to apply for support of tractors come and till the farm. The method that the farmer uses increases the chance of farmers to adopt to the resilient strategy, the less the farmers want to damage their soils by tilling. According to Ghorbani, Wilcockson, Koocheki and Leifert (2009) Tilling also helps break down weed roots, along with the homes of other insects, helping to prevent these pests from intruding your farm.

4.6.6 Cover crops

Educational level, extension support, method used and farming under irrigation are statistically significant. Educational level has a negative relationship with the adoption of cover crops, the more education a farmer has the less likely for them to think of using cover crops as a resilient strategy. Extension support has a negative relationship with the adoption of cover crops. Farmers getting extension support are less likely to adopt to cover crops. Farmers who participate in extension services are more stimulated to participate in climate change adaptation than farmers who do not have any interaction with extension officers (Li, Juhász-Horváth, Harrison, Pinter and Rounsevell, 2017). Method used has a positive relationship with the adoption of cover crops.

4.6.7 Adopting more than two strategies simultaneously

Gender, land ownership and farming under irrigation are statistically significant with adopting more than two resilient strategies. They all have a positive relationship with adopting more than two strategies. The study revealed that more females participate in farming practices, hence the use of more strategies on their farms, for them to provide for their families. Though the findings contradict with a study conducted by Jin, Wang and Gao (2015) which states that male-headed households are likely to adopt adaptive strategies as compared to female-headed households, but generally, there are different sets of factors that influence such decision. The reason the finding contradict is because female farmers are more concerned with taking care of their families and making sure the family is well-fed and males have formal jobs. According to Kuwornu, Suleyman and Amegashie (2013) further revealed some indigenous adaptation strategies applied by smallholder farmers in Northern Ghana to adapt to climate change and variability included crop diversification, mulching, and change timing of farm operation, change of crops and multiple cropping. To cope with the unpredictable conditions of weather and climate change, farmers should adjust their farming practices and water resources and change their existing cropping patterns (Khan et al., 2020). Land ownership helps farmers adopt to more strategies, so they are guaranteed farm operations goes on. A study conducted by Addaney et al. (2021) revealed that women farmers use multiple adaptation strategies such as creating fire belts to prevent fire outbreak in the dry season, creating channels on their farmland to prevent erosion, planting crops that can withstand excessive rain and drought and mixed cropping to overcome livelihood challenges resulting from climatic factor. Farming under irrigation helped farmers adopted to more strategies at a go, as when they have water, they can interchange the strategies to be able to identify which one works for them on the farm and helps them cope with the effects of climate change.

4.7 PRESENTATION AND DISCUSSION OF DESCRIPTIVE ANALYSIS RESULTS ON CHALLENGES FACED BY FARMERS IN ADOPTING THE RESILIENT STRATEGIES

Table 4.7: Lack of agricultural information

Lack of agricultural information	Frequency	Percentage

Yes	121	67.2%
No	59	32.8%
Total	**180**	**100%**

Table 4.7 above shows one of the challenges that the respondents are facing when trying to adopt to resilient strategies. The study found out that most farmers do not have enough agricultural information concerning resilient strategies to cope with the effects of climate change, hence the percentage of them not having information is very high at 67.2%. The study is supported by a study conducted by Kgosikoma, Lekota and Kgosikoma (2018) stated that accessing knowledge on climate change increases farmers' adaptation to climate change by a significant margin.

Table 4.8: Lack of funds

Lack of funds	Frequency	Percentage
Yes	162	90%%
No	18	10%
Total	**180**	**100%**

Table 4.8 above shows the respondents that lack funds. Results from the study sample showed that 90% of the respondents are lacking funds, which is a hinderance when farmers are trying to adopt to resilient strategies whereas 10% of the respondents are not facing any challenges in term of funds in order for them to adopt to resilient strategies.

The study found that farmers have faced challenges while trying to adopt to resilience strategies. According to Biagini et al. (2014) emerging farmers in developing countries are most vulnerable to climate change, they are more worthy to getting financial support, however it is difficult for them to access funds.

It was found that most emerging farmers do not have funds for them to adapt to resilience strategies. Farmers stated that they also need proper guidance in choosing resilience strategies that are suitable for the type of crops they are farming.

Table 4.9: No access to credit

No access to credit	Frequency	Percentage
Yes	124	68.9%
No	56	31.1%
Total	**180**	**100%**

Table 4.9 above shows the percentage of respondents that have no access to credit, the results from the study sampled showed that 68.9% of the respondents have no access to credit in order for them to adopt to resilient strategies whereas 31.1% of the respondents have access to credit.

The study found that farmers are unable to access credit, since farmers do not have assets that belong to the farm and only hold PTO, these findings are supported by a study conducted by Ndamani and Watanabe (2016), stating that regardless of available resilience strategies to farmers credit and access to information were

identified as key determinants to adaptation. Availability of institutional factors such as access to credit, access to extension services, enough available water and wealth plays a vital role in farmers' consideration to make use of different resilience strategies (Ali and Erenstein, 2017).

Table 4.10: No proper guidance on usage of resilient strategies

No proper guidance	Frequency	Percentage
Yes	59	32.8%
No	121	67.2%
Total	**180**	**100%**

Table 4.10 above shows the percentages of respondents that have no proper guidance, results from the study sample showed that 32.8% of the respondents agreed to having no proper guidance on the usage of resilient strategies which hindered with them adopting to suitable resilient strategies, on the other hand 67.2% of the respondents have proper guidance.

Table 4.11: Access to market

Access to market	Frequency	Percentage
Yes	2	1.1%
No	178	98.9%
Total	**180**	**100%**

Table 4.11 above shows one of the challenges which is the access to market,1.1% of the respondents agreed to having access to market and 98.9% of the respondents have disagreed to having access to market and this is one of the challenges faced. Results study sample revealed that farmers are unable to adopt to resilience strategies since they will not be having sales and if there are no sales it means there is no return of investment, which means farmers will find it hard to adopt to resilience strategies.

Table 4.12: Limited access to production resources (water, inputs, machinery, tools, building)

Limited access to water	Frequency	Percentage
Yes	155	86.1%
No	25	13.9%
Total	**180**	**100%**

Table 4.12 above shows the respondents that are facing a challenge with regards to limited access to production resources, results from the study sample revealed that 86.1% of the respondents are facing the challenge of limited access to production resources such as water, inputs, machinery, tools and building when trying to adopt to resilient strategies whereas 13.9% of the respondents have enough production resources on their farms.

The study found that lack of access to production resources such as water, inputs, machinery, tools, and building is an issue for farmers in the Thulamela Municipality, most of the farmers do not have production resources on their farms and they depend on rainwater during the summer, hence the percentage is also very high at 86.1%.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents a summary of the study, it also concludes and recommend. It summarises and briefly discusses the results with respect to objectives and, research questions of the study. It furthermore gives suggestions on future research opportunities.

5.2 SUMMARY

The main objective of this study was to assess resilience strategies that have been adopted by crop farmers in the Thulamela Local Municipality to mitigate against the effects of climate change. The study literature review focused on the resilience strategies that have been adopted by farmers to mitigate the effects of climate change, it also includes definitions and challenges faced by farmers when adopting to resilient strategies. The study was conducted in the Thulamela local municipality with a population of 300 crop farmers, data was collected from a sample size of 180 crop farmers.

Pertaining the findings of the study, regarding socio-economic characteristics of farmers within the study sample the study uncovered that there are more female crop farmers than male crop famers in the Thulamela Local Municipality that are involved in farming practices, also the study found that not a lot of youth are participation in agricultural practices, Majority of the farmers have Permission to Occupy (PTO) the land they farm on, the farmers that have occupied 1ha are leasing the farm where they pay monthly to occupy. The study found that education also played an important role in farmers adoption to resilience strategies.

The study also revealed that farming experience contributed to farmers knowing which resilience strategies. Even though fewer younger crop farmers are involved in farming it shows that are willing to explore other resilience strategies.

while regarding the adoption strategies the study discovered that the most selected resilience strategies were crop diversification, soil conservation practice and crop management, they were classified under environmental strategies, wherein farmers adopted to the strategies mainly because they were concerned about environmental factors.

Regarding factors that influence farmers adoption of resilience strategies, the study revealed that educational level, extension support, farming under irrigation, having an income were statistically significant with influencing farmers to adopt to resilience strategies.

With regards to challenges that farmers faced when they adopted to resilience strategies, the study discovered that farmers are unable to access credit, they do not have enough agricultural information, they have no proper guidance in using some resilient strategies, they do not have enough water on their farms.

5.3 CONCLUSION

The main objective of this study was to assess resilience strategies that have been adopted by crop farmers in the Thulamela Local Municipality to mitigate against the effects of climate change. The study intended to respond to the research questions of the study. The study intended to find socio-economic characteristics that influence the adoption of resilience strategies, wherein the study discovered that socio-economic characteristics that are influence the adoption of resilience strategies are farming experience, land size, gender, income, educational level, and marital status.

The study intended to find the resilience strategies that have been adopted by crop farmers, wherein the study discovered that the adopted resilience strategies were crop diversification, soil conservation practice and crop management, cover crops and rainwater harvesting, fertilizer application and the use of resilient crop varieties.

Furthermore, the study intended to find the factors that influence the adoption of resilience strategies, the study discovered that the factors that influenced the adoption of the strategies were educational level, extension support, farming under irrigation, having an income.

The study also intended to find the challenges that farmers faced when they adopted to resilience strategies, the study discovered that the challenges were that farmers are unable to access credit, they do not have enough agricultural information, they have no proper guidance in using some resilient strategies, they do not have enough water on their farms. In conclusion the study found that a lot of farmers in the Thulamela Local Municipality use resilience strategies to mitigate the effects of climate change.

5.4 RECOMMENDATIONS

The study makes the following recommendations

- The study recommends that extension officers should facilitated networking among farmers, wherein farmers with more extensive farming experience could assist farmers with less experience on the best adoption of resilient strategies.
- There should be mechanisms that could be used to assist farmers to adopt to resilience strategies that farmers find them expensive to adopt within their practices.
- The Department of Agriculture and Rural Development should also connect farmers to stakeholders that will be able to educate the farmers on how the different type of resilient strategies work, so they are able to have options when choosing them.
- There should be financial institutions that will be able to assist farmers in terms of getting financial assistance and the department should make means in terms of assisting farmers with funds and having enough water on their farmers.

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APPENDIX A:

PERMISSION LETTER

Limpopo Department of Agriculture
and Rural Development
Thulamela (Makwarela)
0970

Dear Sir/Madam

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

I am a master's student at the university of Venda in the School of Agriculture under the

Department of Agricultural Economics and Agribusiness presently undertaking a study entitled:

Topic: An Analysis of Crop Farmers Resilience to Climate Change in the Thulamela Local Municipality of Vhembe District Municipality, Limpopo Province, South Africa

The purpose of this study is to assess how farmers in Thulamela Local Municipality are coping with climate change and which resilient strategies are they using to mitigate against the effects of climate change and the challenges they are facing in the process.

The following ethical standards will be followed throughout the research process:

- Informed consent
- Voluntary participation and freedom to withdraw without any penalty
- Names of participants will not be mentioned during discussions

Thank you in advance

Yours Faithfully

Ms. Gwebu MPN. (0812300537)

APPENDIX B:

CONSENT FORM FOR RESPONDENTS

CONSENT FORM **University of Venda** **Topic: An Analysis of Crop Farmers Resilience to Climate Change in the Thulamela Local Municipality of Vhembe District Municipality, Limpopo Province, South Africa** **The consent form is designed to check that you understand the purposes of the study, that you are aware of your rights as a participant and to confirm that you are willing to take part**			
Please tick as appropriate			
		Yes	**No**
1. The nature of the study has been described to me.			
2. I have received sufficient information about the study for me to decide whether to take part			
3. I understand that I am free to refuse to take part if I wish			
4. I understand that I may withdraw from the study at any time without having to provide a reason			
5. I know that I can ask for further information about the study from the research team.			
6. I understand that all information arising from the study will be treated as confidential.			
7. I know that it will not be possible to identify any individual respondent in the study report, including myself.			
8. I agree to take part in the study			
Signature:	**Date:**		
Name in block letters, please:			
I confirm that quotations from the interview can be used in the final research report and other publications. I understand that these will be used anonymously and that no individual respondent will be identified in such report.			
Signature:	**Date:**		
Name in block letters, please:			

APPENDIX C:

STRUCTURED QUESTIONNAIRE

UNIVERSITY OF VENDA

DISCIPLINE: AGRICULTURAL ECONOMICS
QUESTIONNAIRE ON FARMERS RESILIENCE TO CLIMATE CHANGE

Questionnaire number: .....

Questionnaire date: .....

Area of respondent: .....

SECTION A: SOCIO-ECONOMIC CHARACTERISTICS

1. Age

.....

2. Gender

Female	1	
Male	2	

3. Marital Status

Married	1	
Divorced	2	
Single	3	
Widowed	4	
Other (specify)	5	

4. Household size

1	1	
2	2	
3	3	
4	4	
More than 4	5	

5. Home Language

Tshivenda	1	
Tsonga	2	
Other (specify)	3	

6. Educational levels

No formal education	1	
Primary education	2	
Secondary education	3	
Tertiary education	4	

7. If above question is tertiary education, how many years of schooling?

.....

8. Farming experience (in years)

.....

9. Annual income (in Rands)

.....

10. What is your main source of income?

.....

11. Occupation

Employed	1	
Self – Employed	2	
unemployed	3	

12. Other source of income

Social child grant	1	
Old age grant	2	
Remittances	3	
Other (specify)	4	

13. Ownership of the land

Yes	1	
No	2	

14. Land size

.....

15. Do you belong to any farmers' association?

Yes	1	
No	2	

16. If answer on question 14 is yes, which association do you belong to?

.....

17. Do you have any disability?

Yes	1	
No	2	

18. Do you get any agricultural support?

Yes	1	
No	2	

19. If yes on question 17, specify from where?

.....

.....

Section B: RESILIENCE STRATEGIES

20. Do you know climate change?

Yes	1	
No	2	

21. Does climate change pose a threat to farming?

Yes	1	
No	2	

22. Are you familiar with the impacts of climate change?

Yes	1	
No	2	

23. Has your production been affected by climate change?

Yes	1	
No	2	

24. How were you affected?

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25. Has it affected your production yield?

Yes	1	
No	2	

26. If yes explain how it affected your yield

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27. How did it affect the quality of your production?

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28. From the past 5 years, how is the weather pattern in your area?

Floods	1	
Normal rainfall	2	
Drought	3	

29. How can you mitigate climate change?

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.....

30. Do you know the resilience strategies to mitigate climate change?

Yes	**1**	
No	**2**	

31. If yes, which of the following resilient strategies are you familiar with?

Crop diversification	1	
Substitution	2	
Calendar redefinition	3	
Increase in fertilizer application	4	
Resilient crop varieties	5	
Soil conservation practice	6	
Tree cultivation	7	
Crop management	8	
Crop rotation	9	
Terracing	10	
No tillage or Minimum tillage	11	
Agroforestry	12	
Polycultures	13	
Mixed landscapes	14	
Improved irrigation Efficiency	15	
Rainwater harvesting	16	
Cover crops	17	
Pest suppression	18	

32. Which other resilient strategies do you know apart from the ones listed above?

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33. Where did you first hear about the resilient strategies?

Radio	1	
Television	2	
Extension officer	3	
Other	4	

34. Why did you choose the resilient strategy you are using?

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35. Which one have you used?

Crop diversification	1	
Calendar redefinition	3	
Increase in fertilizer application	4	
Resilient crop varieties	5	
Soil conservation practice	6	
Tree cultivation	7	
Crop management	8	
Crop rotation	9	
Terracing	10	
No tillage/ minimum tillage	11	
Agroforestry	12	
Polycultures	13	
Mixed landscapes	14	
Improved irrigation efficiency	15	
Rainwater harvesting	16	
Pest suppression	17	
Cover crops	18	

36. Which production method do you use?

Organic (compost)	1	
Chemical (fertilizers)	2	
Both methods	3	

37. Do you farm under an irrigation system?

Yes	1	
No	2	

38. Which of these strategies is the least expensive?

Crop diversification	1	
Substitution	2	
Calendar redefinition	3	
Increase in fertilizer application	4	
Resilient crop varieties	5	
Soil conservation practice	6	
Tree cultivation	7	
Crop management	8	
Agroforestry	9	
Crop rotation	10	
Terracing	11	
Mixed landscapes	12	
Polycultures	13	
Improved irrigation efficiency	14	
No tillage / minimum tillage	15	
Rainwater harvesting	16	
Pest suppression	17	
Cover crops	18	

39. Are the strategies used working for you?

Yes	1	
No	2	

40. What is the reason for using this strategy?

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.....

41. What can be done to improve adoption of resilient strategies by farmers?

.....

.....

.....

42. 42. Have you received training in relation to climate change?

Yes	1	
No	2	

43. If yes who offered the training?

.....

44. Was the training beneficial to you?

Yes	1	
No	2	

C. SECTION C: CHALLENGES FACED BY FARMERS

45. Have you encountered challenges when adopting to resilience strategies?

Yes	1	
No	2	

46. If yes which of these challenges did you face while trying to adopt to resilience strategies?

Lack of information	1	
Lack of funds	2	
No access to credit	3	
No proper guidance	4	
Limited enforcement policies	5	
Limited access to water	6	

47. Do you think proper guidance would have helped you choose a better resilient strategy?

Yes	1	
No	2	

48. Would you have made a better decision of a suitable strategy to cope with climate change if you had access to credit?

Yes	1	
No	2	

49. If yes on question 47, what will that strategy be?

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Focus Group Discussion Questionnaire

School of Agriculture

University of Venda

Thohoyandou, Limpopo

SOUTH AFRICA

Topic: An Analysis of Crop Farmers Resilience to Climate Change in the Thulamela Local Municipality of Vhembe District Municipality, Limpopo Province, South Africa

Date: .....

Time: .....

Venue:.....

Facilitator: Gwebu MPN

1. **What is your knowledge on Climate Change?**

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2. **How effective is the resilient strategy that you have adopted?**

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3. **After the implementation of these strategies, what are the challenges you have faced?**

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4. How did you deal with the challenges that you have faced as a farmer?

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