Towards a model development for adaptive strategies that will enhance adaptation to climate change for emerging farmers in Limpopo province, South Africa

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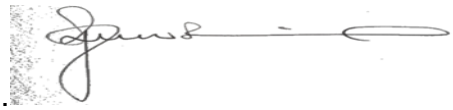
Co-Promoter …  Date 02/092020.

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August 2020

DECLARATION

I, Tshikororo Mpho (14015053), hereby declare that the thesis for the Doctor of Philosophy in Agriculture (Agricultural Economics) at the University of Venda hereby submitted by me, has not previously been submitted for a degree at this or any other university, and that it is my own work in design and in execution, and that all reference material contained therein has been duly acknowledged.

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I would like to dedicate this work to my family: my parents, Mr N.C. and Mrs M.E. Tshikororo; my sisters, Mukhethwa and Fulufhedzani; my brothers, Tshifhiwa, Mashudu and Shudufhadzo. Last but not least, I would also like to dedicate this work to Tondani Odett Vele.

ABSTRACT

Climate change is a global phenomenon that has been of great concern and its tackle is of outmost importance for food security among other things. In response to climate change adaptation, the study intended to determine awareness of climate change, its critical determinants and impacts among farmers, particularly emerging farmers. The study also investigated socio-economic characteristics of farmers that play a vital role in selection of various adaptive strategies, furthermore, institutional factors that contributed in emerging farmers' decision to either adapt or not to climate change were also investigated. The main aim of the study was to develop a model that could be used in future to enhance adaptation to climate change through various identified adaptive strategies in Limpopo province of South Africa. The study was conducted in five districts of Limpopo province, namely: Capricorn, Mopani, Sekhukhune, Vhembe and Waterberg. The study made use of structured questionnaire to collect data from 206 emerging farmers. A two-stage cluster sampling technique was employed to select participants of the study. Statistical Package for the Social Sciences (SPSS; version 25, 2017) was used to analyse the data; cross-tabulation, multinomial and binary logistic models were used for analysis. Preliminary descriptive statistics results from cross-tabulation indicated that farmers were aware of climate change; had noted various critical determinants of climate change and were aware of impacts of climate change during production seasons between 2014 and 2018. Using Multinomial Logit model, further analysis indicated that there are socio-economic characteristics that significantly influenced selection of various adaptive strategies among farmers. Variables that significantly influenced selection of various adaptive strategies were household size, farming experience, formal education, occupation, gender and monthly on-farm income. The study also discovered that institutional factors such as accessing different kinds of extension services, securing source of support and

accessing climate change information such as weather forecast, positively and significantly influence farmers' decision to adapt to climate change. Recommendations of the study were that there should be capacity building in a form of training programmes that promote climate change awareness as farmers need to be capacitated to enable them to take strategic decisions on a daily basis. Furthermore, it was also recommended that training of farmers should target illiterate farmers and farmer without off-farm occupation and specific needs of farmers should be taken into consideration when initiating adaptation initiatives as adaptation to climate change is best monitored at farm level. The study also recommended that various stakeholders such as community of practice, climatologists, and agro-meteorologists should provide various support to emerging farmers to improve farmers' resilience towards climate change through adaptation.

Keywords: Adaptation, Adaptive strategies, Climate Change, Emerging, Farmers, Institutional factors Logistic Regression.

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LIST OF ABBREVIATIONS AND ACRONYMS

AFOLU	Agriculture, Forestry and Other Land-Use
CEC	Commission of the European Communities
DAFF	Department of Agriculture, Forestry and Fisheries
DEAT	Department of Environmental Affairs and Tourism
DOA	Department of Agriculture
FAO	Food and Agricultural Organisation
GHG	Green House Gas
IFAD	International Fund for Agricultural Development
IPCC	International Panel on Climate Change
LDARD	Limpopo Department of Agriculture and Rural Development
LTA	Limpopo Tourism Agency
NAPAs	National Adaptation Programmes of Action
NBI	National Business Institute
RSA	Republic of South Africa
SPSS	Statistical Package for the Social Sciences
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER 1

INTRODUCTION

1.1 Background

Climate change affects agriculture throughout the world (FAO, 2007). Climate change in recent decades has severely affected agricultural productivity in Africa (Ziervogel et al., 2006). Adaptive strategies to climate change could mitigate the impact of climate change on agriculture (Jha & Gupta, 2016). Climate change refers to changes in climatic systems caused by anthropogenic greenhouse gases (GHGs) emissions (FAO, 2008). According to United Nations Framework Convention on Climate Change (UNFCCC, 2011), climate change is additional to natural climate variability observed over comparable time periods. Climate change can also be regarded as a gradual change in climate standards and weather extremes (FAO, 2008).

Impacts of climate change on agriculture are direct results of increase in emissions of carbon dioxide (CO_2) as well as a rise in temperature (Liverman, 2008). According to Pye-Smith (2011), greenhouse gases emissions are a result of different human activities which in turn, considerably influence the impacts of climate change such as increased temperatures, change in rainfall pattern, floods and extreme droughts, and such events have an impact on the agriculture industry. Negative impacts of climate change towards agriculture results in crop failure, lowered productivity among other impacts yet agricultural activities significantly contribute towards causes of climate change. Increased level of food insecurity around the globe has also been identified as an impact of climate

change, yet in a bid to secure food security in 2010 alone, agricultural activities amounted to 10-12% of human-generated greenhouse gas emissions (Pereira et al., 2014; Pye-Smith, 2011).

Various parts of the globe have been noted to be among those that will be impacted by the impacts of climate change with developing countries being anticipated that they will be more vulnerable, particularly emerging and smallholder farmers (Madzwamuse, 2010). Patterns of impact of climate change will be shaped through different factors such as the socio-economic factors of farmers, technological development as well as policy choices in support of agriculture against climate change (Brussel, 2009). Farmers are faced with challenges of changing their choice of produce for products that are likely to survive the climatic changes in order to maintain their income (Warner et al., 2015). Emerging farmers are most vulnerable to climate change and are likely to suffer severely due to their limited adaptive capacity (Aggarwal & Singh, 2010). Emerging farmers are obliged to adjust their farming practices to suit climatic changes taking place around the world (Jost et al., 2016).

South Africa has been listed as the largest CO_2 emitter in Africa (UNFCCC, 2011). Emerging farmers view climate change as a significant hindrance to their future livelihoods development (Debela et al., 2015). Farmers' view of climate change and their farming practices will provide information of ideal interventions for successful adaptation to climate change (Tambo & Tahirou, 2013). There is a necessity of identifying key elements that shape farmers' decisions to adapt to climate change (Mugi-Ngenga et al., 2016). According to the World Resources Institute Climate Analysis Indicator Tool (WRI CAIT, 2015), South Africa contributed a total of 1.1% greenhouse gas emissions globally

in 2010. South Africa's GHG emission is largely dominated by the energy sector with 84% of emission, as of 2014. Agriculture is the second sector to dominate South Africa's GHG emission with 7% of total GHG emission in 2012 (WRI CAIT, 2015). According to Department of Environmental Affairs (DEA), South Africa has indicated to UNFCCC through its Biennial update report that GHG emissions from agriculture, forestry and other land-use (AFOLU) between 2000-2010 has dropped by 15.7% (DEA, 2014). AFOLU contributed about 24% of 2010 total global greenhouse gas emissions; cultivation of crops and livestock as well as deforestation and agricultural activities were responsible for most of the emission of greenhouse gases (FAO, 2014).

In response to climate change, there has been a development of strategies to mitigate the impacts of climate change and also to adapt to climate change by different Departments such as Agriculture, Land Reform and Rural Development, Water Research Commission and South African Weather Services in South Africa (Mpandeli.pers.comm, 2019; RSA, 2004:17). Climate change 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; Deressa et al., 2008). Adaptation can also be regarded as a practice of adjusting ways of doing things to match changing climatic conditions (Phuong, 2018). Furthermore, it has been noted that the adaptation process is best effective when it is carried out effectively at a farm level (Arunrat et al., 2017). Mitigation is a use of different strategies that seek to reduce the pace of GHGs emissions (FAO, 2009). Adaptation strategies on the local context should be designed and implemented appropriately to ensure successful adaptation to climate change (Tambo et al., 2013).

Adaptation to climate change requires different modification of methods and practices to successfully implement different adaptive strategies and such changes may include infrastructure, information processes and technological enhancement (IPCC, 2011). Adaptation to climate change is the most practical strategy to control the impacts of climate change. It is therefore, important to determine farmers' awareness of climate change as well as other factors that are likely to affect their selection of different adaptive strategies (Jha & Gupta, 2016). Lack of knowledge about future trends of climate change impacts among farmers creates a huge barrier for adaptation planning (Warnatzsch & Reay, 2019). Adaptation to climate change is the most practical strategy to control the impacts of climate change and it is important to assess farmers' awareness of climate change and other factors to see what shapes farmers' decision to adapt to climate change (Jha & Gupta, 2016). Adaptation and mitigation of climate change by farmers can be fairly measured by their awareness of climate change and the extent of risks that farmers find climate change posing towards their farming practices (Hyland et al., 2016).

1.2 Statement of the Research Problem

Climate is the primary determinant of agricultural performance (Cline, 2008; Lobell et al., 2008). A study conducted by Hassan and Nhemachena (2008) identified South Africa as one country that features prominently amongst countries that will experience significant effects of climate change, characterised by temperature increases, declining rainfall and persistent droughts. Climate change is already a reality and Limpopo province has been among parts of South Africa that have been experiencing climate variability (Maponya & Mpandeli, 2012; IPCC, 2011). The study was conducted in Limpopo province which is

among other provinces in South Africa that is expected to be vulnerable to climate change as its agricultural production depends on the climatic conditions, largely on the quality and quantity of rainfall (Kgakatsi et al., 2007). From subsistence, micro-scale, small-scale, emerging and established commercial farmers, the government has been investing towards commercialization of emerging farmers and despite such effort, majority of emerging farmers are vulnerable to climate change; the study focused on emerging farmers in Limpopo province. There are different adaptive strategies believed to be suitable for farmers' survival in the face of climate change. Socio-economic characteristics among farmers have proved to be the key determinant for selection of adaptive strategies. A study by Ndamani and Watanabe (2016) indicated that adaptive strategies may not be effective if designed without an in-depth understanding of farmers' perceptions about climate change. Farmers in developing countries, particularly the emerging farmers, are least likely to adopt adaptive strategies due to their lack of information regarding climate change, as well as lack of credit (Tambo et al., 2013). Proposed adaptive strategies may not be practical due to the policy constraints (Touch et al., 2016). Policy plays a vital role in adaptation decision making and it may also pose some difficulties during the implementation process of adaptation response (Madzwamuse, 2010). Studies focusing on institutional and policy contexts would be vital on successful implementation of adaptive strategies, particularly by emerging farmers (Andersson & D'Souza, 2014). There is a need to develop an implementable adaptation framework that reflects different needs of affected farmers (Phillipo et al., 2015). The overarching question that this study sought to answer was "What are the critical factors that impact on farmers as they adapt to climate change outcomes within their

environment?" In the final analysis, the study developed a model that could generally be applied by farmers, policy makers and implementers to enhance farmers' adaptation to climate change.

1.3 Objectives of the study

1.3.1 Main objective

To develop a model that could be used to enhance adaptation to climate change in Limpopo Province

1.3.2 Specific objectives

I. To investigate farmers' awareness of critical determinants and impacts of climate change in Limpopo province
II. To assess the influence of socio-economic characteristics of farmers on the selection of climate change adaptive strategies
III. To investigate if institutional factors could affect farmers' decisions to adapt to climate change in Limpopo Province

1.4 Research questions

I. Are farmers aware of critical determinants and impacts of climate change in Limpopo Province?
II. Do farmers' socio-economic characteristics influence the selection of climate change adaptive strategies?
III. Do institutional factors shape farmers' decisions to adapt to climate change in Limpopo Province?

1.5 Hypotheses of the study

I. Farmers are not aware of climate change.

II. Farmers' socio-economic characteristics do not influence the selection of climate change adaptive strategies.

III. Institutional factors influence farmers' decisions to adapt to climate change.

1.6 Significance of the study

Recognition of negative impacts of climate change on agriculture has led to many studies focusing on identifying possible adaptation strategies that could be used to adapt and mitigate the impacts of climate change. Future predictions based on impacts of climate change have also been another research focal point for many studies. There are different adaptive strategies identified with minimum provision of clear information on how such adaptive strategies could successfully be implemented to enhance adaptation to climate change. In the final analysis, the study developed a model that could guide various stakeholders such as famers, policy makers and implementers to enhance farmers' adaptation to climate change.

1.7 Limitation and delimitation

The study was limited to information gathered in the Limpopo province. The issue of climate change covers the entire globe; hence, the study only focused on emerging farmers in Limpopo province due to cost constraints. The study was also limited by failure to hold focus group discussions that were meant for key informants.

1.8 Outline of the study

Chapter One is the introductory chapter.

Chapter Two, reviews literature relevant to the interests of the study objectives.

Chapter Three give a description of the research methodology that was employed in the study; it indicates sampling technique used and data collection method used.

Chapters Four to Six cover the results of the study whereas

Chapters Seven and Eight give the summary, conclusion, recommendations of the study and the model the study developed.

1.9 Conceptual Framework of the study

Figure 1.1 (on page 11) shows a conceptual framework which served as a guide to the study. The framework comprises the cause of climate change, impacts of climate change and factors that shape farmers' decision to adapt to climate change. This was designed to develop a model that could be used by emerging farmers and other stakeholders to enhance adaptation to climate change.

The below conceptual framework provided the direction of the study. It gave an insight of how climate change could negatively affect agriculture through its impact. Among other human activities that contributes to the cause of climate change, emission of greenhouse gases and deforestation were identified to be the main causes of climate change. Deforestation can be viewed as the removal of forest cover to an extent that allows for alternative land use (Tejaswi, 2007). Emission of greenhouse gases and deforestation are associated with causes of climate change of which the impacts of climate change in agriculture lead to among others, loss of agricultural productivity, loss of farm income and restriction of water availability. Mulinde et al. (2019) noted that among other things, the impacts of climate change include loss of income, food deficiency, abridged soil productivity, and interrupted planting dates. These negative impacts of climate change

lead farmers to adapt to climate change as noted by Zamasiya et al. (2017) who revealed that farmers who have experienced impacts of climate change in their farming practices in the past are more willing to take different adaptive strategies more than their counterparts. Negative impacts of climate change trigger farmers to mitigate and adapt to the effects of climate change. Climate change mitigation is a planned process that seeks to stabilize the pace and scale of climate change through reduction of emissions of GHGs (FAO, 2009) whereas adaptation to climate change among other definitions, can be viewed as a practice of adjusting ways of doing things to suit climatic conditions (Phuong, 2011). The framework also showed different adaptive strategies which farmers could use to adapt to climate change. The study identified various adaptive 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 et al., 2018). Resilient crop varieties is a strategy of using types of crops that are resistant to climate change. Substitution of crops involves a practice of substituting one crop with another one, and fertilizer application refers to a strategy where farmers apply fertilizer or chemicals on their crops, whereas calendar redefinition refers to changing planting date in order to facilitate adaptation by way of planning when to plant such crops (Yéo et al., 2016).

The framework further showed factors that could shape farmers' use of adaptive strategies, namely; socio-economic characteristics and institutional factors. Farmers' socio-economic characteristics play a vital part in their decision to either adopt adaptive

strategies or not. Mulinde et al. (2019) noted that for an effective uptake of climate change adaptive strategies among farmers, their socio-economic characteristics should not be overlooked during adaptation planning process, considerably because adaption to climate change can be well measured at the farm unit. Some socio-economic characteristics believed to have an influence in farmers' decision to uptake adaptive strategies include farmers' age group, gender, educational level, household size and their farming experience. 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 et al., 2019). Furthermore, even some institutional factors are believed to significantly influence farmers' decision to adopt various adaptive strategies. Factors such as access to climate change information, access to extension services and access to various institutional factors play a significant role in taking decisions to adapt to climate change. A study by Bedeke et al. (2019) revealed that farmers with a good relationship with extension agents and who possess membership of local farmers' organisation adapt better to climate change. The framework also presented a functional model to enhance climate change adaptation after combating different aspects that are critical in farmers' action towards adoption of adaptive strategies. The model is believed to enhance farmers' adaptation to climate change and their resilience towards climate change.

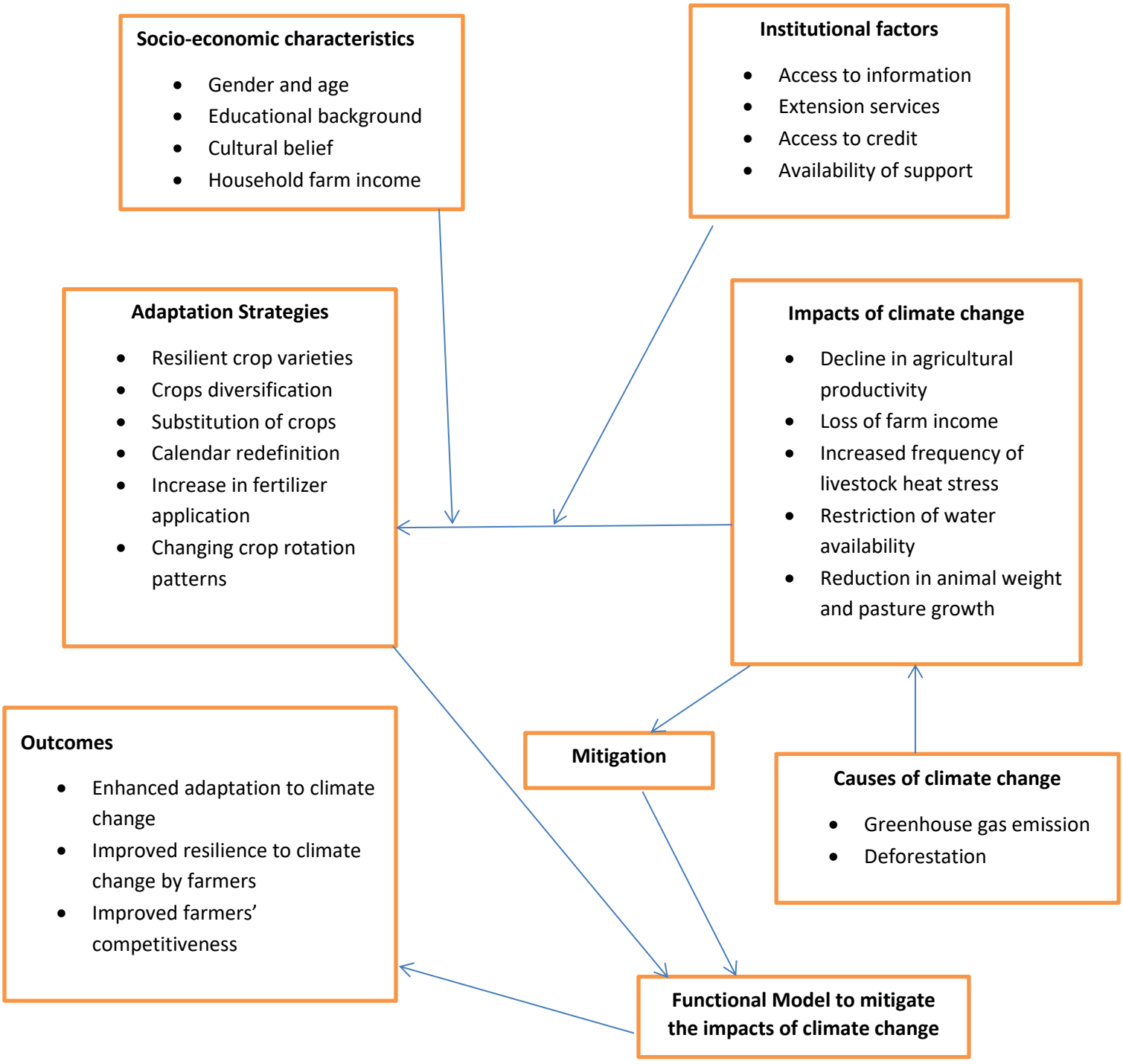

Figure 1.1: Conceptual framework: Source; Adapted from DFID Livelihood (2000)

1.10 Conclusion

This chapter advanced the background on climate change and how climatic changing conditions are negatively impacting agricultural productivity and livelihoods of those who are dependent on agriculture. This section also revealed that mitigation of climate change impacts and efforts to adapt to climate change have been a focal point for various studies in a bid to assist farmers to survive in the face of climate change. This chapter laid a foundation mainly focusing on mitigation and adaptation to climate change. The objectives of the study; mainly to develop a model that could be used by various stakeholders to enhance adaptation to climate change using various climate change adaptive strategies and motivation of the study were elucidated. Furthermore, the chapter also outlined a conceptual framework which guided the study in achieving its objectives. Various climate change strategies have been identified and there is a low rate of their adoption. This chapter lays a foundation on the build-up of critical elements that mainly influence farmers' decision to adopt various climate change adaptive strategies.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A review of past literature is an integral and indispensable part of any investigation. Review of literature offers information to the researcher in relation to the previous works done in their area of research. This chapter therefore presents findings from previous studies related to climate change. Reviews in this chapter among others include awareness of critical determinants of climate change among farmers and how their socio-economic characteristics influence their selection of adaptive strategies. Furthermore, there is a review on how institutional factors are likely to influence farmers' decision to adapt to climate change.

2.2 Farmers' awareness of climate change and its critical determinants

This section present previous studies on farmers' awareness of climate change. It further reviews farmers' awareness of critical determinants and impacts of climate change around the globe. This is in line with one of the objectives of the study.

2.2.1 Awareness of climate change

According to IFAD (2010), it is likely not possible to avoid the impact of climate change. Climate change awareness should be promoted continually, more particularly in developing countries since awareness is more likely to enhance the participation of farmers towards adaptation (Friis-Hansen et al., 2013). For a successful agricultural adaptation to be achieved, there is a need to have an in-depth understanding of different factors that shape farmers' awareness of climate change and its impact that would lead to their adaptive response to such stimulus (Below et al., 2015). The adaptive capacity of a particular country will depend on its awareness of the predicted climatic changes and

socio-economic characteristics of farmers (IPCC, 2011). Farmers' awareness of climate change is understood to be one of the key determinants for adaptation to climate change; hence, there is a lack of conceptual framework of it (Comoé et al., 2015). In a study conducted by Sarkar and Padaria, (2016) it was revealed that the level of adaption to climate change is associated with the level of awareness of climate change. The study further revealed that farmers believed that climate change is a results of human activities which brought disturbance to ecological balance and therefore need a dialogue for action that could minimize and mitigate the impacts of climate change (Sarkar and Padaria, 2016). Farmers are more likely to adopt adaptive strategies that they are aware of (Hyland, 2016). 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 et al., 2015).

2.2.2 Awareness of critical determinants of climate change

Emerging farmers are said to be changing agricultural practices to suit climatic and environmental change (Jost et al., 2016). A study conducted in Limpopo province revealed that farmers have noted some critical determinants of climate change such as warmer days and increased drought occurrence (Maponya & Mpandeli, 2013). From the study conducted by Sarkar and Padaria (2016), farmers may not be well informed all critical determinants of climate change though they may be aware of few determinants since majority lacks detailed information about climate change. A study by Mehar et al. (2016) noted that among farmers who are aware of climate change; there are those who are familiar with weather patterns to a point whereby they consistently keep the records of such climatic changes. Several farmers have shown an observation and noted

changes in temperature and rainfall patterns as imperative indicators of climate change (Bawakyillenuo et al., 2016). Increase in annual temperatures and rainfall are more observed determinants of climate change among farmers (Gunathilaka et al., 2018). Awareness of extreme weather events such as severe heat temperatures has a strong influence on adaptation behaviour among farmers (Li et al., 2017). Farmers from rural areas have perceived changes in rainfall patterns and extended dry spells which they associate greatly with climate change (Belay, et al., 2017). In a study conducted by Arunrat et al. (2017) it was revealed that farmers are quite familiar with a constant increase in temperatures and a decrease in precipitation over time and regard such changes as critical determinants of climate change. Farmers are more perceived of increase in annual temperatures and decreased annual rainfall as key pointers of climate change (Kgosikoma et al., 2018). Warmer weather patterns and a significant decrease in level of annual precipitation has been of a high note among farmers (Amadou et al., 2018).

A study conducted by Shukla et al. (2019) on famers' perception of climate change has found that farmers have noted a decrease in both winter and summer rainfall while there is a gradual increase in summer temperatures. In a study conducted in Cameroon on the determinants of farmers' adaptation to climate change, it was revealed that farmers have noted changes in rainfall patterns and constant temperature increase and farmers have adopted rain-related and temperature-related strategies respectively (Bate et al., 2019). A study conducted in Zimbabwe by Mutandwa et al. (2019) revealed rising temperatures and unpredictability in rainfall patterns as two major critical determinants of climate change noted by farmers. Several studies have noted that farmers in various places have

noted that recently, their areas are characterized by either late or shorter rainfall season (Mutandwa et al., 2019; Mutunga et al., 2017; Mugari et al., 2016).

In a study conducted by Niles and Mueller (2016), farmers in a study area were of a belief that annual precipitation was significantly increasing as a result of climate change while Mase et al. (2017) stated that farmers are aware of climate change with farmers agreeing that human contributes to climate change; with the most common critical determinants of climate change among farmers being extreme rainfall, droughts and disease outbreaks. Farmers in Limpopo province have noted climatic changes such as frequent occurrence of drought and changes in the timings of rain that negatively affect agricultural productivity (Maponya et al., 2013). Pandey et al. (2018) revealed that farmers were more concerned about a decline in water quantity and sudden changes in precipitation patterns as major determinants of climate change in their area. A study by Elia (2018) revealed that farmers are aware of climate change though their knowledge surrounding climate change is limited to different determinants that they have been exposed to instead of the phenomenon holistically. Farmers have a grounded perception about climate change, particularly when translated through rainfall patterns that include delayed rainfall and bad rainfall distributions (Fadina & Barjolle, 2018). Though farmers have noted some climatic changes such as temperature and rainfall patterns, most farmers do not associate such with climate change (Tripathi & Mishra, 2017). There is an existing knowledge within farming communities regarding critical determinants of climate change such as extreme weather events and such knowledge is an important element for successful adaptation plans (Burnham & Ma, 2017).

2.2.3 Awareness of impacts of climate change

Farmers in Africa are likely to experience tragic crop failures, reduced agricultural productivity and diseases outbreak through the impacts of climate change (Zoellick, 2009). The impact of climate change increases the level of food insecurity around the globe (Pereira et al., 2014). Furthermore, it has been noted that agricultural productivity in various areas have been distinguished as sensitive to the effects of climate change and such changes negatively impact the livelihood of households attached to farming practice (Mehar et al., 2016). A study conducted by Maponya et al. (2013) in Limpopo province revealed that there is enough evidence that shows that climate change is affecting different elements of agriculture such as crops and livestock quality. Furthermore, the study also revealed that impacts of climate change within agriculture resulted to low production (Maponya et al., 2013). The study by Mugi-Ngenga (2016) emphasized similar findings that climate variability negatively affects crop productivity. In a study conducted by Mpandeli et al. (2015) on adapting to the impacts of drought by smallholder farmers, it was revealed that farmers have experienced the impacts of drought through which they have lost high volumes of crop and livestock which subsequently has negative impacts on farmers' livelihoods. Farmers have identified livestock and crop loss resulting from climate change impacts taking place around their areas (Belay et al., 2017). Farmers perceive the negative effects of climate change that directly affect their livelihood as they believe it contributes to lowering of crop and livestock productivity and the most critical determinant of climate change is associated with drought (Makuvaro et al., 2018). Climate change is likely to cause an increase of areas categorised as water-stressed, with agricultural productivity likely to reduce time after time

(Kgakatsi et al., 2007). Davis et al. (2016) confirmed that South Africa has been experiencing an increase in warmer days and more decrease in the number of cooler days while the National Department of Agriculture (2011) ascertained that the average annual rainfall of 450mm per year in South Africa is extremely below the world's average of 860mm and it suggests that there will be a major decline in agricultural productivity more especially in the affected areas. Temperatures are expected to increase because of rising frequency of CO_2 emissions; such climatic change is expected to contribute to the reduction of crop yields and their quality. Such climatic change may positively affect crops that require long growing periods, yet overall it is expected to reduce crop yield throughout the globe (AEA Energy and Environmental group, 2007). Since climate change mostly affects developing countries, particularly smallholder farmers; livestock smallholder farmers are most likely to be vulnerable to climatic change of conditions (Madzamuse, 2010).

A study conducted by Mulinde et al. (2019) suggests that common known impacts of climate change among farmers are loss of income, food shortage, abridged soil productivity, and interrupted planting dates. Farmers with low resource security are negatively affected by climate change in food security and income generation (Shukla et al., 2019). Furthermore, the study revealed that agricultural productivity is mostly impacted due to changes in annual precipitation (Shukla et al., 2019).

2.3 Influence of farmers' socio-economic characteristics on selection of adaptive strategies

Successful process of adaptation and mitigation mainly rely on farmers' awareness of climate change and its potential impacts and most importantly adaptive strategies to mitigate such impacts (Hyland, 2016).A study conducted by Maponya and Mpandeli (2012) found that there are various adaptive strategies that farmers in Limpopo province consider as climate change adaptation tools under numerous weather conditions such as excessive heat, cold and abnormal wind among other conditions. Adaptation process to climate change can be promptly influenced by farmers (Mugi-Ngenga et al., 2016). Regardless of available adaptive strategies which farmers could use to avoid the impact of climate change; education, household income, credit, access to information and household size were identified to be important factors of farmers' socio-economic characteristics that influence farmers' adaptation to climate change (Ndamani & Watanabe, 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., 2016). Socio-economic characteristics of farmers such as age, education level and access to climate information do considerably influence the perception of farmers on climate change adaptation since farmers who have access to extension services are likely to get adaptive strategies based on the information and advice they are receiving from extension workers (Debela et al., 2015). Adoption of adaptive strategies in some

instances have mainly relied on gender, age, education and wealth status of farmers (Gichangi & Gatheru, 2018). For an effective uptake of climate change adaptive strategies among farmers, during adaptation, planning farmers' socio-economic characteristics should be significantly considered particularly because adaption to climate change can be well measured at the farm unit (Mulinde et al., 2019). 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 et al., 2019). Farmers' socio-economic characteristics that significantly influence farmers to select various adaptive strategies towards deforestation were found to be age, farming experience and education status (Bzugu et al., 2019).

2.3.1 Influence of farmers' gender on selection of adaptive strategies

Hyland et al. (2016) suggested that farmers may likely decide to adopt adaptive strategies based on their identity as it influences their behaviour towards the implementation of such adaptive measures. 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 (Jin et al., 2015). Another study by Nnadi et al. (2019) revealed that male farmers were found to be more adaptive than female farmers and the reason for this could be the lack of manpower among women-led farms. Male-headed households are likely to make use of new technology related adaptive strategies and are more likely to invest more in farming businesses than female-headed households (Jin et al., 2015). Women have low adaptive capacity, more especially using technological adaptive strategies (Abdul-Razak & Kruse, 2017). A study conducted by Mihiretu et al. (2019) revealed that being a male farmer increases the probability to adapt to climate

change through agro-ecological practices than female farmers. Female and male farmers are expected to have different selection of adaptive strategies based on their education levels, assets access and various services (Bayard et al., 2007). In a study by Jost et al. (2016), it was 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. Male farmers are the ones who take decisions on the type of an adaptive strategy they will deploy and this enhances male farmers' opportunity to adapt more than their counterparts (Mehar et al., 2016). Livestock farmers who are likely to change feeding practice are male and high experienced farmers (Bryan et al., 2013). Male farmers are more willing to adapt to climate change compared to female farmers, more especially those in villages whereby extension officers do not reside within the area; male farmers are mobile and can have access to extension officers than female farmers (Zamasiya et al., 2017). Farmers' gender was found to have a strong influence on the type of strategy a farmer would select to apply in their farming enterprise (Mugi-Ngenga et al., 2016). A study conducted by Chete (2019) revealed that farmers' gender negatively affects their decision to adopt adaptive strategies; the study further stated that female farmers were found to be more willing to adapt to climate change more than male farmers. Males are usually dominant on the selection of adaptive strategies to be used in a farm (Belay et al., 2017). Male farmers are likely to employ different adaptive strategies due to their role as decision-makers in terms of farm planning and operations (Arunrat et al., 2017). Male farmers are more exposed to different adaptive strategies than female farmers (Assan et al., 2018). Male farmers are usually the dominating figures in accessing of newly developed technologies and its implementation than their

counterparts; furthermore, they consider calendar redefinition as their most preferred adaptive strategy (Alih et al., 2019). In a study conducted by Arunrat et al. (2017), male farmers are usually considering crop rotation practice more openly than any other adaptive strategies. Female farmers are unlikely to consider possible ways to adapt to climate change, largely due to insecure land rights and less access to education among them (Yadav et al., 2018). A study conducted by Sadiq et al. (2019) noted that soil related adaptive strategies are mostly influenced by farmers' gender with male farmers taking a lead in adoption of such adaptive strategies.

In a study conducted by Kgosikoma et al. (2018), female farmers are more willing to adapt to climate change compared to male farmers. Most female farmers choose diversification as an adaptive strategy and that could be because majority of them also consider off-farm activities for income generation (Fadina & Barjolle, 2018). Most commonly used adaptive strategies by both female and male farmers are crop diversification, calendar redefinition and improved crop varieties (Assan et al., 2018). Male farmers are more likely to adapt to climate change based on their mobility compared to their counterparts (Zamasiya et al., 2017). Women were found to be more vulnerable to impacts of climate change than men and were also found to be disadvantaged to acquire adaptation resources; thus leading to less adaptation initiatives rate of success (Ford, Berrang-Ford, Bunce, McKay, Irwin & Pearc, 2015). Male farmers were found to have a better understanding of different adaptive strategies as compared to female farmers (Mehar et al., 2016). Age and gender are among the socio-economic characteristics of farmers which influence the choice of adaptive strategies that farmers are willing to employ (Jha & Gupta, 2016).

2.3.2 Influence of farmers' age on selection of adaptive strategies

Farmers' age influences their ability to take decisions with young farmers being in a position to take various adaptive strategies than older ones due to the heavy labour requirements associated with adaptive strategies (Mehar et al., 2016). Age is a positive contributor to farmers' willingness to adapt to climate change, however, another study revealed that any type of farmers are open to use different adaptive strategies regardless their age group (Niles et al., 2016; Prokopy et al., 2008). Alih et al. (2019) stated that age of a farmer positively and significantly influences farmer's adaptation to climate change. Several studies suggested that a farmer's age has a positive and significant association with selection of various adaptive strategies (Chete, 2019; Davis & Ali, 2014; Ozor et al., 2012). Application of adaptive strategies among older farmers is relatively low, more especially for those adaptive strategies that are technology driven (Mugi-Ngenga et al., 2016). A study by Alam et al. (2016) noted that older farmers have good farming experience to know the trend of weather patterns and climate variability and this puts them in a good position to adapt to climate change more than their counterparts. It has been noted that younger farmers are likely to take adaptive strategies such as drought tolerant varieties, calendar redefinition and substitution of crops than elder farmers and this could be because younger farmers are innovative and may want to try out a new technology related strategies while older farmers may not be aware of recent innovations happening around agriculture (Ali & Erenstein, 2017). Young farmers who are usually on livestock production are more familiar with possible adaptive strategies as they possess higher formal education than their counterparts and are generally updated on modern issues (Makuvaro et al., 2018; Masere, 2015). Age has a positive influence on the selection of adaptive strategies among farmers (Belay et al., 2017). Young farmers who

also have better years of schooling have been found to have better chances in selection and application of different adaptive strategies (Asfaw et al., 2018). Older farmers are risk averse and that contributes to them not intending to adapt various adaptive strategies (Chete, 2019). In a study by Awazi and Tchamba (2018), it was revealed that older farmers are more likely to make use of different adaptive strategies though such strategies are more likely to be traditional ones. Older farmers are willing to take improved adaptation program that may also require monetary contribution than younger farmers (Khanal et al., 2018). Farmers aged between 36 and 55 were identified to prefer crop diversification as their ideal strategies than other groups of farmers (Amare et al., 2018). It was found that older farmers are more adaptive to disease resistant crops and irrigation systems that younger farmers (Alih et al., 2019). Age was found to negatively influence adaptation to climate change as older farmers were found to be risk-averse and unlikely to take new technology related strategies (Kgosikoma et al., 2018). An increase in the years of age of farmers increases their probability to use changing planting dates as a strategy to adapt to climate change (Alemayehu & Bewket, 2017). A study by Bedeke et al. (2019) revealed that young farmers prefer climate change adaptive strategies such as soil and water conservation practices, drought resistant seeds and application of fertilizers. 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 preferred by farmers with large household size. Younger farmers were found to be more comfortable with changing of planting and harvesting dates as their adaptive strategies (Alih et al., 2019).

2.3.3 Influence of farmers' education towards adaptation

Formal education of farmers positively contributes to adaptation to climate change and it also plays a significant role in adoption of new technological adaptive strategies (Ashraf et al., 2018). Educational level among farmers significantly increases chances of farmers to adapt to climate change (Mihiretu et al., 2019). Education level of farmers has been found to generally have a low impact on farmers' decision to adapt to climate change but significantly contributes to the usage of changing crop consumption patterns as an adaptive strategy (Alemayehu & Bewket, 2017). Farmers who attained primary and secondary level education had great chances of adopting multiple adaptive strategies (Mutandwa et al., 2019). In a study conducted on farmers' perception of climate change by Abid et al. (2019), it was revealed that though level of education does not significantly influence farmers' adoption of adaptive strategies, instead it plays a key role in understanding of climate change phenomenon among farmers. Farmers' educational level plays a significant role in their ability to perceive and interpret their own agricultural performance in relation to climate change (Alih et al., 2019). Higher educational status improves farmers' ability to understand new and improved technologies as well as its adaptation (Siddiqua et al., 2019). Farmers' education could limit their ability to make use of adaptive strategies if there is limited access of necessary capital (Alam et al., 2017). Educated male and female farmers are most likely to adopt different types of adaptive strategies based on their preferences (Jin et al., 2015). 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. Educated farmers are more aware of climate change and appropriate adaptive strategies and may be more interested in climate change adaptation than their

counterparts (Ali & Erenstein, 2017). Adoption of several adaptive strategies such as irrigation, calendar redefinition, changing crop variety, soil conservation and changing fertilizer increases with an increase in the level of education among farmers compared to those with little or no formal education (Abid et al., 2015; Elahi et al., 2015). Number of years that farmers spent at school plays a vital role in selection of adaptive strategies when farmers intend to respond to climate change (Recha et al., 2015). Education and gender of farmers were identified as some critical determinants of farmers to adapt to the impacts of climate change, particularly crop failure. More farmers' education significantly improves farmers' awareness about adaptation opportunities and also enhances their ability to adopt different adaptive strategies (Coulibaly et al., 2015). Farmers with high level of education adapt to climate change more than those who are not educated; level of education among farmers influences selection of adaptive strategies (Khanal et al., 2018; Alam et al., 2016). Educated farmers who have plenty of resources are more involved in climate change adaptation with the use of multiple adaptive strategies (Eakin et al., 2016). Educated farmers perceive climate change as a threat and are willing to find appropriate adaptive strategies and majority of them were found to read newspapers every day as a way of being updated about climatic changes (Tripathi & Mishra, 2017). A study by Masud et al. (2017) confirms with recent literature on the point that highly educated farmers are aware of impacts of climate change and are more concerned with adoption of relevant adaptive strategies than farmers with less formal education. Farmers with lower educational background were found to be more aware of extreme weather events but instead, have a less actual adaptation behaviour than their counterparts (Li et al., 2017). Formal education attainment helps farmers to consider the use of adaptive

strategies as essential (Asrat & Simane, 2018). Highly educated farmers are well exposed to different phenomenon and such greater exposure helps them to be more responsive to the adaptation process than those who are least educated (Arunrat et al., 2017). Furthermore, farmers with high education level and larger households are likely to be exposed to all adaptive strategies (Arunrat et al., 2017). Farmers' educational level was found to strongly influence the usage of tillage and irrigation adaptive strategies but it negatively influences the changing of planting dates among farmers (Alih et al., 2019). Formal education positively and significantly influences farmers' decision to apply various adaptive strategies as it is considered as an important tool among farmers to choose appropriate adaptive strategies (Chete, 2019).

2.3.4 Influence of farmers' marital status towards adaptation

A study conducted by Alih et al. (2019) showed 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 of female farmers plays an important role in consideration of adaptive strategies by farmers; while among males, a marital status does not have an important role in determining whether a farmer would be able to access certain adaptive strategies. Widows and divorcees are the most disadvantaged groups of female who are unlikely to adopt any of the adaptive strategies.

2.3.5 Impact of farming experience towards climate change adaptation

In case of climate change adaptation and selection of adaptive strategies, farming experience plays a vital than level of education of farmers (Tessema et al., 2018). An increase in farming experience among farmers positively enhances farmers' awareness of climate change adaptation benefits (Sadiq et al., 2019). Farming experience has a

positive influence on adaptation to climate change for both female and male farmers. Farmers' chances of adapting to various climate change adaptive strategies increases with an increase in farming experience (Abid et al., 2019). Various studies have shown that farming experience among farmers plays a significant role in climate change adaptation than just a farmer's age (Mihiretu et al., 2019; Mulatu, 2014). Furthermore, it has a negative impact for female farmers towards adoption of new drought tolerant crop varieties as well as male farmers to adopt new technology for water conversation (Jin et al., 2015). Farmers who might have an experience of a certain adaptive strategies may not be willing to try a different adaptive strategy in the future (Niles et al., 2016). Farmers with more farming experience are familiar with changing crop variety, changing planting dates and crop diversification and find such adaptive strategies helpful (Bryan et al., 2013). Farmers who have experienced impacts of climate change in their farming practices in the past are more willing to take different adaptive strategies more than their counterparts (Zamasiya et al., 2017). Farmers with less farming experience usually have low level of adaptation as it is suggested that less experienced farmers may have little knowledge and information about climate change (Mugi-Ngenga et al., 2016). In a study conducted by Trinh et al. (2018), experienced farmers are likely to make use of crop variety strategy than their counterparts. Adoption of new crop varieties increase with farming experience; experienced farmers are knowledgeable about climatic changes taking place (Siddiqua et al., 2019). Farming experience is quite critical for farmers who opt to employ non-technological adaptive strategies (Tessema et al., 2018). Farming experience is one of the most instrumental key for farmers to perceive impacts of climate change and their behaviour towards choosing relevant adaptive strategies for their

farming enterprises (Tripathi & Mishra, 2017). Different studies have concluded that experienced farmers adapt to climate change better than less experienced farmers and that could be because experienced farmers may have different indigenous adaptation practices that can help them to correctly adjust their farming practices (Masud et al., 2017; Arunrat et al., 2017; Epule & Bryant, 2016; Adam et al., 2015). Personal experience of farmers with the effects of climate change relatively plays a vital role on perception and response of farmers to climate change using appropriate adaptive strategies (Niles et al., 2014). Personal experience on loss of crops and farming experience positively helps farmers to make informed decision on appropriate adaptive strategies (Menapace et al., 2015). Farmers who have been exposed to pests and diseases were found to prefer crop management strategies such as changing planting dates, introduction of new crops and changes in varieties than other strategies (Shikuku et al., 2017). Farming experience among farmers has been found to be a critical determinant that increases farmers' probabilities to adapt to climate change (Arunrat et al., 2017). Farmers with more farming experience have a sound knowledge about farming and the environment which it enhances their decision to identify and implement appropriate adaptive strategies (Arunrat et al., 2017). Farmers with more than 10 years of farming experience consider changing of sowing dates and using crop varieties as their adaptive strategies (Amare et al., 2018). Farmers with more farming experience are considered to make use of non-technological adaptive strategies, more particularly changing planting dates and crop varieties since such strategies require less resources than technological ones (Tessema et al., 2018). Many years of farming experience increase farmers' willingness to consider the usage of multiple adaptive strategies (Khanal et al., 2018). A study conducted by

Shikuku et al. (2017) showed that there is no positive relationship between adaptation to climate change and the farming experience among farmers. Farmers who have past adaptation experience are likely to continuously adapt compared to those who have never adapted before (Burnham & Ma, 2017). Farming experience positively influences adoption of adaptive strategies (Ashraf et al., 2018). Farmers' decision to adapt to climate change is negatively influenced by their farming experience; the more farmers acquire farming experience the lesser they consider to adapt to climate change (Alih et al., 2019). Several studies noted that farming experience among farmers and adaptation to climate change are positively related as more experienced farmers possess useful climate change knowledge (Chete, 2019; Ayanlade et al., 2017, Onubuogu & Esiobu, 2014). Some studies denoted that farmers operating in drier and hotter areas take various adaptive strategies (Tessema et al., 2019; Deressa et al., 2009). A previous experience of climate change impact does not significantly shape farmers' adaptation capacity nor improves their willingness to adapt to climate change (Duong et al., 2019). Findings by Bedeke et al. (2019) suggested that adoption of a certain adaptive strategy is positively influenced by the adoption of another strategy.

2.3.6 Influence of household numbers and income sources

Some studies have noted that the family household size may positively influence farmers' decision to adapt to climate change and this could be suggested by the fact that when the household size is big, there will be enough supply of labour for farming activities (Abid et al., 2016; Ali & Erenstein, 2017), while a study conducted by Ashraf et al. (2018) showed that farmer's household size has a negative relationship with the adoption of different adaptive strategies. In a study by Mihiretu et al. (2019), a household size has a

significant negative influence towards farmers' adaptation to climate change. In a study conducted by Makate et al. (2016), farmers who are likely to adopt crop diversification strategy are those with bigger size of land as a larger farm may influence the idea to consider multiple crops whereas farmers with more farming experience are not likely to consider crop diversification. Enough in-depth analysis of farming households should be done to find their resource allocation strategies which could influence their on-farm decision to adapt to climate change (Andersson & D'Souza, 2014). Large households are expected to adapt to climate change as many large households have access to large farmlands than their counterparts. Households that have access to credit have higher determination to adapt to climate change (Trinh et al., 2018). Farmers with larger households were found to be more responsive to climate change, probably because they have more labour resources to carry-out farming activities (Arunrat et al., 2017). Large household size was found to negatively impact climate change adaptation as farmers with few resources were likely to be under extreme pressure to sustain their families and thus influence other household members to look for off-farm income (Kgosikoma et al., 2018). Farmers' household size has been found to have a negative influence on farmers' decision to adopt any of the adaptive strategies (Alih et al., 2019).

Farmers who also generate income from off-farm activities do adapt to climate change more than their counterparts (Mulinde et al., 2019). Climate change has led to many emerging farmers experiencing a significant crop and income losses which also led to food insecurity (Harvey, 2014). A decline in agricultural output as a result of impact of climate change has led many farmers to reduced income and employment which also led to negative impact on rural economies as a whole (Turpie & Visser, 2013). Income

generation and access to climate change information were found to be among key factors that enhance farmers' capacity in choosing effective adaptive strategies. Future loss of income and food security in the agricultural sector due to the projected impact of climate change will significantly differ on whether such resultant losses are on local or global levels (Hertel & Rosch, 2010). Warmer and drier impacts of climate change severely affect the net farm revenues with emerging farmers being the most vulnerable. Climatic changes are expected to be worse on those who are already vulnerable. There is a good correlation between stable agricultural production and net farming revenue among emerging farmers (Turpie & Visser, 2013). Farmers who earn more on-farm income are quite willing to invest more in various adaptive strategies (Chete, 2019). A negative impact on farm income may lead emerging farmers to adopt limited adaptive actions (Turpie & Visser, 2013). Severe temperatures may reduce an overall farm net revenue, though an investment on heavy machines for some practice could lead to a mitigation of possible impacts of climate change and improve farm revenues (Eid et al., 2006). High-income farmers from both on and off-farm practices adapt better to climate change than their counterparts (Masud et al., 2017). Farmers who earn higher farm income are more determined to adopt different adaptive strategies than farmers who are generating lower income from their farming business (Li et al., 2017). High farm income was found to have a positive significance towards adaptation among farmers and non-farm was found to be important but less influential for farmers to adapt to climate change (Arunrat et al., 2017). Income generation from off-farm activities has a positive influence on the selection and adoption of adaptive strategies (Asfaw et al., 2018). Multiple sources of off-farm income generation have a positive influence on the consideration of different adaptive strategies

(Khanal et al., 2018). Farmers with more income generation go with crop diversification while farmers with lower income generation do consider seed varieties strategy (Amare et al., 2018). Farmers with off-farm income source are more likely to consider different adaptive strategies, particularly changing of planting dates, change crop variety whereas livestock farmers are likely to consider change of feeds (Gichangi & Gatheru, 2018). Farmers with off-farm income opportunities do consider a diversification strategy as it involves variations in crops (Karimi et al., 2018). Wealthy farmers also consider crop insurance as their adaptive strategy and this is because they can meet their premium obligations using off-farm income (Karimi et al., 2018). Farmers with more annual income are more adoptive to various climate change adaptive strategies (Ashraf et al., 2018).

2.3.7 Land ownership and farm size

Farmers who own the land are more likely to take adaptive strategies more than landless farmers (Mehar et al., 2016). A study conducted by Diencere (2019) shows that farmers with land security are more involved in climate change adaptation than their counterparts. Landless farmers are unlikely to consider adaptive strategies as majority of them end up moving to the cities in a bid to improve their livelihood (Alam et al., 2017). Farmers with small farm size prefer intercropping as their adaptive strategy whereas they have a negative association with adaptive strategies such as diversification and mixed farming (Chete, 2019). Farm size has a positive influence on the capacity of farmers to choose effective adaptive strategies (Belay et al., 2017). Farmers with larger farming holdings are more likely to adopt adaptive strategies as majority of them have the capacity to adapt to climate change than farmers with no land ownership (Ali & Erenstein, 2017). A farm size positively influences farmers' adaptation to climate change; as the farm increases,

so does the possibilities of farmers to adapt to climate change (Mulinde et al., 2019). Farmers who have opted to adapt new crop varieties have in the process abounded some of the crops to adapt to climate change and such change is positively associated to farmers with bigger land size (Tessema et al., 2019). Several studies have noted that a physical location at which a farmer is operating has a significant influence on the decision to adapt to climate change or not (Vincent, 2007; Tiwari et al., 2008; Hinkel, 2011; Below at al., 2012; Ali and Erenstein, 2017). Farmers with large farming areas are more likely to use multiple adaptive strategies such as crop rotation, crop diversification, monitoring of weather forecast and crop variety (Trinh et al., 2018). Farmers with larger farming size participate in climate change adaptation whereas farmers with smaller farming areas may likely sell their plots and not consider climate change adaptation. The larger farm size and land ownership enable farmers to consider different effective adaptive strategies without limitations. Farm owners take adaptation to climate change as an investment (Arunrat et al., 2017). Larger farm size positively influences farmers to opt for adaptation to climate change (Awazi & Tchamba, 2018). Farm size and land ownership are key determinants of climate change adaptation, moreover, farmers who own large farms are more willing to consider crop diversification as an adaptive strategy than farmers with smaller farm size (Gunathilaka et al., 2018). Farmers with larger farm size are more driven to adapt to climate change using different adaptive strategies and this could be because with larger farm size, one can simply diversify one's operations (Alemayehu & Bewket, 2017). Farmers with larger landholdings have a better chance of adapting to climate change using various adaptive strategies for suitable adjustment of their farming practice (Siddiqua et al., 2019). Farmers who manage their farming enterprise are likely to adopt

multiple adaptive strategies than farms which are managed by tenants (Li et al., 2017). Farmers with larger farm size consider combination of various adaptive strategies such as improved varieties, crop-livestock diversification and seasonal crops as they do not mind to invest in their enterprises (Fadina & Barjolle, 2018). A study conducted by Mugagga et al. (2019) revealed that farm size has a negative influence in farmers' decision to adapt to climate change as farmers with large farms may not fear to be affected by climate change.

2.3.8 Farmers' cultural belief and perception on climate change

Farmers' religious belief plays a vital role on their willingness 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). Farmers have a traditional way of adapting their farming practices to different weather conditions and should therefore, familiarise themselves with newly developed practices in order to reduce the negative impact of climate change (Okonya et al., 2013). Socio-cultural perception is also an influencer of farmers' decision to mitigate the impacts of climate change through adaptation (Nguyen et al., 2016).

A study on perception of farmers on climate change and adaptation by Maponya and Mpandeli (2013b) stated that there is a greater association between farmers' interaction with extension agents and adaptation to climate change among farmers. Farmers' attitude and belief towards climate change do not correlate to the actual adoption of adaptive strategies, rather they vitally influence only the intentions to adapt (Niles et al., 2016). Farmers' perceptions and their interpretation of climate change influence their decisions to adapt to climate change (Ndamani & Watanabe, 2016). Farmers'

perceptions of climate change seem to shape their behaviour to adapt and influence their selections of adaptation to climate change (Nguyen et al., 2016). Without an in-depth understanding of farmers' perceptions of climate change and adaptive strategies, adaptive strategies may be initiated, but they may not be effective (Ndamani & Watanabe, 2016). Farmers are the key determinants of the success or failure of climate change failure as farmers are the decision-makers at the end (Zamasiya et al., 2017). Farmers are likely to adapt to climate change based on the information they receive concerning a particular adaptive strategy whereby majority of them are familiar with diversifying crops (Alam et al., 2016). In areas where farmers are not terribly concerned about climate change, there are minor changes of making use of adaptive strategies while farmers who perceive climate change as a serious threat to their farming are more likely to adapt to climate change (Woods et al., 2017). The belief of farmers plays a critical role in the decision-making process as to whether farmers will adapt to climate change (Woods et al., 2017). Farmers' surroundings at a farm level may significantly affect the selection of adaptive strategy due to the society's belief (Mase et al., 2017). Farmers' attitude towards farming practices also contributes to selection of adaptive strategies based on how farmers review such a practice (Shikuku et al., 2017). Farmers who have suffered a severe loss through climate change effects are more willing to adapt to climate change than their counterparts (Zamasiya et al., 2017).

2.4 Influence of institutional factors towards adaptation to climate change

Adaptation process is shaped by various factors with developing countries having their own adaptation challenges as compared to developed countries (Juana et al., 2013). Successful adaptation needs integration of various factors as it has to cater different

farmers' adaptive responses (Nguyen et al., 2016). According to Touch et al. (2016), famers' willingness to adapt to climate change is vital since some farmers who are aware of adaptive strategies that could be used to minimize risks and coping with the impact of climate change are hesitant to apply such strategies in their enterprises.

2.4.1 Access to climate change information

Accessing climate change information significantly improves farmers' willingness to adapt to climate change (Mugagga et al., 2019; Arunrat et al., 2017; Bryan et al., 2013). When farmers lack climate change information and exposure to its adaptation, it weakens their adaptive capacity (Burnham & Ma, 2017). Information dissemination methods can impact farmers' decision towards adopting adaptive strategies (Ngigi et al., 2017). Dissemination of climate change information, promoting crop diversification, timely planting and making use of varieties of crops could be very helpful in enhancing climate change resilience among farmers. Climate change information dissemination among farming community proves to be effective than information received from other sources (Arunrat et al., 2017). Dissemination of climate change information timely enables farmers to select effective adaptive strategies such as calendar redefinition (Asfaw et al., 2018). Accessing knowledge on climate change increases farmers' adaptation to climate change by a significant margin (Kgosikoma et al., 2018). The nature of climate change information accessibility significantly affects the attitude and type of adaptive strategies chosen by farmers; farmers who receive information on climate change are unlikely to select crop diversification as an adaptive strategy (Gunathilaka et al., 2018). In most cases, farmers who have access to climate information are only subjected to daily weather forecast

mainly through radio (Gichangi & Gatheru, 2018). A group of farmers found to have a low priority of adaptation plan are those with limited or no exposure to climate information (Pandey et al., 2018). Climate change information is still not well communicated since it does not entirely reach the intended recipients timely and furthermore, farmers find majority of such sources unreliable (Elia, 2018). Farmers who are likely to adopt different adaptive strategies are those who have access to climate change information and who regard their sources of information as reliable (Zamasiya et al., 2017). In a study conducted by Gichangi and Gatheru (2018), majority of farmers couldn't adapt to climate change since they lacked communication that would provide them with climate information as well as having a very limited access to different resources that could support their farming practices. The type of information such as climate and weather information distributed among farmers has a positive influence on farming methods that farmers tend to use (Moeletsi et al., 2013). Improved information on climate change and dissemination of weather forecasts timely significantly improve farmers' adaptive capacity towards climate change adaptation (Nnadi et al., 2019).

A study conducted by Mulinde et al. (2019) revealed that farmers who considered adaptation to climate change were those who were aware of climate change variability. Farmers who notes changes in rainfall patterns adapt to climate change more than those that who do not observe such changes (Sadiq et al., 2019). Farmers with access to climate change information have a better association of relevant adaptive strategies that could be useful in their respective farming practice (Duong et al., 2019).

Emerging farmers in developing countries are vulnerable to climate change; many of them 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 climate change information, assets, technologies and financial services (IPCC, 2007). Few farmers are aware of climatic changes and are subsequently adjusting their farming practices to adapt to climatic changes (Tambo et al., 2013). A study by Antai et al. (2012) suggested that information on how to ease the impacts of climate change on agricultural productivity is still very scarce. Emerging farmers are recently constrained to successfully adapt to climate change by limited access to information regarding climate change and improved technologies (Mapfumo et al., 2013). Lack of access to information together with insufficient early warning seems to be among the leading factors for farmers' failure to adapt to climate change (Juana et al., 2013). In Kenya, some farmers were found to be failing to differentiate between impacts arising from climate change and problems caused by environmental degradation (Mutimba et al., 2010). Availability of climate change and agricultural information plays a vital role for farmers to make informed decisions in agricultural production as it allows them to choose appropriate strategies to adapt to climate change (Baethgen et al., 2003). Male farmers are seen to be dominating in receiving information and extension services which tend to help them to be more adaptive than female farmers. Furthermore, the study reveals that in Uganda, farmers indicated that they usually receive weather information as SMS (short text messages) via mobile phones and the prime minister's office is said to be the source of such information (Jost et al, 2016). Some adaptive strategies are uncommon among farmers and end up limiting their chances to make use of such adaptive strategies (Niles et al., 2016). In a study conducted by Zamasiya et al. (2017), there are majority of farmers who are aware

of climate change but who still have bad attitude towards developed adaptive strategies. Furthermore, the study noted major sources of climate change information among farmers as radio stations, television and extension officers. Considerable differences among farmers exist in terms of access to climate change information and access to resources and such serve as an instrumental key for farmers to participate in social networks and managing climatic changes (Eakin et al., 2016). There is a considerable lack of proper understanding of adaptive strategies among farmers inclined to influence their decision to either use a certain adaptive strategy (Ford et al., 2015). A proper communication channel and free cooperation in social networks among farmers could also improve adaptation among farmers (Bedeke et al., 2019).

2.4.2 Access to extension services

A study conducted by Maponya and Mpandeli (2013a) in Limpopo province discovered that farmers in Limpopo have limited access to extension services and that hinders them to adapt to climate change fully. The study further revealed that agricultural extension agents' role should be communicated to farming communities for farmers to be aware of available services (Maponya & Mpandeli, 2013a). Limited access to extension services at some places has placed farmers in a position where there is no sufficient value chain network for information to support their decisions on how best they can adapt to climate change. A study by Zamasiya et al. (2017) supports the idea that farmers who have regular contact with extension officers are likely to have positive attitude towards climate change adaptation as their interaction may enhance farmers' chances to have access to climate change information. Easy access to extension services helps farmers to know

appropriate adaptive strategies to take when faced with a decision to make; yet on the basis of gender, male farmers are more likely to know which adaptive strategies they will deploy in their farming enterprises since they have a better access to extension services than female farmers (Mehar et al., 2016). Access to extension service, diversified sources of income and farming experience seems to be more supportive of climate change adaptation action among farmers (Bryan et al., 2013). Farmers who are not visited by extension officers and do not have any formal education were found to have minimal awareness of climate change and eventually have a very low adaptation rate towards climate change as they do not perceive it as a threat to their farming practice (Tripathi & Mishra, 2017). Poor extension services and a location in which farmers are operating can limit farmers from making use of available strategies as some adaptive strategies are not known in some areas (Masud et al., 2017). Farmers who participate in extension services and social networks are more stimulated to participate in climate change adaptation than farmers who do not have any interaction with extension officers (Li et al., 2017). The use of extension services to adapt to climate change is more effective than a traditional off-farm information sessions to improve awareness of climate change adaptation (Menapace et al., 2015).

Shikuku et al. (2017) noted that having access to extension services does not positively influence farmers to adapt climate change. Access to extension services influences farmers to adapt to climate change; those who received extension services were found to prefer crop diversification than other adaptive strategies (Amare et al., 2018). Extension services seem to be less important when one regards the use of non-technological strategies and this could be because in some areas, extension services are quite limited

(Tessema et al., 2018). Accessibility of extension services significantly promotes adaptation to climate change with different sources of extension information playing an integral part in selection of adaptive strategies (Mulwa et al., 2017). In a study conducted by Shikuku et al. (2017), access to extension services did not prove to add value on farmers' decision to adapt to climate change or perhaps choose appropriate adaptive strategies. Extension officers play an integral role on whether farmers will adapt to climate change; late response from extension officers has led majority of farmers unwilling to adapt to climate change as they usually do not receive the required assistance timely (Elia, 2018). As noted by Zamasiya et al. (2017), farmers who have access to agricultural extension services have a better chance to adapt to climate change through different adaptive strategies since they usually get climate information timely and they are advised of suitable farming practices to consider in the changing climatic conditions. Farmer to farmer extension is vital in information dissemination and thus, is regarded as one of the key determinants of climate change adaptation among farmers (Alemayehu & Bewket, 2017). Farmers who are most likely to make use of crop diversification adaptive strategy are those who receive support particularly related to agricultural extension services and output price information (Makate et al., 2016).

Farmers who have consultations with extension staff adapt to climate change (Mulinde et al., 2019). Farmers with a good relationship with extension agents and possess membership of local farmers' organisation adapt to climate change (Bedeke et al., 2019). Farmers who receive advisory services from public extension officials are adoptive of various climate change adaptive strategies (Abid et al., 2019). Farmers with constant interaction with agricultural public extension systems possess a high likelihood of

adopting various possible adaptive strategies than farmers with no contact with extension agents (Mutandwa et al., 2019; Opiyo et al., 2015). Farmers who visit extension agents regularly are in a better shape to know suitable adaptive strategies to opt for (Chete, 2019). A study conducted by Siddiqua et al. (2019) stated that having access to extension services does not positively influence farmers' adoption of various adaptive strategies as extension agents are considered ineffective due to their late information dissemination. Farmers who are constantly in contact with extension agents are usually in a better position to be aware of climatic changes, however, it has been revealed that farmers with frequent visits to extension agents do not consider various adaptive strategies in their farming practices (Alih et al., 2019).

2.4.3 Availability of various support and resources

Farmers who are failing to adapt to climate change are faced with lots of challenges including limited resources and at some point, they lack effective support systems to adapt to climate change (Harvey, 2014). Farmers lack vital ability to efficiently cope and adapt to climate change (Touch et al., 2016). Limited access to land resources and lack of water are other contributing factors that affect farmers' adaptive capacity, particularly emerging farmers (Ogola, 2013). Farmers are willing to take sponsorship opportunities for adaptation to climate change since majority are not willing to adapt with their own resources (Tzemi et al., 2016). Access to agricultural support services improves farmers' awareness of climate change as well as farmers' willingness to adapt to changing climatic conditions (Debela et al., 2015). At times, though farmers are aware of climate change, their adaptation is largely restricted by the lack of necessary resources as noted by Elum

et al. (2017) who revealed that farmers may not adapt to climate change largely due to lack of access to insurance products that can protect them from climate change and their inability to afford such insurance premiums that can be their adaptive strategy against climate change. In a study conducted by Bryan et al. (2013), farmers are more willing to adapt to climate change more than they have already done, majority of them view lack of resources such as lack of money or limited investment and lack of reliable information as the major constraints of their adaptation. Furthermore, the study discovered that farmers with access to irrigation are more likely to make use of changing crop varieties among other strategies, particularly to high value crops (Bryan et al., 2013). Availability of institutional factors such as access to credit, access to extension services, size of land and wealth plays a vital role in farmers' consideration to make use of different adaptive strategies (Ali & Erenstein, 2017). Institutional factors that shape farmers' decision to make use of adaptive strategies involve access to land ownership, access to market information, information on weather forecasting and agricultural extension services and influence selection of adaptive strategies accordingly (Ndamani & Watanabe, 2015). Depending on the availability of resources; farmers use different adaptive strategies to cope with impacts of climate change and such adaptive strategies include adjustment of planting dates, crop diversification, improved crop varieties, and use of agricultural inputs like fertilizers and pesticides (Belay et al., 2017). Farmers who are supported with market access have shown willingness to make use of adaptive strategies (Belay et al., 2017). Farmers' decision to adapt to a specific adaptive strategy is also positively influenced by farmers' access to markets (Mulinde et al., 2019). Farmers with access to market information have a higher likelihood to adapt to climate change than farmers with no such

access (Abid et al., 2019). Farmers who have poor access to weather information and input markets are subjected to low net revenue and higher production costs (Bedeke et al., 2019). Lack of resources such as inadequate finance, limited financial resources and lack of access to technology has led many farmers to be less adaptive (Maponya et al., 2013).

2.4.4 Access to trainings and farming organisation membership

Initiating trainings focusing on adaptation to climate change and capacity building among farmers could be a good initiative to enhance the use of adaptive strategies effectively among farmers (Masud et al., 2017). The nature of climate change trainings give farmers different adaptation options (Arunrat et al., 2017). Farmers who have gone through a climate change related training are more willing to use different adaptive strategies than those who have not gone through any form of training as such farmers are more capacitated to adapt to climate change than their counterparts (Trinh et al., 2018). Programs that could offer training to farmers based on their different levels of perception could be cost-effective methods to enhance adoption of different adaptive strategies (Menapace et al., 2015). Farmers who have access to different climate change trainings are more advanced in terms of knowing the adverse of climate change than those who never went through the training (Trinh et al., 2018).

Farmers who have membership of a certain agricultural association are likely to adapt to climate change (Ali & Erenstein, 2017). Farmers who are members of different agricultural associations are negatively associated with the change in crop variety strategy and their organizations may recommend other adaptive strategies (Bryan et al., 2013).

Furthermore, farmers who had social networks and involved in adaptation policy making process were adapting to climate change (Mulinde et al., 2019). Being associated with a farming organization or group negatively influences farmers to adapt to climate change (Alih et al., 2019). Farmers with local organization membership are more responsive towards climate change adaptation (Ashraf et al., 2018). Strengthening local farm organisations or networking increases the probability of farmers to adapt to climatic changing conditions with various adaptive strategies as this may improve farmers' access to climate change information (Diencere, 2019). Farmers with membership of any form of agricultural organisation adopt various climate change adaptive strategies than farmers with no membership as many farmers view such organisations as sources of information and support (Mugagga et al., 2019).

2.4.5 Access to finance and credit

In developing countries, emerging farmers are the identified group most deserving for financial support as they are the most vulnerable to climate change (Biagini et al., 2011). There is an adaptation finance which is intended to support farmers who are severely affected by climate change (Oxfam International, 2010). Farmers who secure credit may find adapting to climate change being quite possible than their counterparts (Mugagga et al., 2019). Access to agricultural finances and extension services positively contributes towards farmers' decision to adapt to climate change (Diencere, 2019). In a study conducted by Alam et al. (2017), it has been revealed that availability of finance and access to climate change information plays a crucial role on farmers' adaptation to climate change. Furthermore, it was emphasized that successful use of adaptive

strategies largely lies within the accessibility and use of capital assets relevant to the adoption of different strategies (Alam et al., 2017). Institutional support such as access to finance, human capital, agricultural technologies and easy access to various operational resources were found to be very useful and efficient on adoption of adaptive strategies on farm level (Abid et al., 2015). Access to financial resources and access to extension services were said to be insignificant if the farmers will make use of traditional adaptive strategies instead of technological related adaptive strategies (Tessema et al., 2018).

Access to credit is also an important component which emerging farmers perceive as essential for their climate change adaptation facilitation (Tripathi & Mishra, 2017). Access to credit facilities has been noted to greatly influence farmers' drive to adapt to climate change (Shikuku et al., 2017). Availability of credit resources plays a crucial role in farmers' decision to adapt to climate change (Khanal et al., 2018). Insufficient credit facilities negatively impact farmers' ability to apply appropriate adaptive strategies (Masud et al., 2017). Furthermore, access to credit has been identified to play a critical role among non-commercial farmers towards adaptation to climate change (Asfaw et al., 2018). Less of credit availability facilitation negatively affects adaptation to climate change among farmers (Kgosikoma et al., 2018). Access to farm credit does not always have a positive influence towards the adoption of adaptive strategies among farmers (Abid et al., 2015). Access to credit significantly increases adoption level of adaptive strategies among farmers (Shikuku et al., 2017). Access to credit positively influences climate change adaptation as it ensures that farmers make some investment through adaptation process (Arunrat et al., 2017). According to Mulwa et al. (2017), failure to secure credit is one of

the most critical contributing factors towards consideration of different adaptive strategies by farmers. In a study conducted by Alam et al. (2016), the study revealed that lack of farm credit access and information on appropriate adaptive strategies are major hindrances of climate change adaptation among farmers. Farmers who have access to credit resources can consider changing farming calendar to adjust their farming in the face of climate change (Trinh et al., 2018). Livestock farmers with access to informal credit are likely to use feeds changing and destocking as adaptive strategies (Bryan et al., 2013). Access to farm credit for female farmers does not seem to have any influence on their decision to adopt any adaptive strategy, but for male farmers, access to credit seems to have a significant role in the adoption of adaptive strategies, particularly investment in irrigation systems (Jin et al., 2015). Access to credit enables farmers to acquire necessary climate change information that improves their adaptation capacity (Sadiq et al., 2019). Farmers who have access to credit are more flexible in adopting various adaptive strategies (Chete, 2019). Farmers consider access to credit as a key role for financial assistance that can improve farmers' adaptation to climate change (Siddiqua et al., 2019).

2.5 Impact of policy on adaptation to climate change

Policy plays a vital role in adaptation decision making by farmers (Climato & Mullan 2010; Urwin & Jordan 2008). In some instances, policy may pose some difficulties during the actual implementation process of adaptation response (Burton et al., 2002; Madzwamuse, 2010). Understanding the status of adaptation is necessary for evaluation of effectiveness of policies that promote adaptation, particularly to inform adaptive

governance at various levels on adaptation needs (Brooks et al., 2011; Ford & King in press; Mannke, 2010, 2011; Preston et al., 2011; Sovacool et al., 2012b). Policies that emphasize the general perception on climate change and its risks among farmers are ineffective in promoting adaptation behaviour among farmers (Li et al., 2017). Effective policy on climate change adaptation should not only focus on the negative impacts of climate change on agricultural production, rather it should also focus on in-depth perception of climate change among farmers, as the extent at which farmers perceive climate change shapes their actual decision to adapt to climate change (Menapace et al., 2015). For an effective policy that would enhance farmers' adaptation to climate change, multiple players from various stakeholders are needed during policy drafting process to come up with practical policies that could contribute on enhancing farmers' perceptions and adaptive capacity (Arunrat et al., 2017).

In most African regions, there should be a development of an implementable adaptation framework that reflects different needs of affected farmers, particularly emerging farmers in different locations as they may need different kinds of assistance (Phillipo et al., 2015). National policies that address adaptation to climate change in most developing countries have been the hindering factor for successful adaptation response (Friis-Hansen et al., 2013). For farmers to successfully execute newly developed adaptive strategies, they should be supported by policies (Burton et al., 2006). 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 & Dercon, 2014). Policies that support maintenance of local adaptive strategies should be

prioritised to achieve successful climate change adaptation. Adaptations driven by policies tend to improve the resilience to environmental change (Stringer et al., 2009).

Some proposed adaptive strategies are not practically adoptable and in other cases, farmers may not be willing to use such strategies due to lack of demonstrations on how to apply them (Touch et al., 2016). Adaptation policies acknowledge the need for change in practices and processes with agriculture to effectively cope with the impact of climate change (Vogel & Henstra, 2015). There is a need to interlink mitigation and adaptation policies since factors shaping such policies differ (Wood et al., 2014). Policies and regulations play a role in the implementation of adaptive strategies by farmers who are exposed to ideal adaptation practices. There should be consistency between policies, regulations and implementation that govern different adaptation approaches (Chesterman & Neely, 2015).

Department of Environmental Affairs and Tourism (DEAT) has been tasked to coordinate South Africa ‘s response to climate change through supporting different suggested interventions and through integration of international agreement at different lower levels, though it does not appear to be playing a vital role in mitigating the effect of climate change (RSA, 2004:17). According to RSA (2004), DEAT is also accountable for giving relevant input into policies and strategies that are the authority of other departments in relation to climate change response. DEAT should ensure that other departments incorporate climate change into their policies though it does not have authority to ensure that such policies are implemented (RSA, 2004). Department of Mineral Resources and Energy has been tasked to determine ways in which South Africa can be less vulnerable in terms of energy subjects. National Business Institute (NBI) mitigates the impact of

climate change through the energy efficiency accord whereby such accord recognises that energy usage is a major source of greenhouse gas emissions (RSA, 2005).

NAPAs have been helping least developed countries to identify priority actions necessary for their urgent implementation of adaptive strategies (Orindi, 2013). Different approaches have been suggested to ensure reduction of GHG emissions, but successful implementation of such approaches will need a long-term process and collaboration from different countries (Bodansky, 2011). Such approaches promote designing of climate change policies at the lowest level of organization (Rayner, 2010). United Nations Framework Convention on Climate change aims to mitigate the impacts of climate change through reducing greenhouse gases emissions. The convention encouraged industrialized countries to stabilize GHG emissions as such countries are said to be responsible for high levels of emissions (IPCC, 2007). Policy that could enhance climate change education among farmers could assist in climate change adaptation since dissemination of climate change information would be vital in the adaptation process (Bedeke et al., 2019).

2.5.1 Challenges posed by policies on adaptation response to climate change

Though some farmers are aware of adaptive strategies, they seem hindered to take such strategies into practice due to limited enforcement of policies and regulations and the other contributing reason to that is that local communities are largely excluded when drafting such policies (Ampaire et al., 2015). Though policies tend to mention the support for adaptation to climate change, there are no concrete efforts to reduce vulnerability of agriculture through such policies (Berrang-Ford et al., 2011, 2014, Biesbroek et al., 2010;

Dupuis & Biesbroek, 2013; Ford & King in press; Ford et al., 2011; Gagnon-Lebrun and Agrawala, 2007; Hanger et al., 2013; Lesnikowski et al., 2011, 2013). There are no well-structured functional operational structures outlined by policies to help farmers to successfully use developed adaptive strategies. Studies focusing on institutional and policy context would be vital on successful implementation of adaptive strategies, more particularly for emerging farmers (Andersson & D'Souza, 2014). Policies pose limited adaptation opportunities since the formulation of such policies minimally involves local government as well as NGOs while local communities are entirely excluded (Ampaire et al., 2010).

2.6 Conclusion

This chapter reviewed several studies related to climate change adaptation. The chapter firstly investigated farmers' awareness of climate change and furthermore, their awareness of critical determinants of climate change. Several studies revealed that farmers were aware of climate change and they have observed several climatic changing conditions across the globe. The chapter further looked at farmers' awareness of critical determinants of climate change. Various studies revealed that farmers have noted various critical determinants of climate change, mainly featuring observation dominated by reduction in annual rainfall, rising temperatures and rainfall distribution. The chapter also investigated the influence of socio-economic characteristics of farmers on selection of various climate change adaptive strategies. This chapter noted that several socio-economic characteristics of farmers contribute to their selection of climate change adaptive strategies. The chapter also looked at how various institutional factors could influence farmers' decision to adapt to climate change. Provision of any form of support

to farmers was found to be significant in influencing their decision to adapt to climate change.

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CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents the methodological approaches followed in this study. This chapter further gives the description of the study location. It further outlines the study population and sampling technique used and the way in which the data was collected. It also discusses data analysis methods used and ethical considerations which the study adhered to.

3.2 Study area

The study was carried out in Limpopo province. Limpopo province is the 5th largest province of the nine provinces in South Africa. It is the northern-most province of South Africa and covers about 125,754 km^2; with the population estimate of about 5 726 800 people (Statistics South Africa, 2015). Limpopo province shares international borders with Botswana, Zimbabwe and Mozambique (LTA, 2014). Limpopo province is divided into five municipal districts; Capricorn, Mopani, Sekhukhune, Vhembe and Waterberg; and 25 local municipalities. The most dominant ethnic group in the province is the Northern Sotho (Sepedi) (57%). The second dominant ethnic group is the Tsonga (Shangaan) (23%). The third ethnic group is Venda (12%) while the Afrikaners ethnic group (2.6%) and the English ethnic group (0.5%) are less dominant (Limpopo provincial government, 2016). More than 45% of the R2-billion annual turnover of the Johannesburg Fresh Produce Market comes from Limpopo province, hence climate change adaptation in this area is important. The province has an abundance of agricultural resources. It is

one of the country's prime agricultural regions well-known for its production of livestock, fruits, vegetables, cereals and tea (LTA, 2014).

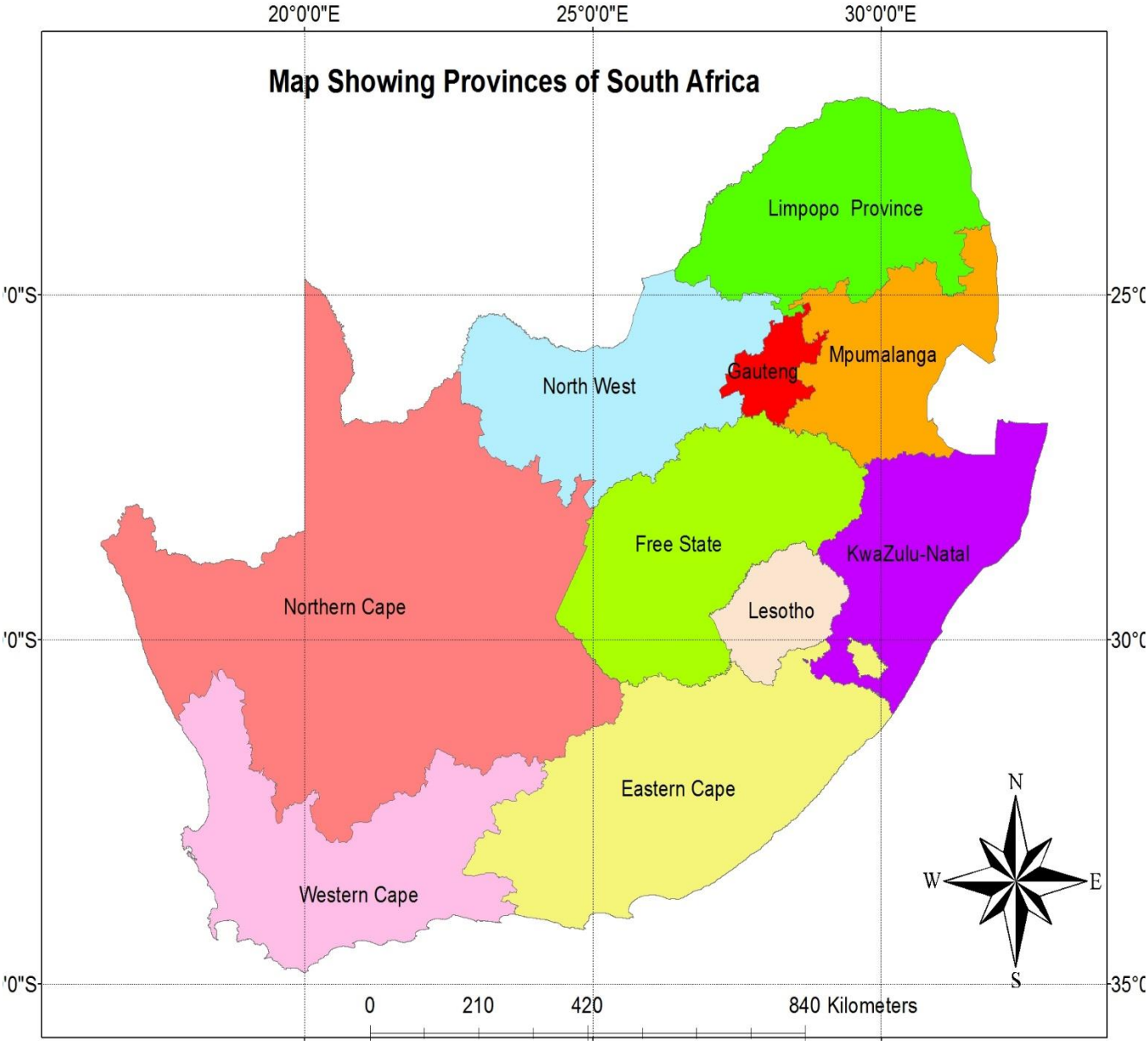

Figure 3.1: Map showing South Africa

Source: (University of Venda; Department of Geography, 2019)

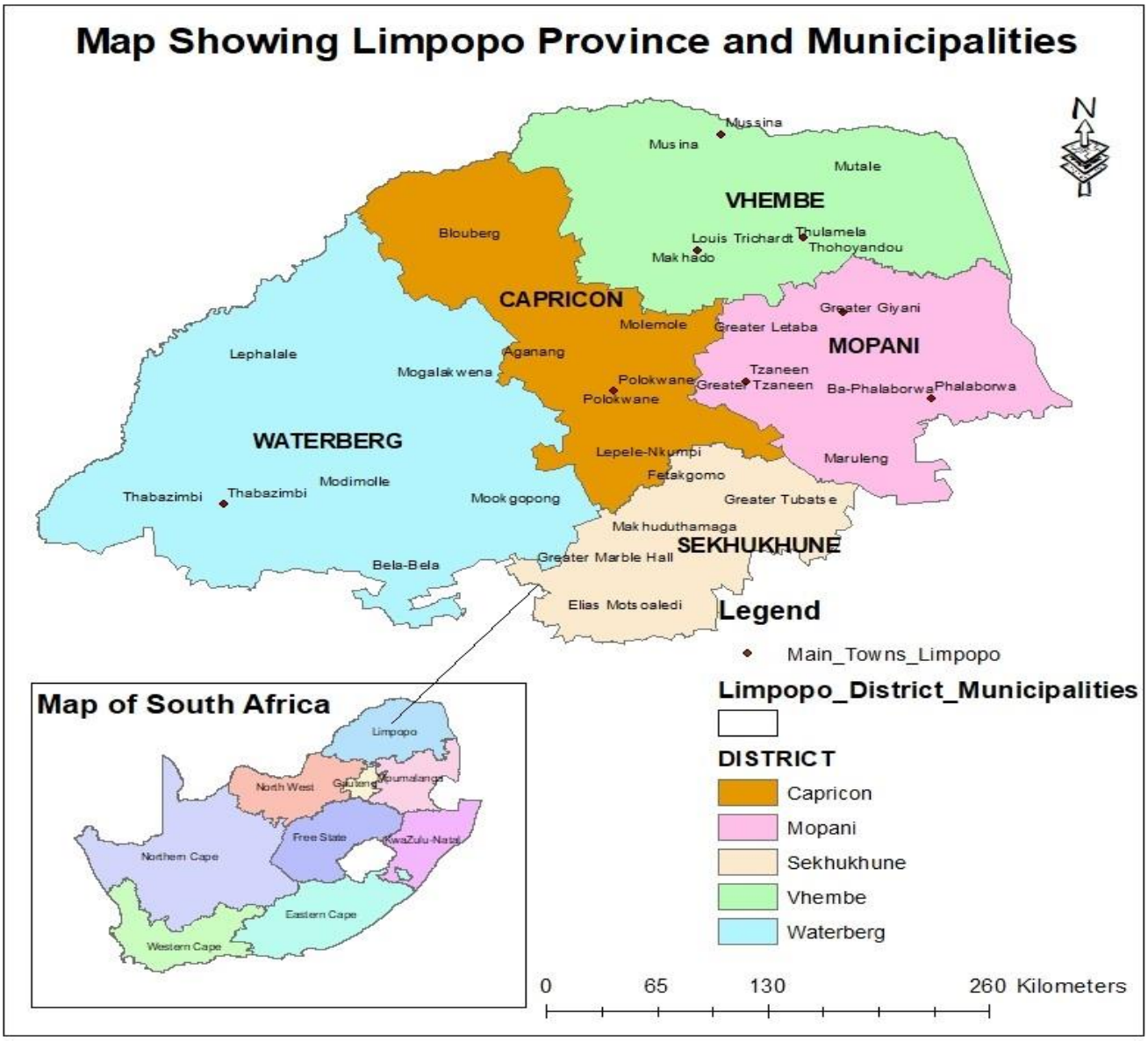

Figure 3.2: Map showing Limpopo Province and Local Municipalities

Source: (University of Venda; Department of Geography, 2019)

3.3 Population and sampling

The population of the study were emerging farmers in Limpopo province. These emerging farmers in South Africa are land reform beneficiaries together with subsistence farmers striving to enter into the commercial farming. Most of them have acquired the farms through land reform programs and in Limpopo most of them are into extensive livestock and crop production. Within the context of the definition of the emerging farmers it is next to impossible to have an accurate census of these farmers as there are no records of those who are transitioning from subsistence and land reform beneficiaries to commercial farming. In this study the crop/livestock commercialization index (CCI) categorization developed by Zantsi, Greyling and Vink (2019) was used to characterize the emerging farmers. For this study, Crop/Livestock Commercialization Indices of 0.5 and 0.66 were used to screen and define the population of the emerging farmers in Limpopo as at the time of the study. As part of the study, 25 emerging farmers participated in the study during pretesting of questionnaire and further 206 emerging farmers were selected for interviews during data collection process. Figure 3.3 below shows the distribution of participants within the five districts of the Limpopo province. A two-stage cluster sampling technique was employed to select the participants. In this sampling technique, the researcher picks groups or clusters, and then from each cluster, the researcher selects the individual subjects and further employs a systematic random sampling as it allows the researcher to add a degree of system or process into the random selection of subjects (Eplorable.com, 2009). Farmers from all five districts of the province were proportionally selected for inclusion using the clustered random selection technique. Farmers were

clustered firstly into five districts and further into local municipalities where they were systematically random sampled from each local municipality.

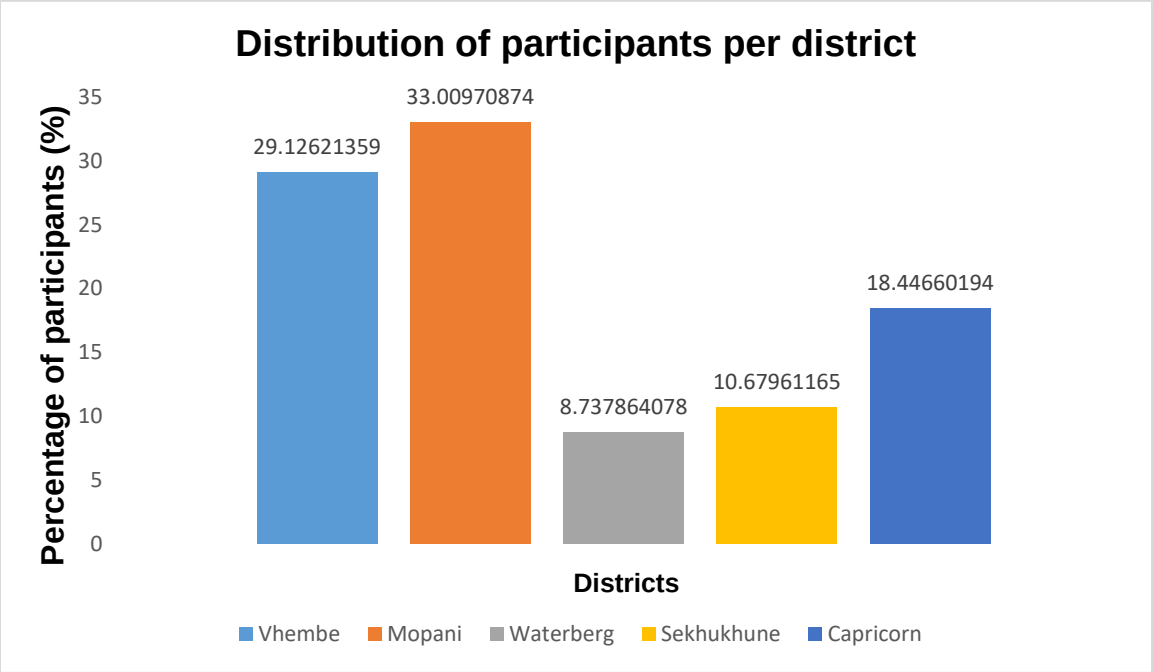

Figure 3.3: Distribution of participants per district. Source: Author's computation (2018/2019)

3.4 Data collection

A structured questionnaire served as a data collection tool. Data collection was carried out through face to face interviews which were held with participants; questionnaires were then administered to participants during face to face interviews. A face to face interview was preferred for its ability to minimize errors and misunderstanding (Bless & Smith, 2000). Questionnaires consisted of both opened-ended and closed-ended questions. During interview sessions, participants were informed about the purpose of the study, the importance of their participation and co-operation during the interviews. The questionnaire referred to in Annexure 5 was designed to capture information on three

sections: Section A covered farmers' socio-economic characteristics, section B covered climate change awareness and related aspects and section C covered institutional factors towards climate change adaptation. Attempts to conduct focus group discussions with key informants proved fruitless; availability of key informants on common dates was a major reason such focus group discussion proving fruitless. Focus groups were supposed to be held at every district as per proposal, but in reality, it was no longer feasible as the financial implications for transport and accommodation was not budgeted for though the study also targeted occasions such as trainings and workshops of farmers. Pretesting of questionnaire was done involving 25 emerging farmers who did not form part of the 206 who were used for data collection; this was to ensure the validity and reliability of the data collection tool used.

3.5 Data analysis

The collected data was captured and analysed using the Statistical Package for the Social Sciences (SPSS; version 25, 2017). Preliminary descriptive statistics of the variables selected were performed and further statistical analysis was conducted. The models reflected below were used as follows: cross tabulations were used to obtain results in chapter 4 as well as the Multinomial regression. Correlation and Multinomial regression were used to obtain results in chapter 5 whereas the Binary logistic was used to obtain results in chapter 6.

3.5.1 To investigate farmers' awareness of critical determinants and impacts of climate change in Limpopo province

In this study, cross tabulation was firstly applied to explore the relationship that existed between selection of adaptive strategies and awareness of critical determinants, and impacts of climate change among farmers in Limpopo province. In a survey analysis, cross tabulations are preferred quantitative research methods appropriate for examining relationship between two or more variables. The technique provides a way of analyzing and comparing results for one or more variables with the results of another (DeFranzo, 2012). For nominal measures similar to this study, chi-square measures are applied to minimize the influence of sample size and degrees of freedom and furthermore, to restrict the range of values of the measure to those between 0 and 1. Without such adjustments, comparison of chi-square values from tables with varying dimensions and sample sizes is meaningless (Norusis, 1988). The *phi coefficient* modifies the chi-square by dividing it by the sample size and taking the square root of the result:

$$\emptyset = \sqrt{\frac{X^2}{N}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where N is the total number of observations, two variables are considered positively associated if most of the data falls along the diagonal cells. To obtain a measure that lies between 0 and 1, Pearson suggested the use of coefficient of contingency which is specified as:

$$C = \sqrt{\frac{X^2}{X^2 + N}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Although the value of this measure is always between 0 and 1, it cannot generally attain the upper limit of 1. The maximum value possible depends upon the number of rows and columns. Cramer introduced the following variant:

$$V = \sqrt{\frac{X^2}{N(k-1)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (3)$$

Where k is the smaller of the number of rows and the columns, Cramer's V can be used to attain the maximum of 1 for tables of any dimension (Norusis, 1988). Furthermore, Multinomial Logistic Regression was used to determine the relationship between selection of adaptive strategies and farmers' awareness of climate change, critical determinants and impacts of climate change. The model was preferred for its ability to give reliable results on ordinal and nominal measures of scale. The same model was used for the second objective of the study and the model specification was shown there as the slight difference would be the explanatory variables that in this case are critical determinants of climate change such as flood and drought occurrence, temperature and rainfall patterns among others.

3.5.2 To assess the influence of socio-economic characteristics of farmers on the selection of adaptive strategies

For the second objective, the study also intended to investigate farmers' socio-economic characteristics of farmers that influences selection of adaptive strategies; therefore, Pearson correlation coefficient was performed to determine variables that could be useful for analysis to avoid using variables that are highly correlated. Pearson correlation coefficient was useful in measuring and quantifying the strength of the association between socio-economic characteristics before logistic analysis (Norusis, 1988).

The Multinomial Logit (MNL) model was used to analyze the influence of socio-economic characteristics on selection of adaptive strategies in the Limpopo province. This method was considered due to its ability to produce robust results on ordinal and nominal scale

of data. The model was also used elsewhere and produced robust results in studies to analyze selection of adaptive strategies (Pundo & Fraser, 2006; Hassan & Nhemachena, 2008). Multinomial logit model (used to analyze two discrete choices) is the extension of the logit model. The advantage of the MNL is that it permits the analysis of assessments across more than two categories, allowing the determination of selection probabilities for different categories (Wooldridge, 2002). The probability that a farmer chooses one type of adaptive strategy is bounded between 0 and 1.

The model requires that the dependent variable be measured at the nominal level, and the independent variables are assumed to be either continuous or ordinal. However, the ordinal variable should be treated as being either continuous or categorical. Independent and dependent variables should have mutually exclusive and exhaustive categories that are not highly correlated with each other (no multicollinearity). Therefore, it is crucial to assess the relationship between independent variables before employing multinomial logit model.

To describe the MNL model, let y (adaptive strategies) denote a random variable taking on the values [0, 1, 2, ..., J] for J, a positive integer, and let **x** denote a set of conditioning variables. In this case, y denotes adaptive strategies and **x** denotes different socio-economic characteristics (Gender, Age group, Marital status, Formal education, Agricultural education, Household size, Farming experience, Occupation, Off-farm income, Farm records, Farm size, and Monthly farm income). The question is *cetirus paribus,* what are the changes in the elements of **x** affecting the selection of adaptive strategies probabilities (P(y = j/x), j = 1, 2 ... J. Since the probabilities must sum to unit, P(y = j/x) is determined once we know the probabilities for j = 2... J.

Assuming **x** to be a 1 x K vector with first element being unit, then the MNL model has response probabilities given as follows:

$$P(y = j|x) = \frac{\exp(x\beta j)}{[1 + \sum^{j}{}_{h-1} \exp(x\beta h), j= 1, \ldots,J]} \quad (1)$$

Where βj is K x 1, j= 1… J.

In this study, the possible adaptive strategies considered are six. Unbiased and consistent parameter estimates of the MNL model in equation (1) require the assumption of independence of irrelevant alternatives (IIA) to hold. In particular, the IIA assumption requires that the probability of selecting a certain adaptive strategy by a given socio-economic character needs to be independent from the probability of choosing another adaptive strategy. The premise of the IIA assumption is the independent and homoscedastic disturbance terms of the basic model in equation (1). The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable, but the estimates do not represent either the actual magnitude of change. Differentiating equation (1) with respect to the explanatory variables provides marginal effects of the explanatory variables given as:

$$\frac{\partial Pj}{\partial xk} = Pj\left(\beta jk - \sum_{j=1}^{j-1} Pj\beta jk\right) \quad (2)$$

The marginal effects are functions of the probability itself and measure the expected change in probability of a particular adaptive strategy selected with respect to a unit change in the independent variable from the mean (Greene, 2003).

3.5.3 To investigate if institutional factors could affect farmers' decisions to adapt to climate change in Limpopo Province

The study employed Binary Logistic Regression to determine if institutional factors could influence farmers' decision to adapt to climate change or not. The model was selected for its ability to give better predictions where the dependent variable is dichotomous as in this study. The Binary Logistic Regression Model (BLRM) was used to determine if institutional factors had an influence on farmers' decision to adapt to climate change.

BLRM is considered useful for situations in which the prediction of the presence or absence of a characteristic or outcome is based on values of a set of predictor variables (Norusis, 2004). The Binary Logistic Regression is similar to a linear regression model but is suited to models where the dependent variable is dichotomous as in this study. BLRM coefficients were used to estimate odd ratios for each of the independent variables in the model. In the Binary Logistic Regression Model, the relationship between the dependent variable Z and the probability of the event of interest is described by the following link function (Norusis, 2004):

$$\pi_i = \frac{e^{z_i}}{1+e^{z_i}} = \frac{1}{1+e^{z_i}} = \frac{1}{1+e^{-z_i}} \quad \text{.....equation 1}$$

or

$$Z_i = \log\left(\frac{\pi_i}{1-\pi_i}\right) \quad \text{.....equation 2}$$

Where: π_i =probability of the i^{th} case; Z_i = value of the independent variable for the i^{th} case. The model assumes that Z is linearly related to the predictors.

Thus:

$Z_i = b_o + b_1X_{i1} + b_2X_{i2} + \ldots + b_pX_{ip}$.....equation 3

Where X_{ij}= predictor for the j^{th} case; b_j=j^{th} coefficient and p=number of predictors. Since Z is unobservable, the predictors are related to the probability of interest by substituting Z in equation 1.

$$\pi_i = \frac{e^{z_i}}{1+e^{z_i}} = \frac{1}{1+e^{z_i}} = \frac{1}{1+e^{-(b_0+b_{i1}X+\ldots+b_pX_p)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{equation 4}$$

The regression coefficients in the above expression were estimated through an iterative maximum likelihood method using SPSS V.25 (Hosmer & Lesmeshow, 2000). In the regression context, it is assumed that there is a set of predictor variables, $X_1,\ldots,X_k$, that are related to Y and, therefore, provide additional information for predicting Y (Greene, 2003).

$$\text{Logit } (P_i) = \ln (P_i / 1\text{-}P_i) = \alpha + \beta_1X_1 + \ldots+\beta_nX_n + {}^{U}t \quad \ldots\ldots\ldots\ldots\text{equation 5}$$

Where:

$\ln (P_i / 1\text{-}P_i)$ = logit for farmers' decision to adapt to climate change (Yes or No)

P_i = Yes; $1 - P_i$ = No; β = coefficient; X_i = covariates; ${}^{U}t$ = error term.

When the variables are fitted into the model in equation 5, the model is presented as:

$$\textit{ln } (P_i / 1\text{-}P_i) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4X_4\ldots..+ {}^{U}t\ldots\ldots\ldots\ldots\ldots\text{equation 6}$$

The estimated model was specified as:

$$Y= \alpha + \beta_1 RWI + \beta_2 RI + \beta_3 SWI + \beta_4 CCC + \beta_5 RIS + \beta_6 SS + \beta_7 TSR + \beta_8 FO + \beta_9 AES + \beta_{10} HRES + \beta_{11} KES + \beta_{12} CCST$$

3.6 Ethical considerations

Ethical clearance certificate was obtained from the University of Venda Research Ethics Committee before embarking on data collection to ensure that the study follows the right procedure. LDARD was also contacted to request for permission to conduct the study (see Annexure 3), and this was done during identification of population and sampling processes as the researcher requested for the list of emerging farmers who are on the LDARD's database. Relevant Tribal authorities were contacted to seek permission to conduct the study. During interview sessions, participants were informed about the purpose and nature of the study. Participants were made aware of their responsibilities and their rights; they were informed that participation was voluntarily and that they were free to withdraw from participating in the study if ever such a feeling arose during their participation. Participants were informed of the nature of the study as well as the purpose of the research (see Annexure 2).

3.7 Expected outcomes of the study

The study was envisaged to develop a model that could generally be applied by different stakeholders such as farmers, policy makers and implementers to enhance farmers' adaptation to climate change through various adaptive strategies. It also aimed at identifying various key elements that shape farmers' decision to adapt to climate change. The findings of the study will be shared through conferences, workshops and peer reviewed publications.

3.8 Conclusion

In this chapter, the study area, sampling procedure and sample size were clarified. Data collection method and tools were also discussed. Data analytical procedures for each specific objectives of the study were also discussed. Ethical considerations followed in this study were also outlined as aligned with the relevant attached appendices.

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CHAPTER FOUR

FARMERS' AWARENESS OF CRITICAL DETERMINANTS AND IMPACTS OF CLIMATE CHANGE IN LIMPOPO PROVINCE

4.1 Introduction

Awareness of climate change in developing countries is relatively low as compared to that of developed countries, with Africa rated as the least (Pelham, 2009). Developing countries are vulnerable to climate change although they are not affected equally (IPCC, 2007). Farmers in Africa are likely to experience tragic crop failures, reduced agricultural productivity and diseases outbreak through the impacts of climate change (Zoellick, 2009). A study on farmers' perception of climate change and adaptive strategies revealed that farmers who have heard about climate change consistently are in a better position to adopt climate change adaptive strategies than their counterparts (Asrat & Simane, 2018). Farmers' awareness of the impacts of climate change enables them to assume relevant adaptive strategies in a bid to reduce the effects of climate change (Shisanya & Mafongoya, 2016). A study conducted by Maponya and Mpandeli (2013) revealed that farmers in Limpopo province reflected knowledge of some critical determinants of climate change such as their observation that it was getting warmer and drier with increased frequency of droughts and changes in the timing of rains.

4.2 Literature review

According to IFAD (2010), it is likely not possible to avoid the impacts of climate change; and thus, vital to promote climate change awareness in order to support local communities from increased vulnerability. Climate change awareness should be

promoted continually, more particularly in developing countries since awareness is more likely to enhance the participation of farmers towards adaptation (Friis-Hansen et al., 2013). A study conducted by Jost et al. (2016) on understanding gender dimensions of agriculture and climate change revealed that emerging farmers have been changing their agricultural practices due to observations of climatic and environmental changes based on their exposure to climate change knowledge. From different impacts of climate change, crop failure seems to take a lead mostly among areas or farmers with limited adaptive capacity given dependence on agricultural production (Bryan et al., 2013). In a study conducted by Coulibaly et al. (2015), it was noted that majority of farmers are responding to climate change not necessarily because they are aware of climate change, instead they are responding to crop failure which majority of them are experiencing.

4.3 Research Methodology

4.3.1 Description of the study area

The study was carried out in Limpopo province, the 5th largest of the nine South African provinces. It is the northernmost province of South Africa, covering about 125,754 km^2; with the population estimate of about 5,726,800 inhabitants (Statistics South Africa, 2015). More than 45% of the R2-billion annual turnover of the Johannesburg Fresh Produce Market comes from Limpopo province. The province has an abundance of other agricultural resources. It is one of the country's prime agricultural regions well-known for its production of livestock, fruits, vegetables, cereals and tea (LTA, 2014).

4.3.2 Sampling procedure

The study employed a clustered systematic random selection technique to collect primary data. In this sampling technique, the researcher picks groups or clusters, and then from each cluster, the researcher selects individual subjects and further employ a systematic random sampling as it allows the researcher to add a degree of system or process into the random selection of subjects (Eplorable.com, 2009). Farmers from all five districts of the province were proportionally selected for inclusion using the above clustered systematic random selection technique. Farmers were clustered firstly from five districts and further into local municipalities where they were systematically random sampled from each local municipality.

4.3.3 Data collection and analysis

4.3.3.1 Data collection

A structured questionnaire served as a data collection tool. Data collection was carried out through face to face interviews which were held with participants. Questionnaires were then administered to participants during face to face interview. A face to face interview was preferred due to its ability to minimize errors and misunderstanding (Bless & Smith, 2000).

4.3.3.2 Data analysis

For the first objective, the study intended to investigate the extent to which emerging farmers were aware of critical determinants and impacts of climate change in the study area; cross tabulations were therefore used to describe and compare the existing relationship between being aware of critical determinants of climate change and various

adaptive strategies which farmers were likely to choose. The models specification is reflected in methodology chapter under data analysis.

Table 4.1: Description of explanatory variables

Variable	Variable description	Type of measure			Expected sign
TEMP	Temperature	Increased = 0	Decreased = 1	Still the same = 2	+
RAIN	Rain	Increased = 0	Decreased = 1	Still the same = 2	+
DROUGHT	Drought occurrence	Regularly = 0	Rarely = 1	No observed changes = 2	+
FLOOD	Flood occurrence	Regularly = 0	Rarely = 1	No observed changes = 2	+
SEAL	Sea level rise	Dummy			
		Occurs = 0	Does not occur = 1		+
ISO	Increased storm occurrence	Occurs = 0	Does not occur = 1		+
SWS	Stronger winter storms	Occurs = 0	Does not occur = 1		+
WWHS	Warmer winter & hotter summers	Occurs = 0	Does not occur = 1		+
HW	Heat wave	Occurs = 0	Does not occur = 1		+

n=206; Dependent variable= adaptive strategies (Resilient crop varieties = 0; Crop diversification = 1; Substitution of crops = 2; Calendar redefinition= 3; Fertilizer application= 4; Crop rotation= 5). Source: Author's computation (2018/2019).

4.4 Results and discussion

4.4.1 Presentation of results

Emerging farmers were interviewed on critical determinants as well as impacts of climate change that they could have observed during the period of 5 years; between 2014 and 2018 (Table 4.2).

Table 4.2 presents descriptive statistics results for awareness of climate change among farmers. Accordingly, majority of farmers (85.9%) were aware of climate change, whereas the rest were among those who were either not sure or not aware of climate change.

Table 4.2: Descriptive analysis between awareness of climate change and selection of adaptive strategies

Adaptive strategies you know	Awareness of climate change		
	Yes, I know	Don't know	I'm not sure
Resilient crop varieties	8	1	1
	3.9%	0.5%	0.5%
Crop diversification	53	12	4
	25.7%	5.8%	1.9%
Substitution of crops	53	2	2
	25.7%	1.0%	1.0%
Calendar redefinition	25	1	0
	12.1%	0.5%	0.0%
Fertilizer application	20	1	2
	9.7%	0.5%	1.0%
Changing crop rotation patterns	18	0	3
	8.7%	0.0%	1.5%
Total	**85.9%**	**8.3%**	**5.8%**

Source: Survey results (2018/2019); n=206

Most farmers who were aware of climate change chose crop diversification and substitution of crops as their most preferred adaptive strategies as both account to 25.7%. Those who were aware of climate change (12.1%) also considered calendar redefinition as their strategy. The least selected adaptive strategy among farmers who were aware of climate change was resilient crop varieties as it accounts to only 3.9%. All the identified adaptive strategies in this study were found to be chosen by farmers who were aware of climate change. Farmers who did not know and those that were not sure of climate change were found to prefer crop diversification as their strategy (5.8% and 1.9% respectively). For all three groups (aware of climate change, don't know and not sure), the most common strategy that farmers preferred was crop diversification with 36.4%, followed by substitution of crops. The least selected strategy among these groups is resilient crop varieties with 4.9% in total. Results in Table 4.3 below show the analysis of selection of adaptive strategies and observation of rainfall and temperatures changes between 2014 and 2018. From the results, majority of farmers (82%) have noted an increase in temperature patterns between 2014 and 2018, followed by those who have noticed a decrease in temperatures (9.7%) during the same period. Farmers who observed an increase in temperatures over time opted to choose crop diversification (28.6%) as their adaptive strategy followed by substitution of crops (23.3%). Farmers who observed a decrease in temperatures also selected crop diversification (3.4%).

Table 4.3: Descriptive results between selection of adaptive strategies and rainfall and temperature

	Associated weather patterns / reactions when or a considered factor when							
Most common Adaptive strategies in case of	**Increased Temperatures**	**Decreased Temperatures**	**Temperatures remain the same**	**No changes observed**	**Rain has increased**	**Rain has decreased**	**Rain has stayed the same**	**No observed changes**
Resilient crop	9	1	0	0	2	7	1	0
varieties	4.4%	0.5%	0.0%	0.0%	1.0%	3.4%	0.5%	0.0%
Crop	59	7	0	3	4	60	0	5
diversification	28.6%	3.4%	0.0%	1.5%	1.9%	29.1%	0.0%	2.4%
Substitution of	48	3	2	4	3	47	1	6
crops	23.3%	1.5%	1.0%	1.9%	1.5%	22.8%	0.5%	2.9%
Calendar	23	0	1	2	2	22	2	0
Redefinition	11.2%	0.0%	0.5%	1.0%	1.0%	10.7%	1.0%	0.0%
Fertilizer	17	4	1	1	0	22	1	0
application	8.3%	1.9%	0.5%	0.5%	0.0%	10.7%	0.5%	0.0%
Changing crop	13	5	0	3	0	18	0	3
rotation patterns	6.3%	2.4%	0.0%	1.5%	0.0%	8.7%	0.0%	1.5%
Total	**82.0%**	**9.7%**	**1.9%**	**6.3%**	**5.3%**	**85.4%**	**2.4%**	**6.8%**

Source: Survey results (2018/2019)

From the results in Table 4.3, majority of farmers (about 85.4%) have noted a decrease in annual rainfall pattern between 2014 and 2018. Farmers who have observed a decrease in rainfall pattern picked crop diversification (29.1%) followed by substitution of crops (22.8%). Farmers who have observed a decrease in rainfall and chose calendar redefinition as their strategy constitute 10.7% while those who considered application of fertilizers are also 10.7%. Farmers who believe that there is an increase in rainfall patterns were found to consider crop diversification (1.9%) followed by substitution of crops (1.5%). Only 1% of farmers who believe that the rain pattern has stayed the same selected calendar redefinition as their adaptive strategy and those who have not observed any changes in rainfall chose substitution of crops (2.9%).

Table 4.4 shows the relationship between drought and floods occurrence. The results from Table 4.4 show that farmers who have noted that drought has been occurring regularly account for 49.5%. Farmers who believed that drought occurrence has been rare and those who did not observe any changes constitute 26.2% and 24.3% respectively. Farmers who believed that flood occurrence has been regular considered crop diversification and substitution of crops constitute 17.5% and 14.1% respectively. Farmers who believe that flood occurrence has been rare selected crop diversification and applied fertilizer constitute 9.2% and 6.3% respectively. The least selected strategy among these groups of farmers was resilient crop varieties constituting 2.9%. Farmers who did not observe any changes in floods occurrence were found to select crop diversification and substitution of crops respectively. The least selected strategy among these groups of farmers was still resilient crop varieties.

Table 4.4: Descriptive analysis of selection of adaptive strategies and drought and flood occurrence

Adaptive strategies you know	Drought occurrence			Flood occurrence		
	Occurs regularly	Rarely occur	No observed changes	Occurs regularly	Rarely occur	No observed changes
Resilient crop varieties	5	2	3	1	1	8
	2.4%	1.0%	1.5%	0.5%	0.5%	3.9%
Crop diversification	36	19	14	1	18	50
	17.5%	9.2%	6.8%	0.5%	8.7%	24.3%
Substitution of crops	29	12	16	0	16	41
	14.1%	5.8%	7.8%	0.0%	7.8%	19.9%
Calendar Redefinition	15	5	6	2	6	18
	7.3%	2.4%	2.9%	1.0%	2.9%	8.7%
Fertilizer application	6	13	4	2	6	15
	2.9%	6.3%	1.9%	1.0%	2.9%	7.3%
Changing crop rotation patterns	11	3	7	0	8	13
	5.3%	1.5%	3.4%	0.0%	3.9%	6.3%
Total	**49.5%**	**26.2%**	**24.3%**	**2.9%**	**26.7%**	**70.4%**

Source: Survey results (2018/2019)

Results from Table 4.5 show selection of adaptive strategies among farmers based on their awareness of impacts of climate change. Results in Table 4.5 show that majority of farmers (about 83.7%) were aware of impacts of climate change. Among farmers who were aware of the impacts of climate change, about 29.1% were found to have selected crop diversification as their strategy, followed by substitution of crops (22.7%).

Table 4.5: Descriptive results of selection of adaptive strategies and awareness of the impact of climate among farmers

Adaptive strategies you know	**Awareness of impact of climate change**	
	Yes	No
Resilient crop varieties	7	1
	4.1%	0.6%
Crop diversification	50	3
	29.1%	1.7%
Substitution of crops	39	13
	22.7%	7.6%
Calendar Redefinition	21	4
	12.2%	2.3%
Fertilizer application	15	4
	8.7%	2.3%
Changing crop rotation	12	3
patterns	7.0%	1.7%
Total	**83.7%**	**16.3%**

Source: Survey results (2018/2019)

Farmers who were aware of the impacts of climate change also considered usage of calendar redefinition and increase in fertilizer application that accounts for 12.2% and 8.7% respectively. The least selected adaptive strategy among farmers who are aware of climate change impacts was resilient crop varieties. Farmers who were not familiar with the impacts of climate change were found to consider substitution of crops (7.6%) as the

suitable adaptive strategy. The strategy which is expected to be selected by both groups of farmers was crop diversification with 30.8% and the least chosen was resilient of crop varieties with 4.7%.

Table 4.6: Parameter estimates of the multinomial logistics regression of awareness of critical determinants of climate change

Explanatory variable	Crop diversification		Substitution of crops		Calendar Redefinition		Fertilizer application		Changing crop rotation patterns	
	Coefficients	P-level	Coefficients	P-level	Coefficients	P-level	Coefficients	P-level	Coefficients	P-level
Impacts of climate change	-1.181	.377	.603	.623	-.253	.848	2.450	.929	-.079	.955
Temperature	.192	.887	.419	.750	1.135	.386	-.768	.347	1.287	.331
Rainfall	1.660	.119	1.921	.070*	1.285	.243	.139	.196	1.683	.144
Drought	-.053	.920	-.179	.734	-.187	.740	-1.039	.981	-.204	.738
Flood	-16.661	.000***	-16.564	.000***	-17.034	.000***	1.845	.000***	-16.995	.162
Climate change awareness	-.158	.999	9.639	.999	-.020	.980	-2.163	.113	.038	.138
Constant	31.361	0.000	31.454	0.000	31.576	0.000	31.898	0.000	30.174	0.000
Diagnostics										
Base category				Resilient crop varieties						
Number of observations				206						
LR chi-square				44.490						
-2 Log likelihood				295.205						
Pseudo-R2				.089						

Cox and Snell (0.451), Nagelkerke (0.507), McFadden (0.271); ***, **,*Significant at 1%, 5%, and 10% probability level, respectively; Source:

Survey results (2018/2019).

Results from Table 4.6 above show that observation of flood occurrence was found to be statistically significant at 1% significance level in selecting crop diversification as a relevant strategy to adapt to climate change. Flood occurrence had a negative but significant relationship with the selection of crop diversification as a strategy. The results denote that an increase in a unit of flood occurrence would decrease selection of crop diversification by 16.6 chances.

Selection of substitution of crops strategy is statistically influenced by farmers' observation of rainfall pattern and flood occurrence. Flood occurrence was significant at 1% while rainfall pattern was significant at 10% level of significance. A unit increase in observing rainfall pattern changes increase selection of substitution of crops by 1.9 chances, while a unit increase in observing flood occurrence progressively decreases selection of substitution of crops by 16.5 chances.

Selection of calendar redefinition is statistically influenced by observation of flood occurrence. Observation of flood occurrence had a negative but significant relationship with the selection of calendar redefinition at 1% level of significance. This implies that a unit increase in observing flood occurrence progressively decreases chances of selecting calendar redefinition by 17 units. This implies that when farmers observe flood occurrence, the more they tend to stop selecting calendar redefinition.

Surprisingly, observing flood occurrence had a positive and significant relationship with the selection of fertilizer application strategy. It is significant at 1% level. A unit increase in observing flood occurrence among farmers increases their selection of fertilizer application by 1.8 chances. The more the farmers observe flood occurrence, the more they choose to apply fertilizers.

The above results show that observation of rainfall pattern and flood occurrence significantly influence selection of various adaptive strategies. Observation of flood occurrence had a negative but significant relationship with the most strategies while observing change in rainfall pattern had a positive and significant relationship with selection of substitutions of crops. Awareness of climate change and its impact among farmers did not significantly influence selection of any adaptive strategy.

4.4.2 Discussion of the descriptive results

The results of this study showed that majority of farmers in Limpopo province were aware of climate change. The findings regarding majority of farmers being aware of climate change correspond to that of Abid et al. (2015) who noted that in various areas across the globe, farmers are aware of climate change and subsequently notable number of farmers make use of adaptive strategies to adjust their farming practices to respond to climatic changes. Furthermore, the findings of this results are quite similar with the findings of various studies, especially dry spells, raining patterns and increasing drought as consequences of climate change (Masud et al., 2017; Limantol et al., 2016).

In terms of critical determinants of climate change, the results showed that farmers have observed an increase in temperature patterns and decline in annual rainfall patterns between 2014 and 2018. These findings are similar to that of Jin et al. (2015) who revealed in a study conducted in China that most farmers have heard about climate change as they have associated it with average increases in temperatures and a decline in average precipitation in the recent years. Furthermore, findings by Alam et al. (2017) also noted that changes in rainfall timing and temperature were two major critical

determinants of climate change. In terms of drought and floods occurrence, results showed that almost half (49.5%) of farmers believed that drought occurrence has been regular while there has been no observation in flood occurrence (70.4%). The above results are supported by the study conducted by Mehar et al. (2016) who indicated that majority of farmers identified drought and floods as critical determinants of climate change. In the case of drought occurrence, the results of the study are also similar to that of Gichangi and Gatheru (2018) who revealed that most farmers have noted drought as one of the most critical determinants of climate change as majority of them had an experience of long drought spells. As reported above, majority of farmers (70.4%) reflected that they have not observed any change in flood occurrence recently in contradiction to literature that reveals the opposite. In a study conducted in Germany by Macholdt and Honermeier (2016) revealed that farmers have noted different determinants of climate change, and among those they have stated the increase in droughts, hot spells and mild winters as the most affecting determinants of climate change.

The results from the study showed that majority of farmers (about 83.7%) were aware of the impact of climate change. Farmers who were aware of climate change have a higher chance to have experienced the impacts of climate change. The above findings agree with that of Trinh et al. (2018) who revealed that farmers cited a decline in agricultural productivity and an increase in production costs as two main impacts of climate change. Specifically, it has been noted that farmers who experienced negative impacts of climate change were more willing to use adaptive strategies as a mitigating tool for climate change. These findings are also supported by the study conducted by Belay et al. (2017)

who revealed that majority of farmers in rural areas are aware of climatic changes, and thus, adoption of different adaptive strategies.

4.4.3 Discussion of the significant variables in Multinomial logistic results

Observation of rainfall pattern was found to be statistically significant in selection of substitution of crops by farmers. An increase in observing changes in rainfall pattern increases selection of substitution of crops by 1.9 chances. The findings of the study are similar to findings of the study conducted by Alam et al. (2017) who revealed that observation of abnormalities in rainfall timing and distribution has been noted to be indeed critical determinants of climate change, and they have a negative impact on agricultural productivity leading farmers to adopt adaptive strategies to improve their productivity. Additionally, the findings are also consistent with that of Bedeke et al. (2019) who stated that farmers have noted that frequent changes in seasonal rainfall negatively affect agricultural production throughout the globe and may consider various adaptive strategies to survive such conditions.

Flood occurrence has also been identified as a driver in selection of various adaptive strategies. For most strategies, an increase in observing flood occurrence decreases chances of selecting various adaptive strategies. This is supported by the study conducted by Bedeke et al. (2019) who stated that farmers have noted critical determinants of climate change to be floods, change in rainy seasons and prolonged drought, and such may need suitable adaptive strategies for farmers. The more farmers observe flood occurrence the more it leads them not to select crop diversification, substitution of crops, calendar redefinition and fertilizer application. Observation of flood

occurrence has a significant but negative association with the selection of adaptive strategies.

4.5 Conclusion and policy implication

The aim of this chapter was to investigate awareness of climate change, including critical determinants and impacts thereof. The findings of the study revealed that majority of farmers in the study area were aware of climate change during data collection period (2018/2019). Farmers in the study area were also aware of the critical determinants of climate change. Furthermore, the findings noted that between 2014 and 2018, farmers observed various changes in climate with their most preferred adaptive strategies having been crop diversification, substitution of crops and calendar redefinition. The findings of the study implies that majority of farmers were aware of climate change. The study therefore, recommends that in order to reach all farmers, there should be dissemination of climate change information through various networks, and furthermore, there should be initiation of training programs that could promote climate change awareness among farmers. Furthermore, the study also recommends that weather institutions should work closely with farmers in order to provide them with updated weather forecast and that would assist farmers to know which adaptive strategies would be appropriate for a certain production cycle. The study also recommend that farmers who have noted climatic changes should be assisted in selecting relevant adaptive strategies in order to adjust their production methods.

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CHAPTER FIVE

INFLUENCE OF FARMERS' SOCIO-ECONOMIC CHARACTERISTICS IN SELECTION OF CLIMATE CHANGE ADAPTIVE STRATEGIES

5.1 Introduction

Climate change and climate variability have been found to be crucial elements affecting agriculture performance across the world (FAO, 2007). Agricultural productivity in Africa has considerably been negatively affected by climate change (Ziervogel et al., 2006) to an extent that the continent's population is being threatened by food and nutrition insecurity. It is within that context that research is being encouraged to understand climate change adaptive strategies that could be used to mitigate impacts of climate change on agriculture (Jha & Gupta, 2016). It is important to adapt agricultural production to climate change as it has been found that agricultural activities also contribute to climate change. In 2010, agricultural activities accounted for about 10-12% of human-generated greenhouse gas emissions (Pye-Smith, 2011). Research has shown that climate change results in high level of food insecurity around the globe (Pereira et al., 2014). This is more pronounced in developing countries, especially for crops and livestock enterprises run by emerging farmers whose adaptive capacity is limited (Madzwamuse, 2010). Adaptive strategies to climate change refer to an adjustment process that occurs through natural and human systems in response to climatic stimuli which might be harmful or beneficial to the system (Deressa et al., 2008; IPCC, 2001). Evidence shows that adaptation process is best effective when it is carried out at farm level (Arunrat et al., 2017). Tambo et al. (2013) noted that adaptive strategies should be locally designed and implemented in order to be successful. Farmers' socio-economic characteristics, the subject of this

chapter, are essential elements in the selection of adaptive strategies to climate change (Mugi-Ngenga et al., 2016).

5.2 Overview of climate change and adaptation strategies by farmers

A study conducted by Maponya and Mpandeli (2012) found that climate change adaptive strategies by farmers are in response to excessive heat, cold and abnormal wind among other conditions. Regardless of available adaptive strategies to farmers, education, household income, credit, access to information and household size were identified as key determinants to adaptation (Ndamani & Watanabe, 2016). Within that context, the design of adaptive strategies should consider specific farmers' context and different needs.

Interaction between the characteristics of the farm household and farm strategy clearly determine differential adoption levels (Hammond et al., 2016). Socio-economic characteristics of farmers such as age, education level and access to climate information influence adaptation since farmers who have access to extension services are likely to acquire adaptive strategies from information and advice received from extension workers (Debela et al., 2015). The above have also been observed in a study by Gichangi and Gatheru (2018) who ended up concluding that adaptive strategies in some cases have mainly relied on gender, age, education and wealth status of farmers. For an effective uptake of climate change adaptive strategies by farmers, socio-economic characteristics should be significantly considered particularly at farm level (Mulinde et al., 2019). The aim of this chapter is therefore, to assess the impact of socio economic factors of emerging farmers in Limpopo province of South Africa.

5.3 Research Methodology

5.3.1 Study area and data collection

The study was carried out in Limpopo province, ranked the 5th largest of the nine provinces of South Africa. Limpopo is located in the northernmost part of the country and covers about 125,754 km^2; with the population estimated to be about 5,726,800 people (Statistics South Africa, 2015). More than 45% of the R2-billion annual turnover of the Johannesburg Fresh Produce Market comes from Limpopo province due mainly to its conducive opportunities. It is therefore the country's prime agricultural regions well-known for livestock, fruits, vegetables, cereals and tea production (LTA, 2014). The study employed a clustered systematic random selection technique to select 206 emerging farmers. Data collection was carried out through face to face interviews using a structured questionnaire.

5.3.2 Empirical Model Specification

The study firstly performed correlation analysis in order to identify variables that would be suitable for MNL analysis. Pearson correlation coefficient was performed to determine variables that could be useful for analysis to avoid using variables that are highly correlated. Multinomial Logistic Regression (MNLR) was used to assess how farmers' socio-economic characteristics would influence selection of adaptive strategies among them. The dependent variable was also adaptive strategies and independent variables were socio-economic characteristics such as gender, age group, marital status, education, household size, occupation and farm monthly income. This model is mostly used in studies involving multiple choices that define the dependent variable (Gujarati & Porter, 2009). The model specification is reflected under methodology chapter.

Table 5.1: Description of explanatory variables

Variable	Variable description	Type of measure					Expected sign
MS	Marital status	Dummy					
		Married = 0		Not married = 1			-
GEN	Gender	Female = 0		Male = 1			+
AGRICEDU	Agricultural education	Has it = 0		Doesn't have = 1			+
FEDU	Formal education	No formal education = 0	Primary = 1	Secondary = 2	Tertiary = 3	Others=4	+
AGE	Age	Under 21= 0	Between 21-39=1	Between 40-59= 2	60 years and above = 3		+
FE	Farming experience	Less than a year=0	Between 1-5 = 1	Between 6-10 = 2	More than 10 years = 3		+
OCC	Occupation	Unemployed= 0	Employed = 1	Pensioner = 2	Self-employed =3		-
OFI	Off-farm income	Employed = 0	Pension =1	Remittances =2	Others =3		-
HSIZE	Household size	Between 1-5=0	Between 6-10=1	Between 11-15=2	More than 15 =3		+
MI	Monthly income	Less than R1000=0	Between R1001-R5000	Between R5001-R10000	More than R10000		+

n=206; Dependent variable= adaptive strategies (Resilient crop varieties = 0; Crop diversification = 1; Substitution of crops = 2; Calendar redefinition= 3; Fertilizer application= 4; Crop rotation= 5). Source: Author's computation (2018/2019).

5.4 Results and discussion

5.4.1 Presentation of results

Table 5.2: Pair wise correlation matrix of explanatory variables

	GEN	AGE	MS	FEDU	AGRICEDU	HSIZE	FE	OCC	OFI	MI
GEN	1									
AGE	-.186**	1								
MS	-.093	-.285**	1							
FEDU	.204**	-.398**	.094	1						
AGRICEDU	.123	.078	-.013	-.132	1					
HSIZE	-.165*	.198**	-.091	-.147*	.005	1				
FE	-.258**	.434**	-.170*	-.288**	.111	.202**	1			
OCC	-.055	.149*	-.007	-.043	.052	-.025	.076	1		
OFI	.217**	-.496**	.086	.312**	.012	-.024	-.294**	-.345**	1	
MI	.027	.062	-.150*	.135	-.198**	.067	-.006	-.044	.025	1

Source: Survey results (2018/2019)

The study performed a correlations analysis to measure the strength and direction of the linear relationship between the relative movements of two variables. As used in the study, the Pearson correlation coefficient was used as a form of measurement to quantify the strength of the association between any two variables through calculating a summary index (Norusis, 1988). The analysis was useful in determining if ever multicollinearity existed in the dataset which could undesirably impact the performance of the model. A relationship that scores a value of 1 indicates a strongest positive relationship between variables, -1 also represent a strongest negative association between variables though such association. 0.5 symbolizes a moderate relationship between variables. As observed in Table 5.2 above, there are no variables that are highly correlated to each other; very few variables share close to moderate relationship while the association among the rest indicates almost non-linear relationship. From Table 5.2, variables that

have a close to moderate relationship is off-farm income and age, followed by farming experience and off-farm income. Multicollinearity may lead to skewed or misleading results; but as observed from Table 5.2, there is no multicollinearity that exists among variables, hence all variables were included in analysis shown in Table 5.4.

The results from Table 5.3 below show the likelihood ratio tests which were used to compare two competing models. A -2 Log likelihood model was used to compare if the inclusion of explanatory variables would improve the prediction of results using the chosen model. It was observed that the inclusion of explanatory variables indeed improved the model. Chi-square was used to test if the observed distribution was due to chance or not with a degree of freedom in this case being 5. Out of 12 explanatory variables, about 8 show that their inclusion significantly improves the prediction of the model statistically.

Table 5.3: Likelihood ratio tests on farmers' socio-economic characteristics towards selection of adaptive strategies

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	540.798	13.189	5	0.022
Gender	540.576	12.967	5	0.024
Age group	539.381	11.772	5	0.038
Marital status	531.304	3.695	5	0.594
Formal education	542.573	14.964	5	0.011
Agricultural education	530.283	2.674	5	0.750
Household size	537.123	9.514	5	0.090
Farming experience	544.811	17.202	5	0.004
Occupation	538.869	11.260	5	0.046
Off-farm income	531.899	4.290	5	0.508
Farm records	539.922	12.313	5	0.031
Farm size	541.652	14.043	5	0.015
Farm monthly income	536.109	8.500	5	0.131

Source: Survey results (2018/2019)

The Likelihood Ratio Test was used to compare the goodness of fit of two models. From the results, the final model was found to give a significant improvement over the baseline intercept-only model. This tells us that the model gives better predictions than if we had just predicted based on the marginal probabilities for the outcome categories. The model used in this case was found fit as -2 Log Likelihood at intercept only was at 540.798 and the final with inclusion of all explanatory variables was at 527.609. Inclusion of explanatory variables improved the prediction of the model.

5.4.2 Results from the multinomial logistic regression model

The estimation of the multinomial logit model for this study was assumed by standardizing one category, which is normally referred to as the ‘‘base category’’ and in this analysis, the base category is resilient crop varieties and it was chosen as it had middle mean. The model explained the relationship between selection of adaptive strategies and farmers’ socio-economic characteristics variables (see Table 5.4). The dependent variable was adaptive strategies with five strategies (crop diversification, substitution of crops, calendar redefinition, increase in fertilizer application and changing crop rotation patterns). The reference group for the study was resilient crop varieties.

Table 5.4: Parameter estimates of the multinomial logistic results (socio-economic characteristics)

	Adaptive strategies									
Explanatory variable	Crop diversification		Substitution of crops		Calendar Redefinition		Fertilizer application		Changing crop rotation patterns	
	Coefficients	P-level	Coefficients	P-level	Coefficients	P-level	Coefficients	P-level	Coefficients	P-level
Gender	1.165	.316	.540	.645	.561	.646	2.450	.051**	.594	.638
Age group	-.368	.635	-1.000	.200	.319	.705	-.768	.355	-.843	.325
Marital status	.132	.902	-.177	.869	-.857	.459	.139	.905	-.502	.670
Formal education	-1.030	.013**	-.857	.038**	-.502	.254	-1.039	.021**	-1.265	.007***
Agricultural education	1.815	.114	1.624	.161	1.833	.171	1.845	.180	1.805	.167
Household size	2.288	.011**	1.685	.062*	2.019	.032**	2.015	.037**	2.280	.018**
Farming experience	-1.820	.016**	-1.833	.016**	-2.009	.010**	-2.163	.006***	-2.461	.002***
Off-farm Occupation	-.347	.302	-.088	.793	.023	.948	-.066	.863	-.765	.064*
Off-farm income	.278	.596	.197	.705	.635	.258	.431	.458	-.098	.868
Farm records	-.057	.953	1.630	.102	.955	.387	.585	.606	.526	.641
Farm size	.666	.375	1.179	.113	.628	.443	-19.138	.	.983	.214
Monthly farm income	-.671	.189	-.259	.612	-.923	.090*	-.486	.382	-.576	.305
Constant	6.349	0.044	6.305	0.044	2.731	0.416	5.077	0.135	8.472	0.013
Diagnostics										
Base category				Resilient crop varieties						
Number of observations				206						
LR chi-square				115.382						
-2 Log likelihood				527.609						
Pseudo-R2				.174						

Cox and Snell (0.429), Nagelkerke (0.447), McFadden (0.174); ***, **,*Significant at 1%, 5%, and 10% probability level, respectively. Source: Survey results (2018/2019)

5.4.3 Determinants of Adaptive Strategies

Results from Table 5.4 above show that household size, formal education and farming experience were found to be statistically significant in selecting crop diversification by farmers as a relevant strategy to adapt to climate change. The household size has a positive and significant relationship with selection of all adaptive strategies. A unit increase in number of household size would increase the probability of farmers to select crop diversification strategy by 2.2. An increase in the number of years of schooling and an additional year in farming experience among farmers would decrease selection of crop diversification by 1.0 and 1.8 times respectively though both have a negative but significant association with the selection of crop diversification.

From Table 5.4, formal education, household size and farming experience were all found to be statistically significant in selection of substitution of crops as an ideal strategy for climate change adaptation. An increase by a unit of both farming experience and years of schooling results in a decrease in the usage of substitution of crops by 1.83 and 0.85 chances respectively while a unit increase in household size increases chances of selecting substitution of crops by 1.7 times.

Selection of calendar redefinition as a strategy is significantly influenced by household size, farming experience and farmers' monthly farm income. Household size has a positive association with the selection of calendar redefinition, an additional unit in the household size increases the usage of calendar redefinition by 2 times more whereas an addition of a year in farmers' farming experience may decrease its selection by 2 times more. Monthly farm income also has a negative but significant association with selection

of calendar redefinition as a strategy whereby an additional unit in monthly farm income decreases its chances of being selected by 0.9 chances.

Selection of fertilizer application as a strategy is statistically influenced by farmers' gender, formal education, farming experience, and household size. Both formal education and farming experience have a negative relationship with selection of fertilizer application whereby an increase of unit in both variables would decrease selection of this strategy by 1.0 and 2.1 times respectively. Farmers' gender and household size positively and significantly increase selection of fertilizer application as a strategy. An increase in a unit of household size would increase selection of this strategy 2 more times while a shift in farmers' gender increases selection of this strategy by 2.4 chances.

Selection of changing crop rotation patterns as a strategy is significantly influenced by formal education, household size, farming experience and off-farm farmers' occupation. Formal education, off-farm occupation and farming experience all negatively influence selection of changing crop rotation patterns strategy as one unit increase in these variables decreases selection of it by 1.6, 0.7 and 2.5 times respectively. An increase of household size by one unit increases selection of this strategy by 2 times more.

It can be deduced from the results in Table 5.3 that the variables that have a higher influence in selection of specific adaptive strategies are farmers' gender, off-farm occupation, formal education, household size, monthly farm income and farming experience. In all selected adaptive strategies, household size was found to have a positive and significant influence on the selection of each adaptive strategy. Both formal education and farming experience have a negative significant influence on selection of all

selected adaptive strategies. This could be due to the fact that farmers with high educational level tend to invest more in off-farm activities.

Variables such as age group and agricultural education of farmers were found to be statistically insignificant in selection of specific strategies but having positive influence on selection of such strategies. In most strategies, off-farm income has a positive but insignificant relationship with the selection of such adaptive strategies whereas monthly farm-income that farmers generate has a negative and insignificant relationship in selection of most adaptive strategies as farmers' adaptation may not be driven by what they generate from their farms rather through available external support; it has a negative significant relationship with the selection of calendar redefinition. Though farm size and keeping farm records has insignificant relationship with selection of specific adaptive strategies, in most adaptive strategies, they both have a positive influence over the usage of such specific adaptive strategies.

5.4.4 Discussion of the significant variables in Multinomial logistic regression results

Household size was found to be statistically significant in the selection of specific adaptive strategies. Probabilities of selecting various adaptive strategies due to the increase in household size ranged between 1.6 and 2.2 times more across all strategies. The finding reflects that when a farmer's household size increases, there are more suitable adaptive strategies that farmers may deem them fit to adapt to climate change due to increased labour force. The findings are consistent with the findings of Asrat and Simane (2018) who noted that household size and the level of on and off-farm income generation play

decisive roles in farmers' consideration to take climate change adaptive strategies. In addition, farming families with larger households are more willing to adopt various adaptive strategies than smaller household families (Awazi & Tchamba, 2018). Farmers with larger households are more willing to make use of different adaptive strategies as more labour will be available to carry out various strategies.

Farmers' gender was found to have a positive significant relationship with selection of application of fertilizers as an adaptive strategy. A shift in farmers' gender from female to male increases selection of fertilizer application by 2.4 chances. This result implies that selection of application of fertilizers is significantly influenced by the gender of farmers. This is supported by the findings of Jin et al. (2015) who noted that there is a notable difference of application of adaptive strategies among female and male farmers. The findings of this study are consistent with the findings of Bedeke et al. (2019) who stated that in Ethiopia, farmers' gender significantly influences their decision in adopting adaptive strategies with male farmers found being leading figures in selection of adaptive strategies such as drought resilient seeds, water conservation practice and application of fertilizers. The findings are also consistent with that of McCright et al. (2013) who revealed that adaptation and selection of adaptive strategies is likely to be taken by males more than females though such findings is contrary to that of Silvestri et al. (2012) who concluded that female are more likely to take adaptive strategies into consideration in developing countries as women are more involved into agricultural activities than men. Furthermore, this is also supported by the findings from a study conducted by Mehar et al. (2016) in India who revealed that farmers' gender is considered one of the key elements for farmers' decision to take an adaptive strategy though it differs with locations.

The results of this study are consistent with that of Bayard et al. (2006) who also discovered that male farmers were more responsive to climate change adaptation possibly because they are the ones who made decisions in the household farming activities.

Though literature points out that farmers who acquires formal education are in a better position to adapt to climate change compared to their counterparts, the study has found quite contrary. Formal education had a negative but significant relationship with the selection of adaptive strategies. Increasing the years of schooling by one unit would result in decrease in selection of crop diversification, substitution of crops, calendar redefinition, fertilizer application and changing crop rotation patterns. Increase in years of schooling would result in decrease of selecting strategies ranging between 0.5 and 1.2 times across various strategies. The findings of this study contradict the findings of Tesfahunegn et al. (2016) who found that chances of educated farmers to adopt different adaptive strategies are high compared to illiterate farmers as being literate increases one's chance to understand climate change better. This could be because farmers with high level of education end up investing more in formal employment or other off-farm activities. Furthermore, education is a key element towards selection of various adaptive strategies and this could be due to farmers' ability to search and understand the application of various adaptive strategies (Fadina & Barjolle, 2018). In this study, probabilities of selecting any adaptive strategy decreases when farmers add another year of schooling. This could also be due to the possibility that the more farmers focus on acquiring formal education, the more such farmers are willing to generate off-farm income as the findings by Abdul-Razak and Kruse (2018) concluded that formal education opens various

opportunities for farmers to earn a living. The findings of this study are also consistent to that of Kabubo-Mariara (2008), who alluded that education was negatively correlated with climate change adaptation as educated farmers had alternative income earning opportunities.

Farming experience plays a significant role in selection of adaptive strategies though it has a significant but negative relationship that exists in selection of specific adaptive strategies. An addition by a year of farming experience progressively decreases selection of specific adaptive strategies ranging from 1.8 to 2.4 times more. The finding of this study that more farming experience has a significant influence on selection of adaptive strategies is consistent with that of Tesfahunegn et al. (2016) who stated that farming experience of farmers is positively linked with exposure to diverse adaptive strategies. Furthermore, various studies have denoted that experience of farmers has positive influence on the selection of adaptive strategies as farmers with more farming experience are aware of previous extreme events and are better informed of adaptive strategies for their farming enterprise (Abid et al., 2015; Maddison, 2007; Nhemachena & Hassan, 2007). However, the finding that an increase by a year of farming experience will reduce selection of crop diversification, substitution of crops, calendar redefinition, fertilizer application and changing crop rotation patterns is contrary to that of Fadina and Barjolle (2018) who observed that farming experience of farmers positively and strongly influences farmers to consider adoption of different adaptive strategies due to the exposure to farming activities and the knowledge they have acquired throughout the years. The findings of this study showing that an increase in farming experience leads to a decrease in selection of specific adaptive strategies is, supported by the findings of

Shikuku et al. (2017) who indicated that more farming experience among farmers negatively affect farmers' decision to select various adaptive strategies. The findings of this study are also supported by that of Jin et al. (2015) who revealed that farming experience also has a negative impact for both male and female farmers towards adoption new adaptive strategies. Furthermore, it is backed up by the study that was conducted by Niles et al. (2016) who stated that farmers who might have an experience of adapting adaptive strategies may not be willing to continue adapting such strategies in the future.

Monthly on-farm income was found to have a negative but significant influence in selection of climate change adaptive strategy. An increase by a unit of farm income results in a progressive decrease of selecting calendar redefinition strategy to adapt to climate change by 0.9 chances. The finding of this study that shows that monthly on-farm income significantly influences selection of adaptive strategy confirms with that of Amadou et al. (2018) who revealed that the level of income generation among farmers has a significant impact on the selection of different climate change adaptive strategies. The findings of this study contrast with that of Burnham and Ma (2017) who revealed that farmers with higher on-farm income positively and significantly influences farmers' intention to adapt to climate change with various change adaptive strategies. The findings of this study may imply that acquiring more income may indeed lead to a progressive decrease in selection of calendar redefinition but that may not apply to every adaptive strategy as the study conducted by Amare et al. (2018) reveals that farmers with more income generation select crop diversification as an ideal strategy however, farmers with lower on-farm income generation select seed varieties strategy instead.

Farmers' off-farm occupation has a negative but significant relationship with selection of adaptive strategy, changing crop rotation pattern. A unit increase of securing off-farm occupation leads to a 0.7 chances of decrease in selecting crop rotation as a strategy. This results implies that farmers with secured off-farm occupation may progressively not select crop rotation as an ideal strategy. The findings of this study are closely related to the findings of Mugi-Ngenga et al. (2016) who attested that farmers with stable off-farming income have a low level of adaptation compared to those who are sorely focused on farming. Furthermore, the findings of this study are constant with that of Mulwa et al. (2017) who revealed that off-farm income has been found to lessen farmers' adaptation to climate change as such farmers end up investing more in off-farm activities.

5.5 Conclusion and policy implication

This chapter assessed the influence of farmers' socio-economic characteristics in the selection of climate change adaptive strategies.

It is important to highlight that from the model, it was discovered that socio-economic characteristics such as gender, formal education, farming experience, household size, off-farm occupation and monthly farm income were all significant in the selection of various climate change adaptive strategies. The results from the fitted model which predicted socio-economic characteristics that influenced the selection of specific adaptive strategies indicated that household size was significant and positive for all adaptive strategies while farming experience and formal education influenced the selection of all adaptive strategies significantly, but had a negative association. Farmers' gender, occupation and on-farm monthly income did not significantly influence selection of all

strategies, instead they significantly influenced the selection of application of fertilizer, crop rotation pattern and calendar redefinition respectively.

The findings above show that when there is an increase in the household size of a farmer, chances for each strategy to be selected progressively increases. This implies that availability of labour force has a positive influence on selection of each climate change adaptive strategy. The results also show that a shift in farmers' gender from female to male progressively increases chances of application of fertilizer being chosen as an ideal strategy. This results could imply that adoption of a certain type of strategy would be selected effectively on the basis of farmer's gender. This could be due to the manpower associated with a particular strategy. Also it could be due to the fact that male farmers could be in a better position to purchase fertilizers at a lower price based on their mobility.

Interestingly, the more the years a farmer spends in farming, the lesser the chances of each strategy to be selected, and the same applies when a farmer spends an additional year of schooling. Farmers who have been farming using a certain method may be resistant to change as farming sector in South Africa is dominated by elderly people, therefore farmers with more experience may find adapting different adaptive strategies difficult, more especially if such strategies are technology oriented. Higher formal education opens more opportunities to make a living for farmers and that may negatively impact farmers' focus on farming as more off-farm opportunities will be opening up. Off-farm income does not influence farmers in selecting suitable adaptive strategies as anticipated, yet an increase in monthly on-farm income progressively decreases selection of calendar redefinition as an ideal strategy. Level of income generated by farmers positively influence adoption of some adaptive strategies while on the other hand it

decreases selection of other adaptive strategies. Furthermore, securing off-farm occupation decreases selection of crop rotation strategy and it was anticipated that off-farm occupation would negatively influence selection of all adaptive strategies.

The study recommends that for each climate change adaptation initiation, farmers' socio-economic characteristics should be taken into consideration. For every adaptive strategy identified, there should be a careful consideration of socio-economic characteristics that suit a certain need for particular farmers since adaptation can be best measured at a farm level. There should be trainings for young and elderly farmers separately based on their specific needs.

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CHAPTER SIX

INSTITUTIONAL FACTORS AFFECTING FARMERS' DECISION TO ADAPT TO CLIMATE CHANGE

6.1 Introduction

Climate change has negative impacts on agricultural productivity, yet agricultural activities contribute significantly towards causes of climate change (Pye-Smith, 2011). Several studies have noted that impacts of climate change towards agriculture result in low agricultural production that leads to increased food insecurity (Pereira et al., 2014; Maponya et al., 2013). Farmers are expected to modify their agricultural practices to align their methods of production with increasing challenges of climate change which directly affect agricultural activities (FAO, 2010). Adaptation to climate change is the most practical strategy to control the impacts of climate change and it is important to assess various factors that shape farmers' decision to adapt to climate change (Jha & Gupta, 2016). Adaptation to climate change requires different modification of methods and practices to successfully implement different adaptive strategies, and such changes may include infrastructure, information processes and technological enhancement (IPCC, 2011). Various institutional factors significantly form part of adoption drivers of climate change adaptive strategies particularly in developing countries (Juana et al., 2013). A study conducted by Bryan et al. (2009) in South Africa and Ethiopia on adaptation to climate change revealed that factors influencing farmers' decision to adapt to climate change were access to climate information, extension services and credit. Factors such as food aid provision, access to land and extension services facilitate farmers' adaptation to climate change among the poorest farmers (Bryan et al., 2009). For a successful

climate change adaptation to be achieved; there is a need to have an in-depth understanding of different factors that shape farmers' agricultural practices and their adaptive responses to such stimulus (Nguyen et al., 2016).

6.2 Literature review

Farmers with no access to institutional support such as access to climate change information and interactions with extension agents may see no need to adapt to climate change as they may not perceive climate change to be a threat (Bryan et al., 2013). Exposure and knowledge about climate change is what critically shapes farmers' willingness and ability to adapt to climate change (Abid et al., 2019). Access to climate change information through extension agents enhances farmers' adaptation decisions (Mugagga et al., 2019). A study conducted by Chete (2019) showed that having access to climate change information has a positive significant influence on farmers' adoption of all adaptive strategies. Access helps farmers to know better about climate change phenomenon. In addition, farmers who are likely to adapt to climate change are those with constant access to extension services, education and training, and the ability to access information related to climate change (Mehar et al., 2016). However, as noted by Niles and Mueller (2016), availability of institutional support for farmers does not always assure farmers' willingness to adapt to climate change. Lack of institutional support through provision of adequate information regarding climate change and lack of credit to finance adaption have led to only few emerging farmers being willing to embrace adaptive strategies (Tambo et al., 2013). Support provision by national and international organizations to reduce the impacts of climate change has been found to positively

influence farmers' decisions to adapt to climate change (Comoé et al., 2015). Government's support for mitigating the impacts of climate change seems to play a significant positive role in farmers' decision to adapt to climate change (Shisanya & Mafongoya, 2016).

6.3 Research Methodology

6.3.1 Study area

The study was carried out in Limpopo province. Limpopo Province is the 5th largest province located in the northernmost part of South Africa. It covers an area of about 125,754 km^2; with the latest population census of about 5,726,800 people (Statistics South Africa, 2015). More than 45% of the R2-billion annual turnover of the Johannesburg Fresh Produce Market comes from Limpopo province. The province has an abundance of agricultural resources. It is one of the country's prime agricultural regions well-known for its production of livestock, fruits, vegetables, cereals and tea (LTA, 2014).

6.3.2 Population, sampling and data collection

The population of the study were emerging farmers in Limpopo province. The study employed a clustered systematic random selection technique to select 206 emerging farmers. A structured questionnaire written in English served as a data collection tool. Primary data was collected by the use of questionnaires which were administrated to participants during face to face interview sessions which were held with the participants. Questionnaires consisted of both opened-ended and closed-ended questions. During data collection, administrated questionnaires helped to assess farmers' awareness of climate change and critical determinants of climate change to investigate farmers' socio-economic characteristics that had an influence in selection of climate change adaptive

strategies and lastly, to determine if institutional factors could influence farmers' decision to adapt to climate change.

6.3.3 Empirical Model

Collected data was analysed through the Statistical Package for the Social Sciences (SPSS; version 25, 2017). The study employed Binary Logistic Regression to determine if institutional factors could influence farmers' decision to adapt to climate change. The model was selected for its ability to give better predictions where the dependent variable is dichotomous as in this study. The dependent variable was farmers' decision to adapt to climate change which had two responses (Yes/No) and independent variables used were institutional factors such as access to climate change information, access to institutional support, access to extension service, access to trainings and organisation membership. Model specification was indicated under methodology section.

Table 6.1: Description of explanatory variables

Variable	Variable description	Type of measure					Expected sign
RWI	Receive weather information	Daily =0	Weekly = 1	Bi-weekly = 2		Monthly = 3	
CCC	Climate change campaign	Dummy					+
		Yes = 0		No = 1			
RIS	Receive institutional support	Yes = 0		No = 1			+
FO	Farmers' organisation	Yes = 0		No = 1			- +
AES	Access to extension service	Yes = 0		No = 1			+
CCST	Climate change special trainings	Yes = 0		No = 1			- +
SS	Support source	Government=0		Private institution=1			+
SWI	Source of weather information	Radio stations=0	Newspapers=1	Television=2	Colleagues=3	Extension agent=4	+
TSR	Type of support received	Inputs provision=0	Training=1	Formal credit=2	Financial assistance=3		- +
KES	Kinds of extension service	Advice on production=0	Climate change=1	Advice on marketing=2	Other services=3		- +

n=206; Dependent variable= Decision to adapt (Yes = 0; No= 1). Source: Author's computation (2018/2019).

6.4 Results and discussion

6.4.1 Presentation of results

6.4.1.1 Results on farmers' decision to adapt to climate change

Table 6.2 presents the results of the estimated model. The estimated model indicated classification rates of 88% for no adaptation, 90.6 % for adaptation and an overall classification rate of 89.3%. These results indicate the degree of accuracy of the model and therefore, the reliability of the resulting estimated coefficients with their accompanying statistics. From the data, the dependent variable would explain between 59.3 % and 75.4 % of the variation in results as indicated by the diagnostics. The non-significance of the goodness of fit indicates that the model fits the data well (Spicer, 2004).

Table 6.2: Parameter estimates of the binary logistic model of climate change adaptation

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
RWI	0.934	0.486	3.686	1	0.055**	2.543
RI	0.179	0.218	0.668	1	0.414	1.195
SWI	0.196	0.125	2.480	1	0.115	1.217
CCC	-0.018	0.465	0.002	1	0.969	0.982
RIS	1.154	0.434	7.060	1	0.008***	3.170
SS	1.268	0.688	3.397	1	0.065*	3.553
TSR	0.141	0.116	1.464	1	0.226	1.151
FO	-0.131	0.460	0.082	1	0.775	0.877
AES	0.528	0.485	1.187	1	0.276	1.696
HRES	-0.114	0.138	0.685	1	0.408	0.892
KES	0.307	0.116	7.034	1	0.008***	1.359
CCST	-1.260	0.758	2.765	1	0.096*	0.284
Constant	-1.540	0.831	3.437	1	0.064	0.214
Diagnostics:	Classification:		Goodness of fit:			
-2 Log likelihood = 56.891	Adaptation = 90.6%		χ2 = 1.234			
Cox & Snell = 0.593	No adaptation = 88%		df = 1			
Nagelkerke = 0.754	Overall = 89.3%		Sig. = 0.947			

***, **,*Significant at 1%, 5%, and 10% probability level, respectively. Source: Survey results (2018/2019).

6.4.1.2 Significant variables in the model

Table 6.2 indicates that five explanatory variables influence farmers' decision to adapt to climate change significantly. Out of twelve explanatory variables used in the model, access to weather information, access to any institutional support, source of support, kind of extension services received and access to climate change special training were statistically significant.

From Table 6.2, access to climate change information such as a weather forecast positively and significantly influence farmers' adaptation to climate change. A unit

increase in accessing weather information would increase farmers' adaptation to climate change by 0.93 chances. The results show that having access to any form of institutional support (P<1%) was also a strong predictor of results. Having access to any form of institutional support significantly influences farmers' decision to adapt to climate change and an increase in a unit of access to institutional support increases farmers' adaptation to climate change by 1.15 chances. Securing source of support from which farmers access various forms of support significantly influences farmers to adapt to climate change. A unit increase in a number of source farmers secure increases their chance of adapting to climate change by 1.12 probabilities. The type of extension services offered to farmers has a positive and significant influence in farmers' adaptation to climate change. An increase in the unit of various types of support offered to farmers increases their chances to adapt to climate change by 0.31 chances. However, access to climate change trainings has a negative but significant influence in farmers' adaptation to climate change. A unit increase in the attendance of climate change training by farmers decreases their adaptation to climate change by 1.26 chances.

6.4.1.3 Variables determining farmers' adaptation to climate change summarized

It can be concluded from the results in Table 6.2 that variables which have a higher influence on farmers' adaptation to climate change are access to weather information, access to any institutional support, securing source of support, accessing kinds of extension services and access to climate change special trainings. Furthermore, access to weather information, access to any institutional support and source of support all had a positive and significant influence in farmers' adaptation to climate change whereas attending climate change special trainings had a negative but significant influence on farmers' adaptation to climate change.

Access to any form of institutional support and accessing different kinds of extension services are the most significant variables influencing farmers to adapt to climate change. They are both significant at 1% level of significance. While farmers' access to weather information is significant at 5% level of significance. Source of support and attending climate change trainings are both significant at 10% level of significance. Belonging to any farmers' organization does not significantly influence farmers' adaptation to climate change as anticipated.

6.4.1.4 Discussion of the significant variables in Binary logistic regression results

Access to weather information increases farmers' adaptation to climate change by 0.93 chances, this implies that farmers who have access to climate change information such as weather forecast are in a better position to adapt to climate change. The findings of this study are consistent with those of Khanal et al. (2018) who stated that farmers who frequently receive information on climate change are more inclined towards adaptation than their counterparts. The findings are also aligned to that of Mulwa et al. (2017) who stated that access to climate change information is a major driver of adaptation among farmers. A recent study also shows that farmers with access to weather forecasting adapt to climate change more than their counterparts (Abid et al., 2019). Access to any form of institutional support significantly influences farmers' adaptation. An increase in a unit of accessing institutional support increases farmers' adaptation to climate change by 1.15 chances. The findings are backed by the study conducted by Below et al. (2015) who revealed that provision of local agricultural support has a positive impact on farmers' response in taking up different climate change adaptive strategies. The findings of the

study are also consistent with that of Comoé et al. (2015) who stated that support provision by national and international organizations to reduce the impacts of climate change positively influence farmers' decisions to adapt to climate change.

Securing a source of support has a positive and significant influence in farmers' decision to adapt to climate change. An increase in the unit of securing a source of support results in an increase of farmers' adaptation by 1.27 chances. This result implies that having a secured source of support positively influences farmers' adaptation to climate change. The results are similar to that of a study conducted by Ngigi et al. (2017) who revealed that a source and channel of climate information dissemination plays a role in farmers' adaptation using various climate change adaptive strategies. In a study conducted by Shisanya and Mafongoya (2016), it was revealed that government's support on mitigating the impacts of climate change seems to play a significant and positive role in farmers' decision to adapt to climate change. A type of extension service that a farmer receives has a positive and significant influence on farmers' decision to adapt to climate change. An increase in a unit of types of extension services farmers receive increases their probabilities to adapt to climate change by 0.30 chances. This result implies that farmers who access different kinds of extension services, are in a better position to adapt to climate change as accessing types of extension services increases their decision to adapt. This is also supported by the study conducted by Mehar et al. (2016) which revealed that enough exposure to extension services and training seems to have a useful impact on farmers' decision to adapt to climate change and their selection of relevant adaptive strategies. The findings of this study are also similar to the study that revealed that accessibility of extension service proves to be an important key for farmers' selection

of adaptive strategies and their willingness to adapt to climate change (Khanal et al., 2018).

The findings of the study as encapsulated in Table 6.2 show that having access to climate change special trainings has a negative but significant influence on farmers' adaptation to climate change. This implies that when farmers attend a special training on climate change adaptation, their chances of adapting decreases by 1.26 chances. The findings of this study are contrary to findings of various studies that suggested that training attendance is positively linked with improved willingness and decision to adapt to climate change among farmers (Trinh et al., 2018; Arunrat et al., 2017).

6.5 Conclusion and policy implication

This chapter investigated the manner in which institutional factors could affect farmers' decision to adapt to climate change. The results from the study showed that there are institutional factors that positively and significantly influence farmers' decision to adapt to climate change. The results from the fitted model that predicted institutional factors that contributes to farmers' adaptation indicated that access to weather information, access to any form of institutional support, source of support, access to kinds of extension services and access to climate change trainings significantly influence farmers' adaptation to climate change.

Binary logistic regression results depicted that:

- Access to weather information increases farmers' adaptation by 0.93 chances.
- Having access to institutional support increases farmers' adaptation to climate change by 1.15 times.

- Securing a source of support positively increases farmers' adaptation by 1.26 times.
- Adaptation to climate change increases by 0.30 chances when farmers have access to different kinds of extension services.
- A unit increase in attending climate change adaptation training decreases farmers' adaptation by 1.26 times.

The findings above show that having access to institutional support positively influences farmers' adaptation to climate change. Although climate change training attendance reduces farmers' adaptation, having access to different kinds of extension services positively influences farmers' adaptation to climate change. Therefore, the study recommends that different stakeholders should provide institutional support to farmers in order to enhance their adaptation. The study also recommends that climate change information such as daily weather information should be disseminated to farmers timely through different channels such as radio, cellphones and television as almost all households have access to such devices. The findings of the study also recommend that effective trainings or workshops that specifically suit a certain group of farmers with common needs and resources should be initiated for farmers in order to improve their adaptive capacity and resilience towards climate change.

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CHAPTER SEVEN

SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

This chapter provides the summary, conclusion and recommendations of the study as aligned with the study objectives. The chapter summarizes the key research discoveries according to the set-out objectives outlined at the beginning of the study. The chapter also includes conclusion and recommendations.

7.2 Summary

The study was intended to contribute to the body of knowledge on the enhancement of climate change adaptation through the adoption of various adaptive strategies. The overarching question that this study sought to answer is “What are the critical factors that impact on farmers as they adapt to climate change outcomes within their environment?” Subsequently, the study intended to develop a model that could generally be applied by farmers, policy makers and implementers to enhance farmers’ adaptation to climate change. The study was conducted in Limpopo Province of South Africa and it focused on emerging farmers. Statistical methods and empirical models were used in this study to:

I. Investigate farmers’ awareness of critical determinants and impacts of climate change in Limpopo province
II. Assess the influence of socio-economic characteristics of farmers on the selection of adaptive strategies; and
III. Investigate if institutional factors could affect farmers’ decisions to adapt to climate change

For this study to achieve its objectives, review of literature was done. Literature based on farmers' awareness of climate change as well as its critical determinants was done. Literature on awareness of impacts of climate change among farmers was also reviewed. The literature review also focused on how socio-economic characteristics of farmers influence selection of climate change adaptive strategies and on how institutional factors affect farmers' decision to adapt to climate change. The third chapter expounded on the characteristics of the study area, population, and methods of data collection. Data was collected using questionnaires and it involved 206 emerging farmers. The research findings were arranged according to the study objectives and are summarized in the next paragraphs.

Awareness of climate change

As aforementioned in Chapter Four, majority of farmers in the study area were aware of climate change. The study also revealed that farmers were also aware of different critical determinants of climate change. Many farmers have attested to have observed an increase in temperatures between 2014 and 2018. Furthermore, many farmers have also noted a decrease in annual rainfall in the study area. With the abovementioned observed climatic changes, the study has uncovered that the most preferred adaptive strategies under such climatic conditions among farmers were crop diversification, substitution of crops and calendar redefinition. The study also revealed that majority of farmers in the study area were aware with the impacts of climate change and farmers select various adaptive strategies to survive the impacts of climate change accordingly.

Furthermore, multiple regression analysis of the study revealed that to mitigate for the negative impact of floods crop diversification, substitution of crops and calendar

redefinition were all found to be significant at 1%. This implies that regarding occurrence of floods as consequences of climate change respondents adopted crop diversification, substitution of crops and calendar redefinition to mitigate its negative impact. Whereas to take advantage of the effects of flood, the study revealed that fertilizer application was found to be positively significant at 1%. Lastly the study revealed that to take advantage of impact of rainfall changing pattern, substitution of crops was significant at 10%. This implies that when respondents observe changing rainfall pattern, farmers adopt substitution of crops to take an advantage of the noted changes.

Socio-economic characteristics

Multiple regression analysis of the study revealed that household size has a positive and significant influence in selecting crop diversification, calendar redefinition, fertilizer application and changing crops rotation pattern at 5% while it has a positive and significant influence on selection of substitution of crops at 10%. Selection of crop diversification, substitution of crops, calendar redefinition, fertilizer application and changing crops rotation pattern increase with an increase in the number of household sizes of farmers. Farming experience among farmers significantly influence selection of crop diversification, substitution of crops and calendar redefinition at 5% while it has influence on selection of fertilizer application and changing crop rotation pattern at 1%. Acquiring more farming experience among farmers has a significant but negative association with selection of all adaptive strategies. When farmers acquire more formal education, selection of crop diversification, substitution of crops, calendar redefinition, fertilizer application and changing crops rotation pattern decreases.

The multiple regression analysis of the study also revealed that formal education has a significant but negative association with the selection of crop diversification, substitution of crops and fertilizer application at 5% and changing crop rotation pattern at 1%. Farmers who acquires more formal education are going to give up on adapting through crop diversification, substitution of crops, calendar redefinition, fertilizer application and changing crops rotation pattern. This implies that when farmers acquire more formal education the more they will not adapt to climate change. Monthly income that respondents generate from their farm activities was found significantly influencing selection of calendar redefinition at 10%. The more farmers generate income from their farming activities the lesser they would adapt to climate change through calendar redefinition. Farmers' gender was found to positively influence selection of fertilizer application at 10%. When more male farmers are involved in farming, the more they're going to apply fertilizer in their farm unit as it has a positive association with selection of fertilizer application. Off-farm occupation was found to be significant at 10% in selecting changing crop rotation pattern strategy. It was anticipated that farmers with off-farm occupation may gradually not adapt to climate change.

Institutional factors

Binary logistic regression results of the study revealed that farmers who receive climate information positively adapt to climate change. Receiving climate change information was found to have a significant influence on farmers' decision to adapt to climate change at 10%. Farmers with access to climate change information positively adapt to climate change. The results also showed that farmers who receive any form of institutional support adapt to climate change. Access to institutional support was found significant at

1% to influence farmers' decision to adapt to climate change. Farmers with access to any form of institutional support positively adapt to climate change. Securing source of support by famers positively influence their willingness to adapt to climate change. Securing source of support was found significant at 10%. Furthermore, access to kinds of extension services was found significant at 1%. Access to kinds of extension services has a positive and significant association with farmers' adaptation to climate change. The study also revealed that attending trainings significantly influence farmers' adaptation to climate change at 10%. Attending adaptation trainings was found to have a negative but signification association with decision to adapt to climate change. This implies that when farmers attend adaptation trainings they end up deciding not to adapt to climate change, though the opposite was anticipated.

7.3 Conclusion

The conclusion of the study was based on the hypotheses mentioned in Chapter One.

7.3.1 Farmers are not aware of climate change

The study rejects the hypothesis that farmers are not aware of climate change on the basis that the results showed that majority of farmers were aware of climate change. Furthermore, the results also confirmed that farmers were aware of various critical determinants of climate change within their farming environment and they have taken some adaptive strategies to adapt to climatic changing conditions.

7.3.2 Some farmers' socio-economic characteristics do not influence the selection of adaptive strategies

The study rejects the null hypothesis. The results showed that some of farmers' socio-economic characteristics such as formal education, farming experience and household size were all significant in influencing the selection of climate change adaptive strategies. Furthermore, the study revealed that specific climate change adaptive strategies were significantly selected based on specific socio-economic characteristics of farmers. Selection of various adaptive strategies is significantly influenced by specific socio-economic characteristics.

7.3.3 Institutional factors influence farmers' decisions to adapt to climate change

The study fails to reject the null hypothesis. The results showed that institutional factors such as access to weather information, access to extension services and access to various institutional support positively influence farmers to adapt to climate change. The study also revealed that the lesser the climate change trainings are offered to farmers, the more the chances would increase farmers' willingness to adapt to climate change. These findings show that indeed, institutional factors do influence farmers' decision to adapt to climate change.

7.4 Recommendations

7.4.1 Awareness of climate change

The results of the study showed that majority of farmers were aware of climate change. The study further revealed that most of farmers were also aware of critical determinants and impacts of climate change within the study area. The study recommends that there

should be an implementable programme in place that promotes climate change awareness in various parts of Limpopo province. Furthermore, the study recommend that various stakeholders should be invited when drafting such programmes to ensure that suitable approaches are used in educating farmers about climate change. Stakeholders such as farmers should also be encouraged to take ownership of climate change adaptation initiatives. The study also recommends that appropriate channels should be used to promote climate change awareness among farmers.

The study also revealed that farmers were familiar with the critical determinants and impacts of climate change. The study recommends that farmers should be made aware of different critical determinants as well as impacts of climate change particularly impacts that farmers might have experienced within their environment. Furthermore, it is recommended that the government should approach different stakeholders who would assist farmers in identifying suitable adaptive strategies for their farming environment. Furthermore, policies that are aimed at promoting farm-level awareness of climate change need to emphasize the critical role of provision of improved formal extension services when promoting climate change awareness. It is also recommended that the government should have clear policies and investments that are geared towards the support of climate change adaptation.

The study revealed that regarding occurrence of floods as consequences of climate change, crop diversification, substitution of crops and calendar redefinition are used to mitigate the negative impacts of climate change. The study therefore recommend that farmers should be trained on the application of crop diversification, substitution of crops and calendar redefinition so that they may use them to mitigate the negative impact of

floods. They study also recommend that farmers should be trained to make use of fertilizer application as an ideal strategy to take advantage of flood occurrence. The study recommends that farmers should be assisted to adopt substitution of crops as their ideal strategy when they observe changes in rainfall pattern within their farming environment.

7.4.2 Socio-economic characteristics of farmers

The results of this study showed that some of farmers' socio-economic characteristics of farmers significantly influence selection of adaptive strategies. Farmers' household size has a positive influence on selection of crop diversification, substitution of crops, calendar redefinition, fertilizer application and changing crop rotation patterns. The study recommends that with sufficient resources such as labour force and land ownership should be trained to adapt different adaptive strategies within their farming unit. The study also revealed that acquiring formal education has a significant but negative association with the selection of all adoptive strategies. The study therefore recommends that training should be prioritized to farmers who are less educated as they may not have many off-farm activities to invest in. The study also recommend that there should be separated trainings for experienced and less experienced farmers. Gaining more farming experience was found to have a significant but negative association with the selection of all adaptive strategies hence the study recommends effective adaptation training for experienced farmers and less experienced farmers in order to cater their specific needs.

The study revealed that monthly farm income has a significant but negative influence on the selection of calendar redefinition as an ideal strategy. The study recommends that farmers should be trained to adopt suitable strategies under various conditions. When more males are involved in farming, fertilizer application as an ideal strategy gets more

chances of being selected. The study recommends that both male and female should be trained to adopt adaptive strategies under various climatic conditions and based on their specific needs. The study revealed that off-farm occupation has a significant but negative influence on the selection of changing crop rotation pattern. The study therefore recommends that for changing crop rotation pattern, assistance to adapt to climate change should be prioritized for farmers who do not have off-farm occupation as it distract farmers from adapting to climate change. The study also recommend that for every climate change adaption initiatives, farmers should be involved and be assisted through various programmes that intends to build farmers' resilience to climate change based on their specific socio-economic characteristics.

7.4.3 Institutional factors

The study results showed that access to institutional support influences farmers to adapt to climate change. This implies that farmers are more willing to adapt to climate change when there is assistance given to them by various institutions. The study recommends that various stakeholders in Limpopo province should provide various kind of support to emerging farmers in order to enhance their willingness to adapt to climate change. Government and private institutions should investigate various needs of farmers within their farming environment in order to identify necessary support that should be given to farmers in order to adapt to climate change as each group of farmers may have their own specific needs. Securing a source of support by farmers also enhances their decision to adapt to climate change within their farming units. It is therefore recommended that groups of emerging farmers should be identified and linked with various sources of support that can facilitate their adaptation process. Securing source of support may also

encourage farmers to perform at their level best. It is also recommended that the government should facilitate orientation that exposes farmers to available support systems that can assist farmers in adaptation process.

The study also revealed that farmers who have access to climate change information such as weather forecasting on a regular basis are more adaptive to climate change. Farmers who receive climate change information are usually updated on the current trend of changes and are in a better position to identify suitable adaptive strategies. The study therefore recommends that different stakeholders i.e. climatologists and meteorologists should assist in the provision of climate information to emerging farmers timely as this could enhance adaptation to climate change. It is also recommended that reliable sources and channels should be used to disseminate climate change information using understandable language. The study also recommend that the government should also update its farmers' database regularly and disseminate climate change information timely using various reliable channels. The study also revealed that farmers who attends climate change trainings progressively decrease their willingness to adapt to climate change; however the study recommends that various stakeholders should be engaged in rendering of climate change adaptation trainings. Furthermore, it is recommended that trainings shouldn't be generic, however there should be a specific and informative trainings that are designed for a certain group of farmers based on their experiences and needs. Also, the study recommend that there should be trainings that are designed to build farmers' adaptive capacity around Limpopo province.

The study also revealed that farmers who have access to different kinds of extension services are more willing to adapt to climate change. Even literature confirms that farmers

who access extension services are in a better position to adapt to climate change. The study therefore recommend that there should be an effective provision of extension services. The study also recommend that there should be a training of government agricultural extension officers on how to effectively render services to farmers. The study discovered that it is possible that within the same area, some farmers may be benefiting from extension services while others are excluded. Therefore, it is recommended that the government should ensure that extension services are rendered accordingly and there should be a record and evaluation of such services. Furthermore, the study recommends that the government should have climate change adaptation champions who regularly monitors adaptation initiatives in various parts of the province.

The study also wanted to find the answer on critical factors that impact on farmers as they adapt to climate change outcomes within their environment; the study discovered that farmers' knowledge about climate change and availability of institutional support are crucial factors that impact farmers' adaptation to climate change.

CHAPTER 8

MODEL

8.1 Introduction

With the impacts of climate change being on the gradual increase, and Limpopo being one of the identified parts of South Africa to be vulnerable; the focal point of the study was to develop a model that could generally be applied by various stakeholders i.e. farmers, policy makers and implementers to enhance farmers' adaptation to climate change through various climate change adaptive strategies. Deforestation and emission of greenhouse gases were identified as major contributors of climate change causes.

Adaptation to climate change is the most practical strategy to control the impacts of climate change and it is important to assess farmers' awareness of climate change and other factors to see what shapes farmers' decision to adapt to climate change (Jha & Gupta, 2016).

There are various climate change adaptive strategies that were identified and are believed to be farmers' lifeline in the face of climate change; adaptive strategies are believed to ensure that farmers mitigate the impacts of climate change and eventually be resilient to climate change in their farming practice. However, there are various critical factors that prompt farmers to adapt to climate change through the identified climate change adaptive strategies. The study had a conceptualized framework that served to give the study direction in investigating fundamental factors that could play a significant role for farmers to adapt to climate change in order to develop an implementable model that could be used to enhance climate change adaptation among emerging farmers in Limpopo province.

8.2 Description of the Model

8.2.1 Farmer awareness of Climate change

The crucial starting point when developing a practical model that can be used to enhance adaptation to climate change by emerging farmers is to investigate the extent of climate change knowledge that exists among emerging farmers. The study results revealed that majority of emerging farmers were aware of climate change in Limpopo province; it is disquieting to note that farmers in Limpopo province are not fully aware of climate change. The study also pointed out that emerging farmers in Limpopo province have observed some critical determinants of climate change such as escalating temperatures and dwindling rainfall among other determinants. Furthermore, the results of the study showed that farmers are also aware of the impacts of climate change.

Therefore, to enhance adaptation to climate change in Limpopo province; Awareness about climate change should be promoted among emerging farmers as farmers who have heard about climate change are in a better position to adapt and be resilient to the impacts of climate change compared to their counterparts. Furthermore, training programmes that will include mitigating negative impacts of climate change through crop diversification, substitution of crops, and calendar redefinition should be promoted among farmers. Emerging farmers should also be trained to take advantage of positive impact of rainfall through the adoption of substitution of crops as an ideal strategy.

8.2.2 Influence of farmers' socio-economic characteristics to choice of adaptive strategies

The study went on to reveal that socio-economic characteristics of farmers such as farming experience, formal education and household size influence selection of climate

change adaptive strategies significantly. Farming experience, formal education and farmer's households' size significantly influence selection of specific climate change adaptive strategies among farmers. When the size of farmer's household increases, selection of a specific adaptive strategy also increases whereas a number of years spent in attending school and an increase in farming experience both decrease selection of a specific adaptive strategy.

Farmers with large household size should be encouraged to take up various climate change adaptive strategies as they can cope with labour force attached to each strategy. Furthermore, there should be training programmes that aims to train farmers on adoption of all possible adaptive strategies and farmers should be grouped according to their specific needs. Trainings should be prioritized for illiterate farmers and those without off-farm occupation. There should be specific trainings for both experienced and inexperienced farmers respectively.

8.2.3 Institutional factors on farmers' decision to adapt to climate change

Availability of institutional support plays a vital role in farmers' adaptation to climate change. Farmers who are failing to adapt to climate change are faced with lots of challenges including limited resources and lack of an effective support system to adapt to climate change (Harvey, 2014). The results of the study showed that farmers who have access to institutional support consider adaptation to climate change than those who do not receive any form of support. Access to climate change information also increases probabilities of farmers adapting to climate change.

To enhance adaptation to climate change, various stakeholders that can support farmers should be identified. Furthermore, various groups of emerging farmers should be

successfully linked with various sources of farming support. It should also be made a priority to provide available climate change information with farmers timely as it helps them during their planning phase. Extension services should be made available to farmers in various regions and such services should be rendered timely.

8.2.4 Outcomes of the functional model

A functional model to enhance climate change adaptation, particularly by emerging farmers should ensure that emerging farmers possess a comprehensive climate change knowledge. It should further ensure that farmers are capacitated to take up various adaptive strategies in their farming units. Over a period of time the model should ensure that farmers resilient to the impacts of climate change leading them to be competitive in the market regardless the climatic changes happening around the globe.

Purpose: Develop a functional model to enhance adaptation to climate change

Adaptive strategies

- Crop diversification
- Substitution of crops
- Calendar redefinition
- Fertilizer application
- Crop rotation

Institutional factors

- Need for provision of support to farmers
- Identify sources of support and link farmers with them
- Provision of climate change information timely
- Offering separate adaptation trainings to farmers and extension officials to build their resilience to climate change
- Need to provide extension services regularly and timely

Farmers' socio-economic characteristics

- To identify adaptation initiatives for specific group of farmers
- Need for training programmes including adoption of crop diversification, substitution of crops, calendar redefinition, fertilizer application and changing crop rotation particularly by farmers with large household size
- Need to train illiterate farmers
- Need for separate trainings for experienced farmers and inexperienced farmers on adoption of adaptive strategies
- Assist farmers to take advantage of suitable strategies considering their gender
- Need to train farmers without off-farm occupation

Awareness of climate change

- Need for programmes to promote climate change awareness
- Need for mitigation for negative impact of flood
- To take advantage of flood occurrence and
- Adoption of crop diversification, substitution of crops and calendar redefinition to take advantage of the positive impact of rainfall

Intervention strategies

Intervention strategies for institutional factors

- Various stakeholders should provide any form of support to farmers
- Linking farmers with sources of support
- Provision of climate change information to farmers timely
- Training programmes for farmers and extension officials on climate change adaptation to build their resilience to climate change
- Providing extension services to farmers timely

Intervention strategies for socio-economic characteristics

- Provision of training programmes including adoption of crop diversification, substitution of crops, calendar redefinition, fertilizer application and changing crop rotation particularly by farmers with large household size
- Trainings should be prioritized for illiterate farmers and those without off-farm occupation
- Specific trainings for experienced and inexperienced farmers should be provided respectively

Intervention strategies for awareness of climate change

- Educational programmes to promote climate change among farmers
- Training programmes that will include mitigating negative impacts of climate change through crop diversification, substitution of crops and calendar redefinition
- Provision of trainings that includes substitution of crops to take advantage of rainfall.

Final outcomes

- Comprehensive climate change knowledge
- Capacitated adaptive farmers
- Improved farmers' resilience to climate change
- Improved farmers' competitiveness

Figure 8.1: A Model to enhance adaptation to climate change, Author: 2019.

Impacts of climate change

8.3. Conclusion

The chapter looked at major results of the study which were further used to develop a model that can be used to enhance adaptation to climate change. With identified adaptive strategies, it was imperative to investigate determinant factors that play a role in farmers adopting such adaptive strategies. It was noted that the knowledge about climate change among farmers is one of the key components that enhances adaptation to climate change. Several socio-economic characteristics were identified that influenced selection of specific adaptive strategies, furthermore intervention strategies were identified to ensure that adoption of adaptive strategies among farmers could increase. Institutional factors that enhances adaptation to climate change were identified and possible strategies were also mentioned that could improve adoption of various strategies. Various stakeholders are still to be engaged to ensure validity and reliability of the model that this study has developed.

References

Harvey, C.A., Rakotobe, Z.L., Rao, N.S., Dave, R., Razafimahatratra, H., Rabarijohn, R.H., Rajaofara, H. & MacKinnon, J.L., 2014. *Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar*. Phil. Trans. R. Soc. B, 369 (1639): p.20130089.

Jha, C.K., & Gupta, V., 2016. Climate Change Adaptation in Indian Agriculture Assessing Farmers' Perception and Adaptive Choices: In *Climate Change Adaptation, Resilience and Hazards* (pp. 275-288). Springer International Publishing.

Annexures

Annexure 1: Consent form to be completed by the focus group members

TOPIC: **Towards a model development for adaptive strategies that will enhance adaptation to climate change for emerging farmers in Limpopo province, South Africa**

a) I have read information regarding my participation and I have understood the nature and purpose of the research project.

b) I understand the purpose of my involvement.

c) I understand that I may withdraw from the research project at any stage and that this will not affect my status within the project.

d) I understand that my personal identity will remain anonymous throughout the study.

e) In case of audio tape recording, I acknowledge that I reserve the right to terminate the recording during data collection stage.

f) I understand that data will be held confidentially.

g) I understand that I may contact the Research Director if I require further information about the research, and that I may contact the Research Ethics Coordinator of the University of Venda if I wish to make a complaint relating to my involvement in the research.

Signed: ..... (Research participant)

Print name: .....

Date: .....

Annexure 2: Consent form to be completed by all participants

CONSENT FORM

University of Venda

Topic: Towards a model development for adaptive strategies that will enhance adaptation to climate change for emerging farmers in 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:			

Annexure 3: Letter to Department of Agriculture Limpopo (LDA)

P.O. Box 405

Thohoyandou

0950

Dear Sir/Madam

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

I (Tshikororo Mpho), a doctoral student at the University of Venda in the School of Agriculture under the Department of Agricultural Economics and Agribusiness, hereby request for permission to conduct a research project in Limpopo Province which is entitled:

Towards a model development for adaptive strategies that will enhance adaptation to climate change for emerging farmers in Limpopo province, South Africa

The purpose of the study is to develop the model for climate change adaptation by emerging farmers in Limpopo province.

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

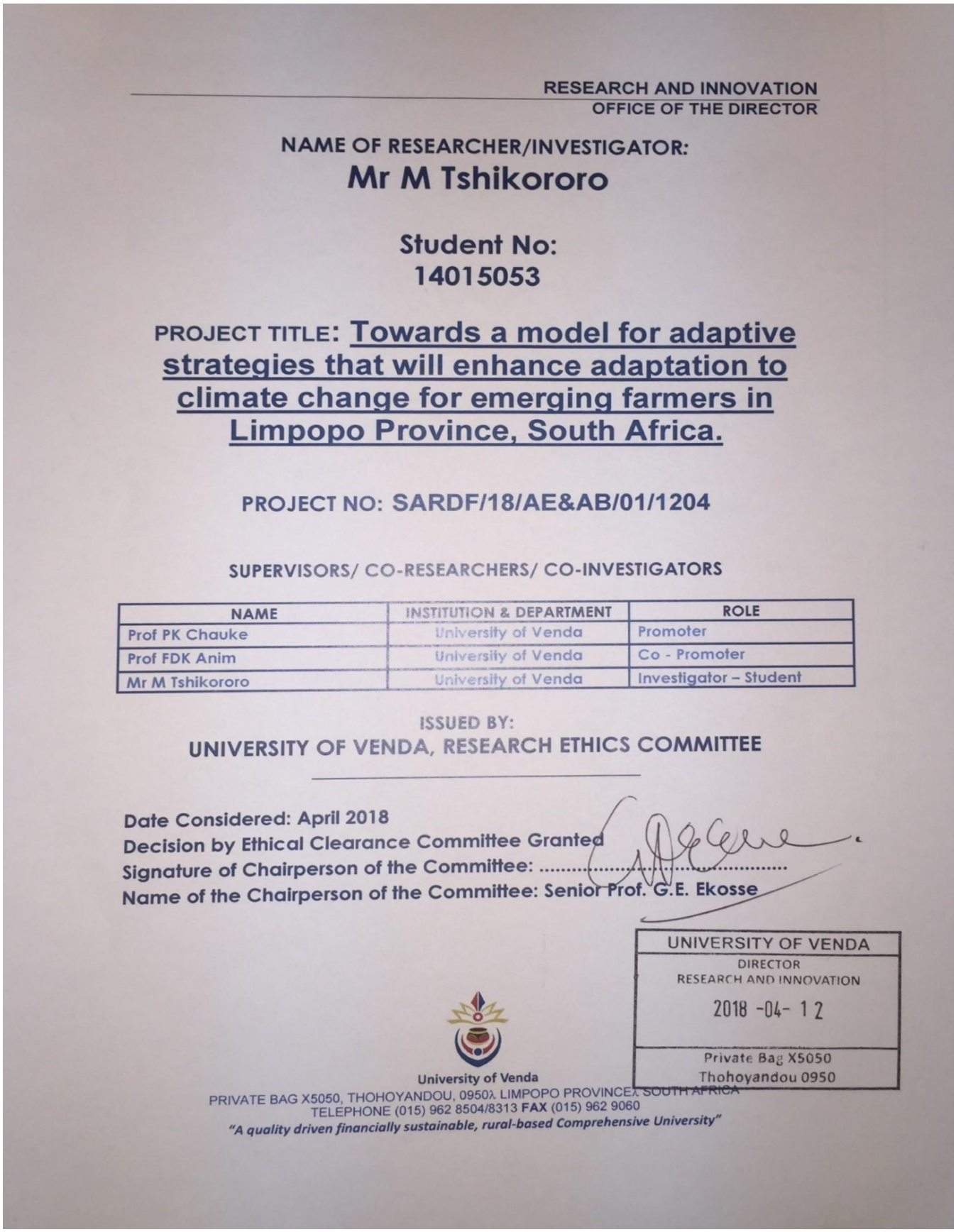
I. Informed consent
II. Voluntary participation and freedom to withdraw without any penalty
III. Names of participants will not be mentioned during discussions

Thank you in advance

Yours Faithfully

Tshikororo M. (071 205 9868/063 231 9556)

Annexure 4: Ethical clearance certificate



RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:
Mr M Tshikororo

Student No:
14015053

PROJECT TITLE: **Towards a model for adaptive strategies that will enhance adaptation to climate change for emerging farmers in Limpopo Province, South Africa.**

PROJECT NO: **SARDF/18/AE&AB/01/1204**

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Prof PK Chauke	University of Venda	Promoter
Prof FDK Anim	University of Venda	Co - Promoter
Mr M Tshikororo	University of Venda	Investigator – Student

ISSUED BY:
UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE

Date Considered: April 2018
Decision by Ethical Clearance Committee Granted
Signature of Chairperson of the Committee: .....
Name of the Chairperson of the Committee: Senior Prof. G.E. Ekosse

UNIVERSITY OF VENDA
DIRECTOR
RESEARCH AND INNOVATION
2018 -04- 12
Private Bag X5050
Thohoyandou 0950

University of Venda
PRIVATE BAG X5050, THOHOYANDOU, 0950λ LIMPOPO PROVINCEλ SOUTH AFRICA
TELEPHONE (015) 962 8504/8313 **FAX** (015) 962 9060
"A quality driven financially sustainable, rural-based Comprehensive University"

Annexure 5: QUESTIONNAIRE

University of Venda

Topic: Towards a model for adaptive strategies that will enhance adaptation to climate change for emerging farmers in Limpopo province, South Africa

N.B This information is confidential and the name and address of respondents will not be disclosed for any purpose other than for the monitoring and evaluation of the university. Names will not be linked to the information that is gathered and are required only for the monitoring purpose.

Name of the interviewer: .....

Name of farmer (Optional): ….....

Date of the interview: ……

District	Municipality	District	Municipality
Vhembe	Makhado	Sekhukhune	Fetakgomo
	Thulamela		Makhuduthamaga
	Musina		Elias Motsoaledi
	Collins-Chabane		Ephraim Mogale
Mopani	Maruleng	Capricorn	Molemole
	Greater Tzaneen		Polokwane
	Greater Giyani		Lebepe-Nkumpi
	Greater Letaba		Blouberg
	Ba-Phalaborwa	Waterberg	Bela-Bela
			Lephalale
			Modimolle
			Mogalakwena
			Thabazimbi

Questionnaire no: ……..

Section A: Household characteristics

A1	A2	A3	A4	A5	A6	A7	A8	A9
Gender Female…..0 Male……..1	**Age group** <21……0 21-29….1 30-39….2 40-49….3 50-59….4 60& >60..5	**Marital status** Single... 0 Married. 1 Widowed……... 2 Other (specify)	**Highest educational qualification** No formal…..o Lower matric….1 Matric……..2 Certificate……3 Diploma……..4 Degree……5 Postgraduate… 6 Other (specify)…7	**Level of agricultural education** No formal…..o Certificate…1 Diploma…..2 Degree……3 Postgraduate. 4 Other (specify)…5	**Household size no** 1-3…..0 4-8…..1 9-15…2 >15….3	**Farming experience (in years)** Less than a year……..0 1-5……1 6-10…….2 More than 10…….3	**Occupation** Farming…0 Unemployed… 1 Employed…… 2 Pensioner…… 3 Self-employed……4	**Off-farm source of income** Old age pension ……. .0 Child grant….1 Remittances…….2 Other (specify) …3

A10	A11	A12	A13	A14
Disability Yes…..0 No…….1	**Do you keep farm records?** Yes…..0 No…….1	**What is the size of your farm?** 0.5 -1 ha …..0 1.5 -2 ha …..1 2.5 - 3 ha …..2 3.5 – 4 ha….3 Other (specify)…..4	**What did you produce last season?** Crops …….0 Livestock……1 Mixed…….2	**What is the level of your on-farm income monthly?** <1000…….0 1001-3000…1 3001-5000...2 More than 5000……3

A15	A16	A17	A18	A19	A20	A21	A22	A23
Which crops do you produce? Cabbage…..0 Onion……..1 Spinach……2 Carrots…….3 Potatoes…..4 Lettuce……5 Beetroot….6 Others (specify)….7	**How much quantity produced in?** 2013…… 2014…… 2015…… 2016…… 2017……	**How much quantity was sold in?** 2013… … 2014… … 2015… … 2016… … 2017… …	**Which commodity was highly consumed?**	**Do you irrigate your crops?** Yes …..o No …….1	**List animals you keep for farming** Sheep…..0 Goats……1 chickens…2 Cattle…….3 Pigs……..4 Ducks……5 Others (specify)….6	**How many animals have you kept recently?** 2013…… 2014…… 2015…… 2016…… 2017……	**How many animals did you sell in?** 2013…… 2014…… 2015…… 2016…… 2017……	**What do you use your animals for?** Sell…..0 Rituals…1 Ceremonies…2 House consumption……3 Others (specify) ……..4

Section B: Farmers' awareness of critical determinants of climate change and adaptive strategies

B1. Are you aware of climate change?

Yes, I know	0
Don't know	1
I'm not sure	2

B1.1. If yes, proceed to B2

B1.2. If no, proceed to B15

B2. What do you know about climate change?

_____

_____

B3. What do you think causes climate change?

_____

_____

B4. Do you regard climate change as a threat to farming?

Yes	0
No	1

B5. Do you think anything can be done to tackle climate change?

Yes	0
No	1

B6. If yes, what do you think can be done?

_____

_____

B7. Do you receive any information on climate change?

Yes	0
No	1

B8. Does such information make any difference?

Yes	0
No	1

B9. If yes, what difference does it make?

_____

_____

B10. How often do you receive such information?

Daily	0	Bi-weekly	2
Weekly	1	Monthly	3
Others (specify)			

B11. What is the source of information on climate change?

Radio stations	0	Colleagues	3
Newspapers	1	Extension officers	4
Television	2	Other (specify)	5

B12. Is there any awareness on climate change made in your area?

Yes	0
No	1

B13. Are there any impacts of climate change that you are familiar with?

Yes	0
No	1

B14. If yes, what are they?

_____

_____

B15. What is your observation about the pattern of the weather generally from 2014 to date?

Temperatures have increased	0	Temperatures are still the same	2
Temperatures have decreased	1	Not observed any changes in temperatures	3

B16. What are the rain pattern changes you have observed from 2014 to date?

Rain has increased	0	Rain has stayed the same	2
Rain has decreased	1	Not observed any changes in rainfall	3
Floods	4		

B17. What do you think of recent drought occurrence?

Occurs regularly	0
Rarely occur	1
Not observed any changes in drought occurrence	2

B18. What do you think of flood occurrence recently?

Occurs regularly	0
Rarely occurs	1
Not observed any changes in flood occurrence	2

B19. Tick all critical determinants of climate change that you have observed.

Sea level rise	1	Increased occurrence of storm	2
Increase in frequency of flooding	3	Stronger winter storms	4
Warmer winters and hotter summers	5	Heat waves & lowering of ground water table	6

B20. List other determinants of climate change that you know.

_____

_____

B21. Do you think the use of adaptive strategies is important to survive climate change?

Yes	0
No	1

B22. Is there a strategy on adaptation to climate change established that you know?

Yes	0	Yes, but not implemented	2
No	1	I don't know	3

B23. Have you attempted to adopt any of the adaptive strategies?

Yes	0
No	1

B23.1 If yes, please proceed to B24

B23.2 If no, please proceed to B28

B24. If yes, which strategy did you attempt?

_____

_____

B25. Was the adaptive strategy effective?

Agree	0
Do not know	1
Disagree	2

B26. What are your reason (s) to adopt that particular strategy?

Increase income		Good yield	
More food		Other (specify)	

B27. What are the challenges you faced when you tried adopting a particular strategy?

_____

_____

B28. Please tick all adaptive strategies that you know?

Resilient crop varieties	0	Calendar redefinition	3
Crops diversification	1	Increase in fertilizer application	4
Substitution of crops	2	Changing crop rotation patterns	5

B29. Please list other adaptive strategies that you know.

_____

_____

B30. What are other challenges that you have faced when adopting different established adaptive strategies?

_____

_____

B31. What do you think should be done to improve the use of adaptive strategies effectively?

_____

_____

B32. Do you think there is a lack of adaptive capacity around your area?

Yes	0
No	1
Not sure	2

B33. Do you think there is a need to improve farmers' adaptive capacity around your area?

Yes	0
No	1

Section C: Availability of institutional factors on farmers' decision to adapt to climate change

C1. Which type of enterprise do you prefer the most?

Crop related	0
Livestock related	1

C2. What has been your focus in the past five years (2014-2018)?

Crop related	0
Livestock related	1
Both	2

C3. Do you receive any form of institutional support about climate change?

Yes	0
No	1

C4. If yes, what is the source of such support?

Government	0
Private institution	1

C5. What kind of support do you receive for climate change effects?

Inputs provision	0	Training/ workshop	3
Formal credit	1	None	4
Financial assistance	2	Other (specify)	5

C6. How will you rate the effectiveness of the support you receiving?

High	0	Low	3
Moderate	1	No change	4
Fairly moderate	2		

C7. Are you associated with any farmers' organisation?

Yes	0
No	1

C8. If yes, please specify: ……

C9. Have you ever received any extension service?

Yes	0
No	1

C10. If yes, how often do you receive extension services?

Weekly	0	Monthly	2
Bi-weekly	1	Other (specify)	3

C11.How was the assistance in C8 offered?

Face to face	0	Workshop	
Telephonic	1	Consultation	
Farm visit	2	Other (specify)	

C12. What kind of extension services do you receive?

Advice on production	0	Climate change issues	3
Advice on marketing	1	Other services	4
Record keeping	2	Other (specify)	5

C13. How do you view the quality of extension service that you receive?

Excellent	0	Poor	3
Good	1	Very poor	4
Satisfactory	2		

C14. Do you have access to credit?

Yes	0
No	1

C15. Which sources of credit do you have access to?

Commercial banks	0	Agricultural cooperatives	2	Other (specify)	4
Land bank	1	Credit Union	3		

C16. Have you ever been denied credit?

Yes	0
No	1

C17. If yes, what were the reasons?

_____

_____

C18. Is there any privilege given to climate change victims? (Please, state how)

_____

_____

C19. Do you receive special trainings or workshops that entirely focus on adaptation to climate change?

Yes	0
No	1

C20. Are there any different stakeholders involved in your farming methods?

Government officials	0	Traditional leadership	2
Sponsors	1	Other (specify)	3

THANK YOU FOR YOUR PARTICIPATION!!!!!!