Agroecological location of farms and choice of drought coping strategies of smallholder farmers in Swaziland

by

Temndeni Amnestantia Khumalo

Submitted in partial fulfilment of the requirements for the degree Master of Science Degree in Agricultural Economics

in the

Department of Agricultural Economics, Extension & Rural Development
Faculty of Natural and Agricultural Science
University of Pretoria
SOUTH AFRICA

January 2019

DECLARATION OF ORIGINALITY

I hereby declare that this dissertation which I submit for the degree of MSc Agric (Agricultural Economics) at the University of Pretoria is my own work and it has not been previously submitted by me for a degree at this or any other institution of higher learning.

Signature ………………………………………………………………………………

Temndeni Amnestantia Khumalo

Date ………………………………………………………………………………..

Approved by:

Signature ………………………………………………………………………………

Prof E.D. Mungatana

Date ………………………………………………………………………………..

DEDICATION

I dedicate this dissertation to my Lord God. In trying times I never gave up because He was always there.

ACKNOWLEDGEMENTS

First; I would like to thank my supervisor, Professor E.D Mungatana for his support throughout my research. I attained research skills I would not have otherwise attained had it not been for his world class research skills and expertise. I would also like to pass my gratitude to my scholarship; Mastercard Foundation. Words fail to describe how grateful I am for them, as I would not have been able to pursue my degree without their financial assistance. They provided me with a lifeline when I was in desperate need. Special thanks also go to the company that provided me with an internship, Manstrat Agricultural Solutions. Many thanks for understanding my schedule and for making it a point to put my academic work first, and always allowing access to campus whenever I needed. Special thanks also goes to Thomas DeRidder for helping me with my research when the need arose.

I would also like to thank organizations that helped me with data collection and other drought related information. Mr Victor Matsebula and staff members from the National Disaster Management Agency (NDMA) and Mr Dumisani Hlanze from Swaziland Water and Agricultural Enterprise (SWADE) were of tremendous help during the data collection phase of my study. Lastly; I would like to pass my sincere gratitude to my family. Their never ending love, support and encouragement sustained me throughout the study period. Pursuing a degree takes a toll on anyone, but with friends and family surrounding me it seemed like I could achieve anything I set out to do.

AGRO-ECOLOGICAL LOCATION OF FARMS AND CHOICE OF DROUGHT COPING STRATEGIES OF SMALLHOLDER FARMERS IN SWAZILAND

BY

TEMNDENI AMNESTANTIA KHUMALO

Degree: MSc. Agric (Agricultural Economics)

Supervisor: Prof E.D Mungatana

Department: Agricultural Economics, Extension, and Rural Development

This study uses data from Swaziland to test whether variations in local agro-ecological regions levels of drought susceptibility and other socioeconomic factors significantly determine farmer selected drought coping and adaptation strategies. This was in response to the policy need to understand how livelihoods of poor, rural, smallholder farming communities can be made more resilient in the face of recurrent droughts. Swaziland's agro-ecological regions were divided into those that were highly susceptible (Lubombo and Lowveld) and those that were relatively less susceptible (Highveld and Middleveld) to drought. Using structured questionnaires and face-to-face interviews, the study compared 115 randomly selected farmers from the former and 50 farmers from the latter region based on the following household level indicators: behavioural responses to perceived long-term changes in temperature and precipitation; the impact and behavioural responses to the most recent drought event; how farmers would have responded if they had *ex ante* information on the most recent drought event; *ex ante* private investment in anticipation of future drought events; and finally farmer preferences for *ex ante* public investments in anticipation of future drought events.

Regarding farmers' behavioural responses to perceived long-term changes in temperature and precipitation; all farmers in the two agro-ecological zones clearly perceived climate change variability and in response adopted strategies to mitigate the effects. There were, however, marked differences in strategy selection between the two regions. On perceiving these changes; farmers in the more susceptible regions were more interested in adopting adaptation strategies, whereas those in the less susceptible regions were much more reluctant

to apply any drought coping and adaptation strategies. To determine the significance and validity of these differences in adaptation; chi square tests were conducted on each strategy applied in the two regions and those that were significantly different between the two zones were further analysed using probit analysis to determine socio-economic, biophysical, and policy variables that contributed to the selection of these strategies.

The results of the chi square test revealed that adaptation strategies that were significantly selected between the two regions in the past ten years were purchasing water (51%), construction of livestock shelter (51%), purchasing hay (50%), changing livestock type to more drought tolerant animals such as goats (41%), and migration of livestock to areas with better grazing (35%). Factors that influenced the decision to change livestock type were region of farmer location (p=0.001), income source (p=0.084), availability of extension (p=0.049), the decision to proceed with farming (p=0.007), and the need for credit (p=0.007). The decision to purchase hay, on the other hand, was influenced by region of farmer location (p=0.007), whether the farmer owned a trailer or not (p=0.042), availability of maize fields (p=0.012), availability of fields for other crops besides maize (p=0.012), extension services (p=0.004), and the need for credit (p=0.050). Factors that influenced farmers' decision to migrate their livestock to better pastures were region of farmer location (p=0.007), income source (p=0.022), gender (p=0.022), occupation (p=0.044), number of children (p=0.034), extension services (p=0.024), the decision to proceed with farming (p=0.008), and the need for credit (p=0.032). With regards to purchasing water as a coping strategy; factors such as region of farmer location (p=0.08) influenced the decision, together with income source (p=0.088), ownership of a trailer (p=0.016), livestock units (p=0.073), availability of extension services (p=0.046), and government support (p=0.021). Lastly, factors that contributed to farmers' decision to construct livestock shelter were region of farmer location (p=0.019), average income (p=0.070), gender (p=0.096), availability of fields for crops other than maize (p=0.087), availability of extension services (p=0.050), and the decision to proceed with farming (p=0.010).

With respect to impacts of the most recent drought; farmers were severely affected in their crop and livestock production. In livestock production, farmers mainly experienced cattle deaths (53%); but relatively less deaths in chicken and goat production (21% and 3% respectively). In crop production; extensive losses were experienced in maize production. On average, farmers in the more susceptible region lost E964/ plot and those in the less susceptible region lost E648/plot. In response to the drought; farmers in both regions responded in a reactive manner as they were ill prepared to deal with the impacts of the drought. The coping strategy that was used by 84% of the farmers in crop production was changing planting dates; which basically means that farmers waited for first rains which in turn delayed planting as the drought resulted in late first rains. The second most applied strategy (by 10% of farmers) was that of not planting at all; as some farmers took late first rains to be a sign of an imminent drought. The rest of the farmers irrigated (2%), applied more chemicals (2%), changed crop type (1%), replanted (1%), and started practicing conservation farming (1%). Farmers did not adopt any strategies with respect to livestock production when the drought hit.

Strategies that farmers would have selected if they had received ex-ante information on the drought were shifting planting dates to correspond with first rains (94%), changing type of crop to more tolerant crop types such as root crops and legumes (67%), purchasing hay for livestock (58%), construction of livestock shelter to protect animals (58%), changing livestock mix to drought resistant species such as goats and chickens (54%), and livestock migration to better areas (38%). Factors that influenced the decision to shift to drought tolerant crops were age (p=0.004), average income (p=0.007), ownership of goats (p=0.020), availability of livestock shelter (p=0.010), and growing crops other than maize (p=0.001). The decision to change type of livestock to more drought tolerant species such as goats and chickens was influenced by region of farmer location (p=0.000), level of education (p=0.041), average income (p=0.050), ownership of a trailer (p=0.0042), ownership of goats (p=0.048), extension services (p=0.003), need for credit (p=0.001), and the availability of governmental support (p=0.000). Lastly; purchasing hay was influenced by region of farmer location (p=0.002), cattle ownership (p=0.048), availability of livestock shelter (p=0.071), access to credit (p=0.050), willingness to purchase supplementary inputs for livestock (p=0.018), and the need for credit (p=0.019).

With respect to private investments in anticipation of future droughts; farmers were willing to adopt a few strategies in preparation. There was more interest in preparing for future droughts mainly from farmers in drought susceptible areas compared to those that were in less susceptible areas. Strategies that more than 50% of farmers in the drought prone areas were willing to adopt include changing crop type to those that are less susceptible to drought (82%), changing livestock from cattle to more drought tolerant livestock such as goats (64%), construction of livestock shelter to protect livestock from climate extremes (65%), and purchasing hay to supplement grazing (70%). Farmers in the region were not willing to use an alternative water supply (74%) as they stated that severe droughts in their areas compromise water from all sources therefore such a strategy is not a viable option. In the

less susceptible region; farmers were willing to adopt only two strategies, these being changing crop type (60%) and utilizing alternative sources of water (50%).

Regarding public investments farmers would like implemented in anticipation of future droughts; farmers were mostly interested in relief measures such as food, water, and money. Only 15% of farmers mentioned the need for inputs and reservoirs for irrigation (12%). Other less popular strategies included community grain storage facilities for rationing during drought periods, education on drought coping and adaptation, and assistance with non-agricultural business start-up costs. Farmers in middle class households were also concerned about their exclusion in relief measures; thus they recommended that the government should reconsider their selection criteria.

In conclusion; small scale farmers are severely impacted by drought, and on perceiving such impacts, they adopt strategies to reduce the impacts on their enterprises. The severity and nature of drought impact differs across agro-ecological locations, thus bringing to light the importance of area specific strategies when dealing with drought. It is therefore recommended that all stakeholders involved in developing drought resilience measures for small holder farmers should put into consideration agro-ecological location and farmer specific characteristics when formulating policies that address drought incidences. Farmers, non-governmental organizations, and the government should work hand in hand in this regard to increase farmer resilience to future droughts in Swaziland.

Keywords: Drought coping and adaptation, factors influencing selection, probit analysis, small-scale farmers, Swaziland, agro-ecological zones.

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER ONE

INTRODUCTION

1.1 Background

Drought is a natural phenomenon that occurs when least expected. It is a prolonged and abnormally dry and hot period which causes a scarcity of water for the normal needs of the affected community and ecosystem (Thiongo, 2016). It is a result of a period of inadequate precipitation which leads to hydrological stress, and is one of the most challenging shocks, particularly to developing countries (Birhanu, 2017). The most affected by it are the poor, rural smallholder farmers who have no means of counteracting its effects on their enterprises (Etwire et al, 2013).

Climate change has resulted in recurrent drought conditions. The agriculture sector is the hardest hit in these conditions, due to the fact that direct impacts of drought affect primary agricultural production (Ziolkowska, 2016), subsequently leading to indirect and induced impacts of drought. Direct impacts are the immediate effects of drought, such as increased temperatures and reduced precipitation (Hadgu, 2015). They are immediately observed, and involve stock effects such as physical damage to land, capital and machinery (Jenkins, 2013). Indirect impacts lead to flow effects, which cause forward and backward multiplier effects in the economy that affect downstream industries and household welfare (Mungatana, 2017, Kilimani, 2015). Lastly, induced effects of drought are those that impact consumers and businesses further upstream and downstream primary agriculture (Mungatana, 2017), such as long term effects on the economy resulting from the heightened need to import agricultural goods while exporting less. Focus on reducing the direct impacts of drought through drought coping and adaptation can serve to eliminate the likelihood of the indirect and induced effects occurring, thus reducing total losses due to drought (Gil, 2013)

Subtle differences such as agro-ecological location (which influences exposure, perceptions, and level of sensitivity to drought) notably affect individual farmer resilience to drought. According to Ade and Bosede (2017), not only are there marked differences in behaviour amongst farmers in different agro-ecological locations, there are also differences between farmers in relatively similar areas. To increase farmer resilience to drought, therefore, various factors that differ amongst farmers have to be considered, such as farmer location, farming system, and other factors that eventually trickle down to individual farmer characteristics (O'Farrel *et al*; 2009). Resilience to drought means that a farmer can survive consecutive droughts without having to cease production in the next production period (Ranjan, 2011). Resilient farmers are able to recover after a drought episode based mainly on their wealth, which contributes to the adoption of drought resilient technologies and drought conscious farming practices. Poor, rural smallholder farmers faced with climate extremities and differentiated response mechanisms do not have the capacity to adopt drought coping and adaptation strategies. Therefore, assistance is required to increase their resilience for their survival in consecutive drought incidences (Ranjan, 2011).

As has been documented by various researchers, smallholder farmers in general often face a myriad of constraints that jeopardise their success in agricultural production (Mpandeli and Maponya, 2014; Kirsten and Van Zyl, 1998). Recurrent droughts heighten these challenges (UNDP, 2004), implying that farmers have to invest in developing resilience to drought in normal production so as not to be caught off guard when recurrent drought episodes do occur. Resilience to drought is directly linked to farmers' exposure to climate change and their adaptive capacity to cope with drought (Ford and Smit, 2004; Schroter *et al*., 2005). Seeing that poor, rural smallholder farmers cannot control their exposure to climate change (Mutembei, 2017); long lasting resilience can only be achieved with external help through well-tailored, area specific coping and adaptation strategies that factor in both the extremity of exposure to climate change and their adaptive capacity. When faced with drought conditions, farmers do implement coping and adaptation strategies to overcome the effects of drought; but these have proved to be unsustainable in the long run (Manyatsi, 2010). Understanding farmer behaviour towards drought therefore enables the development of effective strategies, and increases chances of survival in subsequent droughts (Rakgase, 2014).

Looking deeper into rural farmer behaviour regarding coping and adaptation contributes to crucial information that can serve to enable farmers and policy makers to come up with better drought coping and adaptation strategies (Obayelu et al, 2014). According to Mdungela, Bahta, and Jordaan (2014), in depth knowledge on farmer behaviour and perception towards drought could also contribute to technological advancement in the field of drought adaptation, as valuable local traditional knowledge can be obtained from farmers and further developed (Obayelu et al, 2014). Further focus on farmer specific characteristics such as agro-ecological location enables farmers to adopt strategies that specifically address problems experienced in their respective areas. This is because farmers in different agro-ecological locations experience droughts in a markedly dissimilar nature, thus calling to attention the importance of tailored coping and adaptation solutions for smallholder farmers (Hadgu, 2015). The appropriate suite of drought coping and adaptation responses is usually very area specific, and to understand their wide-scale uptake, one needs empirical data on attitudes, perceptions and uptake constraints.

Swaziland has experienced numerous droughts in the past. Major droughts were those in 1983, 1992, 2001, 2007, and 2008 (Manyatsi, 2010); and the decrease in the intervals between consecutive droughts clearly indicates that climate change has increased the frequency of droughts. The agriculture sector is the hardest hit in these conditions, due to the fact that direct impacts of drought affect primary agricultural production (Ziolkowska, 2016). The most severe drought was in 1992, with cattle being the most affected as 92 000 head of cattle were lost (Manyatsi, 2010). In the most recent drought (2015/2016), 63 000 head of cattle were lost. Maize production also fell considerably during these drought episodes, with the 2015/2016 drought recording a 63% decrease in maize production due to decreased rains and increased temperatures (Swaziland Drought Assessment Report, 2016). Arable land cultivated has decreased over the years as farmers have become more cautious with recurrent droughts and thus they reduce investments in farming. This trend is more evident in the Lowveld, as this region is more susceptible to drought episodes compared to the other three regions (i.e. Highveld, Middleveld and Lubombo mountains). This emphasises the need for coping and adaptation measures that cater for respective locations as drought impacts each agro-ecological location in different ways and as result farmers' behavioural responses are different (Etwire, 2013). This therefore necessitates a study that will focus on these differences across regions to determine area specific challenges that farmers face and come up with relevant coping and adaptation strategies in imminent droughts.

1.2 Statement of the problem

Over time, drought has become a serious issue in Swaziland. Recovery seems to be more challenging as subsequent droughts hit; especially for poor, rural smallholder farmers. They do not have the capacity to deal with the losses that come about because of drought incidences; therefore, they suffer more than resource-endowed farmers do. Their responses to drought result in ineffective mitigation (Manyatsi, 2010); and this leads to increased vulnerability when there are consecutive droughts. However, there is not enough evidence of how farmers in different regions behave in response to drought; therefore, they continue to suffer losses as the frequency of droughts increases. The one solution to recurrent drought events is investment in coping and adaptation but the challenge is the fact that farmers and other stakeholders cope with drought in a reactive manner, with generic solutions (mainly relief) being applied across all regions.

Swaziland has four main agro-ecological locations with varying levels of vulnerability to drought. This implies that there is a variation in farmers' coping and adaptation behaviour, as drought impacts are distinctly different between regions (Eklund and Thompson, 2017). Currently, drought studies and relief efforts mainly focus on drought prone regions for relief and drought adaptation education. With recurrent droughts, agro-ecological locations that were previously relatively more resilient to drought suffer more losses than before. This brings focus to the fact that drought studies should be across various regions in order to develop relevant mitigation options for different areas. Leaving out less vulnerable regions increases their vulnerability to oncoming droughts.

Differences in impacts and behavioural responses in the four agro-ecological locations are unclear, and this hinders further progress on uncovering ways in which farmers can be successfully equipped to prevent extensive losses from drought incidences in their respective regions. Generic solutions that focus on relief do not help farmers in the long term. There are numerous studies on the impacts of drought on farmers, but less information is available on the differences in perceptions and adaptation options by farmers in different agro-ecological locations. Understanding these differences in farmer behaviour across locations will bring farmers and policy makers closer to achieving resilience to drought for farmers through coping and adaptation. Delving deeper into differences in behaviour will also provide valuable information on preparedness for future drought incidences, thus providing a holistic approach on tackling losses due to drought.

Based on the above; this research is therefore designed to provide clarity on farmers' historical perceptions and behavioural responses to drought. It will also uncover the impacts of the most recent drought on farmers in each respective zone together with their *ex ante* and *ex post* responses to the drought. Their private investments in anticipation of future drought events will also be determined; and lastly how public stakeholders prepare for future drought incidences.

1.3 Hypotheses

Based on literature on farmers' responses to incidences of drought; it is therefore hypothesized that:

1. Agro-ecological location of farmers in Swaziland has no impact in the way they perceive historical changes in temperature and precipitation.
2. Agro-ecological location has no influence on the level and type of drought impacts farmers are subject to.
3. Farmers' agro-ecological location has no influence on their hypothetical responses to the most recent drought (if they had been provided with ex-ante information prior to the drought).
4. Farmers' agro-ecological location has no influence on their choice of private investments in preparation for future drought events.
5. Agro-ecological location has no impact on farmers' choice of public investments they would like implemented when dealing with drought alleviation in an effort to prepare farmers for future drought events.

1.4 General objective of the study

The general objective of the study is to understand how livelihoods of poor, rural, smallholder farming communities in different agro-ecological locations in Swaziland can be made more resilient in the face of recurrent droughts through understanding their behavioural responses to drought.

1.5 Specific objectives

This study was guided by the following specific objectives:

1. To investigate whether farmers' agro-ecological location has an impact in the way they respond to perceived historical changes in temperature and precipitation
2. To determine if there were significant differences in the nature and level of drought impacts across various agro-ecological locations in the most recent drought
3. To determine if agro-ecological location has an influence on farmers' hypothetical responses to the most recent drought (in the event that they had received reliable ex-ante information on the most recent drought event)

4. To determine farmers' private investments in preparation for future drought events in different across agro-ecological locations
5. To determine public investments farmers in various agro-ecological locations would like implemented in anticipation of future drought events

1.6 Organization of the thesis

This thesis consists of 5 chapters; with chapter 1 presenting the background, objectives, hypotheses and importance of the study. Chapter 2 presents literature on the influence of agro-ecological location on drought adaptation behaviour, impacts of drought on smallholder farmers, and farmers' drought coping and adaptation behaviour. Chapter 3 presents the study area, sampling techniques, survey instrument and development, survey implementation, socioeconomic characteristics of the sample, and data analysis of the study. Chapter 4 presents the results of the study in this order: production characteristics, farmers' perceptions on climate change variability, impacts of the drought, immediate responses to the most recent drought, hypothetical responses with prior information, and farmers' preparedness for future drought incidences. Lastly, chapter 5 presents the conclusions and recommendations of the study.

CHAPTER 2

THEORETICAL AND EMPIRICAL LITERATURE

2.1 INTRODUCTION

The literature review begins with a historical account of drought incidences in Swaziland with the view of showing that drought incidences and their impacts have worsened over time (section 2.2). Section 2.3 is on location in agro-ecological zones and how it influences crop and livestock production choices made by farmers in response to drought. Section 2.4 focuses on how the characteristics of smallholder farmers exacerbate their vulnerability to drought in recurrent drought conditions. The impacts of drought are dealt with in section 2.5, with focus on the various levels at which drought affects the agriculture sector and subsequently all sectors of the economy at wide. The importance of public and private entities in dealing with drought impacts is discussed in section 2.6, and finally a summary of the literature reviewed is presented in section 2.7.

2.2 DROUGHT IN SWAZILAND

The agriculture sector is the hardest hit in drought conditions, because the direct impacts of drought affect primary agricultural production (Ziolkowska, 2016), subsequently leading to indirect and induced impacts of drought. Direct impacts are the immediate effects of drought, such as increased temperatures and reduced precipitation (Hadgu, 2015). They are immediately observed, and involve stock effects such as physical damage to land, capital and machinery (Jenkins, 2013). Indirect impacts lead to flow effects, which cause forward and backward multiplier effects in the economy that affect downstream industries and household welfare (Mungatana, 2017; Kilimani, 2015). Lastly, induced effects of drought are those that impact consumers and businesses further upstream and downstream of primary agriculture (Mungatana, 2017), such as long term effects on the economy resulting from the heightened need to import agricultural goods while exporting less. In Swaziland; the 2015/2016 El Nino drought first compromised agriculture (as a result of water shortages), then consequently resulted in inadequate sanitation as a result of reduced availability of water, which further affected education as there were higher incidences of water related illnesses in children such as diarrhoea (resulting in dropouts and a reduction in the quality of education). Other multiplier effects include separation of families, as most subsistence farmers had to abandon rural areas in search for employment in cities such as Mbabane and Manzini. Drought, therefore; is not an issue to be focused on only by the agriculture industry, but is also detrimental to other sectors as well. In every developing country; agriculture is a vital sector in the economy; therefore focus on reducing the direct impacts of drought through drought coping and adaptation can serve to reduce total losses in the economy incurred due to drought (Gil, 2013).

Prior to increases in the frequency of droughts; Swaziland was self-sufficient in terms of food production. In current times, however; the country cannot produce enough to cater for domestic needs, and imports 60% of food from neighbouring countries (Vilane, 2015). Climate change is partly to blame, as it is clearly evident in the country through hydrological disasters such as floods, hailstorms, shifts in rainfall regime and severe droughts that have become more common with time (Vilane; 2015; Gamedze, 2006). Drought negatively affects farmers' productivity and thus discourages annual agricultural activity amongst farmers. In Swaziland; droughts have become a norm such that farmers in arid and semi-arid areas have ceased farming to cushion themselves from the adverse effects of drought (Masarirambi, 2011). In the past 40 years; Swaziland has experienced severe droughts with increasing frequencies (Manyatsi, 2010); with the most disastrous occurring in the years 1983, 1992, 2001, 2007, and 2008. The most recent drought (2015-2016) was declared a national emergency and the worst in 30 years (NDMA, 2016). During this drought, ground water was severely depleted, major rivers dried up, with other rivers and dams around the country having the lowest water levels in history (NDMA, 2015). As a result; major cities in the country had to ration water. Rains (for those areas that received them) came 30-90 days later (WFP, 2016), resulting in increased food insecurity in the country as both subsistence and commercial agricultural production was compromised.

According to Gamedze (2006), vulnerability surveys have proved that some agro-ecological locations in Swaziland are more prone to droughts compared to others; implying that farmers in arid regions suffer much more severely from droughts compared to farmers in less arid regions. Rainfall trends differ considerably between regions (Masarirambi and Oseni, 2011) as rainfall trends in less drought prone areas are somewhat stable as droughts occur whereas those in more prone areas declined after each drought event. Farmers of cotton, which is the mainstay for small scale commercial farmers in arid zones; have had to cease production in an attempt to prevent losses as even crops believed to be tolerant to insistent droughts are not spared as droughts progress. In a study conducted across three regions in Swaziland (Middleveld, Lowveld, and Lubombo), which differ considerably in drought vulnerability, differences were noted in the extent of drought impact and level of response in each respective region (Manyatsi, 2010). In Swaziland; the focus when conducting drought studies is usually in more drought susceptible areas, even though with increase in the occurrence of droughts regions that were previously considered tolerant are now adversely affected by drought (Shongwe, 2013; Vilane, 2015).

2.3 AGRO-ECOLOGICAL ZONES AND DROUGHT RESPONSE

Swaziland is a landlocked country that is mostly rural, with 76% of the population residing in rural areas and depending on agriculture for their livelihood. The country is divided into four agro-ecological zones, according to elevation, landforms, geology, soils, and vegetation (FAO, 2008; Deressa et al, 2010). An agro-ecological zone is the average annual length of growing period for crops, which depends mainly on average rainfall and temperature (Mabiru, 2010). Agro-ecological zones in Swaziland are displayed in Table 1 below:

Table 2.1: Agro-ecological zones in Swaziland

Ecological zone	Rainfall (mm/year)	Average temperatures (^{0}C)	Coverage (%)
Highveld	700-1550	16	29
Middleveld	500-850	19	26
Lubombo mountains	550-850	19	8
Lowveld	400-550	22	37

Table adapted from: FAO (2008)

Increasing evidence shows that shifts in Swaziland's climate have already occurred and are continuing over time. There are notable decreases in stream flows, which adversely affect irrigated agriculture. There is also higher variation in the amount of rainfall received, and there are notable changes such as hydrological disasters, changes in rainfall regimes, harsh weather conditions, delayed rains and frequent drought. These impacts vary over each agro-ecological zone; with the Lowveld and Lubombo regions being the most susceptible to experiencing higher losses (Knox et al, 2010). Although these regions have plenty of arable land; (Nkondze, Masuku, and Manyatsi, 2013); they are also characterised by vulnerability to adverse conditions, and being more prone to drought and poverty compared to the Highveld and Middleveld regions. As a result of prolonged changes in climate, the country has experienced a sharp decline in crop production which has been more apparent in the two vulnerable regions as 40% of arable land has not been cultivated in the past ten years (Mavuso, 2014).

According to Deressa et al (2010), Tazeze (2012), Mensah Bonsu et al (2011), Okonya (2012); Morris et al. (1999); agro-ecological zones have an effect on farmers' decision on drought adaptation and the strategies selected for drought adaptation. Agro-ecological zones result in varying effects amongst farmers, thus implying a difference in coping and adaptation behaviour (Nti, 2012; Etwire, 2013). Households in different areas do not apply similar strategies, as these are determined by the specific conditions of an area. Farmers in arid areas are observed to adopt strategies that address climatic conditions such as adjusting planting dates, whereas those in less arid areas adopt strategies that focus on increasing yields in such conditions such as using drought tolerant crop varieties. This is due to the fact that some farmers in less drought prone areas still get some yield during droughts compared to no yield at all in drought prone areas.

According to Deressa et al. (2010), farmers living in more arid areas are more likely to react proactively to drought compared to farmers in less arid areas because changes in precipitation and temperature are more severe in arid areas. Moreover; higher precipitation results in less likelihood of adaptation. Farmers in areas that are less prone to drought incidences experience drought as a shock and are therefore ill prepared when severe droughts affect them. Those in areas with higher temperatures and less precipitation, however, are used to such extreme conditions and are therefore better able to deal with severe droughts. Tazeze (2012) corroborates the same notion; stating that farmers in more arid areas are more likely to adopt drought coping and adaptation strategies compared to those in less arid areas, further attesting to the fact that strategies differ across agro-ecological zones.

Agro-ecological zones are important for other reasons too. Some regions tend to be poorer than others in terms of resource endowment and social development (Mabiru, 2010; Smit and Skinner, 2002). This reduces a farmer's resilience to drought impacts, which further affects decisions on coping and adaptation. Some farmers may be in less arid areas but not be able to access drought related information, extension services, and other resources that are vital to drought preparedness (Etwire, 2013). All these factors contribute to added vulnerability for farmers in certain areas when droughts reoccur.

2.4 SMALL SCALE FARMERS

According to Kirsten and Van Zyl (1998), a small scale farmer is one whose scale of operation is too small to attract the provision of the services he/ she needs to be able to significantly increase his/her productivity. Small scale farmers are viewed in a negative light as primitive, under productive, and non-commercial farmers that farm for subsistence purposes. In most parts of the world; small scale farmers are located in rural areas, with limited access to services. They are mistakenly considered to be of no importance to the economy of their respective countries, but, on the contrary, they are instrumental in improving the livelihoods of rural communities (Kongolo and Dlamini, 2012). Small scale farmers typically do not use advanced technology on their farms due to setbacks such as literacy, access to credit, access to information and other facilities in general.

Swaziland is no different, as small scale farmers have the same constraints. Small scale farmers in Swaziland are mostly pensioners who farm for subsistence; therefore, they utilise minimum inputs on their farms. They have limited access to information that can contribute to better ways to deal with drought and other natural hazards. This places small scale farmers in a vulnerable position and they tend to lose more in yields than they would have if they had access to the facilities that large scale, well established farmers possess (Bishaw *et all*, 2013). According to Bhebe (2014), small holder farmers are less resilient to the effects of drought due to compromised access to resources; therefore, they require assistance in order to prevent and overcome the adverse impacts of drought on their farming enterprises.

2.5 IMPACTS OF DROUGHT

Drought is a shock to farmers therefore preparedness and adaptation is important prior to drought conditions. Its beginning and end is difficult to determine, and effects last longer and affect the whole economy. Drought has physical, economic, social, and environmental costs to societies (Whilhite, Svoboda, and Hayes, 2007). Some of these include food insecurity, malnutrition, starvation, poverty, lack of investment in human capital, and reduction in fiscal resources (Pandey, Bhandari, and Hardy, 2007). All these increase vulnerability especially for the poor, and they become much more likely to be adversely affected by recurring droughts.

Mungatana (2017) states that in rain fed agriculture, farmers suffer losses in terms of average yield produced in drought conditions. During drought, there is a significant decrease in productivity of fertilizer, labour, pesticides, herbicides, and manure. Regarding input use, farmers affected by drought decrease the purchase and usage of inputs such as fertilizer, herbicides, and pesticides. Drought also encourages weed growth, which further leads to more labour requirements for weeding. This results in more expenses on inputs whereas the likelihood of good yields is decreased during such conditions. Cattle farmers, on the other hand are mostly affected by loss in forage, which leads to weight loss in cattle (resulting in reduced household income). This further leads to a decrease in cattle owned and sold in drought conditions and an increase in cattle deaths from lack of feed (Mungatana, 2017).

Impacts of drought can be categorized as direct and indirect. Some of these include reduction in crop productivity, increased fire risk incidences, reduced forestry production, increased livestock mortality rates, and damage to natural habitats. These lead to indirect impacts such as reduction in income for agribusinesses, increased unemployment rates, hikes in food prices (due to a reduction in the supply of food), migration (which robs communities of valuable labour), increased crimes, reduction in farmers' loan repayment rates (which further affects the banking industry), and reduction in government tax revenues (Wilhite, Svoboda, and Hayes; 2007).

According to Alsten and Kent (2007), in a study conducted in Australia to determine the socioeconomic impacts of drought on farmers, it was discovered that drought has an effect on health and education, increases workloads as farmers have to work harder to counteract the effects of drought on farm, and increases conflicts over water sources. Drought also increases the divide between rural and urban communities as the former is mostly comprised of farmers thus is more vulnerable to drought, compromises access to health services, loss of interest from young people as farming seems risky and unsuccessful due to drought, social isolation and reduced social capital.

2.6 DROUGHT COPING AND ADAPTATION

Coping can be defined as the manner in which people act within existing resources and ranges of expectation in a particular context to achieve various ends. Coping involves temporary adjustments in response to change to mitigate the negative effects of drought on farmers (Opiyo et al, 2015, Ndlovu, 2011). Adaptation, on the other hand, is an adjustment in farmers' behaviour that reduces the vulnerability of farmers to changes in the climate system including its current variability and extreme events as well as long term climate change. Adaptation results in long term resilience, to create conditions in which society and ecosystems are able to absorb the adverse consequences of drought (Obaleyu et al, 2014)

2.6.1 Drought coping and adaptation strategies

Drought coping strategies are used after drought has occurred for farmers to suffer fewer losses, whereas drought adaptation strategies are those that are used to reduce the risk of being adversely affected by drought (Pandey, Bhandari, and Hardy, 2007). Drought coping strategies have been studied extensively, and those popularly used by livestock farmers include feeding of stored crop residues, purchasing of feed materials, less frequent feeding and watering to save feed, water wetting, storage of crop residues, and use of unconventional materials to feed livestock (Sankhala, 2016). Another strategy that has proven effective in alleviating drought in animal production is relocation/migration (Butt et al, 2009). It reduces stress faced by farmers by lowering the average total distance and time travelled for grazing, directs cattle to more richer grazing areas, and concentrates livestock to the richest grazing areas. Livestock farmers that do not relocate during drought were found to experience more stress from drought conditions (Butt et al, 2009).

To further cope with drought conditions, livestock farmers also sell grass growing on their farms as a way of generating income. They also shift from livestock production to crop production, migrate livestock to forests, purchase feed, sell livestock and seek assistance from livestock specialists. Since the incidence of disease increases during drought conditions, farmers have been observed to apply indigenous knowledge to deal with diseases, such as using a hot iron rod to burn swollen lymph nodes (Ogalleh et al, 2012).

According to Anhurat (2016), Pandey, Bhandari, and Hardy, (2007) and Acquah (2011), crop production farmers adopt strategies such as diversification, use of drought resistant varieties, crop rotation, change in farm calendar to adapt to changing weather patterns, changing of planting location, and irrigation. Other strategies include construction of conservation furrows, micro-catchments, trench bunds, field bunds (using stones or vegetation), water harvesting, and groundwater recharging (Stefanski, 2006). The suitability of all these strategies for particular areas is determined through thorough drought risk assessment. Farmers are also encouraged to practice irrigation technology, irrigation scheduling, and regulated deficit irrigation (Pacific Institute, 2014).

According to Ashraf et al (2013), other non-farm strategies that farmers adopt include agricultural inputs adaptation, water management, income diversification, economization of expenditure, migration, and asset depletion. Ndamani and Watanabe (2016) postulate that crop diversification, irrigation, intercropping, alternate income streams, minimum tillage, farm diversification, change of planting dates, improved crop varieties, farm diversification, and agro forestry are some of the most popular strategies that farmers adopt to deal with drought. Prayer was also referred to as one of the drought coping strategies used by farmers (Acquah, 2011).

In a study conducted in Zimbabwe, Masendeke and Shoko (2013) state that farmers adopt strategies such as those that have to do with production, consumption, indigenous weather forecasting, and food storage. All these strategies were found to be highly effective in helping farmers cope with drought. It was suggested that for farmers to be able to able to adopt drought coping strategies, they should receive support from the government, non-governmental organizations, and also migrate to better farming areas. Farmers were also encouraged to deter from depending on the government and NGO's, and also to accumulate assets in good years so that farm products can still be available even in drought years.

In a study done in India, Thailand, and China, farmers were found to be employing drought coping strategies such as dependence on wage income to farm, increased borrowing, liquidation of production assets, higher rate of seasonal out-migration, increased dependence on forests for food, forced reduction on expenditures that are not related to farming. These strategies move focus away from farming; and this indirectly increases farmers' vulnerability in the case of recurrent droughts. Commercial and more diversified farms were found to be less likely to be hard hit by drought (FAO, 2009). It was suggested that there should be technological interventions, an increase in insurance use, better weather information dissemination, an improvement in farmers' capacity to manage drought and improvement in rural infrastructure and markets so that farmers can diversify their income sources and reduce income risk in times of drought (FAO, 2009).

In a study conducted in Kenya to uncover farmers' drought coping strategies and their effect on productivity, farmers stated that they use coping strategies such as relying on relief food, out-migration to better farming areas, destocking-restocking, remittances and donations, market exchanges, and more dependence on credit facilities and savings (Thiongo, 2016). Farm specific strategies included planting indigenous crops, planting new crops, crop diversification, different planting dates, shortening length of growing season, changing land under cultivation, switching from crops to livestock, switching to non-farming enterprises, switching from subsistence to commercial farming, irrigation, increased use of fertilizers and pesticides, using shading through tree planting. These strategies were found to be highly effective and positively related to farm production. Farmers were also found to be aware of drought, with some noticing from the onset of drought and some using a fall in yield as an indicator for drought (Pandey, Bhandari, and Hardy, 2007).

In another study conducted in Kenya, Ogalleh et al (2012) state that farmers have knowledge on crop varieties to plant based on the amount of rain in a particular season. Some farmers even go as far as mixing both rainy and dry season varieties to increase the likelihood of high yields. Farmers also used strategies such as planting early and late maturing varieties together, planting whenever there is a likelihood of rain, continuous planting, seed preservation, and use of expired batteries to make basins around crops. All this is done to deal with reduced water availability. To overcome increasing temperatures; farmers mulch and irrigate crops, for increasing wind farmers intercrop crops of various height. To fight with the higher incidence of diseases, farmers consult extension officers and use primitive methods such the use of ash to destroy pests (Ogalleh et al (2012)).

UNDP (2012) postulates that farmers and governments can also invest in conservation and organic agriculture, early warning systems, draught animal power, variety in livestock production, reduction in stock numbers, increasing extension services, shifting from livestock to game. Other suggestions include the expansion of dams, financial support and subsidies from government to reduce the impact of drought on farmers, rotational grazing, construction on new reservoirs, and irrigation water conservation (Mungatana, 2017).

2.6.2 Factors influencing choice of drought coping and adaptation strategy

A myriad of factors influence farmers' everyday production decisions. Some of these include path dependency, what other farmers are doing, and what they perceive to be the correct response based on the knowledge they have. According to Hallam, Bowden, and Kasprzyk (2012); these factors can be divided into external, internal, and social factors. Social factors are behaviours by other farmers and stakeholders in the farming sector that eventually influence a farmer's decision to adopt particular drought coping strategies. External factors are those that a farmer cannot alter for his benefit, such as economic, agro-ecological, and demographic factors, but they do influence his farm decisions. An example can be that of the climate of a particular area and a farmer's age. These two factors have been proven to affect farmers' drought coping and adaptation but they are out of the farmers' control. Internal factors are those factors that are specific to a particular farmer such as beliefs, attitudes, and behaviours. Farmers can have the same external influences but have distinctly different behaviours with regards to drought coping and adaptation.

Chopeva (2014) states that farmers' likelihood to adopt particular innovations or new methods of farming can be determined by categorising farmers into innovators, early and later adopters; as some farmers do not adopt strategies not because they will not work but because they need to observe the success or failure of using such strategies on the early adopters. On the contrary; non-adopters do not adopt drought coping strategies because they prefer not to observe what successful farmers are doing but would rather get advice from input providers (Defrancesco *et al,* 2007). Therefore; it is worthwhile to uncover the intricate details behind farmers' lack of proactivity in drought adaptation.

Coping and adaptation is also influenced by the farmer's level of access to funds, farming system and purpose of farming, and the level of education or exposure to knowledge (Chopeva, 2013). Various studies also state that farmers' behaviour towards drought is determined by their perception of drought, the severity of the drought, and their beliefs (Arbuckle *et al.*, 2013). Due to all these limiting factors farmers are subjected to; they perceive changes in climate but do not adopt any coping and adaptation strategies. Some farmers do not adapt because they have negative attitudes towards coping strategies (Zamasiya, Nyikahadzoi, Mukamuri, 2016). Various studies have been conducted to uncover reasons behind farmers' behaviour in drought conditions. A study conducted in Pakistan concluded that farmers adopt drought coping strategies due to factors such as landholding, annual income, livestock ownership, credit access, farmer-to-farmer extension, governmental and non-governmental support (Ashraf et al, 2013). These factors were proven to increase a farmer's likelihood to adopt drought coping strategies.

Sadegh (2016) states that farmers are well aware of the effects of droughts and in response adopt strategies such as agricultural insurance and planting early maturing varieties. Farmers were found to be willing to adopt drought mitigation strategies, and the factors positively influencing adaptation were found to be farm size and household income. Poor households are less likely to adopt drought coping strategies compared to high income households (Ding, 2004). This is due to the fact that they do not have resources such as tractors or the financial capacity to adapt their farming practices to droughts. They also do not have resources they can diversify and invest in better farming practices to enable them to deal with droughts when they hit. The study was conducted in Iran, and the author emphasized on the importance of understanding farmers' perception on a local level to come up with locally relevant solutions for drought mitigation.

Mdungela (2016), on the other hand, states that access to land, income, experience, and education affect a farmer's likelihood to adopt drought adaptation and coping strategies. Also, farmers that are vulnerable to not having any drought coping strategies are those that do not have access to water, resources, finance, and timely information. It was emphasized and recommended that further studies should look into farmers' choice behaviour, and that any strategies recommended should be locally adapted and suitable for farmers at hand. Farmers with improved access to the above mentioned resources are at a better position to properly react to drought and reduce the impacts of drought on their farming enterprises.

According to Ndamani and Watanabe (2016), socioeconomic factors determine farmers' attitude towards drought coping strategies. Factors such as education, access to credit, access to information, and larger household size have a significant positive relationship with the likelihood of adaptation to climate change. Education contributes positively to drought coping and adaptation as educated farmers are exposed to information and can correctly apply it in dealing with drought. Access to credit; on the other hand, is important because credit enables resource poor farmers to access amenities that will contribute to their surviving droughts. Such amenities include irrigation water and facilities, improved varieties, and providing shelter and water for livestock. In the absence of credit, farmers succumb to letting their enterprises die because they do not have the financial muscle to cushion themselves against the effects of drought. Access to information provides farmers with ample time to prepare for drought incidences as they are informed about the drought beforehand and can therefore prepare for it. Farmers' characteristics are one of the main factors that most influences likelihood of adoption of drought coping strategies (Van Duinen, 2015).

Farmers also expressed cost effectiveness, level of soil fertility, extent of erosion, environmental impact of the strategy, and effect of the strategy on rate of maturity of crops as determinants of choice of adaptation strategy (Acquah, 2011). In a study conducted in Ghana, farmers' willingness to pay for drought coping was found to be positively correlated with age, years of education and ownership of land. Farmers also cited access to water, high cost of adaptation, lack of information, lack of knowledge on adaptation, insecure property rights, insufficient access to inputs and lack of access to credit as factors that hinder adaptation to drought conditions (Acquah and de-Graft, 2011)

According to Thiongo (2016), farmers' choice of drought coping strategies is influenced by socio-economic characteristics, and there is a relationship between drought knowledge, strategies used and the impact on agricultural production. Selection of strategies is also shaped by demography, access to information, assets and vulnerability levels. It was recommended that farmers should have drought management workshops, have better early warning systems, drought insurance, water harvesting, and an integration of sectors such as agricultural extension, meteorology, and academic research.

Other factors that affect adoption of drought coping strategies are age and gender of household head, livestock ownership, temperature, household size, availability of credit, and extension (Apata, 2011). Contrary to Sadegh (2016), farm size was found to be negatively related to the likelihood of adopting drought coping measures. Annual average precipitation was also discovered to be having a negative relationship with adaption to climate change.

Prior information on drought incidences is a crucial factor in n determining farmer behaviour to drought incidences. Accroding to Mdungela (2017), information is positively related to the likelihood of adopting some form of drought coping and adaptation measure. Farmers who receive relevant prior information tend to react better to drought compared to farmers who do not. Prior information on drought hazards reduces the impacts of drought on farmers and increases preparedness (IFAD, 2009). This further puts emphasis on the importance of relevant information from extension officers as this serves to advantage farmers in the long run.

2.7 THE SIGNIFICANCE OF PUBLIC AND PRIVATE ENTITIES TO DROUGHT COPING AND ADAPTATION

The involvement of government in drought coping and adaptation is crucial for farmers' survival (Shongwe, 2013). Subsistence farmers do not have the resources required to adopt sustainable coping strategies, thus government and private entities have to contribute to assist in reducing losses due to drought. This has, however, been proven not to be beneficial to farmers in the long term as they become dependent on aid rather than working towards becoming more sustainable (Gamedze, 2013).

Farmers can cope with drought without the help of institutions; but adaptation can rarely ever occur properly without input from various institutions. Institutions include both private and public entities that have a role to play in drought conditions. These institutions are key in capacitating communities to adapt to drought incidences rather than dealing with it as an emergency when it occurs. This increases resilience in communities thus making it easier to deal with future drought incidences. According to IFAD (2009); institutions should focus on providing resilience through subsidized agricultural inputs, construction/ improvement of irrigation facilities, continued support when drought is over, involvement of community members and local organizations in planning and implementation of adaptation options, and the implementation of sustainable policies that support agricultural development.

2.7.1 Swaziland Water and Agricultural Enterprise (SWADE)

This organization is a government parastatal that is involved in community projects that involve areas with the abject need for water. It is located strategically in the Lowveld of Swaziland, where water scarcity is highly prevalent. This region is also well known for its good soils, hence the need for better access to water to enable improved agricultural production. Specifically, in relation to the prevalent droughts this region is susceptible to; the organization has helped farmers construct concrete water tanks, which were under way during the period of data collection. In previous periods; extension officers thoroughly trained farmers on drought adaptation, with various trainings involving water conservation, suitable crops for drought prone areas, and varieties that can withstand adverse water scarcity. Farmers are also well trained on conservation agriculture, construction of earth dams, and water harvesting. For livestock production, farmers are trained on hay bailing for their livestock to have feed during dry seasons.

2.7.2 The National Disaster Management Agency (NDMA)

The involvement of government in drought coping and adaptation is crucial for farmers' survival in natural disasters such as drought. This organization mainly deals with relief for all natural disasters in the country. In the recent 2015/2016 El Nino drought, the organisation provided relief for farmers in the form of water sanitation packs and water for hard hit areas. Due to the severity of the drought, National Drought Mitigation and Adaptation Plan was developed to counteract the effects of droughts, prepare farmers for imminent droughts, improve local maize production, and revitalize water systems. The agency also assists farmers with post disaster needs, and facilitates other forms of relief from Non-Governmental Organizations. They are instrumental in the type of information that farmers have access to during drought conditions, therefore they could play a crucial role in drought coping and adaptation for smallholder farmers.

2.7.3 Non-Governmental Organizations (NGO's)

Swaziland has a number of NGO's that assist farmers during disasters such as drought. Such organizations include the World Food Programme (WFP), United Nations Development Programme (UNDP), Africa Cooperative Action Trust (ACAT), amongst others. All these organizations work hand in hand with government agencies to ensure that farmers survive drought conditions. These organizations provide smallholder farmers with food parcels, water, and food for work opportunities; and these are all relief based interventions. This leaves farmers even more vulnerable when recurrent droughts occur, and does not prepare them on how to save their farm operations during drought, and how to cushion against drought (Bhebe, 2014). Therefore, it is imperative for all organizations involved in drought coping and adaptation to prepare farmers for drought incidences before they occur; and in this way increase their resilience in the long run.

2.8 ANALYTICAL FRAMEWORK

The decision on whether or not to adopt a new technology is considered under the general framework of utility maximization (Deressa, 2007, Apata, 2011). Based on this framework; the assumption is that economic agents (in this case farmers) adopt coping and adaptation strategies *only* when they perceive the utility of using a particular strategy as higher than farming without it. Utility is not directly observed; but farmers' actions are observed through the choices they make. If, for example, Y_j and Y_k represent a farmer's utility for two adaptation options (U_j and U_k); the linear random utility model can be specified as:

$$U_j = \beta_j' X_i + \mathcal{E}_j \text{ and } U_k = \beta_k' X_i + \mathcal{E}_k \quad (1)$$

Where:

U_j = utility of adaptation method J

U_k = utility of adaptation method K

X_i = vector of explanatory variables that influence the perceived preference of a certain adaptation strategy

β_j and β_k = parameters to be estimated

$\mathcal{E}_j$ and $\mathcal{E}_k$ = error terms assumed to be independently distributed

Therefore; if a farmer decides to use a particular strategy (say, strategy J), it implies that the utility from this option is greater than that of other options. This is depicted as follows:

$$U_{ij} (\beta_j{'}X_i + \varepsilon_j) > (U_{ik} (\beta_k{'}X_i + \varepsilon_k), k \neq j \qquad (2)$$

Based on the above; the probability of a farmer using option J can be defined as:

$$P (Y = 1 \mid X) = P (U_{ij} > U_{ik}) \qquad (3)$$
$$P (\beta_j{'}X_i + \varepsilon_j - \beta_k X_i - \varepsilon_k > 0 \mid X) \qquad (4)$$
$$P (\beta_j{'}X_i - \beta_k{'}X_i + \varepsilon_j - \varepsilon_k > 0 \mid X) \qquad (5)$$
$$P (X^*X_1 + \varepsilon^* > 0 \mid X = F (\beta^*X_i) \qquad (6)$$

Where:

P = Probability function

$\varepsilon^* = \varepsilon_j - \varepsilon_k$: Random disturbance term

$B_j = (\beta_j{'} - \beta_k)$: Vector of unknown parameters that are a net influence of the vector of independent variables influencing adaptation.

$F (\beta^*X_i)$ = Cumulative distribution function of ε^* evaluated at β^*X_i. The exact distribution of F on the distribution of the random disturbance term, ε^*. Depending on the assumed distribution that the random disturbance term follows, several qualitative choice models can be estimated.

2.9 SUMMARY OF LITERATURE REVIEWED

This chapter provided insight from literature on the prevalence of drought in Swaziland, the extent to which of agro-ecological location determines farmers' behavioural responses to drought coping and adaptation, the vulnerability of small scale farmers to climate extremiti, impacts of drought, the factors that influence selection of drought coping and adaptation strategies, together with private and public intervention in drought conditions. A careful study of previous literature on drought coping and adaptation revealed a gap in understanding drought related differences in different agro-ecological locations, as most studies focus on drought prone areas. Studies have not been localised enough, and farmers' relative behaviour in different locations is not known. All available studies focus on factors influencing farmers' likelihood to adapt to drought, but leaves out factors influencing farmers' choices given particular strategies and how these differ across regions with varying agro ecologies.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter presents the methods utilised in this study and contains various sections that elaborate on each part of the methodology. In section 3.2 the study area is discussed, with focus on the biophysical characteristics of each area and their relative susceptibility to incidences of drought. Section 3.3 presents sampling criteria applied when selecting areas of interest, the sample frame, and the final sample. Section 3.4 covers survey instrument development, and provides detail on the various stages of developing the questionnaire that was eventually utilised for data collection. Survey implementation is presented in section 3.5, with details on how the survey was conducted, how long it took and how interviews were conducted. In section 3.6 demographic and socioeconomic characteristics of the sample are discussed, with data analysis being discussed in section 3.7. This section (data analysis) provided intricate details on how raw data was analysed after the survey, and the methods used for analysis. Lastly, section 3.8 summarizes the chapter.

3.2 THE STUDY AREAS

To obtain a representative sample of subsistence farmers affected by drought in the country, study areas were selected in each of the four agro-ecological locations in Swaziland (Lowveld, Lubombo, Middleveld, and the Highveld). The Lowveld of Swaziland is located in the Eastern part of the country, and constitutes 40% of the country's total area. It has an undulating landscape ranging from 200-300m above sea level. It is semi-arid and warm, with annual rainfall ranging from 18-26^{o} C (Tefera et al, 2007). This region is the worst affected by drought, and arable land has not been utilised in the past five years due to recurrent droughts (Manyatsi, 2010). The Lubombo Plateau forms only 5% of the country's total area and is almost similar to the Middleveld region in its characteristics. As with the Lowveld region; it is characterised by its vulnerability to drought (Swazi Government, 2016). The Middleveld and Lubombo Plateau are similar as they are both subtropical and dry, with rainfall ranging between 550mm-850mm annually. The Middleveld constitutes 25% of the country. The Highveld region, on the other hand, takes up 30% of the country and is sub humid and temperate, with rainfall ranging from 700-1550mm per year, with a mean temperature of 17^{0}C.

In the Lowveld and Lubombo Plateau; the Mpolonjeni, Mehlwabovu, Sithobela, Somntongo, Phonjwane, and Matsanjeni, areas were used for the study. These areas are well known for experiencing severe losses due to drought, and are usually targeted in drought relief. More areas were selected in the Lowveld region because it is the most vulnerable region during drought periods. In the Highveld and Middleveld regions, the Masibini, Nkambeni, and Mbekelweni constituencies were the areas of focus. These areas are excellent representations of each of the regions in terms of temperature, soils, and precipitation. All the communities in the study are rural communities that depend on agriculture for sustenance.

3.3 SAMPLING

The population consisted of all male and female farmers in the study areas who were subject to the recent El-Nino drought in all four regions. Respondents were selected based on the knowledge and random selection of the National Disaster Management Agency (NDMA) and Swaziland Water and Agricultural Enterprise (SWADE) personnel who are responsible for extension and relief in those particular areas. In areas where these organizations were not involved (such as the Highveld), the researcher randomly selected subsistence farmers in each target area. In each community, a minimum of 20 respondents were interviewed. Sampling was both purposive and random; as some communities were selected by National Disaster Management Agency (NDMA) and Swaziland Water and Agricultural Development Enterprise (SWADE) but the respondents were interviewed based on their availability at the time the interviews were conducted. More farmers were selected from communities in the relatively drought susceptible areas as a result of the involvement of the above mentioned organisations in these areas and the fact that the drought susceptible region (Lowveld) covers more area than the other regions. These communities were easier to access as a result of the presence of these organizations; as they regularly provide drought related information and relief to these areas. These organizations fully support drought related studies in these areas as they serve to enhance well-tailored responses to these communities, thus they are willing to provide support through transportation and bringing farmers together for interviews. Areas that are relatively less susceptible to drought do not have the support of such organizations, therefore are much harder to access. As a result; more farmers from the Lowveld and Lubombo regions were interviewed compared to those from the Highveld and Middleveld. This did not, however, result in sampling error as the study was purely on a dichotomous basis between the two regions and not an aggregation of the country as a whole.

The sampling frame consisted of subsistence farmers who practice mixed farming and have been affected by the recent recurrent drought events. Rural subsistence farmers were selected because they are the most affected in drought conditions as they do not have the means to counteract the effects of drought as commercial farmers do. Farmers in different agro-ecological locations were selected because differences in behavioural responses to drought have been observed in farmers that are in different locations; implying that solutions to drought impact should be more area specific and not generic as they are at the moment. Therefore; the strata consisted of rural farmers from both regions strategically selected to represent their respective communities, with non-farmers being excluded from the study. From each area in the respective regions; farming households were randomly selected. The main crop grown by farmers was maize, with other crops including sweet potatoes, beans, sorghum. Livestock farming mainly consisted of cattle, goats, and poultry. Farming is dependent on rain fed agriculture, with only a small number of small scale vegetable farmers irrigating their crops from nearby rivers.

3.4 SURVEY INSTRUMENT DEVELOPMENT

The survey instrument was developed to specifically address the objectives of the study. It was divided into 5 sections; each addressing various aspects of the objectives. To ensure a high quality instrument and an efficient data collection process; pre-survey interviews were conducted on ten randomly selected farmers in the Mahamba area (Highveld region). This was done to ensure accuracy of the questions, their relevance to the objectives of the study, and ease of understanding by the respondents. Development of the instrument was therefore an iterative process between the researcher, study leader, and other experts in the agriculture industry. Before survey implementation, partner organizations (Swaziland Water and Agricultural Development Enterprise and National Disaster Management Agency) also reviewed the instrument to ensure that the contents were relevant and easy to relay to farmers.

Section 1 addressed general household characteristics and farming information, while section 2 focused on respondents' resource endowment. Section 3 focused on crop and livestock production information, which addressed part of objective 2. Section 4 covered objective1; focusing on farmers' historical perceptions on climate change and their responses to these perceived changes in the past ten years. Section 5 addressed respondents' experience with the 2015/2016 El Nino drought on their crop and livestock production, covering objective 2. Section 6 dealt with future aspects regarding drought coping and adaptation, and this included respondents' plans for future drought and how they would like to be better facilitated to deal with it through the help of various stakeholders.

3.5 SURVEY IMPLEMENTATION

The survey was conducted through the use of a survey instrument and face to face interviews with the respondents. The researcher conducted all the interviews, with the help of Swaziland Water and Development Enterprise (SWADE) and the National Disaster Management Agency (NDMA). These organizations were key with regards to logistics and organization of respondents, as it was easier to reach respondents if they were organized prior by reputable government agencies. The interviews were conducted from the 2nd to the 19th of July 2017. The number of interviews conducted per day was 8-10, with variation depending on the availability of SWADE and NDMA personnel and respondents themselves. To ensure that respondents understood the questions; the researcher explained in detail what the research was about before every interview. Respondents were also made aware of the fact that information obtained would not be publicized or used against them in any way.

The interviews were 30-45 minutes per farmer, with variations depending on the level of understanding respective respondents had of the study and their attitude towards general research in the country. Most farmers had a problem with the fact that research is done with the promise that it will contribute to their livelihood but they never receive anything. Some farmers did not want to participate for this reason, or became less responsive when they learnt about association with government agencies. To ensure that such biases were well catered for; farmers were ensured of confidentiality or excluded from the survey in cases where the latter failed.

3.6 DEMOGRAPHIC AND SOCIO ECONOMIC CHARACTERISTICS OF THE SAMPLE

The study had a sample size of 165 respondents from the four agro-ecological regions of Swaziland. There were 115 (70%) farmers from the two regions of Swaziland that are susceptible to drought (the Lowveld and Lubombo regions); and 50 (30%) respondents were from the two regions that are less susceptible to drought (Highveld and Middleveld).

Table 3.1: Demographic and socio-economic characteristics of the sampled respondents.

Variable	Regions relative susceptibility to drought More	Less	Total
Relationship to HH			
Self	46 (40%)	30 (60%)	76 (46%)
Wife	62 54%)	8 (16%)	70 (42%)
Child	7 (6%)	12 (24%)	19 (12%)
Gender			
Female	88 (77%)	30 (60%)	118 (72%)
Male	27 (23%)	20 (40%)	47 (28%)
Marital status			
Married	81 (70%)	19 (38%)	100 (61%)
Widowed	22 (19%)	13 (26%)	35 (21%)
Never married	11 (10%)	17 (34%)	28 (17%)
Divorced	1 (1%)	1 (2%)	1 (2%)
Occupation			
Unemployed	68 (59%)	28 (56%)	96 (58%)
Farmer	29 (25%)	2 (4%)	31 (19%)
Trader	12 (10%)	5 (10%)	17 (10%)
Civil servant	3 (3%)	9 (18%)	12 (7%)
Private sector	3 (3%)	2 (4%)	5 (3%)
Self employed	0	4 (8%)	4 (2%)
Level of education			
Primary level	54 (47%)	21 (42%)	75 (45%)
Secondary level	47 (41%)	27 (54%)	74 (45%)
No formal education	12 (10%)	0	12 (7%)
Tertiary certificate	1 (1%)	1 (2%)	2 (1%)
Tertiary diploma	0	1 (2%)	1 (1%)
First degree	1 (1%)	0	1 (1%)
Age			
Min	19	16	16
Max	86	80	86
Mean	52	53	52
Std deviation	15	16	16

Source: survey data

A majority of the respondents were either heads of their respective households (46%) or wives to household heads (42%). This gives assurance in terms of the validity of the data as the respondents were adults who had a clear picture of farming activities in their respective households, thus were more likely to provide valid information. Also; the respondents can be considered as low income households as 52% have an average monthly income below R3000.

All respondents had some form of income, but were dependent on old age grants (which amount to R200 per month) and subsistence agriculture. This is also reflected in the ages, as 68% of the respondents were above the age of 50. This expresses the respondents' level of dependency on agriculture for their livelihood, especially in the drought prone areas as more respondents from these areas were full time farmers.

With respect to gender; female respondents dominated the sample, as 72% were female, and only 28% were male. This is as a result of having most males working in the city and most households being left in the hands of women (Hassan, 2007; Shongwe, 2013). The results also revealed that 61% of the respondents were married, with 21% being widowed, 17% never married, 1% separated, and 1% divorced. This further strengthens the validity of the data as a large percentage of the respondents were responsible adults who were familiar with the household economy. A majority of the respondents had some form of education; with those who only went up to primary school having a share of 45%, which was the same percentage as respondents who went up to high school. Only 1% had tertiary education, and 7% were uneducated. Basic education was an advantage as it was easier to get reliable information from respondents as they understood the study and could follow the questionnaire. Most respondents only had basic education due to their age range (above 50), thus did not go further than primary school but were literate.

3.7 DATA ANALYSIS

On collection from the field; data was captured, coded, and cleaned using Excel (2013). To move a step further in preparing data for analysis; STATA 14 was also used for cleaning and coding. Finally; the chi-square test and probit analysis were also performed in STATA 14.

3.7.1. Chi square test model

For the study; a Chi-square test was performed to determine if there were any significant differences in adaptation choices in the two regions. The test was also used to verify the influence of socioeconomic, biophysical, and policy variables on respondents' choice of drought coping strategies. The model was run in STATA 14.

3.7.1.1 Chi square model specification

$$x_c^2 = \sum \frac{(O_\mathrm{i} - E_\mathrm{i})^2}{E_\mathrm{i}} \qquad (8)$$

Where x^2 = The chi square statistic

O = Observed

E = Expected

3.7.2 Probit model

This model has been used in numerous choice analysis studies, and for this study the simple probit was selected because a twostep process was not required for farmers to select drought coping strategies as they all perceived climate change variability. Therefore; analysis only comprised of determination of factors that influence farmers' selection of coping and adaptation strategies across the two agro-ecological zones.

According to Wooldridge (2012); the probit model is a binary response model, and in such models the interest lies in the response probability:

$$P\ (y=1 \mid X) = P\ (y=1 \mid X_1, X_{2, \dots}\ X_k), \qquad (9)$$

Where:

X: Full set of independent variables

Y: Binary dependent variable eg coping strategy ("yes" for adoption or "no" for not adopting that particular strategy).

In linear probability models, the assumption is that the response probability is linear in a set of parameters, β_j. To avoid the limitation of these models, binary response models are specified as:

$$P\ (y=1 \mid X) = G\ (\beta_0+\beta_1X_1+\ldots+\beta_kX_k) = G\ (\beta_0+x\beta) \qquad (10)$$

G = a function taking on values strictly between 0 and 1: $0<G\ (z)<1$ for all real numbers z. this ensures that the estimated response probabilities are strictly between 0 and 1. For the probit model, G is the standard normal cumulative distribution function (CDF) which is expressed as an integral:

$$G\ (z) = \Phi\ (z) = \int_{-\infty}^{z} \emptyset(v)\mathrm{d}v \qquad (11)$$

Where Φ (z) is the standard normal density.

$$\Phi (z) = (2\pi)^{-1/2} \exp (-z^2/2) \quad (12)$$

The probit model is derived from an underlying latent variable model. Let Y* be a latent variable and suppose that

$$Y^* = \beta_0 + x\boldsymbol{\beta} + e, \; y=1(y^*>0) \quad (13)$$

Where we introduce the notation [·] to define a binary outcome. The function [·] is called the indicator function, which takes on the value of one if the event in brackets is true, and zero otherwise. This implies that y is one if $y^*>0$, and y is zero if $y^*\leq 0$. We assume that e is independent of X and that e has either the standard normal distribution or the standard logistic distribution. E is symmetrically distributed about zero, which means that 1-G (-z) = G(z) for all real number z. The normality assumption for e is more favoured by economists; which is why the probit model is preferred to the logit model. Moreover, with the probit, several specification problems are easily analysed.

3.7.2.1 Variables for the probit model

The dependent variable was choice of drought coping and adaptation strategy. These include changing of livestock mix, purchasing hay, migration of livestock, construction of livestock shelter for livestock production, changing crop and purchasing water for crop production. These factors were selected based on studies done in various African countries (Shongwe 2013, Hadgu, 2015), and were also updated with farmer specific strategies from farmers in Swaziland.

The explanatory variables were those hypothesized to have an effect on farmers behavioural responses to drought; and these are agro-ecological location, socioeconomic characteristics and other factors such as extension services, access to loans, membership to a cooperative or farmer organization, access to climate change information, and other factors that are specific to particular groups of farmers (Obayelu, 2013; Hadgu, 2014; Tazeze, 2012).

3.8 DESCRIPTION OF EXPLANATORY VARIABLES

Table 3.2: Description of explanatory variables

Variables	Description
Household size	Continuous (number of children and adults in the household)
Farming experience	Continuous (number of years as a farmer)
Source of income	Dummy: 0 if farming; 1 if other
Occupation	Categorical (farmer or otherwise employed)
Age	Continuous
Education	Continuous
Extension	Dummy: 1 if yes, 0 otherwise
Credit	Dummy: 1 if yes, 0 otherwise
Agro-ecological zone	Categorical: 1 if Lowveld, 0 otherwise
Sex (household head)	Dummy: 1 if male, 0 otherwise

Source: survey data

Household size: This variable is expected to have a negative relationship with adaptation because a majority of subsistence farmers deal with drought as a shock; thus farm income is diversified to household needs during drought. This implies that farmers will purchase household items rather than invest in drought coping and adaptation (Tazeze, 2012).

***Experience*:** Experience is expected to have a positive relationship with farmers' likelihood of adaptation as it reflects farmers' familiarity with agriculture. More experienced farmers are more likely to try different strategies to salvage their crop compared to less experienced farmers. These farmers also have more information on climate change and various drought coping and adaptation options (Nhemachena and Hassan, 2007).

Income source: Full time farmers are expected to be more likely to adopt coping strategies compared to farmers with an alternative source of income (Lien, 2008). Therefore, a positive relationship is expected between full time farming and adoption of drought coping strategies as their livelihoods depend on it.

Average income**:** This variable is expected to be positively related to drought adaptation as the more income a household has; the more likely it is that they will invest in technology that will enhance their drought coping abilities (Ndamani and Watanabe, 2015).

Age: *A*s much as age may have a positive influence on the likelihood of adaptation as it is related to the experience a farmer has; it might also be a hindrance in the sense that older farmers may not be as receptive to change compared to younger farmers (Shongwe, 2013) Therefore, the coefficient for age can either be positive or negative.

Education**:** Education increases the likelihood of adaptation as the more educated the farmer is, the more the access to information and adaptation technology they have (Ndamani and Watanabe, 2015). Therefore, education is expected to positively influence the adoption of drought coping strategies.

Extension**:** Unlimited access to free extension services is expected to have a positive influence on the likelihood of adopting drought coping and adaptation strategies. Farmers with reliable information on drought coping and adaptation strategies are more likely to successfully reduce risks brought about by drought (Gbetibouo, 2009).

Access to credit: Farmers with unlimited access to credit are expected to be more likely to adopt drought coping and adaptation strategies than those who do not. Farmers can purchase inputs that can counteract the impacts of drought such as irrigation equipment and drought resilient varieties when they have access to credit (Deressa *et al,* 2009).

Agro-ecological zone: Farmers in different agro-ecological zones are expected to have different adaptation strategies. This is due to the fact that climatic conditions and soils determine appropriate adaptation options for farmers in various zones as they adopt strategies to counteract and address the specific discrepancies that zone has (Deressa *et al,* 2009*)*.

Gender**:** female respondents are expected to be more inclined to adopt drought coping and adaptation compared to males. Women participate more in farming activities, but men are usually the breadwinners for their families so they have more financial capability to adopt drought coping strategies than women (Shongwe, 2013). Males are also more likely to adapt because they are relatively more informed and experienced than female farmers (Ndamani and Watanabe, 2015; Tazeze, 2012). This variable can therefore be either negative or positive.

3.7 CONCLUDING SUMMARY

This section provided information on the execution of different stages of the research. The study had study areas in all four agro-ecological zones in Swaziland. There were 165 respondents; with 50 in the less drought prone areas and 115 in the drought prone areas. Sampling was both purposive and random; and the respondents were interviewed using a structured questionnaire. Data was captured, coded and analysed using Excel spreadsheet and STATA 14, and analysis was performed through the use of the Chi-quare test and bivariate probit analysis.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter comprises of several sections that reflect the different stages of data analysis. Section 4.2 presents production characteristics of the sampled farmers. Farmers' perceptions and responses to long term changes in temperature and precipitation are elaborated on in section 4.3, with impact of the drought on farmers' production processes being presented in Section 4.4. Farmers' immediate responses to the drought are discussed in Section 4.5, followed by how farmers would have responded if they had received prior information on the drought in Section 4.6. Lastly; Section 4.7 presents farmers' preparedness for future drought incidences.

4.2 PRODUCTION CHARACTERISTICS OF FARM HOUSEHOLDS

Before addressing the objectives; the chapter presents a background on the production characteristics of sampled households of relevance to coping or adaptation to drought. Behavioural responses to drought are highly dependent on a farmer's attributes and resource endowment, hence the importance of specific farmer details when attempting to explain behaviour during drought incidences. The following section will therefore cover farmers' crop and animal production characteristics together with inputs utilised in each respective enterprise. It will also focus on farmers' resource endowment.

4.2.1 Crop production

All the respondents were involved in some form of crop production, and the main crop produced was maize for subsistence purposes. Farmers were asked questions about the years of experience they had in farming, the type of crops they produced, the production system used for these crops, inputs used in the production of each of these crops; and the amount of yield obtained for the main crop which was maize. Displayed in Table 4.1 below are farmers' responses.

Table 4.1: Farmer's production characteristics

Characteristics	Region's relative susceptibility to drought		Total
	More susceptible	Less susceptible	
Crops produced			
Maize	114 (99%)	49 (98%)	163 (99%)
Other crops			
Peas	14 (25%)	1 (5%)	15 (20%)
Beans	5 (9%)	8 (38%)	13 (17%)
Vegetables	8 (14%)	4 (19%)	12 (16%)
Sweet Potatoes	5 (9%)	6 (29%)	11 (14%)
Peanuts	9 (16%)	0	9 (12%)
Cotton	9 (18%)	0	9 (12%)
Pumpkin	2 (4%)	2 (9%)	4 (5%)
Sorghum	2 (4%)	0	2 (3%)
Potatoes	1 (1%)	0	1 (1%)
Maize farming system			
Monocropping	12 (10%)	3 (6%)	15 (9%)
Mixed Cropping	103 (90%)	47 (94%)	150 (91%)
Farming system for other crops			
Mono-cropping	43 (80%)	13 (26%)	56 (68%)
Mixed Cropping	11 (20%)	15 (30%)	26 (32%)
Farming experience (years)			
0 - 20	41 (36%)	12 (24%)	53 (32%)
21 - 50	68 (59%)	33 (66%)	101 (61%)
50 – 80	6 (5%)	5 (10%)	11 (7%)

Source: survey data

Respondents were highly experienced in farming, as 71% had more than 20 years farming experience. This is due to the fact that a majority of interviewees were elderly people who have been dependent on farming all their lives, therefore preferred particular types of crops such as maize even in unfavourable conditions. This might not be an advantage in terms of ability to carry out farming activities and adopt new coping strategies, as most cannot carry out tedious tasks on the farm (Shongwe, 2013). As per the norm in Swaziland; maize was the most produced crop with 99% of the respondents producing it (Mlipha, 2015). Maize is an exotic crop in Swaziland, but due to the number of years farmers have been producing it they now consider it as a staple crop in the country.

Farmers in the two regions farm distinctly different alternative crops; with those from the vulnerable region having more alternative crops compared to the less affected region. Of all the alternative crops; peas were the most popular, particularly in the drought prone areas. Farmers in the drought prone areas considered peas more drought tolerant compared to other crops, as they withstand extreme temperatures and do not die off completely as is the case with maize in drought conditions. They are more aware of drought and the types of crops adapted to drought conditions. This is because they have excellent extension services from governmental organizations such as Swaziland Water and Agricultural Enterprise (SWADE) and National Disaster Management Agency (NDMA) on drought tolerant crops and strategies to cope with drought, thus they are more adapted to drought conditions (Mhlanga-Ndlovu and Nhamo, 2016). Farmers in the other regions do not get as much attention in terms of drought coping and adaptation, therefore they stick to maize farming even in unfavourable conditions.

With regards to maize farming systems, 91% of the respondents preferred mixed farming (maize planted together with other crops such as pumpkins and squash), which was contrary to what farmers preferred for their alternative crops. As it was the case with Mlipha (2016), maize and pumpkin is a popular combination of Swazi farmers; and this has become the most popular maize farming practise for a majority of farmers. This crop combination saves costs and space for farmers if produced simultaneously. For alternative crops; however, farmers preferred to practice mono-cropping; and this is due to the specific mono-cropping requirements alternative crops such as sweet potatoes and groundnuts require. These crops have been observed to give less yield when intercropped compared to when they are planted individually (Mlipha, 2015). Operations such as weeding and maintenance are also easier when these crops are planted individually, but maize does not have special considerations when it comes to such.

4.2.1.1 Inputs for crop production

Farmers were requested to provide information on the basic inputs used for general crop production and the quantities applied. Table 4.2 below presents the information farmers provided.

Table 4.2 Inputs for crop production

Inputs	Region's relative susceptibility to drought		Total
	More	Less	
Fertiliser (kg)			
None	93 (81%)	13 (26%)	106 (64%)
1-10	17 (15%)	19 (38%)	36 (22%)
11-20	3 (2%)	11 (22%)	14 (9%)
20+	2 (2%)	7 (14%)	9 (5%)
Herbicides			
None	113 (98%)	43 (86%)	156 (95%)
1-5 litres	2 (2%)	5 (10%)	7 (3%)
10-30 litres	0	2 (4%)	2 (2%)
Purchased seed (in kg)			
None	1 (1%)	1 (2%)	2 (1%)
1-20kg	91 (79%)	41 (82%)	132 (80%)
21-40kg	22 (19%)	6 (12%)	28 (17%)
41-60kg	1 (1%)	1 (2%)	2 (1%)
61-80kg	0	1 (2%)	1 (1%)

Source: Survey data

For crop production; respondents used basic inputs, namely fertiliser and seeds. More farmers (74%) in the less susceptible region applied fertiliser, and only 19% farmers in the susceptible region utilised fertiliser. Farmers from the latter region cited the fact that soils in their areas do not take well to fertiliser, therefore they prefer not to apply it. Farmers also cited being short of funds as a constraint to using more inputs, and this has been a long running complaint amongst most subsistence farmers (World Bank, 2011). Drought prone areas in Swaziland have with time become riddled with poverty as a result of recurrent droughts, and this worsens the plight of these subsistence farmers. Farmers also did not use herbicides; but preferred to do manual weeding to save costs. They also believe that herbicides destroy soil structure in the long run, therefore preferred not to use them. Some farmers from the less drought prone areas (14%) did use herbicides; but for the most part farmers in both areas did not apply them due to the reasons cited above. For seed; farmers from both regions use modern varieties but supplement them with indigenous seeds from their previous crop depending on how much money they have set aside to purchase seeds (Mlipha, 2015). When inquired about the importance of drought tolerant varieties; farmers expressed concern that no variety can withstand the extreme conditions droughts bring; hence they prefer the use of indigenous maize varieties as they are easier to access and are from the previous crop thus farmers do not incur any costs.

4.2.2 Livestock production system

In Swaziland, livestock production has value both economically and culturally. The main livestock kept in the country are cattle, goats, and chickens, and their numbers increase yearly. This section therefore provides information on the cattle, goats, and chickens respondents kept at the time of data collection, together with the inputs they utilized for livestock production.

Table 4.3: Livestock production

Type of Livestock	Quantity	Region's relative susceptibility to drought		Total
		More	Less	
Cattle	None	64 (56%)	27 (54%)	91 (55%)
	1-10	39 (34%)	16 (32%)	55 (33%)
	11-20	9 (8%)	7 (14%)	16 (10%)
	21-30	2 (1%)	0	2 (1%)
	41-50	1 (1%)	0	1 (1%)
Goats	None	53 (46%)	39 (78%)	92 (56%)
	1-10	46 (40%)	10 (20%)	56 (34%)
	11-20	12 (10%)	1 (2%)	13 (8%)
	21-30	2 (2%)	0	2 (1%)
	31-40	0	0	0
	41-50	2 (2%)	0	2 (1%)
Chickens	None	17 (15%)	6 (12%)	23 (14%)
	1-10	55 (48%)	23 (46%)	78 (47%)
	11-20	27 (23%)	15 (30%)	42 (25%)
	21-30	11 (10%)	3 (6%)	14 (8%)
	31-40	1 (1%)	0	1 (1%)
	41-50	1 (1%)	3 (6%)	4 (3%)
	51-100	3 (2%)	0	3 (2%)

Source: Survey data

Respondents were requested to provide information on the types of livestock they had during the time of data collection; and 55% stated that they did not have cattle at all. For the rest of the farmers; 2% had more than 21 cattle, 10% had more than 10 cattle and 33% had less than 10 cattle. In normal conditions; the average number of cattle per household in Swaziland is 11, but for the sample the average number of cattle owned per household was only 4. Cattle are an important symbol of wealth in the country; thus a decrease in the number owned per individual farmer reflects the extent to which the drought affected farmers (World Bank, 2011). Respondents stated that cattle died due to lack of water and feed during the drought, and the government provided farmers with hay at a later stage; when thousands of cattle had already died. Farmers still retained their cattle and did not sell to abattoirs as the drought worsened. The situation was no different for goat farming; as 55% farmers stated that they had no goats; and only 45% kept goats. Goats are considered to be more resilient to drought, and farmers in the more drought prone region kept goats compared to those in the less prone region. Farmers in the former areas claimed that goats survive droughts because they are better foragers than cattle, therefore they provide an alternative source of wealth to cattle. A higher percentage of the respondents had chickens; with only 14% expressing that they did not have any at all. This goes to prove the hardiness and easier management of chickens during drought conditions (as expressed by the respondents).

4.2.2.1 Livestock inputs

Farmers were requested to provide information on the types of basic inputs they used on their cattle, goats, and chickens. Although a majority of subsistence farmers do not use extra inputs on their livestock; some of these inputs are displayed in Table 4.4.

Table 4.4: Livestock inputs

Inputs	**Region's susceptibility to drought**		**Total**
	More	**Less**	
External livestock inputs			
None	74 (65%)	29 (64%)	103 (63%)
Yes	41 (35%)	21 (36%)	62 (38%)
Input type			
Grower mash	14 (34%)	8 (38%)	22 (35%)
Hay	5 (12%)	5 (24%)	10 (16%)
Yellow maize	17 (41%)	5 (24%)	22 (35%)
Medicine	5 (12%)	3 (14%)	8 (13%)

Source: Survey data

Subsistence farmers rely on grazing areas and community dip tanks for the upkeep of their livestock (World Bank, 2011). Farmers that purchase inputs are usually resource endowed in comparison to other farmers, therefore can afford to purchase extra inputs such as grower mash for chicks, hay to supplement grazing areas, yellow maize to add to kitchen waste that chickens are usually given, and medicinal items such as vaccination or drought induced illnesses in cattle. A majority of farmers (63%) in both drought susceptible and less susceptible regions did not purchase supplementary inputs for their livestock. Of the few (38%) that did purchase inputs; those from the less susceptible region preferred to purchase more hay, but those from the more drought prone region bought less because the government had already donated hay when the drought worsened. They did, however, purchase more yellow maize because donated livestock feed was only provided for cattle. When obtained in a timely manner; these inputs to some extent help farmers overcome drought impacts on their livestock. Drought compromises grazing areas and results in an increase in the incidence of diseases in livestock; therefore, these inputs are detrimental in supplementing drought induced impacts on livestock.

4.2.3 Resource endowment

This section will serve to indicate agricultural assets farmers had; and also give a picture of general assets farmers had and if they had an influence on farmers' production decisions.

Table 4.5: Resource endowment

Resources owned by farmers	**Region's relative susceptibility to drought**		**Total**
	More susceptible	**Less susceptible**	
Tractor	2 (2%)	1 (2%)	3 (2%)
Plough	6 (5%)	10 (20%)	16 (10%)
Planter	5 (4%)	8 (16%)	13 (8%)
Trailer	5 (4%)	5 (10%)	10 (6%)
Radio	115 (100%)	50 (100%)	165 (100%)
TV	100 (87%)	42 (84%)	142 (86%)
Mobile phone	115 (100%)	50 (100%)	165 (100%)
Irrigation equipment	4 (3%)	1 (2%)	5 (3%)
Livestock shelter	90 (78%)	39 (78%)	129 (78%)
Borehole	79 (69%)	47 (94%)	126 (76%)
Conservation structure	0	0	0
Electricity	81 (70%)	45 (90%)	126 (76%)
Computer	5 (4%)	11 (22%)	16 (10%)
Internet	1 (1%)	1 (2%)	2 (1%)
Insurance	0	0	0

Source: Survey data

As in the case of most subsistence farmers; respondents did not have basic implements for agricultural production. In both regions; they had household amenities such as electricity, television, and cell phones, but were resource poor in terms of farm production implements. More than 90% of the farmers did not have a trailer, planter, plough or tractor. All respondents depended on rented government tractors, and only 3% farmers had their own tractors. On average, farmers from the less susceptible region were more resource endowed, and this can be attributed to the fact that the more susceptible region experiences more drought episodes, and this increases poverty rates in these areas (International Food Policy Research Institute, 2009). This gives insight in terms of the extent to which farmers are vulnerable to drought; as not having basic implements makes farmers more susceptible to easier losses as they redistribute funds used to rent implements to purchasing food during drought conditions. For farmers who had these implements; they only gave up after having tried farming. This goes to prove that resource endowment serves as a cushion for drought impact.

4.3 FARMERS' BEHAVIOURAL RESPONSES TO HISTORICAL PERCEPTIONS OF DROUGHT

Swaziland has been experiencing generally extreme and unpredictable climatic conditions for the past ten years (Manyatsi, 2010; Ndlovu, 2015). To evaluate respondents' perceptions on these conditions; they were asked questions on how temperature and precipitation have changed in the last ten years. Farmers were therefore required to state whether temperatures have been increasing or not, and also if precipitation has been decreasing in the past ten years. As shown in Table 4.5; irrespective of region's susceptibility to drought; all respondents perceived an increase in temperatures and a decrease in precipitation (as corroborated by Ndlovu, 2016).

Table 4.6: Farmers' historical perceptions on drought

Perception	Region's relative susceptibility to drought		Total
	More susceptible	**Less susceptible**	
Temperature			
Increase	115 (100%)	50 (100%)	165 (100 %)
Rainfall			
Decrease	115 (100%)	50 (100%)	165(100%)

Source: survey data

Farmers were also presented with various adaptation strategies on their crops and livestock choices to determine their responses to perceived changes in temperature and precipitation. Farmers then provided information on other actions they took in response to perceived changes in temperature and precipitation. These results are presented in Table 4.6 below, and the difference in choices of adaptation between the two regions was apparent. Severe droughts affect farmers in all regions, but there are differences in their adaptation and coping options (Okonya, Syndicus, and Kroschel; 2013). These differences might be tied to farmers' resource endowment, the nature and extent of drought impact, adaptive capacity, and level of dependency on rain fed agriculture. The more susceptible areas tend to be less resource endowed due to poverty, and this limits their capability to respond promptly to drought incidences (Ntwi-Agyer *et al*, 2011).

Table 4.7 Responses to historic shifts in temperature and precipitation

Strategies that farmers applied	**Regions relative susceptibility to drought**		**Total**
	More susceptible	**Less susceptible**	
Change planting date	105 (91%)	40 (80%)	145 (88%)
Change crop type	50 (43%)	14 (28%)	64 (39%)
Change variety	68 (59%)	31 (62%)	99 (60%)
Invest in irrigation	28 (24%)	7 (14%)	35 (21%)
Change livestock type	61 (53%)	7 (14%)	68 (41%)
Change livestock breed	7 (6%)	1 (2%)	8 (5%)
Shelter for livestock	68 (59%)	16 (32%)	84 (51%)
Water for livestock	65 (57%)	18 (36%)	83 (51%)
Purchase hay	69 (60%)	14 (36%)	83 (50%)
Migrate livestock	49 (43%)	9 (18%)	58 (35%)
Insurance	6 (5%)	1 (2%)	7 (4%)

Source: Survey data

In response to historical changes in temperature and precipitation, 91% of the respondents in the drought prone area and 80% of those in the less prone region adjusted planting dates because seasons shifted, implying that rains came later than in a normal production period. More farmers in the drought prone region changed planting dates as drought indicators are much more vivid in such areas. Planting at the usual planting period would have meant that farmers risked losing their crops as the first rains have been commencing later than usual in the past ten years. Farmers have had to plant as late as January whereas they were used to planting in October in drought free production periods.

Most farmers did not change their crops from maize to more drought tolerant crops such as sweet potatoes and sorghum, even though they knew about the vulnerability of maize in drought conditions. More farmers in the drought prone areas changed their crop type to more resilient crops such as peas, mainly due to better access to drought related information in their areas. Most farmer in the less drought prone areas cited the importance of maize in their households for consumption, therefore stated that they would rather risk losing maize than successfully grow drought tolerant crops. Other farmers mentioned that high temperatures have devastating impacts on all crops; thus there is no advantage in switching to other crops. The same reasons applied to not changing type of livestock, adding the fact that cattle are a symbol of wealth thus farmers are not willing to trade them for more drought tolerant livestock such as goats and chickens.

With regards to providing water for livestock or irrigation in maize fields; farmers were reluctant because drought implies severe water scarcity, and they cannot afford implements required for irrigation or the money to purchase water from the Swaziland Water Services Corporation (Shongwe, 2013). Irrigation was only practiced by farmers who had small backyard gardens (51% of the respondents). More farmers in the arid zone were willing to invest in irrigation because droughts wipe out every water source in such areas. As with irrigation, farmers in the arid zone were more willing to change livestock type to resilient livestock such as goats and chickens, mainly because the latest drought resulted in more cattle deaths in their areas compared to the less arid areas. Out of the 55 farmers who mentioned cattle deaths as an impact of drought, only 10 were from the less arid zones. These farmers also provided shelter for their livestock in response to climate change, and also provided feed for their livestock. Some farmers preferred to migrate their livestock to areas that were less affected by the drought, but only 35% of the respondents did because they cited problems such as theft and untrustworthiness of the people they have entrusted their livestock to in the past. Once more; farmers in drought susceptible areas were more willing to move their livestock to better grazing areas compared to farmers in less susceptible zones.

Therefore, in essence; the two regions had distinctly different approaches to drought coping and adaptation. Farmers from the drought prone regions were more receptive to adjusting their production decisions in response to climate shifts compared to farmers in the less drought prone areas. A majority of farmers from the less susceptible region preferred not to adopt 5 of the six strategies, whereas in the susceptible region more farmers adopted these strategies.

To determine if there is a statistically significant difference in response between the two regions to historical changes in climate; a chi square test was performed. The results are presented in Table 4.7; and the strategies that were significantly different across the two regions were changing livestock mix, purchasing extra hay for livestock, livestock migration, constructing livestock shelter, obtaining supplementary water for livestock, changing planting date, and switching from maize to drought tolerant crop types. On selecting these strategies; a probit analysis was performed on each to determine factors that affect the selection of each of these strategies. The results are presented in Table 4.8.

Table 4.8: Chi square test results for differences in drought coping and adaptation strategies

Strategies farmers applied	**Regions relative susceptibility to drought** More susceptible	Less susceptible	**Chi-sq**	**p-value**
Change livestock mix	61 (53%)	7 (14%)	21.9	0.000
Purchase hay	69 (60%)	14 (36%)	14.3	0.000
Migrate livestock	49 (43%)	9 (18%)	9.2	0.002
Livestock shelter	68 (59%)	16 (32%)	10.3	0.015
Water for livestock	65 (57%)	18 (36%)	5.9	0.015
Change planting date	105 (91%)	40 (80%)	4.2	0.041
Change crop	50 (43%)	14 (28%)	3.5	0.061
Change variety	68 (59%)	31 (62%)	0.12	0.730
Irrigate	28 (24%)	7 (14%)	2.2	0.135
Change breed	7 (6%)	1 (2%)	1.3	0.261
Purchase insurance	6 (5%)	1 (2%)	0.89	0.35

Source: Survey data

4.3.1 FACTORS AFFECTING CHOICE OF ADAPTATION STRATEGY IN THE PAST TEN YEARS

All respondents claimed to have perceived temperature and precipitation changes in the past ten years in Swaziland. They were then requested to provide coping and adaptation strategies they had applied after perceiving climate change variability over the years as an attempt to reduce impacts on their farming enterprises. For each strategy; a chi square test was performed to test whether there was a significant difference in the selection of a strategy between the two regions. A binary probit regression was then run to determine factors that contribute to their selection in the two regions.

Binary probit estimates are presented in Table 4.8 below. The five models present different coping strategies as dependent variables and the factors hypothesized to influence their adoption in the two agro-ecological zones. The strategies of choice are altering livestock mix to more drought tolerant species, purchasing hay to complement grazing, migration of livestock to less drought prone areas, purchasing water to make up for lack of rains, and construction of livestock shelter to provide protection from extreme temperatures. Each of these models have different explanatory variables, even though an attempt was made to fit all strategies to the same model. Some variables such as education level were positive but not significantly related to the likelihood of adopting drought adaptation strategies. In previous studies, education was a crucial factor in determining farmers' strategies, therefore it was a basic variable for all five models. Other variables that were positive and insignificant but improved overall model fit were included in all the models, and these are number of maize fields and fields for alternative crops.

Table 4.9: Factors affecting farmers' choice of coping and adaptation strategies

Covariates	Change livestock mix		Purchase hay		Migrate		Purchase water		Livestock shelter	
	Coef.	*p-value*	*Coef.*	*p-value*	*Coef.*	*p-value*	*Coef.*	*p-value*	*Coef*	*p-value*
SEC's:										
Region	-0.97	0.001***	-0.69	0.007***	-0.81	0.007***	-0.44	0.08*	-0.63	0.019**
Education										
Secondary	0.045	0.865	-0.27	0.296	0.14	0.598	-0.39	0.124	-0.12	0.649
No education	0.222	0.603	0.13	0.773	0.14	0.752	0.14	0.740	0.20	0.662
Age	0.001	0.896	-0.006	0.490	0.00	0.986	0.003	0.700	0.01	0.223
Income source	-0.40	0.084*			-0.58	0.022**	-0.39	0.088*	-0.27	0.224
Average income	-0.40	0.157	2.02	0.332					0.41	0.070*
TV	-0.36	0.268								
Trailer ownership			1.17	0.042**			1.48	0.016**	0.32	0.521
Gender					-0.64	0.022**			-0.43	0.096*
Occupation			1.82	0.012**	-0.14	0.044**				
Children			0.43	0.012**	-0.10	0.034**				
Livestock units					-0.004	0.540	0.01	0.073*		
Cattle							0.009	0.691		
Goats									0.007	0.590
Biophysical										
Maize fields	0.459	0.478			1.09	0.101	0.27	0.649	0.78	0.229
Other crops	0.144	0.424			0.03	0.857	0.05	0.728	0.31	0.087*
Extension	-0.456	0.049**	-0.68	0.004***	-0.56	0.024**	-0.46	0.046**	-0.45	0.050**
Proceed	-0.492	0.031**			-0.65	0.008***			-0.55	0.011**
Need for credit	0.762	0.007***	0.495	0.050**	0.67	0.032**				
Government support	0.003	0.993			0.36	0.173	0.704	0.021**	0.255	0.457
Statistics										
Observations	165		165		164		164		165	
Log likelihood	-88.98		-90.79		-80.433		-94.28		-96.558	
LR Chi square	45.66		47.15		52.23		52.23		35.57	
Prob>chisq	0.000		0.000		0.000		0.000		0.0020	
Pseudo R2	0.204		0.2061		0.2451		0.2451		0.1555	

4.3.1.1 ALTERING LIVESTOCK MIX AS AN ADAPTATION STRATEGY

Based on chi square test results; there is a significant ($p<0.01$) difference between the two regions with regards to changing livestock mix. To explain the difference; a binary logistic regression was run to test the effect of sociodemographic, policy, and biophysical variables on the decision to alter livestock mix as a response to climate change and variability.

The results indicate that the higher the incidence of drought in a region; the higher the probability of changing livestock mix as an attempt to mitigate against the impacts of drought. Generally, farmers in different agro-ecological settings select different coping strategies (Deressa *et al,* 2008), with farmers in less drought prone regions adopting less coping strategies compared to farmers in more drought prone regions. Farmers in drought prone areas also have distinctly different livestock choices from farmers with less drought incidences (Udmale, 2014). As droughts persist, farmers in more prone areas keep more drought tolerant species such as sheep and goats rather than keeping cattle and chickens, whereas as drought incidences decrease more chickens and cattle are kept (Seo and Mendelsohn, 2006). With time; they adapt their farming activities to drought conditions as they are frequently subject to them.

Income source has a significant ($p<0.1$), negative effect on the probability of altering livestock mix as an adaptation option. This implies that part time farmers are less likely to adopt changing livestock mix as a strategy compared to full time farmers. According to Shongwe (2013), full time farmers are more likely to attempt to salvage their livestock during drought and dedicate their resources to adaptation; but part time farmers diversify their income to purchasing food instead of adopting improved technologies to deal with drought. The higher the proportion of non-farm income; the lower the probability that a farmer will alter livestock in response to climate change (Mulwa *et al*, 2017).

Extension also has a significant ($p<0.05$) but negative effect on the probability that a farmer will alter livestock in response to drought. Therefore; having access to extension services lowers the probability that a farmer will change their livestock mix as a drought coping strategy in response to climate change indicators over the past ten years. Extension services in Swaziland include the Swazi Government and Non-Governmental Organizations such as World Vision and Africa Cooperative Trust (ACAT). Extension services from NGO'S are mainly provided as relief, and services from government are provided on need basis (farmer consults extension officer on encountering a problem). This creates discrepancies in terms of drought adaptation as farmers can only react to drought but are unprepared for future incidence as they lack proper information on drought coping and adaptation.

Farmers that are willing to proceed with farming as drought persists are much more likely to alter livestock mix as a response to climate change in comparison to farmers who are not willing to continue with farming. This variable had a significant ($p<0.01$) and positive effect on selecting livestock mix as an adaptation strategy. This indicates that these farmers are not willing to completely give up on farming but would rather make the necessary adjustment that will keep them in agriculture. Some farmers were not willing to alter their livestock mix due to the fact that even though goats are more resilient to drought conditions (Seo and Mendelsohn, 2006); they are high maintenance compared to cattle. Therefore farmers prefer to stop livestock farming altogether rather that opt to rear resilient livestock species.

Level of education is insignificant, but has a positive effect on the likelihood of changing livestock mix as a strategy. This reflects the importance of reliable knowledge on farmers' decision making skills, as with education farmers are better able to correctly perceive climate change and make the necessary adjustments to their farming enterprises (Roco and Engler, 2015). Similarly, age was insignificant but positive. According to Deressa (2008), age represents experience; thus the older a farmer gets the higher the likelihood that they will adjust to climate change. In a study conducted in Swaziland, however, age negatively influenced the likelihood of adopting drought coping strategies (Shongwe, 2013). The reasons stated were that as farmers get older; they are less inclined to adopt new technologies as a result of path dependency (Uddin, Bokelmann, and Entsminger, 2014). Age can therefore be considered a context specific variable as there are discrepancies in similar research regarding its influence.

4.3.1.2 PURCHASING HAY

For this study, the variable "hay" referred to any supplementary feed sources farmers attempted to obtain during the drought period. This was in the form of hay from government, crop residues farmers collected from previously cultivated fields, and grass cuttings from dormant fields.

Region significantly ($p<0.01$) affects the likelihood that a farmer will purchase hay as a coping strategy. This implies that a farmer in the more susceptible region is less likely to attempt to save livestock through providing alternative feed for livestock. Farmers in this region mentioned that hay provided by government as drought relief came late but there was a reduction in cattle deaths because of it. However, farmers cannot afford to purchase hay, and crop residues are significantly reduced during a drought, especially in drought prone regions.

Farmers also mentioned that hay without water is not a worthwhile strategy to take up as livestock require both to survive.

Owning an ox drawn trailer also significantly ($p<0.05$) affects farmers' decision to purchase hay as a drought coping strategy. This means that farmers with assets such as trailers are more likely to purchase hay or harvest it from neighbouring farms as cattle feed because they have easily available transportation for it. The number of fields a farmer has for maize and other crops also had a significant ($p<0.05$) and positive effect on the likelihood of using hay as a strategy to cope with drought for livestock producers. As mentioned prior; some farmers use crop residues to feed their livestock during droughts. Therefore; the higher the number of fields the more likely it is that a farmer will be able to have access to more forage to collect as livestock feed.

Extension services are need based in Swaziland; therefore if farmers do not request services they cannot access extension services. With regards to purchasing hay; extension had a significant ($p<0.01$) but negative influence on the probability of purchasing hay as an adaptation strategy. This reveals the importance of relevant and timely information through extension as a pre-emptive measure to increase drought resilience for farmers. Farmers were also asked if they had an increased need for credit in the last ten years due to climate change. The results in Table 4.8 above revealed a significant ($p<0.05$), positive relationship between higher need for credit and adaptation through purchasing hay for livestock. This implies that these farmers are willing to explore other financial sources for them to be able to obtain extra feeding material for their livestock.

4.3.1.3 MIGRATION OF LIVESTOCK TO BETTER GRAZING AREAS

Farmers in Swaziland entrust livestock to herders in better areas for various reasons, and this practice is termed "*kusisa*". One of the major reasons is severe drought conditions similar to the 2016/2016 El Nino drought. This can be used as a way in which farmers can save their livestock even during severe climate variability. Sampled farmers in the survey were then asked if they had migrated their livestock in the last ten years to save their livestock (especially cattle). Presented below are the factors that influence farmers' decision to migrate livestock to better areas.

Region significantly ($p<0.01$) affects the decision to either migrate livestock to better pastures or not to. The more drought prone a region is, the less likely that farmers will migrate (sisa) their livestock to less drought vulnerable areas. A majority of farmers in the more susceptible region stated that migration is not beneficial because the people entrusted with the livestock are not trustworthy, thus they still lose their livestock as they would during a drought.

Gender also had a negative and significant ($p<0.05$) effect on the likelihood of migrating livestock to better areas. According to the results; being female reduces the probability of migrating livestock. Women usually participate only in tending to livestock, and they face barriers with regards to decision making on the farm when compared to men (Patel *et al*, 2016). They do not have as much access to information as men, and are subject to traditional restrictions that men are not subject to (Obayelu, Adepoju, and Idowu, 2014). This emphasises the need for reform in terms of equal rights for women to dispel cultural barriers that hinder women from contributing to important decisions.

Occupation also had a positive and significant ($p<0.05$) effect on the decision to migrate livestock. The sample was divided into three categories; full time farmers, otherwise employed subsistence farmers, and unemployed subsistence farmers. According to the results; full time private sector and government employees are less like to migrate their livestock compared to full time farmers. Part time farmers with good income alternatives are more likely to focus their efforts on non-farm income when agricultural production fails compared to full time farmers who will exhaust all alternatives to save their livestock. Similarly, unemployed subsistence farmers are less likely to migrate their livestock compared to full time farmers.

The number of children in a household also has a significant ($p<0.05$) but negative effect on the probability of migrating livestock to better areas. This implies that households with more children are less likely to migrate their livestock to better areas. According to Nti (2012), having a larger household size increases the chances of adopting adaptation strategies because of labour endowment, but in the case of children it might have the opposite effect.

Access to extension services had a significant ($p<0.01$) but negative effect on the likelihood of livestock migration. According to Obayelu, Adepoju, and Idowu (2014), regular and reliable extension has a positive influence on adaptation in general. This, however, depends on the nature of the information farmers are provided with. In the case of Swaziland, farmers do not have regular extension services providing timely information on climate change, and even when services are available the information is not drought adaptation oriented but more on solving farmers' problems with livestock diseases. The services are more solution based but not preventative.

The decision to proceed with farming is significant ($p<0.01$) but negatively related to livestock migration. Moving livestock and entrusting them to other farmers indirectly implies that the farmer is not willing to continue with farming due to extreme drought conditions in his area. The negative relationship implies that a farmer willing to attempt to proceed with farming during a severe drought in his immediate area is less probable to migrate livestock to better areas.

Farmers expressed concern over inaccessible credit facilities during drought conditions. Farmers were then asked if they had felt the need for more credit during the drought period. According to the results; the heightened need for access to better credit during the drought significantly ($p<0.05$) affects the decision to migrate livestock. This means that the higher the need for credit, the higher the probability of migrating livestock. This might imply that these farmers are willing to migrate their livestock at any cost; but are hindered by financial constraints. Finances were one of the main reasons a majority of farmers did not adopt most of the adaptation strategies.

4.3.1.4 PURCHASING WATER

Region had a significant ($p<0.1$) negative effect on the likelihood of purchasing water as an adaptation strategy. Farmers in drought prone areas struggle to access water in drought free periods due to aridity. When droughts hit, the situation escalates as what little water they have dries up. This might be why farmers in these areas are less interested in purchasing water to make up for losses due to drought, as it becomes even more expensive to access when drought hits. Income source also had a significant ($p<0.1$) effect on farmers' decision to purchase water as an adaptation strategy. This implies that full time farmers are less likely to purchase water to cope with drought compared to part time farmers. This might be due to the fact that part time farmers have alternative sources of income thus can afford to purchase water when agricultural production is compromised.

Owning a trailer also had a positive and significant ($p<0.05$) influence on the likelihood of purchasing water, which was similar to livestock ownership. Number of livestock units also significantly ($p<0.1$) affects the probability of purchasing water. The higher the number of livestock, the better are the chances of purchasing water. Some farmers sell livestock to cope with droughts, and this provides them with income to purchase amenities made short by drought. As with all other adaptation strategies; extension had a negative and significant ($p<0.05$) effect on the likelihood of purchasing water. Receiving government aid, however, had a positive and significant ($p<0.05$) effect on the likelihood of drought adaptation through purchasing water. Farmers received basic food aid which included maize, beans, and cooking oil. This gives farmers the opportunity to diversify their income and purchase water as they no longer need to purchase food.

4.3.1.5 LIVESTOCK SHELTER

Region has a significant ($p<0.05$), negative relationship with the probability of selecting livestock shelter as a strategy. The higher the incidence of drought in a region, the lower the likelihood of constructing livestock shelter as a coping strategy. Livestock shelter has been used successfully before in other drought prone areas (LEGS, 2008); but respondents in the drought prone region expressed concern over the fact that drought resulted in mostly cattle deaths, and constructing shelter for cattle is impractical and costly.

Average income has a positive, significant ($p<0.1$) effect on the likelihood of constructing livestock shelter as a drought coping strategy. This implies farmers earning income more than R3000 are more likely to construct livestock shelter compared to farmers earning less than R3000. This result is in line with Ndamani and Watanabe (2016), who stated that an increase in income positively influences a farmer's likelihood of adopting drought coping strategies. According to Obayelu, Adepoju, and Idowu (2014), households with higher average incomes are better able to adapt drought strategies such as those that require capital investment.

Gender had a significant ($p<0.1$) but negative effect on the probability of constructing shelter for drought as an adaptation strategy. Male farmers are more likely to construct livestock shelter compared to female farmers because they have more information, resources, and less cultural barriers compared to women (Obayelu, Adepoju, and Idowu (2014). This allows males to access various amenities that women are not eligible to obtain. Having fields for crops other than maize also had a positive and significant ($p<0.1$) effect on the likelihood of livestock shelter as an adaptation strategy. Having alternative crops reflects a farmer's dedication to farming, thus increasing their likelihood of having livestock shelter to protect livestock from extremes brought about by drought.

Farmers in Swaziland do not have regular and reliable access to extension services. Extension officers are available only on request, and very little effort is made to educate farmers on drought coping and adaptation. The results reveal that extension has a negative and significant ($p<0.05$) effect on the likelihood of constructing livestock shelter as an adaptation option. This implies that the more access a farmer has to extension, the less likely they are to adopt livestock shelter as a strategy. This puts to light the importance of well functional extension services that provide farmers with timely, reliable and relevant information at all times. Farmers are better able to make decisions on better strategies to utilise if they are well informed on oncoming droughts (Ndamani and Watanabe, 2015).

During the interviews; farmers were asked if they were willing to proceed with farming if droughts persist. This variable also had a significant ($p<0.01$) positive influence on the likelihood of constructing livestock shelter as an adaptation strategy. Farmers who are willing to proceed with farming even though climate change and variability worsens are better able to develop resilience as they are determined not to give up on farming. Livestock shelter prevents livestock deaths from climate extremes, and this is the goal that most farmers who do not want to quit farming have in mind.

4.4 RESPONSES WITH PRIOR INFORMATION

Prior information on an oncoming drought is a crucial factor in farmers' preparedness for drought alleviation (Smit and Skinner, 2002; Wilhite, Sivakumar, and Pulwarty, 2014). Subsistence farmers in Swaziland depend on television and radio for short term; day to day weather forecasts which do not provide comprehensive, long term information on climate trends (Manyatsi, 2010). Respondents expressed concern with regards to information, stating that they did not know about the drought prior to its occurrence. Farmers were then asked questions based on how they would have responded if they had received prior information on the 2015/2016 drought. Farmers were presented with various production options and requested to indicate if they would have applied any of them had they received prior information on the drought. Table 4.10 below displays farmers' choices.

Table 4.10: Actions farmers would have taken if they had received prior information on the 2015/2016 drought

Action that farmers took	Region's relative susceptibility to drought		Total
	More susceptible	Less susceptible	
Proceed with farming	71 (62%)	30 (60%)	101 (61%)
Change planting dates	111 (97%)	44 (88%)	155 (94%)
Change crop	84 (73%)	27 (54%)	111 (67%)
Change variety	91 (79%)	36 (72%)	127 (77%)
Irrigate	56 (49%)	19 (38%)	75 (45%)
Intercrop	90 (78%)	41 (82%)	131 (79%)
Purchase water	99 (86%)	43 (86%)	142 (86%)
Delay chemicals	98(85%)	41 (82%)	139 (84%)
Change livestock mix	79 (69%)	10 (20%)	89 (54%)
Change breeds	4 (3%)	1(2%)	5 (3%)
Shelter	77 (67%)	18 (36%)	95 (58%)
Alternative water source	72 (63%)	19 (38%)	91 (55%)
Hay	77 (67%)	18 (36%)	95 (58%)
Migrate (livestock)	53 (46%)	9 (18%)	62 (38%)
Insurance	8 (7%)	3 (6%)	11 (7%)

Source: survey data

With regard to prior information on upcoming droughts; 81% of the respondents considered it useless, mainly because they do not have any means to mitigate against drought upon being informed about it. Another reason why farmers do not value prior information is the fact that they do not trust the legitimacy of weather predictions. As stated in Manyatsi (2010), Swazi farmers believe more in supernatural powers than predictions from the Meteorological Department. This hinders successful preparation for droughts as farmers will be resistant to interventions that are based on predictions about eminent droughts. Farmers prefer to risk farming and hope that there will be rain rather than make informed production decisions based on predictions by the Meteorological Department.

Aspects of production farmers were willing to change if they had prior information included changing planting date (94%), changing the type of crop (67%) and changing the type of livestock (54%). Of all the respondents; (67%) stated that they would have changed crop type if they had known about the drought before the planting season commenced. As mentioned in Shongwe (2013) farmers are willing to switch to other crops just after the drought; but they never implement in practice because they prefer maize production. Lastly; 58% of the farmers stated that they would have purchased hay for their livestock if they had prior information on the drought as it was beneficial for those farmers who purchased it, but would not have migrated their livestock even if they knew about the drought beforehand. Farmers are wary of theft and untrustworthiness of the individuals entrusted with their livestock.

After observing the differences in adaptation with prior information across the sample; chi square tests were then performed to determine if there are any significant differences in strategy selection between the drought tolerant and drought susceptible regions. The chi-square results are presented in Table 4.11.

Table 4.11: Strategies farmers would have adopted if they had prior information on the drought

Strategies farmers would have adopted	Relative Susceptibility		Total	Chi-sq	pvalue
	More susceptible	Less susceptible			
Change livestock mix	79 (69%)	10 (20%)	89 (54%)	33.25	0.000
Shelter	77 (67%)	18 (36%)	95 (58%)	13.67	0.000
Hay	77 (67%)	18 (36%)	95 (58%)	13.67	0.000
Migrate (livestock)	53 (46%)	9 (18%)	62 (38%)	11.72	0.001
Change crop	84 (73%)	27 (54%)	111 (67%)	5.7	0.017
Change planting dates	111 (97%)	44 (88%)	155 (94%)	4.4	0.035
Proceed with farming	71 (62%)	30 (60%)	101 (61%)	0.044	0.833
Change variety	91 (79%)	36 (72%)	127 (77%)	1.0	0.317
Irrigate	56 (49%)	19 (38%)	75 (45%)	1.6	0.205
Intercrop	90 (78%)	41 (82%)	131 (79%)	0.297	0.585
Water	99 (86%)	43 (86%)	142 (86%)	0.0002	0.988
Delay chemicals	98(85%)	41 (82%)	139 (84%)	0.27	0.602
Change breeds	4 (3%)	1(2%)	5 (3%)	0.26	0.611
Insurance	8 (7%)	3 (6%)	11 (7%)	0.05	0.821

Source: survey data

4.4.1 FACTORS INFLUENCING STRATEGY CHOICE WITH PRIOR INFORMATION

On determining strategies that are significantly different across the two regions; further chi-square and probit tests were run to zero in on the demographic, socioeconomic, biophysical, and policy variables that contribute to farmers' choices of each of the significantly different strategy choices. The results are presented in Table 4.12.

Table 4.12: Factors affecting choice of drought coping strategies with prior information

Covariates	Change crop		Change livestock mix		Purchase hay	
	Coef.	*p-value*	*Coef.*	*p-value*	*Coef.*	*p-value*
SEC's:						
Region	-0.23	0.398	-1.40	0.000***	-0.81	0.002***
Education						
Secondary	-0.27	0.341	0.34	0.228	0.26	0.321
No education	-0.31	0.485	1.04	0.041**	0.54	0.248
Age	-0.03	0.004***	-0.000	0.979	0.00	0.979
Income source					0.10	0.675
Average income	-0.67	0.007***	-0.50	0.050**		
Trailer ownership			1.17	0.042**		
Livestock units					0.00	0.974
Cattle					0.05	0.048**
Goats	0.06	0.020**	0.04	0.048**	-0.01	0.745
Livestock shelter	0.73	0.010**	-0.01	0.976	0.48	0.071*
Credit					-10	0.050**
External inputs					0.60	0.018**
Biophysical						
Maize fields	-0.91	0.178	0.28	0.695	-0.22	0.755
Other crops	0.63	0.001***	0.05	0.797	-0.009	0.960
Policy						
Extension	-0.28	0.269	-0.79	0.003***	-0.29	0.224
Proceed with farming	-0.40	0.101	0.06	0.807	-0.09	0.694
Need for credit	0.36	0.176	0.96	0.001***	0.67	0.019**
Government support	0.30	0.322	1.24	0.000***		
Observations	165		165		164	
Log likelihood	-75.94		-75.31		-90.39	
LR Chi square	56.75		77.09		43.04	
Prob>chisq	0.000		0.000		0.000	
Pseudo R^2	0.272		0.339		0.1923	

Source: own calculations

4.4.1.1 PURCHASING HAY

One of the strategies farmers were asked about was that of purchasing hay or obtaining it from fallow fields. Region had a negative and significant (p<0.01) relationship with the likelihood of obtaining hay as an adaptation strategy. This implies that even if farmers receive prior information on droughts, being in the more drought susceptible region reduces the likelihood of purchasing hay to save their cattle. This is in line with what farmers implemented over the past ten years in response to recurrent droughts as they did not purchase hay even then. The number of cattle owned had significant ($p<0.05$) positive effect on the probability that farmers would have purchased hay to cope with climate variability had they received prior information on the 2015/2016 drought. This means that farmers with more cattle are more likely to attempt to save their livestock by purchasing/ accessing hay.

Constructing livestock shelter also significantly ($p<0.1$) and positively influences the likelihood of purchasing hay as an adaptation strategy. This means that farmers who have livestock shelter in drought conditions are more likely to purchase supplementary feed (hay) as an adaptation strategy. This reveals that farmers who are willing to have a permanent structure to protect their livestock are also willing to go the extra mile and obtain feed for their livestock. Credit had a significant ($p<0.05$) but negative influence on the likelihood of purchasing hay. Farmers who desperately need and can access credit during a drought use the money for household needs rather than to salvage their crops and livestock. Farmers with extra, non-credit income are more likely to use the extra funds they have to adapt to drought compared to those that are in desperate need for credit.

Purchasing external inputs, however, had a positive and significant ($p<0.05$) on the likelihood that a farmer with prior information would purchase hay. External inputs refer to extra feed and chemicals farmers purchase in normal conditions to supplement grazing. Therefore; farmers who go the extra mile for their livestock in normal conditions are highly likely to do the same in drought conditions. The heightened need for credit also positively influenced the likelihood of purchasing hay. Farmers were asked if they had access to credit during the drought period; and only 9% could access credit from commercial banks. Farmers were then asked if they felt the need for more credit during drought conditions, with 75% of the sample attesting to needing more credit to supplement farm losses. This implies that farmers require *extra* credit before they can adopt drought coping strategies as they use normal credit for house hold expenses.

4.4.1.2 CHANGING CROP TYPE AS AN ADAPTATION STRATEGY

One other strategy that farmers use to adapt to drought is that of changing crop type to more drought tolerant crops that require less water compared to maize (such as peas and sweet potatoes as expressed by farmers). Region had an insignificant but negative relationship with the likelihood of changing crop type as an adaptation strategy. This means that being in the drought prone region reduces the likelihood of changing crops in an effort to cope with drought even with prior information. Farmers in these regions are familiar with arid conditions; therefore their selection of crop type in normal conditions is an adaptation strategy on its own. Farmers mentioned that during droughts the conditions are so extreme such that no crop, no matter how resilient, could survive. Age negatively and significantly ($p<0.01$) affected the likelihood of changing crop as an adaptation strategy in the event that farmers were provided with information prior to the drought. According to Shongwe (2014) age negatively affects the likelihood of drought adaptation in general, as the older a farmer gets, the less likely they are to adopt new technology.

Average income also significantly (5%) and negatively affected the probability of changing crop type in a bid to reduce drought impact in the event that farmer are forewarned about it. Previous studies (Ndamani and Watanabe (2016); Gbetibuou (2009)) have reported that average income positively influences the likelihood of adaptation as because farmers have the financial capability to adopt and implement various coping strategies. The current study might be context specific because Swazi farmers; no matter their wealth, prefer maize farming compared to farming other drought resistant crops even in drought conditions. Maize is a staple food in the country.

Number of goats owned also positively and significantly ($p<0.05$) affected the likelihood of changing crops as an adaptation strategy. This means that farmers who keep goats are more likely to change their crops to more drought resilient crops. Goats are a drought resilient type of livestock; therefore a farmer who has more goats is more likely to switch to a drought resistant crop too. Similarly; livestock shelter also had a positive and significant effect ($p<0.05$) on the likelihood of changing crops as an adaptation strategy. Farmers that have livestock shelter display awareness and dedication to farming in all conditions, which is why such farmers do not abandon farming altogether but find ways to counteract drought impacts.

Lastly; having alternative crops also significantly ($p<0.01$) and positively affects the likelihood of switching from maize to other crops. This is because farmers who are already well established in farming other crops in addition to maize will most likely not have a problem with dropping maize in the event that production is compromised due to droughts. This makes the transition easier than it would be for a farmer who only produces maize.

4.4.1.3 CHANGING LIVESTOCK MIX AS AN ADAPTATION STRATEGY

Apart from changing the types of crops as an adaptation strategy, farmers were also queried on whether they would be willing to change their livestock from cattle to more tolerant species such as goats. As with the other strategies; chi square tests were conducted to determine factors that determine if a farmer will change livestock mix if informed about a drought prior to its occurring.

As displayed in Table; region had a negative and significant ($p<0.01$) effect on the likelihood of changing livestock mix to cope with shift in temperature and precipitation. This means that farmers in the more drought susceptible are less likely to change their livestock mix from cattle to goats. Generally; cattle in Swaziland are a symbol of wealth. Farmers are therefore not willing to let go of cattle even when there are thousands of cattle deaths due to drought. This poses a challenge for extension workers and other officials to attempt to change farmers' perception and help them understand that switching to resilient livestock is actually beneficial for them. Another reason why farmers are not willing to switch to goats is that they are difficult to manage; therefore farmers prefer cattle.

Education also had a significant (5%) effect on choosing livestock mix as an adaptation strategy. Farmers with no formal education are less likely to change their livestock mix compared to farmers that have primary education. This brings to light the importance of basic education for farmers, as it encourages awareness and risk reduction (Nduda and Mungatana (2012); Obayelu, Adepoju, and Idowu, (2014)). Average income had a significant ($p<0.05$) but negative effect on the likelihood of altering livestock mix to reduce drought impacts. Farmers who earn more than more than R3000 are less likely to alter their livestock mix compared to farmers who earn less. Farmers with more income most likely use their money to purchase livestock feed and water for their livestock in an attempt to keep them during drought periods, but those who have less money probably trade them as they would die without extra inputs. Owning a trailer also positively and significantly ($p<0.05$) influences the probability of changing livestock mix during drought periods. This goes to prove the importance of resource endowment for drought coping and adaptation. Rurinda *et al (*2014), however, states that there is no direct relationship between resource endowment and drought adaptation as drought impacts affect resource endowed farmers the same way as those that do not have resources. Rather; it is a mix of factors such as socioeconomic and biophysical factors that explain the vulnerability of particular farmers, not just one factor.

Owning goats also has a significant ($p<0.05$) and positive influence on the likelihood that a farmers will alter their livestock mix in a bid to survive the severity of drought impacts. Goats are more drought resistant that cattle; therefore the higher the number of goats a farmer keeps before a drought increases the likelihood of a farmer changing to goat production as they are already used to it. Farmers who keep a smaller number of goats are therefore less likely to change their livestock mix when a drought occurs.

Extension services had a negative and significant ($p<0.01$) relationship with the likelihood of changing livestock mix as an adaptation strategy. As with strategies farmers have adopted over the past ten years to cope with recurrent drought; extension in Swaziland is not regular as it is need based. The negative relationship might imply that the information that is disseminated in not relevant to drought condition or it is not timely enough for farmers to implement when the drought hits. Farmers do have access to extension services, but it does not directly translate to farmers having better farming methods during drought conditions.

The need for credit also positively and significantly ($p<0.05$) influenced the probability of changing livestock mix during drought conditions when informed prior about it. This implies that farmers who have need for more credit during drought periods are more likely to alter their livestock mix in an attempt to cope with the drought. Lastly; having access to government support also had a positive and significant ($p<0.01$) effect on the likelihood of drought coping through changing livestock mix. During droughts; the Swazi government provides relief in the form of food, hay, water in very dry areas, and food for work in the less hard hit areas. Being provided with basic food amenities may encourage farmers to make an effort to keep their livestock through trading their les resistant livestock for hardy species such as goats. When farmers do not have to worry about selling off their livestock to obtain food, they might come up with ways to save their livestock.

4.5 FARMERS' IMMEDIATE RESPONSES TO THE 2015/2016 EL NINO DROUGHT

The table below displays the actions farmers took when they realised (based on late first rains) there was an imminent drought. It is important to note that these actions were taken either right before the farmer planted or (for a majority of farmers) when the maize crop had already been planted. Farmers were unaware of the drought, thus had not prepared any coping mechanisms to overcome it.

Table 4.13: Farmers' responses to the most recent drought

Strategy	Region's susceptibility to drought		Total
	More	Less	
Change planting dates	94 (82%)	35 (70%)	129 (78%)
No planting	8 (7%)	9 (18%)	17 (10%)
No action	2 (2%)	4 (8%)	6 (4%)
Irrigation	2 (2%)	2 (4%)	4 (2%)
More chemicals	3 (3%)	0	3 (2%)
Change crop type	2 (2%)	0	2 (1%)
Replanting	2 (2%)	0	2 (1%)
Conservation farming	2 (2%)	0	2 (1%)

Source: Survey data

When the drought hit; the strategy 78% of the farmers used was that of changing planting dates. These were the same results obtained in a study conducted in the Lowveld region of Swaziland where farmers were observed to adjust dates when signs of drought were noticed (Shongwe, 2013). This is because farmers claim that planting time is the most affected aspect of farming in a drought (Ndlovu, 2016). Late planting was more a reaction than a strategy, as farmers use the first rains to mark the start of a production season (Okonya, Syndikus and Kroschel, 2013). Due to the drought, however, first rains delayed thus farmers had to wait longer than usual. Even after the first rains commenced; the subsequent rains were not enough to sustain the crop full term. Ten percent of the farmers decided not to plant at all due to the delayed rains and the extremely high temperatures. Some farmers (4%) did not take any action at all and produced as they would in a normal production period. More farmers in the susceptible region adopted coping strategies compared to those in the other regions. Farmers were not willing to change their crop types to more drought tolerant crops, irrigate, replant, practice soil conservation, and apply more chemicals as an attempt to salvage their crop.

4.6 IMPACT OF THE MOST RECENT DROUGHT ON CROP AND LIVESTOCK PRODUCTION

This section will provide information on how the 2015/2016 drought affected respondents' crop and livestock production process. For crops; the focus will mainly be on maize production as it is the main crop produced in Swaziland. For livestock production; the impact on cattle, goats, and the chickens is discussed as they are the most widely kept livestock in Swaziland.

4.6.1 Impact of the drought on maize production

Maize is the staple crop in Swaziland, and all respondents in the sample grew maize as their main crop. The results in Table 4.6 below present the impact of the drought on the maize crop planted during the drought period. Drought impact is divided according to each of the regions' level of susceptibility to drought, and is expressed by the differences in kilograms per plot in the respective production periods. Table 4.7 presents the minimum and maximum yield values overall and in the two regions, together with the mode yield value in the respective regions.

Table 4.14: Impact of the drought on average maize yield

Region	Output in a normal production period	Output in the recent drought	Kg/ha lost due to the drought
	Kg/plot	Kg/plot	Kg/plot
More susceptible	42 (E216)	3.9 (E130)	38.1 (E216)
Less susceptible	44 (E216)	10.9 (E130)	33.1 (E216)
Overall	42 (E216)	6.07 (E130)	35.93 (E216)

Source: Authors elaboration and National Maize Council price data

**Plot size is equivalent to 15 by 5m. Farmers had varying numbers of plots allocated to maize*

**Price for a 50kg bag in the 2016/2017 production period is E216*

**Price for a 50kg bag in the 2015/2016 production period was E260*

**Emalangeni (E) is the official currency in Swaziland; and its value is equivalent to the South African Rand.*

Table 4.15 Minimum and maximum maize yield values for the sample

Regions	Output (kg/plot) normal period			Output in the 2015/2016 drought		
	Minimum	Maximum	Mode	Minimum	Maximum	Mode
More susceptible	0	320 E1180)	20 (E108)	0	48 (E216)	0
Less susceptible	4 (E108)	200 (E864)	20 (E108)	0	48 (E216)	0
Overall	0	320 E1180)	20 (E108)	0	48 (E216)	0

Source: Own calculations

All respondents produced maize during the drought; and producing in such conditions led to extreme reductions in yield. Farmers normally wait for the first rains to mark the beginning of a production season, but because of the drought commencement of rain was delayed by a period of three months. Farmers still produced in these conditions, all to realise that the normal rains that usually come after the first rains would not come at all. Temperatures were also extremely high, and this heightened evaporation rates thus leading to crop failure.

As a result of these extreme conditions, farmers either harvested very little maize or received nothing at all. The average decrease in yield was 35.93kg/ha; and this led to severe shortages of maize for individual households; which later culminated to shortages nationwide. These shortages were a result of a nationwide drop in maize production by 60% in the 2015/2016 production period. As displayed in Figure 3; losses in maize yields were severe. As a result of unpreparedness; crop failure was much more severe than it could possibly have been otherwise, and farmers experienced financial losses as they purchased inputs for production but later had to purchase maize and other food items from traders at a higher price than normal due to an increase in demand.

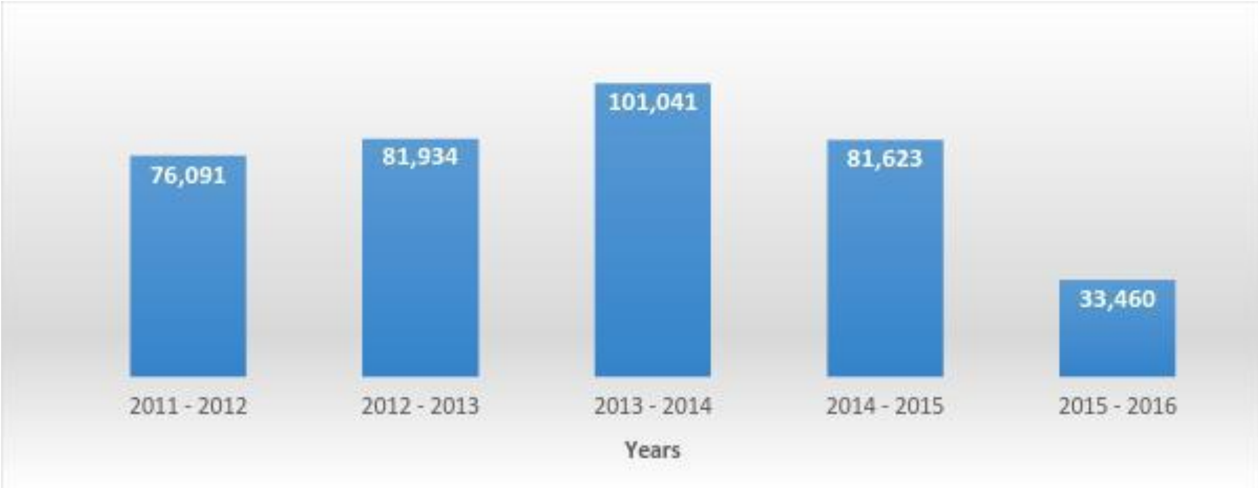

Figure 1: National Maize Production Trends

Adapted from the National Vulnerability Assessment Committee report (2016)

The impact of the drought was higher in the Lowveld and Lubombo regions (more drought susceptible regions), as they experienced higher losses in yield during the drought compared to a normal production season. Yield in these two regions dropped by 38kg/ha, whereas in the less susceptible region the decrease in yield was 33kg/ha. Some farmers replanted when they realised that germination rate was very low, but they experienced further losses as the drought worsened. Some farmers were willing to attempt to irrigate their maize crop; but had no implements and water levels were very low in the local rivers. When inquired about the impact of losing their staple food crop drought; some farmers stated that children had to drop out of school as money was redirected to purchasing food they usually grow in normal conditions.

4.6.2 Impact of the drought on general crop production

The table below displays information on the main crops that farmers grew during the drought period; and the impact of the drought on these crops according to farmers' experiences.

Table 4.16: Impact of the drought on general crop production

	Region's relative susceptibility to drought		**Total**
	More susceptible	**Less susceptible**	
Crops affected			
Maize	112 (97%)	49 (98%)	161 (97%)
Beans	2 (2%)	0	2 (1%)
Potatoes	0	1 (2%)	1 (1%)
Vegetables	1 (1%)	0	1 (1%)
Impact of the drought			
Crop died	85 (74%)	35 (70%)	120 (73%)
Reduced yield	24 (21%)	2 (4%)	26 (16%)
Crop stunted	1 (1%)	4 (8%)	5 (3%)
None	5 (4%)	9 (18%)	14 (8%)
Total	**115**	**50**	**165**

Source: Survey data

The 2015/2016 drought was severe in Swaziland, and this can be confirmed by the impact of the drought on respondents' crop production. Most farmers planted maize; and 73% of the respondents stated that their crop died due to the extremely high temperature and inadequate precipitation. Some farmers did get a small amount of yield (16%); but mentioned that yield was reduced considerably compared to normal, drought free production seasons. Only 8% of the respondents did not experience any losses due to the drought, and these were the farmers that either irrigated or replanted their crops. When the drought hit; the strategy 78% of the farmers used was that of changing planting dates, but 10% of the farmers decided not to plant at all. The drought was such a shock that farmers did not have any time to prepare and make decisions that would reduce the impact of the drought on production.

4.6.3 Impact of the drought on livestock production

Livestock production is an important aspect of subsistence farming in Swaziland. The three main types of livestock produced are cattle, goats and chickens. Table 4.8 presents farmers' responses when inquired about how the drought affected livestock production. Farmers were given the liberty to state their observations; and the most prevalent impacts were livestock deaths, weight loss, disease spread and no impact at all. The detailed results are presented below.

Table 4.17: Impact of the drought on livestock production

Type of livestock	**Impact**	**Region's susceptibility to drought**		**Total**
		More	**Less**	
Cattle	Death	45 (64%)	10 (29%)	55 (53%)
	No impact	12 (17%)	13 (39%)	25 (24%)
	Weight loss	9 (13%)	10 (29%)	19 (18%)
	Disease spread	4 (6%)	1 (3%)	5 (5%)
	Total	70 (67%)	34 (33%)	104
Goats	No impact	35 (57%)	11 (58%)	48 (57%)
	Death	16 (25%)	2 (10%)	18 (21%)
	Weight loss	8 (12%)	3 (16%)	11 (14%)
	Disease spread	3 (5%)	3 (16%)	6 (7%)
	Reduced reproduction	1 (1%)	0	1 (1%)
	Total	65 (76%)	19 (24%)	84
Chickens	No impact	94 (70%)	29 (58%)	111 (82%)
	Disease spread	5 (4%)	9 (18%)	14 (11%)
	Weight loss	3 (3%)	3 (6%)	6 (4%)
	Death	4 (4%)	0	4 (3%)
	Total	94 (70%)	41 (30%)	135

Source: Survey data

For respondents that kept cattle; 53% experienced loss through death from both extremely high temperatures and lack of feed and water. Cattle have been cited as the most vulnerable livestock to drought, as there are usually more cattle deaths compared to other livestock (Gamedze, 2006). Other respondents reported that there was no impact on their cattle; and most of these farmers were from the less vulnerable region or those from the vulnerable region that had purchased feed for cattle before the drought worsened. Farmers in the less vulnerable region experienced less cattle deaths compared to the other regions. Cattle were the most affected and most vulnerable livestock kept; as a majority (82%) of farmers that also kept chickens stated that the drought had no impact on them. Only 10% of chicken farmers expressed concern over perpetuated disease spread as a result of the drought. According to the respondents; chickens are easier to manage and feed during drought periods compared to cattle. Most farmers even constructed shelter and bought feed for their chickens, and this contributed to their surviving extreme conditions.

4.7 FARMERS' PREPAREDNESS FOR FUTURE DROUGHT INCIDENCES

Drought is not a preventable phenomenon; but it can be dealt with in such a way that farmers suffer less losses when it occurs through well planned drought preparedness strategies. Preparedness increases farmers' resilience to drought, and empowers them to cope better with it when it eventually occurs (Sohl and Ghinkel, 2014). The respondents in the study suffered major losses as a result of lack of preparedness, thus they could only react to the drought and attempt to cope with it to no success. In a bid to encourage farmers to prepare for future imminent droughts; they were requested to provide information what they were willing to do to cushion themselves against them. Farmers were asked questions on if they were willing to take long term farming decisions such as using alternative water sources to irrigate, change crop type, change livestock mix, provide shelter for livestock, purchase hay, or migrate if droughts become a norm in the next ten years. Table 4.18 displays farmers' responses.

Table 4.18: Long term farming decisions farmers are willing to take to cope with possible future droughts

Farming decisions farmers are willing to take	Region's relative susceptibility to drought		Total
	More susceptible	Less susceptible	
Alternative water supply	30 (26%)	25 (50%)	55 (33%)
Change crop type	94 (82%)	30 (60%)	124 (75%)
Change livestock	74 (64%)	10 (20%)	84 (51%)
Livestock shelter	75 (65%)	14 (28%)	89 (54%)
Purchase hay	81 (70%)	14 (28%)	95 (58%)
Migrate	60 (52%)	10 (20%)	70 (42%)

Source: survey data

As shown in Table 4.18 above; farmers were willing to apply all the adaptation options except for the use of alternative water sources. Sixty-seven percent of the respondents are not willing to use alternative water sources if droughts persist. They expressed concern regarding the fact that purchasing water is costly, therefore this option is not realistic for them (Shongwe, 2013). More farmers from the drought tolerant region were willing to explore other sources of water because not all water sources are compromised during a drought, as is the case of drought prone regions.

With regards to farming more drought tolerant crops; 75% of the farmers are willing to change from maize to crops such as sweet potatoes and beans, but they expressed concern over the fact that no crop is spared during drought periods, as it compromises crop production in general. Farmers did seem reluctant to shift from maize farming as it is the staple food in Swaziland, but due to the 2015/2016 drought farmers had first-hand experience of severe crop losses and realized the vulnerability of maize to severe drought conditions. Farmers from the hard hit areas were more willing to switch to more drought tolerant crops, and this can be attributed to the wealth of information these farmers have from government agencies that train farmers from regions that are vulnerable to drought incidences. These farmers have adapted to these conditions as their areas are dry even in drought free periods.

Farmers are also willing to provide shelter for their livestock if extreme drought conditions persist and purchase hay to supplement lack of grazing, but as with changing livestock type, more farmers from the drought prone region were willing to make these adjustments compared to those in less drought prone areas. The same trend applied to migration, as less farmers in the less susceptible region were willing to migrate their livestock; mainly because farmers in drought susceptible areas migrate their cattle to farmers in regions that are considered to be better than theirs in terms of water availability. This might also be due to the fact that thousands of cattle were lost mainly in the drought prone region, whereas the less vulnerable region experienced major crop losses, but there were no major livestock losses for the most part.

In general; as with adoption of strategies to cope with historic incidences of drought; farmers in the more susceptible region were more willing to adopt adaptation strategies compared to those in the less susceptible region. The situation was the same for farmers in irrigated and non-irrigated agriculture in India; as farmers who had less secure access to water were more equipped with strategies for coping with drought compared to those who had secure access to irrigation water (Ichikawa, Manadhar, and Kiem, 2014). The only strategy farmers in the more susceptible region were not keen on was that of using an alternative water supply, and they expressed concern over the fact that water scarcity is normal even in drought free periods, and worsens during severe droughts.

4.8 FARMERS' PERSPECTIVES ON HOW THEY COULD BE FACILITATED TO BETTER DEAL WITH FUTURE DROUGHT INCIDENCES

Table 4.19: Interventions farmers would like in place to deal with drought

Provider	Intervention	Region's relative susceptibility to drought		Total
		More susceptible	Less susceptible	
Government	Food	56 (49%)	30 (60%)	86 (52%)
	Inputs	18 (16%)	6 (12%)	24 (15%)
	Dams	14 (12%)	6 (12%)	20 (12)
	Water	17 (15%)	1 (2%)	18 (11%)
	Money	3 (2%)	3 (6%)	6 (4%)
	No discrimination	3 (2%)	1 (2%)	4 (2%)
	Water access laws	0	2 (4%)	2
	Grain Storage	0	1 (2%)	
	Education	2 (2%)	0	
	Business start up	2 (2%)	0	
Government 2*	Water	24 (30%)	6 (14%)	30(24%)
	Money	6 (8%)	23 (52%)	29(23%)
	Dams	15(19%)	7 (16%)	22 17%)
	Inputs	15 (19%)	2 (5%)	17 (14%)
	Food	10 (12%)	0	10 (8%)
	Education	5 (6%)	1 (2%)	6 (5%)
	Business start-up	3 (4%)	3 (7%)	6 (5%)
	Water access laws	1 (1%)	1 (2%)	2 (2%)
	Grain Storage	1 (1%)	0	1 (1%)
	No Discrimination	0	1 (2%)	1 (1%)

Source: survey data

*Only 80 farmers had two suggestions for interventions

Table 4.17 above represents farmers' opinions on how the government could help in the long run as drought conditions become more frequent. Farmers provided suggestions on how best the government could be of assistance, and most farmers had one option, but some provided two options (the second option displayed in Table 4.17 as “government 2”). Most farmers, however, preferred short term interventions that do not serve to sustain agricultural production in the long run such as food, water and money. More farmers from the drought prone region selected interventions of a more sustainable agricultural production nature, whereas those in the less susceptible zone preferred relief based measures. These strategies lead to dependence on aid rather than resilience to drought conditions (Manyatsi, 2010). To a lesser extent, farmers did suggest provision of dams and grain storage facilities to provide water for irrigation and grain storage during drought free production periods. This expresses the need to train farmers and equip them to be less dependent on food aid through practising more drought tolerant production methods.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The general objective of the study was to understand how livelihoods of poor, rural, smallholder farming communities in different agro-ecological locations in Swaziland can be made more resilient in the face of recurrent droughts through understanding their behavioural responses to drought. To achieve this; the country was divided into two broad agro-ecological locations: drought susceptible regions (the Lubombo and Lowveld regions) and less susceptible areas (the Middleveld and Highveld regions). Farmers' perceptions and behavioural responses in both regions were determined through the use of face to face interviews and a questionnaire so as to determine differences in behavioural responses in the two regions. These differences were investigated using the following indicators: behavioural responses to perceived long-term changes in temperature and precipitation; the impact and behavioural responses to the most recent drought event; how farmers would have responded if they had ex ante information of the most recent drought event; private investment in anticipation of future drought events; and finally the public investments they would like implemented in anticipation of future drought events.

To determine if differences in behavioural responses to drought were significant across the two regions; chi square tests were conducted. For those strategies that were significantly different across the two regions, binary probit regression was performed to determine factors that affect farmers' selection of these strategies. These factors were mainly socioeconomic, socio-demographic, biophysical, and policy variables. This chapter will therefore provide information on the conclusions, recommendations and policy implications, and limitations for further research of the study.

5.2 CONCLUSIONS OF THE STUDY

Farmers perceive climate change variability; but their responses are clouded by context (location), path dependency, and wealth. Some farmers are willing to adopt strategies such as construction of livestock shelter to protect animals from climate extremes, but cannot afford the material to do so. Path dependency and context result in farmers not being keen to explore new methods of farming, and farmers in the relatively more drought prone regions tend to easily give up as no agricultural enterprises survive the severe droughts they experience. Those in better areas are not accustomed to severe drought conditions, thus it takes a longer time for them to be open to adjusting their farming patterns to climate change. This leads to the conclusion that farmers in areas with varying degrees of drought vulnerability react differently to drought incidences, thus policies aimed at reducing drought impacts and preparing farmers for future imminent droughts should cater for such differences.

The impacts of the drought on farmers were severe (thousands of cattle deaths and crop losses), and could have been prevented with proper prior information and preparation. Due to lack of prior information; farmers were rendered helpless as they were caught off guard and thus ill prepared for a severe drought. Strategies farmers would have applied if they had received prior information include changing crop type, changing livestock mix, and purchasing hay. As much as prior information might seem like a panacea; farmers do not accept projections from climate experts, and they would rather use their own experience in agriculture to decide whether they should continue farming or not. Technology has allowed for better warning systems, therefore efforts should be made to change farmers' views on technology based projections.

Factors that affected farmers' choice of drought coping strategy in the last ten years of climate variability were determined using Chi square (x^2) tests and bivariate probit analysis. These factors were mainly policy related; and these included extension services, willingness to proceed with farming in the event of a drought, and the need for credit. Other factors included region (location), income source, and age. Strategies that were significantly different across the two agro-ecological zones were altering livestock mix, purchasing hay, livestock migration, purchasing water, and construction of livestock shelter. These are strategies that make a difference in terms of drought adaptation as they are not temporary adjustments but help farmers prepare for future drought incidences, thus farmers need to adopt these in their farming enterprises.

Climate change has increased the frequency of drought incidences; and it is to a farmer's advantage to apply private precautions that will serve to cushion them from the impacts of drought. A majority of farmers, after being subject to recent climate extremities, are willing to invest in precautions that will reduce the relative impacts of drought on crop and livestock production. As a result; farmers are willing to change their crops from maize to drought tolerant crops such as sorghum, change livestock mix from predominantly keeping cattle to more resilient livestock such as chickens, provide shelter for livestock, and purchase hay. However; a majority of farmers willing to adopt these strategies were from the more vulnerable areas. To prevent increased losses from drought in areas previously less affected by droughts; farmers from these areas need to be encouraged to consider adaptation measures so as not to increase the reach of drought as climate change persists over time.

Another important aspect of farmers' drought coping and adaptation is their outlook on how best they can be equipped for future drought incidences through public investments. Farmers perceptions on interventions by government emphasize the importance of training and information dissemination on drought coping and adaptation; as a majority of farmers preferred relief oriented solutions to imminent drought impacts. Some of these included food, water, and money, and these are basic relief measures that farmers are normally provided with in extreme drought episodes. A few farmers mentioned the need for long term interventions such as community grain storage facilities to store grain in drought free periods and water storage facilities, but generally farmers preferred short term interventions from government.

5.3 RECOMMENDATIONS AND POLICY IMPLICATIONS

Based on the results, it is recommended that farmers be provided with more drought coping and adaptation information before and during drought periods. In addition to this; extension services should not only be on a request basis. Community members meet on a weekly basis in almost every constituency in Swaziland; and such gatherings can be used by extension officers to equip farmers on emergent issues in agriculture. Besides such meetings, media outlets accessible to farmers should not only provide daily weather information, but also train farmers on drought coping and adaptation. Investments in technology that improves information dissemination should also be explored. Every farmer in the sample had a mobile phone, and these can be used to provide information through short message services (SMS) to give farmers regular updates on important information.

Organizations such as National Disaster Management Agency (NDMA) and Swaziland Water and Agricultural Enterprise (SWADE) do provide information on drought coping and adaptation to selected areas in the drought susceptible areas in the country such as Siphofaneni and Lonhlupheko. It is recommended that the scope of such services be widened to cater for other areas that are considered to be less prone to drought incidences. With recurrent droughts, zones that are considered drought tolerant are now part of the affected areas. Therefore, there should be no excluded areas when it comes to trainings and information dissemination on drought coping and adaptation. Lastly, the Government of Swaziland needs to help farmers not only with food parcels that help them survive drought periods; but also farm related material such as drought tolerant seeds and irrigation equipment where water is available.

5.4 LIMITATIONS OF THE STUDY AND AREAS FOR FURTHER RESEARCH

Some of the major limitations of the study included time constraints and logistics. The researcher would have preferred to obtain a larger sample for better representation of various farming conditions; especially in remote areas. However; it was difficult to organise farmers in some areas without the help of governmental organizations. This is because farmers are no longer interested in participating in academic studies as they claim that they are of no benefit to their farming enterprises. Door to door interviews were also challenging due to logistics, as only farmers in areas that were accessible via public transportation could be included in the sample. Farmers in secluded areas have a wealth of information on drought incidences, but are hard to reach.

Areas of further research would be to carry out a study on fool proof, affordable agro-ecological zone specific farming methods farmers can apply moving forward to cushion against drought. Also, further studies should incorporate locus of control as a determining factor regarding farmers' behavioural responses to drought incidences, as it has been proven to affect farmers' decision making process (Abay K.A., Blalock, G., and Berhane, G. (2017)). Lastly; the exact economic losses due to drought should be quantified so that farmers can accurately weigh their options when deciding to continue with farming during drought periods.

List of References

Abay K.A., Blalock, G., and Berhane, G. (2017). Locus of Control and Technology adoption in developing country agriculture: Evidence from Ethiopia. *Journal of Economic Behaviour and Organization, 143, 98-115.*

Ade A.T. and Bosede S.J., 2017. Ordered Probit Analysis of Factors Influencing Farmers' Contributions to Climate Change Adaptation Decisions in Southwest Nigeria. *Trends in Agricultural Economics, 10: 1-11.*

Allahyari, M.S., Ghavami, S., Masuleh, Z.D., Michailidis, A., and Nastis, S.A., 2016. Understanding Farmers' Perceptions and Adaptations to Precipitation and Temperature Variability: Evidence from Northern Iran. *Climate 2016, 4: 58.*

Alston M. and Kent J., (2004*). Social Impacts of Drought: A report to NSW Agriculture.* Centre for Rural Social Research, Wagga Wagga, N.S.W.

Antwi-Agyei, Fraser, Dougill, Stringer, and Simelton, 2011. Mapping the Vulnerability of Crop Production to Drought in Ghana using Rainfall, yield, and socioeconomic data. *Centre for Climate Change Economics and Policy: University of Leeds. Applied Geography 32:324-334.*

Apata, 2011. Factors influencing the perception and choice of adaptation measures to climate change among farmers in Nigeria. Evidence from farm households in Southwest Nigeria. *Environmental Economics 2 (4).*

Arunrat, N., Wang, C., Pumijumnong, N., Sereenonchai, S., Cai, C., 2017. *Farmers' intention and decision to adapt to climate change: A case study in the Yom and Nan basins, Phichit province of Thailand.* [Online] Available from: http://www.sciencedirect.com.uplib.idm.oclc.org/science/article/pii/S0959652616321138. [Accessed: 28 March 2018]

Ashraf, M; Routray, J.K; Saeed, M., 2014. *Determinants of farmers' choice of coping and adaptation measures to the drought hazard in northwest Balochistan, Pakistan.* [Online] Available from:
http://search.proquest.com.uplib.idm.oclc.org/docview/1865246830?OpenUrlRefId=info:xri/sid:wcdiscovery&accountid=14717. [Accessed: 12 May 2017]

Bhebe B.O., 2014. *Assessing Non-Governmental Organizations' (NGO's) drought risk management strategies in Gwanda District, Zimbabwe*. Retrieved from: http://hdl.handle.net/11660/7542 [Accessed: 15 January 2018.]

Bishaw B., Neufeldt H., Mowo J., Abdelkadir A., Muriuki J., Dalle G., Assefa T., Guillozet K., Kassa H., Dawson I.K., Luedeling E., and Mbow C.. 2013. *Farmers' Strategies for Adapting to and Mitigating Climate Variability and Change through Agroforestry in Ethiopia and Kenya*. Forestry Communications Group, Oregon State University, Corvallis, Oregon.

Butt, B., Shortridge, A., and WinklerPrins M.G.A. *Pastoral Herd Management, Drought Coping Strategies, and Cattle Mobility in Southern Kenya.* Annals of the Association of American Geographers 99 (2): 309-334.

Deressa T. T., Hassan, R. M., and Ringler C.R., 2010. Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *The Journal of Agricultural Science, 149 (1), 23-31.*

Diggs D., 1991. Drought Experience and Perception of Climate Change among Great Plains Farmers. *Great Plains Research: A Journal of Natural and Social Sciences.*

Eklund, L., and D. Thompson. 2017. Differences in resource management affects drought vulnerability across the borders between Iraq, Syria, and Turkey. *Ecology and Society 22(4):9.*

Etwire P.M., Al-Hassan R.M; Kuwornu J.K.M.; Osei-Owusu Y., 2013. Smallholder Farmers' adoption of technology for Adaptation to Climate Change in Northern Ghana. *Journal of Agricultural Extension and Rural Development; 5(6):121-129.*

FAO (Food and Agricultural Organization), 2007. *Swaziland.* [Online] Available from: http://www.fao.org/nr/water/aquastat/countries_regions/swz/SWZ-CP_eng.pdf
[Accessed 10 April 2017]

FAO (Food and Agricultural Organization), 2008. *Special Report: FAO/WFP Crop and Food Supply Assessment Mission to Swaziland*. [Online] Available from:
http://www.fao.org/docrep/010/ai471e/ai471e00.htm. [Accessed: 10 April 2017]

Food and Agricultural Organization, undated. *Livestock losses and post-drought rehabilitation in Sub-Saharan Africa.*
Available from: http://www.fao.org/wairdocs/ILRI/x5439E/x5439e02.htm#effects of drought on the farming sector. [Accessed: 10 March 2017]

Ford J.D., Smit, B., & Wandel, J., 2005. Vulnerability to climate change in the Arctic: A Case Study from Arctic Bay, Canada. *Global Environmental Change 16 (2006) 145- 160.*

Grawal A., Kononen M, Perlin N., (2009). The role of local institutions in adaptation to climate change. Washington, D.C.: World Bank.

Guha-Sapir, D, Hoyois Ph., & Below, R. (2013). *Annual Disaster Statistical Review 2012: The numbers and trends. Centre for Research on the Epidemiology of Disasters*. [Online] Available from: http://www.cred.be/sites/default/files/ADSR_2012.pdf. [Accessed: 29 June 2017]

Hadgu G., Tesfaye K., Girma M., Kassa B., 2015. Farmers' climate change adaptation options and their determinants in Tigray Region, Northern Ethiopia. *African Journal of Agricultural Research. 10 (9): 956-964.*

International Food Policy and Research Institute (IFPRI), 2009. *Economic Losses and Poverty Effects of Droughts and Floods in Malawi*. IFPRI Discussion Paper.

Kirsten J.F. & Van Zyl, 1998. *Defining small-scale farmers in the South African context* http://ageconsearch.umn.edu/record/54898/files/26%20Kirsten%20_%20van%20Zyl%20-%20December%201998.pdf [Accessed: 11 January 2018]

Kongolo and Dlamini, 2012. *Small* - Scale Livestock Farming in Developing Areas of Swaziland and South Africa. *African Journals Online 1(3): 100-101.*

Lien, 2008. *Determinants of part-time farming and its effect on farm productivity and efficiency*. [Online]
Available from: http://ageconsearch.umn.edu/record/6701/files/cp08li01.pdf. [Accessed 7 November 2017].

Manyatsi A.M., Mhazo N., & Masarirambi M.T., 2010. Climate Variability and Change as Perceived by rural communities in Swaziland. *Research Journal of Environmental and Earth Sciences 2(3): 164-169.*

Masarirambi & Oseni (2011). *Effects of Climate Change on Maize (Zea Mays)* [Online] Available from:
http://hpccc.gov.in/PDF/Agriculture/Effect%20of%20Climate%20Change%20on%20Maize%20(Zea%20mays).pdf

Masendeke S., and Shoko K., 2013. *Drought Coping Strategies and their effectiveness: The Case of Ward 12 in Mberengwa District Zimbabwe*. [Online] Available from: http://dx.doi.org/10.11114/ijsss.v2il.299 [Accessed: 12 March 2017].

Mavuso S.M., Manyatsi A.M., Vilane B.R.T., 2015. *Climate Change Impacts, Adaptation and Coping Strategies at Malindza, a Rural Semi-Arid Area in Swaziland*. [Online]. Available from: doi: 10.11648/j.ajaf.20150303.14 [Accessed: 12 May 2017]

Mdungela M.N., Bahta Y.T., and Jordaan A.J., 2016. *Farmers' Choice of Drought Coping Strategies to Sustain Productivity in the Eastern Cape Province of South Africa*. [Online] Available from: www.mdpi.com/books/pdfdownload/article/10/1 [Accessed: 13 May 2017]

Mubiru, 2010. *Climate change and adaptation options in Karamoja.* Available from: http://www.fao.org/fileadmin/user_upload/drought/docs/Karamoja%20Climate%20Change%20and%20Adaptation%20Options.pdf [Accessed: 15 July 2017].

Mpandeli, S. & Maponya, P., 2014. *Constraints and Challenges facing the Small Scale farmers in Limpompo Province, South Africa*. [Online] Available from: https://www.researchgate.net/publication/269687532 [Accessed: 13 December 2017]

Mulwa C., Marenya P., Rahut D.B., Kassie M., 2017. *Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics*. Available from: https://ac.els-cdn.com/S2212096317300062/1-s2.0-S2212096317300062-main.pdf?_tid=46e757f2-cab0-11e7-999c-00000aab0f26&acdnat=1510824591_bef2f968afed79766e3ac0f416a06e94 [Accessed: 24 April 2017]

Mungatana E., 2017. *Impacts of drought induced water shortages in South Africa: An Economic Analysis*. Unpublished paper. [Accessed: 22 March 2017].

Ndamani, F., and Watanabe, T., 2016. *Determinants of farmers' adaptation to climate change: A micro level analysis in Ghana*. [Online]. Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S010390162016000300201&lng=en&nrm=iso>. ISSN 0103-9016.

National Disaster Management Agency (NDMA), 2016. *Swaziland National Drought Response*. Retrieved from: http://ndma.co.sz/wp-content/uploads/2016/06/Final-Report-Swaziland-National-Drought-Response-Situation-07-June-2016-draft-004.docx

National Disaster Management Agency, 2015. *National Emergency Response, Mitigation and Adaptation Plan.* Available from: https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/swaziland_national_emergency_response_mitigation_and_adaptation_plannermap1_1-2.pdf

Ndlovu B., 2014. *Drought Coping Strategies at Mutasa District in Zimbabwe.* [Online] Available from: http://www.ufs.ac.za/docs/librariesprovider22/disaster-management-training-and-education-centre-for-africa-(dimtec)-documents/dissertations/2295.pdf?sfvrsn=2
Accessed: 29 March 2017.

Nhemachena C., Hassan R., 2007. Micro-Level Analysis of Farmers' Adaptation to Climate Change in Southern Africa. *IFPRI Discussion Paper 00714*.

Nhemachena C., Hassan R., Chakwizira J., 2014. Analysis of Determinants of farm level Adaptation Measures to Climate Change in Southern Africa. *Journal of Development and Agricultural Economics.* 6 (5): 232-241.

NOAA National Weather Service, 2008. *Drought Public Fact Sheet.* Available from: http://www.nws.noaa.gov/os/brochures/climate/Drought2.pdf

Obayelu A.O., Adepoju A.O., Idowu T., 2014. *Factors influencing farmers' choices of adaptation to climate change in Ekiti State, Nigeria.* Journal of Agricultural and Environment for International Development 108 (1): 3-16

O'Farrell P.J., Andersonb P.M.L., Miltonc S.J., and Dean W.R.J. *Human response and adaptation to drought in the arid zone: lessons from southern* Africa. South African Journal of Science 105: 1:2

Ogalleh S.A., Vogl C.R., Eitzinger J., and Hauser M., 2012. Local Perceptions and Responses to Climate Change and Variability: The Case of Laikipia District, Kenya *Sustainability 4 (12); 3302-3325.*

Okonya, Syndicus, and Kroschel; 2013. *Farmers' Perception of and Coping Strategies to Climate Change: Evidence from Six Agro-ecological Zones in Uganda.* Available from: http://www.ccsenet.org/journal/index.php/jas/article/viewFile/26639/17280
[Accessed : 8 March 2018]

Opiyo, F., Wasonga, O., Nyangito, M. et al., 2015. Drought Adaptation and Coping Strategies among the Turkana Pastoralists of Northern Kenya. *International Journal of Disaster Risk Science 6 (3): 295-309.*

Pacific Institute, 2014. *Agricultural Water Conservation and Efficiency Potential in California.* [Online] Available from: https://www.nrdc.org/sites/default/files/ca-water-supply-solutions-ag-efficiency-IB.pdf [Accessed: 2 February 2017]

Pandey, S., Bhandari, H., and Hardy, B., 2007. *Economic costs of drought and rice farmers' coping mechanisms: a cross-country comparative analysis* [Online] Available from: http://books.irri.org/9789712202124_content.pdf [Accessed: 22 March 2017]

Ranjan, R., 2011. *Drought Resilient Strategies*. [Online] Available from: https://works.bepress.com/ram_ranjan [Accessed: 1 November 2017]

Roco and Engler, 2015. *Farmers' perception of climate change in Mediterranean Chile*. [Online] Available from: http://zwickcenter.uconn.edu/journal_reprints_55_2433008449.pdf [Accessed: 15 November 2017].

Sankhala G., Singh, M., Kant K., Prasad K., 2016. Drought coping strategies followed by dairy farmers in Bundelkhand region of Uttar Pradesh. *Indian Journal of Animal Sciences 86 (10): 1181-1186.*

Seo, N., and R. Mendelsohn. 2006. *Climate change adaptation in Africa: A Microeconomic Analysis of Livestock Choice*. CEEPA Discussion Paper No. 19. Centre for Environmental Economics and Policy in Africa.

Shongwe P., Manyatsi A.M., Masuku M.B., 2013. Cost benefit analysis of Climate Change Adaptation Strategies on Crop Production Systems: A Case of Mpolonjeni Area Development Programme (ADP) in Swaziland. *Sustainable Agriculture Research* 3(1): 37-48.

Stefanski R., 2006. *Overview of Drought Preparedness and Coping Strategies.* [Online] Available from: http://www.wamis.org/agm/meetings/etdret09/WOS3-Stefanski.pdf [Accessed: 27 January 2017]

Swaziland Drought Assessment Report (2016). *Swaziland Rapid Assessment Report.* [Online] Available from: www.humanitarianresponse.info/en/operations/swaziland/document/swaziland-drought-assessment-report-20152016-season. [Accessed: 12 December 2017]

Tazeze A., Haji J., Ketema M., 2012. Climate Change Adaptation Strategies of Smallholder Farmers: The Case of Babilie District, East Harerghe Zone of Oromia Regional State of Ethiopia. *Journal of Economics and Sustainable Development* 3(14).

Thiongo K., Ngaira J.K.W., China S., 2014. Strategies used by farmers to cope with drought in Machakos County, Kenya. *International Journal of Applied Management Science 2(6):1-10.*

Uddin N., Bokelmann W., and Entsminger J.S, 2014. Factors Affecting Farmers' Adaptation Strategies to Environmental Degradation and Climate Change Effects: A Farm Level Study in Bangladesh Mohammed. *MDPI Climate 2(4): 223-241.*

Udmale P., Ichikawa Y., Manandhar J., Ishidaira H., Kiem, S.A, 2014. Farmers' perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. *International Journal of Disaster Risk Reduction 10(A): 250-269.*

UNDP, (2004). United Nation Development Programme in South Africa (Press release)

Van Duinen R., Filatova T., Geurts P., Van der Veen, A., 2015. *Coping with drought risk: Empirical analysis of farmers' drought adaptation in the South-West Netherlands.* [Online] Available from: http://doc.utwente.nl/96872/1/art_10.1007_s10113-014-0692-y.pdf [Accessed: 10 March 2017].

Vilane B.R.T, Manyatsi A.M, & Shabangu K., 2015. Drought coping strategies at Lonhlupheko Community, a semi-arid rural area in Swaziland. *African Journal of Agricultural Research 10(8): 783-758.*

Wilhite, Svoboda, and Hayes; 2007. *Understanding the Complex Impacts of Drought: A Key to Enhancing Drought Mitigation and Preparedness.* [Online] Available from: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1042&context=droughtfacpub Accessed: 27 March 2017.

WFP (World Food Programme), 2016. The Kingdom of Swaziland: Humanitarian Needs Overview. [Online] Available from: https://reliefweb.int/sites/reliefweb.int/files/resources/swaziland_hno_11042016.pdf [Accessed: 25 March 2018]

Wooldridge J., 2012. *Introductory Econometrics, A Modern Approach,* 5th edn, Cengage Learning, Canada.

Wreford A, Adger, W N, 2010. Adaptation in agriculture: historic effects of heat waves and droughts on UK agriculture. *International Journal of Agricultural Sustainability 8(4): 278-289.*

APPENDIX A: LETTER OF CONSENT

Informed consent for the participation in an academic research study.

Department of Agricultural Economics, Extension and Rural Development

AGRO-ECOLOGICAL LOCATION OF FARMS AND CHOICE OF DROUGHT COPING STRATEGIES OF SMALLHOLDER FARMERS IN SWAZILAND

Research conducted by:

Miss T.A. Khumalo (16182775)

Cell: +268 76341948

Dear respondent

You are invited to participate in a research study conducted by Temndeni Khumalo, a Masters student from the Department of Agricultural Economics, Extension and Rural Development at the University of Pretoria.

The purpose of the study is to investigate smallholder farmers' behavioural responses to drought in Swaziland.

The study aims to address the following questions;

1. Do agro-ecological location matters in the way farmers respond to perceived historical changes in temperature and precipitation?
2. Are there significant differences in drought impacts across agro-ecological locations in Swaziland
3. Are there statistically significant differences in farmers' hypothetical responses to the most recent drought in the event that they had received reliable ex-ante information?
4. What are farmers' private investments in anticipation of future drought events; and do these differ across agro-ecological locations?
5. What public investments (by the government and non-governmental organizations) would farmers like implemented in anticipation of future drought events?

Participation in this survey involves responding the questions that will be asked and this should take less than an hour. The questions require you to provide information on your household characteristics, assets, agricultural inputs, agricultural outputs, access to agricultural markets as well as any other information that relate to agriculture production. Please note the following when responding;

- This study involves an anonymous survey. Although your name will appear on the questionnaire, the information you provide will be treated strictly as confidential.
- Your participation in this survey is very important to us and the study. However, this is a voluntary exercise and you may choose not to participate and you may stop participating at any time without negative consequences.
- Please respond to the questions as honestly as possible.
- The results of this study are solely for academic purposes as well as influencing policies that impact on agriculture and may be published in academic journals. If interested, we will provide you with a summary of the results of this study.
- Please contact my supervisor, Prof E D Mungatana at eric.mungatana@up.ac.up if you have any queries or comments about the study
- Please sign this form to indicate that you understand the information provided above and that you are willing to participate in this study on a voluntary basis.

Respondent signature…………………………..Date…………

APPENDIX B: SURVEY INSTRUMENT

SECTION 1: INTERVIWEE INFORMATION, HOUSEHOLD HEAD CHARACTERISTICS, AND FARM INFORMATION

1.1 Name of interviewee	**1.2 Relationship to HH head**	**1.3 Primary source of income**	**1.4 Average monthly income (E)**
	1= Self 2= Wife 3= Husband 4= Manager 5= Parent 6= Child 7= Other	1= Farming 2= Other	

1.5 Age (years)	1.6 Gender	1.7 Marital status	1.8 Main Occupation	1.9 Education level	1.10 Household size
	1 = Female 2 = Male	1= Married 2= Never married 3=Divorced 4=Separated 5=Widowed	1 = Farmer 2 = Employed in private sector 3 = Civil servant 4 = Trader 5 = Not in the labour force 6 = Other (specify):	1 = Primary level 2 = Secondary level 3 = Tertiary certificate 4 = Tertiary diploma 5 = First degree 6 = Postgraduate 7 = No formal education	**Adults:** 18 years and above: ______________ **Children:** 17 years and below: _______________

Farm information

1.11 Years of farming experience	1.12 Number of maize fields	1.13 Number of fields for other crops	1.14 Three most important crops grown in the other fields	1.15 Crop farming system	
				Maize fields	**Other crops**
			(1) (2) (3)	(1) Mono-cropping (2) Mixed cropping, (3) Others (specify):	(1) Mono-cropping (2) Mixed cropping, (3) Others (specify):

SECTION 2: RESOURCES AND OTHER ENDOWMENTS

2.1 How many of the following assets did you own in the 2015/ 2016 production period? Please tick where applicable.

Farm Assets		**Year purchased**
2.11 Tractor		
2.12 Ox drawn plough		
2.13 Ox drawn planter		
2.14 Ox drawn trailer		
Transport-related Assets		
2.15 Motorbike		
2.16 Vehicle		
Appliances and Electronics		
2.17 Radio		
2.18 TV		
2.19 Mobile phone		

2.2 Further questions on asset ownership during the drought period

Please circle the appropriate response to the questions below. All questions refer to the 2015/2016 production season.

QUESTION/STATEMENT	**YES**	**NO**
3.21 Did you have **irrigation equipment** in the 2015/2016 production season?	YES	NO
3.22 Did you have **livestock shelter** in the 2015/2016 production season?	YES	NO
3.23 Did you have access to a **well or a borehole** in the 2015/2016 production season?	YES	NO
3.24 Did you have any **soil and water conservation structures** in the 2015/2016 production season?	YES	NO
3.25 Did you have **electricity** in the 2015/2016 production season?	YES	NO
3.26 Did you have a **computer** in the 2015/2016 production season?	YES	NO
3.27 Did you have **access to the internet** in the 2015/2016 production season?	YES	NO
3.28 Did you have any **crop insurance** in the 2015/2016 production season?	YES	NO

SECTION 4: CROP AND LIVESTOCK PRODUCTION INFORMATION

Interviewer: the questions that follow refer to the 2016/2017 **production year** (drought free period).

4.1 Crops

Crop type (please select)	**Quantity harvested**	**Input type**			
		Fertiliser (kg)	**Herbicides (kg)**	**Insecticides (l)**	**Seeds (kg or bundles)**
Maize (emagogogo[1])					
Beans (kg)					
Sweet potatoes (emagogogo)					
Potatoes (10kg sacks)					
Sorghum (kg)					
Other crop:					

[1]Emagogogo refers to 20L buckets farmers use as a unit of measurement when storing or selling their grain.

4.2 Livestock Production

In a normal production period; what type of livestock do you own?

Type of livestock	**Young**	**Mature**
Cattle		
Goats		
Chickens		

Other:____________		

Do you use external inputs for your livestock? **1. YES** **2. NO**

If yes, please fill in the table below:

Input types (e.g. chemicals)	**Quantity applied**

SECTION 5: EXTENSION, INFORMATION SERVICES, AND ACCESS TO CREDIT

5.1 Extension Services

This section focuses on the extension and advisory services you had access to in the 2015/2016 production season.

5.1.1 Did you utilize any kind of advisory or extension service on your farm? **1. YES** **2. NO**

5.1.2 Which of the following provided extension advice? 1**.** Government agency (national) 2.Government agency (regional/ local) 3.Cooperatives 4.Private extension group/NGO 5. Input companies 6. Marketing companies 7. Other ________________________________

5.1.3 Approximately how many times did they visit your farm? ____

5.1.4 Was the information obtained from extension officers of any significance in the most recent drought? **1. YES** **2. NO**

5.1.5 Please explain: ____

5.2 ACCESS TO CREDIT

5.2.1 During the 2015/16 production period; did you borrow from the following? 1**.** Relatives 2**.** Commercial banks 3**.**Farmer associations/ cooperatives 4**.**Thrift and loan society 5**.**Friends 6**.** Other____________

5.2.2 Did the drought increase or decrease the need to borrow? **1. YES** **2. NO**

SECTION 6: HISTORICAL PERCEPTIONS ON CLIMATE CHANGE

<u>Interviewer</u>: Temperature and rainfall patterns have been changing in the last few years. This has resulted in shifts in planting seasons, due to delays or early onset of the first rains. Temperature and rainfall directly influence agricultural activity, thus it is crucial for farmers to be aware of both and to further formulate counteractive measures to deal with shifts in temperature and rainfall patterns. The questions that follow refer to your perceptions on whether temperature and rainfall has been changing **in the last 10-15 years**, and if you have applied any adjustments in response to the changes brought about by climate change.

6. 1 TEMPERATURE		
6.1.1 Have you noticed any long term shifts in temperature in your farm area?	**YES**	**NO**
6.1.2 Has it become cooler or hotter?	**1. Cooler**	**2. Hotter**
6.1.3 What kinds of adaptations have you made to the temperature shifts you have perceived in the last 10-15 years?		
6.1.3.1 Crops		
i. Change of planting dates	**YES**	**NO**
ii. Change crop types	**YES**	**NO**
iii. Use different crop varieties (hybrid or genetically modified)	**YES**	**NO**
iv. Made irrigation investments (such as sprinkler and or groundwater pump)	**YES**	**NO**
v. Other: ____		
6.1.3.2 Livestock		
i. Alter livestock mix	**YES**	**NO**
ii. Invest in new breeds	**YES**	**NO**

iii. Build winter, spring, autumn, shelter for animals	**YES**	**NO**
iv. Make investment for water (such as digging wells)	**YES**	**NO**
v. Build storage for hay and fodder	**YES**	**NO**
vi. Migrate to new pasture	**YES**	**NO**
vii. Purchase livestock insurance	**YES**	**NO**
viii. Other	**YES**	**NO**
6.2 RAINFALL 6.2.1 Have you noticed any long term shifts in **rainfall** in your farm area?	**YES**	**NO**
6.2.3 Has it become drier or wetter?	**1. Drier**	**2. Wetter**
6.2.4 What kinds of adaptations have you made for rainfall shifts in the past 10-15 years?		
6.2.4.1 Crops		
i. Changed planting dates	**YES**	**NO**
ii. Changed crop types	**YES**	**NO**
iii. Use different crop varieties (hybrid or genetically modified)	**YES**	**NO**
iv. Made irrigation investments (such as sprinkler and groundwater pump)	**YES**	**NO**

6.2.4.2 Livestock		YES	NO
i.	Alter livestock mix	**YES**	**NO**
ii.	Invest in new breeds	**YES**	**NO**
iii.	Build winter, spring, and autumn shelter for animal	**YES**	**NO**
iv.	Made investment for water (such as digging well)	**YES**	**NO**
v.	Build storage for hay and fodder	**YES**	**NO**
vi.	Migrate to new pasture	**YES**	**NO**
vii.	Purchase livestock insurance	**YES**	**NO**
viii.	Other		
6.1.4 Why do you use the option selected?			
6.1.5 If none of the above was used, state reasons.			

SECTION 7: EXPERIENCE WITH THE MOST RECENT DROUGHT

Interviewer: The questions that follow specifically refer to the most recent drought **(2015/2016 production period).**

7.1 In section 4.1 you stated your harvest for a normal (drought free) production period. For the same crops; what was the specific impact of the drought, and how much did you harvest during the 2015/2016 production period?

Crop affected	Quantity harvested (2015/2016 period)	Nature of impact
Maize (emagogogo[1])		
Beans (kg)		
Sweet potatoes (emagogogo)		
Potatoes (10kg sacks)		
Sorghum (kg)		
Other crop:		

[1]Emagogogo refers to 20L buckets farmers use as a unit of measurement when storing or selling their grain.

7.2 Did you take any actions to minimize crop losses attributed to drought? **1. YES** **2. NO**

If **YES**, enumerate in the space provided below the actions you took:

____
____
____

7.2.1 What was the approximate expenditure on the actions you took?

____
____
____

7.2.2 If **NO**; please state reasons why:
____

7.4 In section 4.2; you stated the type of livestock you keep in a normal production period. Please state the effects of the drought on your livestock in the 2015/2016 production period:

Livestock affected	**Type of Impact**	**Number currently owned**	**Livestock Sold**	**Deaths**
Cattle				
Goats				
Chickens				
Pigs				
Other: ___________				

7.5 Did you get any support from government during the most recent drought? **1. YES** **2. NO**

7.5.1 If **YES**, enumerate in the space provided below the kind of support

____
____
____

7.6 Did you get any support from other agencies (e.g. NGOs) during the most recent drought? **1. YES** **2. NO**

7.6.1 If **YES**, enumerate in the space provided below the kind of support:

____
____
____

7.7 Interviewer: The questions that follow require you to assume that you had timely and reliable prior information on the 2015/16 drought. An example can be that of the **national meteorology department confirming in 2014 that there would be a severe drought in the 2015/16 production period**, and if this information would have affected your production decisions.

7.7.1 In your view, what are the advantages of warning farmers in advance about drought? ____

QUESTIONS		
7.7.2 If you had known; would you have proceeded to farm and rear livestock?	**YES**	**NO**
7.7.3 What would you have done differently in your production choices?		
7.7.3.1 Crops:		
i. Change of planting dates	**YES**	**NO**
ii. Change crop types	**YES**	**NO**
iii. Use different crop varieties (hybrid or genetically modified)	**YES**	**NO**
iv. Made irrigation investments (such as sprinkler and or groundwater pump)	**YES**	**NO**
v. Intercropping	**YES**	**NO**

vi.	Start water harvesting	**YES**	**NO**
vii.	Delay chemical usage	**YES**	**NO**
7.7.3.2 Livestock			
i.	Alter livestock mix	**YES**	**NO**
ii.	Invest in new breeds	**YES**	**NO**
iii.	Build winter, spring, autumn, shelter for animals	**YES**	**NO**
iv.	Make investment for water (such as digging wells)	**YES**	**NO**
v.	Build storage for hay and fodder	**YES**	**NO**
vi.	Migrate to new pasture	**YES**	**NO**
vii.	Purchase livestock insurance	**YES**	**NO**
viii. Other			
7.7.4 Why do you use the option selected?			
7.7.5 If none of the above was used, please state reasons.			

7.8 Interviewer: Due to the current climatic conditions; it has been predicted that climate change will result in more frequent droughts and other irregular shifts in weather patterns. This calls for proactive action to prepare for such conditions from all stakeholders involved, not only in the agriculture sector. The questions that follow require you to assume that **droughts will occur more frequently going forward in the future**, thus influencing your current production practices.

7.8.1 If drought incidences are predicted with certainty for the next ten years; would you proceed to farm? **1. YES** **2. NO**

7.8.2 What would you do differently in your **CROP PRODUCTION** choices?

7.8.2.1 Conservation farming **1. YES** **2. NO**

7.8.2.2 Invest in irrigation equipment **1. YES** **2. NO**

7.8.2.3 Invest in other sources of water other than surface water (e.g. ground water) **1. YES** **2. NO**

7.8.2.4 Change crop type permanently to more drought resistant crops such as sorghum **1. YES** **2. NO**

7.8.2.4 Other: ____

7.8.3 What would you do differently in your **LIVESTOCK PRODUCTION** choices?

7.8.3.1 Alter livestock mix to more drought tolerant animals such as goats **1.YES** **2. NO**

7.8.3.2 Permanently change breed of livestock reared **1. YES** **2. NO**

7.8.3.3 Build winter, spring and autumn shelter for animals **1. YES** **2. NO**

7.8.3.4 Build storage for hay and fodder **1. YES** **2. NO**

7.8.3.5 Migrate to new pasture **1. YES** **2. NO**

7.8.3.6 Purchase livestock insurance **1. YES** **2. NO**

7.8.3.8Other ____

7.8.4 What long term interventions would you like to see government implement in preparation for future droughts?

____

7.8.5 What long term interventions would you like to see the private sector/NGOs implement in preparation for future drought incidences?

____

8. Please provide any other general suggestions on drought, its mitigation and how it affects farmers and communities in general in the space provided below: ____

____

____

THANK YOU FOR YOUR TIME!