RESILIENCE OF HOUSEHOLDS TO AGRICULTURAL DROUGHT IN THE NORTHERN CAPE, SOUTH AFRICA

BY

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Submitted in accordance with the requirements for the degree

MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS

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DECLARATION

I declare that the research proposal hereby submitted for the degree of Master of Agricultural Economics at the Department of Agricultural Economics, in the faculty of Natural and Agricultural Sciences, University of the Free State, is my own independent work and has not previously been submitted by me for a degree at this or any other University. I furthermore cede copyright of this work to the University of the Free State. I, Ringetani Clementine Matlou, student number 2010143424, hereby declare that I am fully aware of the University of the Free State's policy on research ethics and I have taken every precaution to comply with the regulations. I have obtained an ethical clearance certificate from the University of the Free State Research Ethics Committee and my reference number is the following: **UFS-HSD2018/0597.**

Matlou R.C   Date

DEDICATION

This dissertation is dedicated to my parents, Phuthi and Mikateko Matlou, who have been so understanding and supportive throughout my education.

ACKNOWLEDGEMENTS

Firstly, I would I like to thank God for His everlasting and sufficient love, without Him I would not have made it this far (**Psalm 23 verse 1 to 6).**

Thank you to the National Research Foundation (NRF), Thuthuka funding instrument for their support and funding for this masters degree.

I would like to thank my supervisor, Dr. Yonas T. Bahta, for his guidance and encouragement. I would also like to thank Dr Abiodun Ogundeji for his support through the difficult times; when I felt like giving up, he encouraged me not to. Ntsako Maluleke, Brent Jammar and Moeletsi Donaldson Thari, thank you for assisting with my data collection, I really appreciate the good work you have done. Thank you to the following people: Ina Combrinck for her support during data collection, as stressful as it was but you simplified everything. I appreciate Mr. Petso Mokhatla for his support over the years. Tosho, Sebastian and Dr Enoch Owusu thank you very much with assisting with my data analysis and supporting and encouraging me throughout the year. To the Department of Agricultural Economics at the University of the Free State, thank you for believing in me.

I want to acknowledge the following extension officers, Malebogo Mocwiri, Tidimalo Tlhaloganyo, Boitumelo Mokemane, Andrie Farmer, Johan Le Roux and Modisaotsile Motlashuping from the Northern Cape Department of Rural Development and Land Reform for assisting with data collection and all the farmers who had participated in the study. To Thuso Mokwa and Reoagile Modise from Standard Bank, thank you for assisting with data collection. I want to thank Sydwell Lekgau and Tshifiwa Madima for sharing their knowledge and always encouraging me to pursue my dreams. I would like to thank my former colleagues at Potatoes South Africa, most specifically Dr André Jooste.

I would like to thank my parents, siblings and extended family for their encouragement and support throughout my studies. My son, Vunene, for being patient with me all the years I was not at home. Also, to Ashley, Thama, Racheal, Teboho, Innocent and Danail for their love, support and encouragement. Whenever I needed help, I knew I could always count on you. To my friends Fumani, Zimbini, Lutho, Reatile, August, Nqobile, Nontobelo, and Thobekile. Thanks to everyone who, directly or indirectly, contributed in this research.

ABSTRACT

The recurring drought is a major challenge to livestock smallholder farmers in the Northern Cape province of South Africa. The objective of the study was to determine household resilience to recurrent agricultural drought among smallholder livestock farmers by identifying strategies that affect these households resilience to agricultural drought, identifying factors that can be adopted by the farming households and other strategies which will assist farmers to absorb adverse welfare effects due to agricultural drought. This study used a mixed approach to collect data (primary and secondary data) with 207 smallholder farmers interviewed. The results show that most farming households in the Frances Baard District Municipality in Northern Cape were not resilient to agricultural drought. Drought resilience can be defined as the capacity of farmers to survive during a drought season or dry season or periods of low rainfall. Out of 207 smallholder farmers interviewed, only a few farming households were resilient to agricultural drought. Moreover, small-holder farmers refers to farmers that own small sizes of land, where they grow subsistence livestock and have limited resource endowment as compared to commercial farmers. A total of 189 farming households were non-resilient and vulnerable to agricultural drought, and only 18 were resilient. The study revealed that gender, educational level, financial support from relatives, being part of a co-operative, institutional support and government assistance are the significant factors that determine the resilience of a farming household to agricultural drought in the Frances Baard District Municipality. The study further shows that factors such as feed cost, other farming operational expenses and labour have a significant impact on the welfare of a farming household, whereas land tenure and agricultural drought resilience index were insignificant. Furthermore, one of the strategies that farming households adopt during dry periods is to sell their livestock to be able to feed the remaining livestock. During the 2015/2016 drought, farmers received coupons from the government to purchase feed. However, this initiative did not help much as most of the farmers had already started selling and losing (by death) their livestock. Based on the findings of this study, resilience of farming households to agricultural drought is a broad issue that needs comprehensive intervention.

Key words: Agricultural Drought, Resilience, Households, Livestock, Smallholder Farmers.

OPSOMMING

Langdurige droogte skep 'n reuse-uitdaging vir kleinboere in die Noord-Kaap provinsie van Suid-Afrika sover dit veestapels aanbetref. Die doel van hierdie studie was om huishoudings se vermoë om langdurige landboudroogtes onder kleinboere in die veebedryf te weerstaan deur faktore te identifiseer wat huishoudings se uithouvermoë teen droogte beïnvloed; en deur metodes te identifiseer wat deur die boerehuishoudings aangewend kan word om die aanhoudende nadelige invloed van sulke droogtes op hulle welstand en welvaart teen te werk. Hierdie studie het gebruik gemaak van 'n gemengde metode om inligting in te win (primêre en sekondêre data) waar onderhoude met 207 kleinboere gevoer is. Die navorsing het aangetoon dat die oorgrote meerderheid van huishoudings in die Noord-Kaap (Frances Baard Distriksmunisipaliteit) glad nie voorbereid was op landboudroogtes nie. Slegs enkele plaashuishoudings, vanuit 'n totaal van 207 waarmee onderhoude gevoer is, was in staat om weerstand teen droogtes te bied. 'n Totaal van 189 huishoudings was gladnie in staat om enige weerstand te bied nie; teenoor slegs 18 wat paraat was om weerstand te kon bied. Die studie het verder aangedui dat geslag, opvoedingspeil, finansiële bystand vanaf naasbestaandes, koöperasie-lidmaatskap, bystand vanaf ander instansies of die regering, die aanduidende faktore was om die weerstand van 'n boerehuishouding teen langdurige droogte in die Frances Baard Distriksmunisipaliteit te bepaal. Die studie het ook aangedui dat veevoerkoste, ander operasionele boerderyuitgawes en arbeidskoste, 'n aansienlike uitwerking op die plaashuishouding se welvaart het; waarteenoor eiendomsreg van die grond asook weerstand teen landboudroogte 'n onbeduidende invloed op die indeks getoon het.

Verder het dit ook geblyk dat boerehuishoudings geneig was om van hul vee te verkoop, om dan eerder veevoer vir die oorblywende veestapel aan te koop. Gedurende die 2015/2016-droogte het kleinboere koepons vir die aankoop van veevoer vanaf die regering ontvang. Ongelukkig het hierdie inisiatief die boere te laat bereik, omdat sommiges alreeds diere verkoop het, of weens veevrektes verloor het. Dit blyk dus uit die bevindings van hierdie studie dat weerstand en paraatheid van veeboere ten opsigte van landboudroogtes 'n saak van breë nasionale belang is en dus dringende, omvattende en ingrypende maatreëls benodig.

Sleutelwoorde: Droogte, Weerstand, Huishoudings, Veestapel, Kleinboere.

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LIST OF ACRONYMS

ADRI:	Agricultural Drought Resilience Index
CAGR:	Compound Annual Growth Rate
CGE	Computable General Equilibrium Model
DAFF:	Department of Agriculture, Forestry and Fisheries
DRI	Drought Resilience Index
DWS:	Department of Water and Sanitation
EIU:	Economist Intelligence Unit
ENSO:	El Niño-Southern Oscillation
FAO:	Food and Agriculture Organization
FBDM	Frances Baard district municipality
IHS	Integrated Household survey
IPCC	Intergovernmental Panel on Climate Change
KPMG:	Klynveld Peat Marwick Goerdeler
NC:	Northern Cape
NDMC:	National Drought Mitigation Center
PCA:	Principal Components Analysis
SAWS:	South African Weather Services
SFA	A Stochastic Production Function
SPSS:	Statistical Package for the Social Science
STATS SA:	Statistics South Africa
UNDP	United Nations Development Programme
USD:	United States Dollar

Chapter 1 : Introduction

1.1 Introduction and Background

Changes in climate have a significant impact on food production around the world. Climate change may have an extensive effect on the global livestock industry and production may be affected in several ways, including productivity losses owing to temperature increase, increased cost of animal housing (cooling systems), increased resource prices (e.g. feed and energy disease epidemics), fodder quality and quantities (Thornton, 2010). According to the Food and Agriculture Organization (FAO) (2013) and Wilhite, Sivakumar and Pulwarty (2014); the period, intensity and occurrence of droughts are anticipated to increase due to climate change. Drought can be defined as a natural disaster caused by large-scale climatic variability which leads to severe environmental and socioeconomic impacts (Van Lool and Van Lanen, 2013; Wilhite, Sivakumar and Pulwarty, 2014; Bachmair, Kohn and Stahl, 2015). Droughts are one of the worst natural disasters to occur affecting most people in the world and contribute adversely to the livelihoods and welfare of most people especially in developing countries (Sivakumar, 2014; Banda *et al*., 2016).

Globally, drought is the costliest natural disaster with an estimated amount of 6 to 8 billion United State Dollars (USD) annually and more people are affected when compared to the impact of other forms of natural disasters such as floods, hurricanes, tornadoes and earthquakes, etc. (FAO, 2013). The effects of drought in both developing and developed countries seem to be rising, putting pressure on natural resources (sustainability of resources). African regions (including South Africa) are the most vulnerable regions to drought, with the recurrent drought waves which created worldwide interest, because of the famines and massive social and economic disruptions it has caused (FAO, 2013).

Agriculture is the first and most affected sector when compared to other sectors during drought periods (Wilhite et al., 2014). Droughts may lead to reduction in crop yields and livestock productivity (Intergovernmental Panel on Climate Change (IPCC), 2012). Agricultural production (both crop and animal) depends or rely highly on weather conditions and availability of water in most countries. Drought impacts on livestock can lead to poor productivity, fertility, health and increased livestock mortality (Udmale *et* *al.*, 2014). Livestock production is an important agricultural commodity for food security; providing the world with 17% kilocalorie consumption and 33% protein consumption and contributes to the livelihoods of 1.0 billion poor people globally (Rojas-Downing, Nejadhashemi, Harrigan and Woznicki, 2017).

In South Africa, livestock production has great potential to alleviate food insecurity and poverty for households (Mapiliyao, Pepe, Chiruka, Marume and Muchenje, 2012). The livestock industry contributes approximately 48% of South Africa's agricultural output and employs approximately 500 000 people nationwide (Department of Agriculture, Forestry and Fisheries (DAFF), 2016a). Land suitable for mainly extensive livestock farming in South Africa comprises approximately 80%, but livestock is also found in areas where the animals are kept in combination with other farming enterprises (DAFF, 2018). Livestock is by far the largest sub-sector in the South African agricultural sector, contributing an estimated 25 – 30% of the total agricultural output per year. Cattle, sheep and goat farming in South Africa occupy approximately 53% of all agricultural land (Blignaut, De Wit, Knot, Midgley, Crookes, Drimie and Nkambule, 2014).

However, approximately 590 000 km^2 of the area used for cattle, sheep and goat farming was badly affected by drought. As a result, the grazing area was badly affected, and livestock mortality increased in most South African provinces (DAFF, 2018). About 33.8 million hectares in the Northern Cape are classified as farmland with about 86% of the land used for grazing livestock (Klynveld Peat Marwick Goerdeler (KPMG), 2012). The province is more concentrated on livestock when compared to the other agricultural activities. Sheep and cattle production plays a very important role in the South African livestock industry, because it is a source of cash income; therefore, contributes to the livelihood of farmers.

1.2 Problem Statement

Recurrent drought is a challenge to smallholder farmers due to unavailability of resources and their resilience on own production for household food security (Agri SA, 2016). Smallholder farmers in South Africa are faced with constraints that have undermined their potential to produce adequate output. Some of the notable constraints include a higher demand for agricultural land, lack of capital, rising prices of farm inputs, low prices of farm output, which together with other challenges such as lack of assets, information, access to services, poor physical and institutional infrastructure, which have resulted in a cost-price squeeze for farmers (DAFF, 2012; Mpandeli and Maponya, 2014). Besides the challenges, farmers have also been victims of unpredictable rainfall and other weather-related problems resulting from climatic variability.

In South Africa, it was declared that the driest year yet occurred in 2015 with the lowest annual rainfall yet recorded since 1904 (Maré, Bahta and Van Niekerk, 2018). The economic damage caused by drought in 2015 accounted for 2 billion US Dollars. South Africa received an average of only 403 mm of rain, being the lowest rainfall received ever since 1945, when the country received 437 mm (South African Weather Services (SAWS), 2016). Prolonged droughts are regular and recurrent features affecting smallholder farmers and are one of the most important natural disaster's in economic, social and environmental terms in Southern Africa, including South Africa (Buckland, Eele and Mugwara, 2000; Rouault and Richard, 2003).

The 2015/2016 drought resulted from a very strong El Niño system, which is comparable with the droughts of 1933 and 1982. According to the DWS (2015), about 173 out of 1 628 water supply schemes across the country were affected by drought. These water schemes supply approximately 2.7 million households in South Africa. Droughts in South Africa caused farmers' losses up to R10 million in 2015 (Bahta, Jordaan and Muyambo, 2016). The agricultural production declined by 8.4% during the year 2015. The decline in agricultural production was attributed to the worst drought conditions which intensified in January 2015. The livestock industry (cattle and sheep) was one of the industries that were severely affected by drought, with a reduction of 15% in the national herd (AgriSA, 2016).

Currently, there is no actual number of beef and sheep losses on record. However, the Red Meat Producer's Organisation (RPO) estimated that more than 40 000 cattle had died due to drought at the end of 2015 in KwaZulu-Natal, excluding the other provinces. According to the Red Meat Industry Forum (RMIF) as cited by Agri-SA (2016), during November to December 2015, about 23% of cattle and 37% of sheep increases in red meat slaughter rate due to drought were reported. Although the number of red meat slaughtering increased during that period, smallholder farmers are most vulnerable to drought as compared to commercial farmers. The intensity of drought creates additional stress on the cash flow and mental status of livestock smallholder farmers. Therefore, this justifies the need to study the resilience of smallholder farmers to agricultural drought in the Northern Cape.

Existing international and national studies, such as Vetter (2009); Sallu, Twyman and Stringer (2010); Banda *et al*. (2016) and Mdungela, Jordaan and Bahta (2017) focused on the application and relevance of resilience; understanding and managing ecosystem change and enhancing the capacity of land users to adapt to droughts; identifying factors that affect resilience to drought among smallholder farmers; assessing livelihood dynamics and factors influencing farmers' choice of coping strategies. Jordaan (2012), focused on drought risk reduction in the Northern Cape. Based on available information, there has not been a scientific study specifically conducted on resilience of livestock farming households to agricultural drought in the Northern Cape Province of South Africa.

1.3 Research Questions

The study attempts to answer the general question "What are the main aspects that allow smallholder livestock farming households in the Northern Cape Province of South Africa to resist, absorb and recover from agricultural drought?"

The main question is followed by the following sub-questions:

- How is the households' resilience to recurrent agricultural drought among smallholder livestock farmers?
- Which factors affect smallholder livestock farming households' resilience to agricultural drought?
- What are the effects of drought resilience on the welfare of smallholder livestock farming households?
- Which factors can be adopted by the farming households and other factors that will help farmers to absorb the adverse welfare effect due to agricultural drought?

1.4 Motivation of the study

During the year 2018, the Northern Cape was one of the three provinces that were declared provincial disasters by the South African government (Tandwa, 2018). This is not the first time the province declared to be a disaster area; in 2016 seven provinces including the Northern Cape, were declared as "provincial state of drought disaster" by the DAFF, 2016b. Majority of the farmers in the province are involved in livestock production as compared to crop production. According to Statistics South Africa (Stats SA) (2016), approximately 75% of agricultural households (in 2016) were involved in livestock production in the Northern Cape. This study was motivated by the aspiration to better understand the resilience of livestock smallholder farmers to agricultural drought in South Africa, specifically the Northern Cape.

1.5 Research Objectives

The main objective of the study is to determine household resilience to recurrent agricultural drought among smallholder livestock farmers in Northern Cape Province of South Africa.

The main objective will be achieved through the following specific objectives:

- Determine factors that affect smallholder farming households' resilience to agricultural drought.
- Determine the effect of drought resilience on the welfare of smallholder livestock farming households.
- To identify factors that can be adopted by the farming households and other factors which will assist farmers to absorb the adverse to welfare effect due to agricultural drought.

1.6 Research Hypotheses

The main objective of the study is to measure the resilience of farming households to agricultural drought.

The hypotheses for this study are thus stated as:

- A household's social-economic, institution and farm characteristics do not affect their resilience to agricultural drought in the Northern Cape province of South Africa.
- Households' social-economic, institution and farm characteristics have an effect on its resilience to agricultural drought in the Northern Cape Province of South Africa.

1.7 Methodology and Data

Primary data was collected from smallholder livestock farmers in the Northern Cape Province using a structured questionnaire. A survey was conducted using multi-stage samples of 207 livestock smallholder farmers to determine which factors affect smallholder farming households' resilience to agricultural drought and the effect of drought resilience on the welfare of smallholder livestock farming households in the Northern Cape Province of South Africa. All the collected data were subjected to statistical analysis using Statistical Package for the Social Science (SPSS) and STATA software.

To identify whether a household is resilient to drought or not, Principal Components Analysis (PCA) was used to aggregate four production and consumption-related indicators into the Agricultural Drought Resilience Index (ADRI). A Probit regression model was employed to identify factors that determine resilience among farming households. Furthermore, a stochastic production function for livestock was also estimated in order to find out the second hypothesis "whether agricultural drought resilience has any significant effect or not on the welfare of farming households".

1.8 Significance of the study

By focusing on the 2015-2016 drought event, this study will contribute to the existing literature by constructing Agricultural Drought Resilience Index (ADRI) and will use it to determine the impact of agricultural drought resilience on the welfare of smallholder farmers' households in the Northern Cape. The findings of this study will help policy makers and stakeholders to improve current or formulate future strategies and policy interventions that will boost smallholder farmers' resilience to agricultural drought.

1.9 Definition of terms and concepts

An overview of the key concepts utilized in this research are defined as follows:

Agricultural drought: Lack of precipitation during the growing season impinges on crop production or ecosystem function in general due to soil moisture drought (IPCC, 2012).

Drought frequency: Spinoni, Naumann, Carrao, Barbosa and Vogt (2014) defined as the number of drought events occurred, drought duration as the number of months in drought conditions, and drought severity as the sum of the integral area below zero of each event.

Drought Resilience: Defined as the capacity of farmers to survive during a drought season or dry season or periods of low rainfall (Ranjan, 2011).

Resilience: Refers to the capacity to absorb, predict, accommodate or recover from the effects of natural hazards in an efficient way through restoration, improvement or preservation, of its crucial basic structures and functions through risk management (IPCC, 2012).

Smallholder farmer: Farmers that own small sizes of land, where they grow subsistence livestock, completely relying on family labour and have limited resource endowment as compared to commercial farmers (DAFF, 2012).

Vulnerability: Conditions that are determined by the economic, environment, physical and social issues which increase the weakness of a community to the impact of natural disasters (Kumpulainen, 2006; Girasole and Cannatella, 2017; Muyambo, Jordaan and Bahta, 2017).

1.10 Outline of the study

The study is structured into five chapters. The relevant literature related to the research is discussed in Chapter 2. Chapter 3 presents the description of the study areas, research design, sampling procedure, data collection and analysis procedures. Chapter 4 discusses the empirical results and discussion from the analysis. Finally, Chapter 5 presents the conclusion and recommendations from the research.

Chapter 2 : Literature Review

2.1 Introduction

Drought is a temporal phenomenon which is related to the failure of usual precipitation (Zolotokrylin, 2018). Although drought is temporal, the effects of drought can be felt over a long period of time and farmers, especially smallholder farmers, are the most affected (Shoroma, 2014). Over the years, various researchers have looked at causes of drought, frequencies and severity of drought, impacts of drought (costs associated with drought) and drought responses and appropriate strategies that can be implemented to reduce drought effects (Wilhite and Glantz, 1985; Wilhite, 2000; Dai, Trenberth and Qian, 2004; Calow *et al.*, 2010; Campbell, Barker and McGregor, 2011; Masih *et al*., 2014; Shiferaw *et al*., 2014; Spinoni *et al.*, 2014; Banda *et al*., 2016; Katchele, Qing Yang and Batebana, 2017). In order to come up with strategies that smallholder livestock farmers can adopt and thus respond to agricultural drought in the Northern Cape, it is essential to understand the fundamental theory of resilience to agricultural drought. Therefore, this chapter outlines the theoretical concept of agricultural drought, resilience and review some of the recent empirical studies of resilience to agricultural drought that have been done in various countries for different agricultural commodities.

2.2 Historical trends of droughts

During the 20th century, areas affected by drought have increased significantly and attributed to extensive barrenness over most parts of the northern mid-high latitudes, East and South Asia, Africa, southern Europe and eastern Australia, ever since 1970s (Masih *et al.*, 2014). Over the past thousand years, severe droughts have regularly occurred worldwide (Dai, 2011). Globally, approximately 642 drought events were reported during the period 1900-2013, most of those drought events occurred in Africa (45%), while the other continents have shown the least drought event occurrences (Masih *et al.*, 2014). According to Dai, Trenberth and Qian (2004), most parts of Africa, Alaska, Canada, Eastern Australia and Eurasia became drier from 1950 to 2002. Central Africa, Russia, Amazonia, Southern Europe, Southern and Central Australia, United States (central), China, the Sahel region and India were severely affected by drought during the periods 1951-1970, 1971-1990, and 1991-2010 (Spinoni *et al.*, 2014). One of the most severe droughts in history ever recorded was the 1982-1983 El Niño (Boken, Cracknell and Heathcote, 2005). Drought occurrence is expected to continue rising in the 21st century (Masih *et al*., 2014).

2.2.1 Sub-Saharan Africa historical trends of drought

In Southern Africa, extreme and periodic drought occur frequently (Vogel, 2000). Since the1960's (over four decades), approximately 382 drought events have been reported in Africa (Shiferaw *et al*., 2014). Africa has historically experienced some devastating droughts over the past years, including 1972-1973, 1983-1984 and 1991-1992; more severe within the African continent including Sub-Saharan Africa (Masih *et al.*, 2014). Katchele *et al*. (2017), assessed drought trends and frequencies using the Standardized Precipitation Evapotranspiration Index (SPEI) and Self-Calibrating Palmer Drought Severity Index (sc-PDSI) between two periods (1901-2010 and 1951-2010) for Sub-Saharan Africa and Central-North China; the results showed downward trends of drought index values and upward trends of drought frequencies for both Central-North China and Sub-Saharan Africa. Drought frequency is recorded to be increasing in Sub-Saharan Africa, affecting many countries (FAO, 2015).

2.2.2 South African historical trends of drought

South Africa forms part of the countries globally that experience severe drought frequently (Spinoni *et al.*, 2014). In the past, three prominent dry periods were experienced (below-normal rainfall) in major parts of South Africa. The years 1991-1992, 1997-1998 and 2001-2002 were the major drought years on record during which South Africa has experienced severe droughts (Austin, 2008), including the recent severe drought, 2015-2016. According to Vogel (1995), one of the most serious droughts on record in South Africa was in the early 1990s, which significantly affected food production and vulnerable communities.

2.3. Categories of drought and causes

Normally it takes close to three or more months for the effect of drought to realise. However, the period differs substantially depending on the timing of the initiation of the shortages in rainfall (Wilhite, 2000). Meteorological drought, agricultural drought, hydrological drought and socio-economic drought are the four categories of drought, all types originating from lack of precipitation that result in water shortages (Dai, 2011;

Botai *et al.*, 2016; Manderson, Kubayi, and Drimie, 2016). Figure 2.1 shows the different kinds of droughts, their occurrence and impacts.

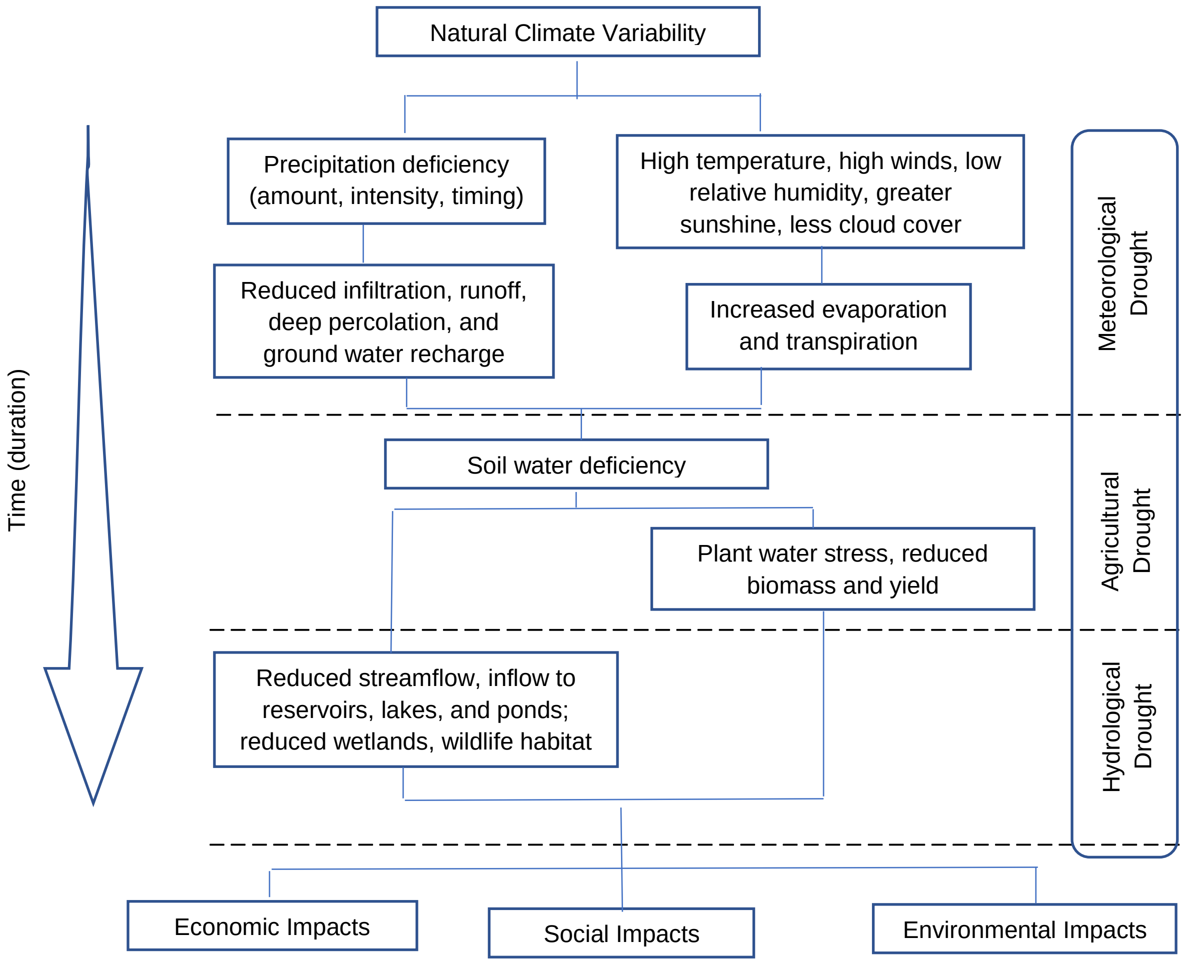

Figure 2-1: Different kinds of droughts, occurrence and impacts

Source: National Drought Mitigation Center (NDMC) (2018)

Meteorological drought (Climatological): Occurs when a specific region receives low or lacks rainfall or a period without significant rainfall sustained (Wilhite, 2000). This type of drought occurs fast and ends quickly (occurs for a short period of time).

Agricultural drought: Arises when there are shortages in soil moisture which results or leads to absence of water supply to crops (leads to crop yield failure) and food imbalance (Wilhite and Glantz, 1985; Dai, 2011; Manderson, Kubayi, and Drimie, 2016). Agricultural drought typically has a much shorter time scale than Hydrological drought (McKee, Doesken and Kleist, 1993). This study focused on agricultural drought.

Hydrological drought: This type of drought occurs when there are shortages in the stream-flow or channel runoff which results in low water supply to lakes, rivers or reservoirs (Spinoni *et al*., 2014). It typically happens after many months of meteorological drought and takes a longer time to develop than to recover. It occurs for a long period of time as compared to the other types of drought.

Socio-economic drought: All the different types of drought results in socio-economic drought relating to the imbalance between supply and demand ratio of various commodities due to drought (Spinoni *et al*., 2014; Golian, Mazdiyasni, and AghaKouchak, 2015).

2.4. Effects of drought

Natural disasters such as drought constitute direct and indirect threats to the livelihoods and food security of smallholder farmers in the world (FAO, 2017). Often the effects of drought gather gradually over a certain time frame and can remain for quite a long time after it has departed; it is difficult to determine when drought started and ended (Wilhite, 2000). Drought can affect communities in many ways (Calow *et al*., 2010) leading to deaths, suffering, economical damages, famine, epidemics, food shortages and fire, etc. (Panagoulia and Dimou, 1998; Masih *et al.*, 2014). Lives, infrastructure, livelihoods, assets, production and health can be directly affected by drought and can contribute to poverty and food insecurity. About 11 million individuals died and approximately 2 billion individuals were affected by drought between 1990 and 2011 (Spinoni *et al*., 2014). Droughts may be identical in terms of their intensity, duration, and spatial characteristics for a specific region or area, but the effects will not be the same (Wilhite and Glantz, 1985). According to Dellal *et al*. (2010); the effects of drought are based on the frequency, severity, degree and vulnerability of the region or area.

The effect of drought can be seen from environmental, economic, social and food security aspects. The following sub-section explains the different types of effects caused by drought.

2.4.1 Environmental effects

Drought effects on the environments differ every time it occurs. However, it should not harm the environment when managed properly (Msangi, 2004). The environment can be affected by drought in many different ways such as poor soil quality, lack of food and drinking water for animals as well as human beings. (National Drought Mitigation Center (NDMC), 2018). Shortages of water in the surface area lead to soil moisture being affected, with absence of soil moisture (influenced by recent shortage of rainfall) and water stored in other reservoirs (affected by much longer-term precipitation totals) identified as the two major causes of drought (Wilhite, 2000). Droughts have an impact on the availability of ground water in rural areas; for example, many people in rural areas in Southern Africa were left without water during the 1991-1992 drought and in Zimbabwe boreholes and wells failed during the 1990's droughts (Calow *et al*., 2010). Droughts also reduce the productivity of livestock, causing changes in the composition and size of the herd (Msangi, 2004). Furthermore, drought can increase forest fires because of increasing temperature and low humidity; this can result in the forest and wildlife species declining (Kala, 2017).

2.4.2 Economic effects

The effects of drought on the economic conditions can be seen from the local level to the global level. Agriculture is the most affected sector when compared to other sectors, as it highly depend on water (Kala, 2017). Economic effects of drought include an increased price of farming commodities, sale of livestock at reduced prices, increased capital shortfall, demand for water, increased debt, increased risk to financial institutions, reduced employment opportunities, insufficient drinking water and forage for livestock, which affects the economy of their owners (Vogel *et al.*, 1999; Zarafshani *et al.*, 2016; Kala, 2017). Drought does not only affect people living in areas that are vulnerable or affected by drought, it affects everyone including all the different sectors. Besides agriculture, the energy sector is also affected, especially the hydropower projects which may not produce enough energy because of water shortages; as a result, the cost of energy may increase and consumers may be affected (Kala, 2017).

2.4.3 Social effects

Pauw, Thurlow and Van Seventer (2010) highlighted that drought affects production levels by reducing the size of the area planted and/or reducing crop yields through crop failure. Some of the social impacts of droughts are: migration, increased conflicts between water users, poverty, reduce quality of life, reduced or no income, malnutrition, public health risks (anticipation and depression about the economy declining because of drought, may create conflicts and disturb the peace of mind for farmers), social unrest, social pressure, increased food insecurity. It may lead to forest fires threatening the lives of people living in the forests; and people may be forced to sell their properties as a life-saving method because of drought (Vogel *et al*., 1999; Kala, 2017). Furthermore, poor communities are more likely to suffer from the adverse effects of drought due to a lack of resources and stock (crops or livestock) to sustain them during dry periods (Kala, 2017).

2.4.4 Effects on food security

Drought and other natural hazards can have a negative impact on food security leading to an increase in food-insecurity vulnerability (FAO, 2017). Severe famine in some countries and food shortages can be caused by agricultural drought, which may result in reduction of human and livestock population (Boken, Cracknell and Heathcote, 2005). Globally (including African countries), the problem of climate change and its impact on food security is increasingly acknowledged, and South Africa is one of the countries that is vulnerable to drought and its impacts (Masipa, 2017). Schmidhuber and Tubiello (2007) indicated that climate change has a significant impact on food security; between 5 million and 170 million individuals are estimated to be in danger of hunger by 2080. For example, Swift and Hamilton (2003) have argued that food security at household level arises from several causes and that adverse effects are more devastating to a given household if more than one cause affects the household at the same time.

Figure 2.2 indicates food insecurity and climate change vulnerability in different countries in the world with the exception of most developed countries, countries that are very small and those with little or no domestic production. Sub-Saharan Africa has the highest levels of vulnerability to food insecurity in the world due to climate change, but South Africa is one of the countries with the least medium level vulnerability to food insecurity. According to Economist Intelligence Unit (EIU) (2017), South Africa is the 44th most food secure country in the world, and the highest ranked in Africa.

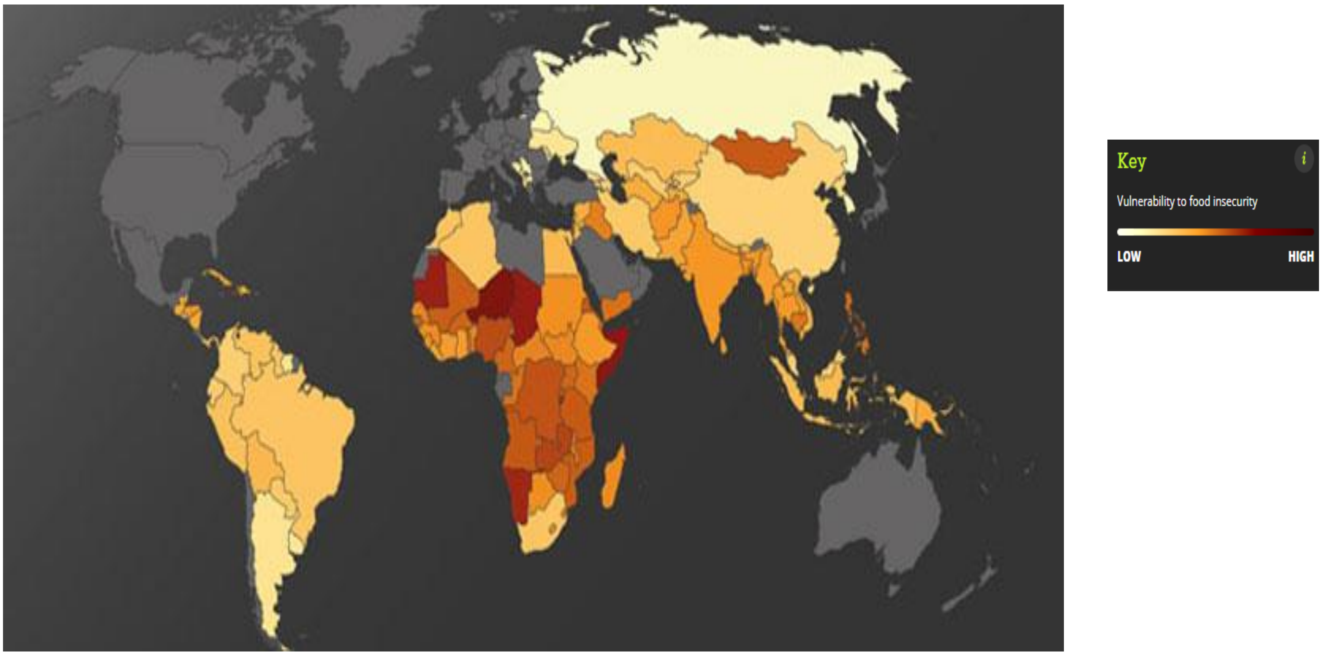

Figure 2-2: Food Insecurity and Climate Change vulnerability map
Source: Piesse (2016).

The recurrent drought placed food security in South Africa in general, and provinces and districts in particular under threat, as many crops and livestock have been destroyed. For instance, agricultural drought in the Eastern Cape Province has claimed more than 150 000 head of livestock, with smallholder farmers suffering the greatest losses (De Kock, 2016). Most of the provinces in South Africa are highly vulnerable to disaster owing to a high level of environmental degradation, poverty, lack of access to resources, low standards of living and poor household economies. Countries in Southern Africa rely on South African produce to sustain their food supplies; as a result, South Africa is the net exporter of food in the region. According to the Piesse (2016), 14 million South Africans experienced some form of deprivation, including, but not limited to, food insecurity, as the impact of the drought continues to unfold; 49 million people across Southern Africa are now estimated to be at an increased risk of food deprivation.

2.5. Household and livelihood in agricultural drought

Livelihoods have been undermined by frequent extreme events, which have led to hardship for rural and subsistence farming households, resource scarcity (water) and economic losses (Osbahr *et al*., 2008). Natural disasters compromise a large number of agricultural livelihoods every year (FAO, 2017). For example, the livelihoods and sources of water for individual households may be lost, food shortages, health issues and the country's economy might be seriously affected (Masih *et al.*, 2014). A livelihood comprises of activities needed as a means of living, capabilities and assets such as material and social resources (Department for International Development (DFID), 1999; Krantz, 2001; Osbahr *et al*., 2008).

When individuals or communities are able to adapt and recover from any stresses or shocks, while maintaining their capabilities and assets without exploiting natural resources, then the individual or community is said to be sustainable (United Nations Development Programme (UNDP), 2017). To understand and analyse the livelihoods of poor people and evaluating the efficiency of existing efforts to reduce poverty, a Sustainable Livelihoods Framework (SLF) was established (Department for International Development (DFID), 1999). Figure 2.3 shows the Sustainable Livelihoods Framework which demonstrates the factors that have an impact on the livelihoods of people and the relationship between them.

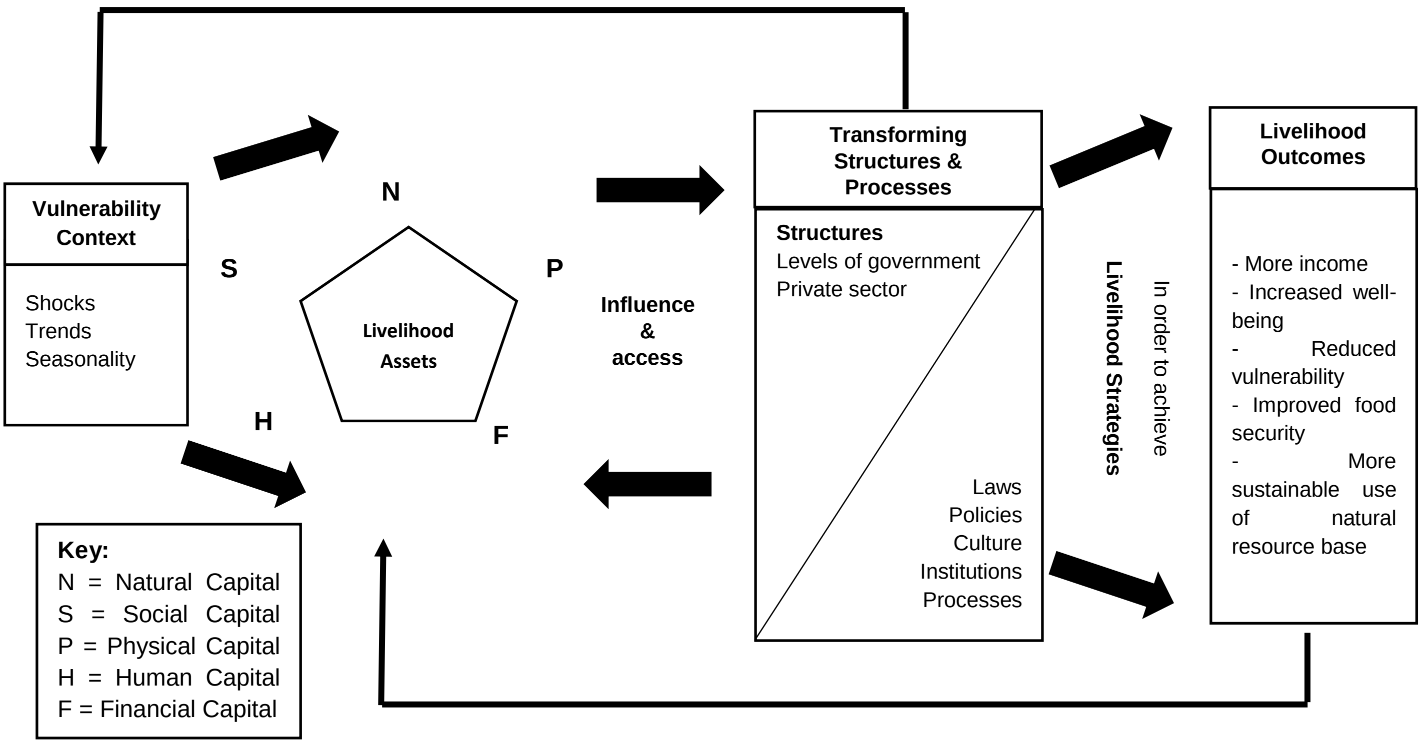

Figure 2-3: Sustainable Livelihood framework
Source: The Department for International Development (DFID) (1999).

The framework includes the following elements:

1. Vulnerability context,
2. Livelihood assets,
3. Transforming policies, structures and processes,
4. Livelihood Strategies, and
5. Livelihood Outcomes.

The first three elements focus on the livelihoods, linking concerns over work and employment with poverty reduction as the major issue of adequacy, security, well-being and capability. Whereas, the last two elements add the sustainability dimension resilience of livelihoods and their natural resource (Scoones, 1998).

2.6 Resilient livelihoods

Climate change exposes rural households and farmers to new and unfamiliar circumstances (Osbahr *et al*., 2008). Globally, production of livestock provides food and livelihood to approximately one billion of poor people, mostly in dry and infertile regions where other agricultural practices are less practicable (FAO, 2010). Livelihood responses are influenced by different barriers and motivators, which comprise of aspects such as gender, social norms, ethnic groups, household assets, individual perceptions, class and networks (Osbahr *et al*., 2008).

Responding to agricultural drought will not be the same for farmers, although they may be experiencing drought at the same time. Drought constitutes an incredible threat to the livelihoods of communities and households that are reliant on farming. Expanding adaptation options and enhancing resilience within the agricultural sector can be done through the knowledge of what farmers do in response to drought events (Campbell, Barker and McGregor, 2011). When challenged by severe drought, resilient agricultural systems will continue providing an important service like food production (Lin, 2011). Socio-economic and political context determines the ability of communities to respond to environment and climate dynamics (Osbahr *et al*., 2008).

2.6.1 Resilience characteristics

Resilience presents a new and valuable context of analysis and perception on how the environment, communities, organizations and individuals can adjust in a changing world facing several uncertainties and difficulties (Folke, 2016). Figure 2.4 shows the different characteristics of resilience.

Figure 2-4: Characteristics of resilience
Source: McAslan (2010).

McAslan (2010) discussed the following as characteristics of resilience:
Threat and Events: When defining resilience, all definitions refer to threats and events that are unusual in terms of their timing, scale and form. Resilience is viewed as the capacity to adapt to unusual threats and events, be they enemy actions, or disturbance from climate change, or natural hazards such as floods, drought and economic shocks. Resilience also refers to communicating, identifying and assessing the risk from threats and events especially those descriptions that particularly involve organisations, individuals and communities.

Positive outcomes: Positive outcome refers to the ability of an individual, group or organisation to recover or adjust easily from some sort of surprise or shocks or unexpected event.

Being prepared: Resilience includes the ability to adjust and then recuperate from an unusual event. Countries, organisations, communities and individuals that are prepared and ready (developing plans, standards and operational procedures, or by developing physical, economic and/or human capital) for unusual events, tend to be more resilient than those that are not prepared and ready.

Desire/commitment to survive: Individuals or communities that exhibit strong commitment to survive are able to accept extreme and unusual conditions, recover from traumatic events.

Adaptability: The world is constantly advancing through natural processes and in other cases through the intervention of mankind. Systems, organisations and people tend to be more resilient when they are capable and eager to adapt.

Gaining experience: The capacity and eagerness to learn is frequently linked to adaptability and being prepared. The learning may come from personal experience or by studying the lessons of others in a formal manner. This includes collecting and analysing data, by conducting research in an objective, independent and balanced manner, and by communicating the results, conclusions and recommendations.

Collective and coordinated response – interdependency: As society becomes more complex and interconnected, and the impact of global factors becomes quicker and more obvious, they find themselves more exposed to disruptive events. When faced with such interconnected threats, communities and organisations that are resilient tend to be those that are well coordinated and who share common values and beliefs.

2.7 Strategies for managing drought and enhancing resilience

Development of resilient agricultural systems is important because many individuals, communities or societies rely upon the provisioning ecosystem services of such systems like fodder, food and fuel. for their livelihoods (Lin, 2011). Calow *et al*. (2010) argue that policy responses to drought in many countries focus mostly on food needs, while other aspects of vulnerability such as access and use constraints that determine household water security and the water availability receive less attention, although there is evidence that access to safe water can be a serious problem. To be able to manage and enhance resilience, individuals, communities and organisations need to anticipate, and prepare for, each climate-related challenge (Marshall, 2010). Several agriculture-based economies have limited livelihood strategies, with small-scale farms having little capital to invest in expensive adaptation strategies. This increases the vulnerability of rural, agricultural communities to a changing environment (Lin, 2011). Table 2.1 highlights some of the important strategies proposed by Calow et al. (2010); Marshall (2010) and Shiferaw et al. (2014).

Table 2-1: Summary of the strategies for studies reviewed

Reference	Strategy	Remarks
Calow *et al.* (2010)	Improve water coverage and prioritize vulnerable areas.	Improved supply of water coverage can reduce the impact of drought on livelihoods.
	Increase reliability of sources	Ensuring that water access is not constrained by using proper technologies.
Marshall (2010)	Maintaining the properties that confer resilience	Industries, communities and policy-makers can effectively support the capacity of farmers to manage and adapt to climate change.
	The use of climate technology (Seasonal climate forecasts)	Assisting farmers in minimising losses.
	Influencing the adaptive capacity of farmers	By helping them develop transferable skills, increase their environmental knowledge, develop financial security and adopt seasonal climate forecasts, in combination, may enhance the capacity of farmers to effectively cope and adapt to climate change.
Shiferaw *et al*. (2014)	The integrated technological, institutional and policy interventions	Strengthening livelihoods through improved agricultural productivity and building the capability of households to diversify incomes to manage drought-induced shocks in consumption.

Source: Author compilation (2018).

2.8 Factors affecting smallholder livestock farming households' resilience

There are past studies that have been conducted by different researchers highlighting the factors that affect smallholder farming households' resilience. Jiri, Mafongoya and Chivenge (2017), for example, studied building climate change resilience through adaptation in smallholder farming systems in semi-arid Zimbabwe. They concluded that households with increased access to climate information through extension services, possession of livestock and access to credit were likely to have better adaptation abilities. Tesso, Emana and Ketema (2012) also found that younger farmers were likely to better adapt to climate change given their flexibility to adopt new techniques and their access and use of modern information and technology. Furthermore, farming households were found to have a higher probability of adapting as most adaptation strategies are labour intensive and are likely to have better adaptation abilities.

2.9 The effects of drought resilience on the welfare

The welfare of smallholder farming households is the most affected when drought occurs. This is because most smallholder farmers are vulnerable to drought. The welfare of smallholder farmers is measured by their production income. There is a limited literature available on the effects of drought resilience on the welfare of smallholder farmers. Banda *et al*. (2016) determined household resilience to drought in Malawi. The study has found that there is a positive correlation between resilience and improved household welfare.

2.10 Factors that can be adopted by the farming households and other factors that will help farmers to absorb adverse welfare effects due to agricultural drought

Factors such as possession of liquid assets, access to credit, the level of technical efficiency in agricultural production, propensity to invest in natural resources, preparedness, diversity of income sources (livelihood diversification), access to input/output markets, social capital (involvement in local institutions), educational level age of the household head, size of the farm family, insurance contracts, landholding size, and the number of immediate family members living outside the household, can be adopted by the farming households to enhance their resilience to agricultural drought (Tesso et al., 2012; Banda *et al.*, 2016). Alinovi, Mane and Romano (2009) argued that in the richest and more stable areas of East Jerusalem, most resilience depends on income and food access capacity, while in the Gaza Strip most depends on social safety nets; while factors such as land, farm inputs (seeds or feed, etc.) and investment can help farmers to absorb adverse welfare effects due to agricultural drought (Banda *et al.*, 2016).

2.11 Drought and livestock production

Drought has a major impact on livestock production. Drought leads to the reduction of natural grazing (grass) and water. These two components are essential for livestock growth. The sub-sections below look at the global, South African and the Northern Cape production of livestock.

2.11.1 Global livestock production

Livestock is a vital provider of nutrients for smallholders and vulnerable communities and is an important strategy for risk reduction. However, livestock has both negative and positive impacts on social equity, natural resources, economic growth and public health (Thornton, 2010). Over the years, the global livestock industry has expanded rapidly and is expected to continue doing so as the demand for meat and dairy products continue to grow. In many developing regions, livestock plays an important role in providing income, food, draught power for ploughing and transport (FAO, 2010). The industry employs approximately 1.3 billion people and in developing countries it directly supports the livelihood of an estimated 600 million smallholder farmers that are poor (Thornton, 2010). Figure 2.5 presents the global production of cattle, sheep and goats over a period of sixteen years. The production of cattle, sheep and goats has increased over the years. The world population is projected to rise to 9.7 billion by 2050 and 11.2 billion by 2100, with the highest projection in developing countries (United Nations, 2015); this will result in an increase in the demand for agricultural commodities such as meat and meat products.

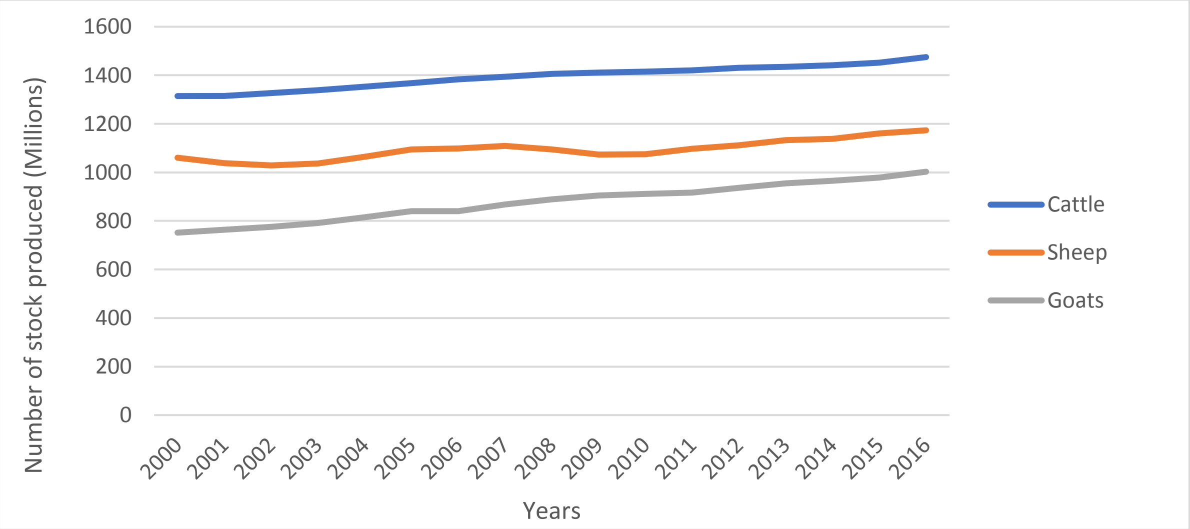

Figure 2-5: Global production of cattle, sheep and goats
Source: Author compilation based on FAO data (2018).

2.11.2 South African livestock production

In South Africa, livestock is produced throughout the country with numbers and species varying according to climatic conditions (DAFF, 2018). Table 2.2 presents the livestock numbers for South Africa over a period of 5 years. Over the years, the livestock numbers have been increasing. However, the livestock numbers declined slightly in 2016. Livestock numbers declined by 1,21% Compound Annual Growth Rate (CAGR) from 44,4 million of livestock numbers in 2012 to 42,3 million of livestock numbers in 2016. The decline in the number of livestock in South Africa could be attributed to the severe drought, amongst others, which left most farmers – especially smallholder farmers – vulnerable. The number of goats was mostly affected when compared to the cattle and sheep numbers. The number of goats declined by 2,20% CAGR (5,6 million), while cattle declined by 0.89% (13,4 million) and sheep by 1,15% (23,2 million). The South African beef cattle contributes about 80% of the total number cattle in the country with herds ranging from small farms (less than 20 head of cattle) to large farms and feedlots (more than 4 000 head). South Africans consume more beef as opposed to other red meat. About 1million ton of beef and veal and 193 000 tons of mutton were consumed during the year 2015/2016 (DAFF, 2018).

Table 2-2: Number of livestock

Livestock	2012	2013	2014	2015	2016
Cattle	13 887 898	13 861 194	13 915 301	13 694 582	13 400 272
Sheep	24 391 112	24 527 671	24 122 558	23 937 984	23 287 247
Goats	6 141 817	6 027 966	5 971 202	5 872 332	5 618 473
Total	**44 420 827**	**44 416 831**	**44 009 061**	**43 504 898**	**42 305 992**

Source: Author compilation-based FAO data (2018).

2.11.3 Northern Cape livestock production

The Northern Cape is one of the smallest producers of cattle and goats; the province had about 513 000 goats and 510 000 cattle by the end of August 2016. The number of cattle increased in 2016 when compared to the number of cattle at the end of August 2012, which was 507 000, although drought had a negative impact (DAFF, 2018). Furthermore, the province is the second largest producer of sheep in the country with a share of 25% just after the Eastern Cape (29%). They are kept mainly for mutton and wool production and the flock sizes varies between less than 50 to 1 800 animals.

Sheep flocks are larger when compared to flocks of goats intended for meat production. Figure 2.6 shows the distribution of livestock in the Northern Cape. As depicted in the figure, the total number of livestock in the Northern Cape was estimated to be 6,9 million by the end of August 2016, with approximately 85% sheep (5,8 million), 8% goats and 7% cattle.

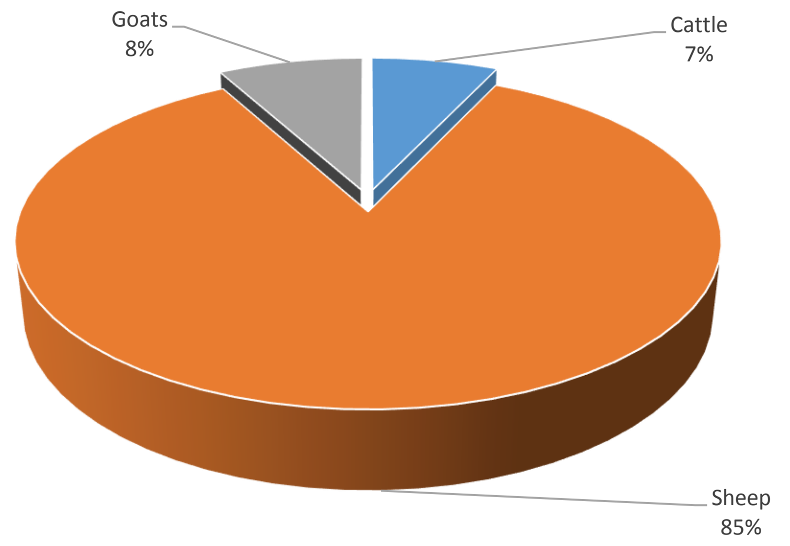

Figure 2-6: Distribution of livestock in the Northern Cape
Source: Author compilation based on DAFF data (2018).

2.12 Empirical studies on drought

Different authors have suggested different criteria for measuring droughts. Pauw, Thurlow and Van Seventer (2010) indicated that different indices exist to facilitate the identification of droughts. These indices vary from simple to complex ones. Most of these indices use precipitation and evaporation (or temperature as a proxy) to identify the droughts. An example of simple indices is the Standard Precipitation Index (SPI) which was developed by McKee, Doesken and Kleist (1993), which uses precipitation data only. SPI permits measurement of the drought's duration, intensity, and severity. The authors indicated that to measure the impacts of the dry periods on crop output, regression models are used to describe the statistical relationship between droughts of different severities and associated crop losses. Production losses are calculated as the difference between the actual realized (observed) yields and the expected yields, which is taken as the closest crop production achieved during the most recent normal year. Exposure, and hence risk, to a natural shock depends on several factors such as severity of the weather event, the location of farmers and their cropping patterns.

Edossa, Babel and Gupta (2010) employed the SPI to analyse the temporal and spatial meteorological drought and generated drought severity maps using Arc View/GIS by summarizing the percentage of occurrence of droughts in Awash River Basin, Ethiopia.

Droughts have been known to have adverse effects on the welfare of the affected individuals. To measure the economic losses associated with droughts and floods in Malawi; Pauw, Thurlow and Van Seventer (2010) applied a Computable General Equilibrium Model (CGE) on the 2004/05 Malawi Integrated Household survey data (IHS). They suggested that smallholder farmers, nonfarm and urban households are the most affected by shocks such as drought. Juana, Makepe and Mangadi (2016) employed a CGE model to investigate the socio-economic impact of climate change on water resources in Botswana. The simulation results showed that a decline in the amount of water available for industrial activities or use due to climate change (precipitation) generally leads to a significant decline in industrial output, factor remuneration and deterioration of households' welfare, especially rural households that depend on agriculture for their livelihoods.

Jordaan (2012) applied the disaster risk assessment methodology to compute the risks of drought in the Northern Cape. Onyekuru and Marchant (2014) highlights impacts resulting from climate change by identifying delay in the onset of rainfall, less rainfall, early rains followed by dry weeks, erratic rainfall patterns, uncertainty in the onset of the rainfall season, long dry season, desertification, drought, heat waves, drying of streams and rivers as some of the impacts have resulted from changes in rainfall and temperatures. Table 2.3 summarises some of the empirical studies related to drought. All the studies mentioned above are not applicable to this research as researchers focused on agricultural drought and not on the factors that affect the farmers' resilience on agricultural drought. However, it is still important to show research conducted in the past by other researchers regarding drought.

Table 2-3: Empirical studies on drought (Methodology)

Reference	Methodology	Findings
McKee, Doesken and Kleist (1993)	Developed Standard Precipitation Index (SPI).	Duration of drought increases linearly with time scale, while frequency decreases inversely.
Edossa, Babel and Gupta (2010)	Employed Standardized Precipitation Index to analyse temporal and spatial meteorological drought and generated drought severity maps using Arc View/GIS by summarizing the percentage of occurrence of droughts in areas within the study basin.	The results showed that most frequently extreme drought category on 12-month time scale indicated that extreme events occur in the upper and Middle Awash Basin.
Pauw, Thurlow and Van Seventer (2010)	Applied a Computable General Equilibrium Model (CGE) on the 2004/05 Malawi Integrated Household survey data (IHS) to measure the economic losses associated with droughts and floods.	Results indicated that economic losses in Malawi due to extreme climate events are significant, amounting to 1.7% of its gross domestic product on average each year because of combined effects of droughts and floods
Juana, Makepe and Mangadi (2016)	Employed a computable general equilibrium model to investigate the socio-economic impact of climate change on water resources in Botswana	Any percentage reduction in water availability for sectoral activities because of climate change (precipitation) generally leads to a significant decline in deterioration in households' welfare, sectoral output and factor remuneration with most rural households in Botswana vulnerable to climate change impact on water resources.
Jordaan (2012)	Applied the disaster risk assessment methodology to compute the risks of drought in the Northern Cape.	The research illustrated the complexity of today's risk-related problems and the importance of a holistic approach to risk assessments.
Onyekuru and Marchant (2014)	Highlighted impacts resulting from climate change by identifying delay in the onset of rainfall, less rainfall, early rains followed by dry weeks, erratic rainfall patterns, uncertainty in the onset of the rainfall season, long dry season, desertification, drought.	The results showed that more than 75% of the households interviewed from Mangrove, Rainforest, Guinea savanna and Sudan savanna in Nigeria had experienced impacts of climate change on forest resources with the exception of Montane forest zone where 35% of the households were affected.

Source: Author compilation of different studies (2018).

2.13 Empirical studies on resilience

There are a number of studies on resilience. Banda *et al*. (2016) identified factors that affect resilience to drought among smallholder farmers using a Drought Resilience Index (DRI) and uses it to determine the effect of drought resilience on the welfare of farming households. Principal Components Analysis (PCA) was used to construct the ADRI. Keil *et al*. (2008) identified factors that determine farmers' resilience towards El Niño-Southern Oscillation (ENSO) related drought in Central Sulawesi, Indonesia. PCA was employed to aggregate the indicators into ADRI that serves as dependent variable in a regression model to identify its influencing factors. The study found that even though there are ENSO forecasts in Central Sulawesi, most farmers did not have access to this information. Furthermore, there is evidence that ENSO effects on agricultural production in this mountainous area are more difficult to predict than in various other parts of Indonesia.

Alinovi, Mane and Romano (2009) used the PCA to measure the resilience of Palestinian households to food insecurity and a regression model to determine the role of the resilience index on vulnerability to food insecurity. Tesso, Emana and Ketema (2012) also applied PCA to compute the vulnerability index. The study was based on the analysis of vulnerability and resilience of farm households to climate change in North Shewa, Ethiopia, with a Probit regression model used to identify and analyze the determinants of households' resilience to climate change. The results showed that farmers who lived in the highland areas are more vulnerable to natural shocks, compared to those who lived in the lowland area.

In Ethiopia and Honduras, Carter *et al*. (2007) measured the resilience of households using livestock assets and the study results showed that poor households struggle the most with shocks, adopting coping strategies which are costly in terms of both short-term and long-term wellbeing. Andersen and Cardona (2014) proposed a simple way of measuring livelihood diversification, with a regression analysis used to identify factors associated with high vulnerability and high resilience. The results showed that a working and income-earning spouse in the household is the single most important strategy for resilience. Birhanu *et al*. (2017) applied a resilience-building framework grounded theory approach to understanding the resilience vulnerability factors, adaptive and coping strategies to recurrent droughts which provide potential resilience intervention among pastoralist communities in Ethiopia. Table 2.4 summarises some of the past studies related to resilience.

Table 2-4: Empirical studies on resilience

Reference	Methodology	Findings
Carter *et al*. (2007)	Measured the resilience of households using livestock asset.	Analysis of the weakly data revealed a pattern of asset smoothing among the lowest wealth households, meaning that the households at the bottom try to hold on to their few assets even as income and consumption possibilities dwindle during the period of severe losses in agricultural production
Keil *et al*. (2008)	Employed PCA to aggregate the indicators into DRI that serves as dependent variable in a regression model to identify ENSO influencing factors Central Sulawesi, Indonesia.	The study showed that possession of liquid assets, access to credit, and the level of technical efficiency in agricultural production strengthened the households' drought resilience.
Alinovi, Mane and Romano (2009)	Applied PCA to measure the resilience of Palestinian households to food insecurity.	The analysis showed that while in the richest and more stable area (East Jerusalem), most resilience depends on income and food access capacity, in the Gaza Strip most depends on social safety nets.
Tesso, Emana and Ketema (2012)	Applied PCA to compute the vulnerability index in North Shewa, Ethiopia	The result showed that farmers living in the highland areas were extremely vulnerable to natural shocks when compared to those farmers living in the lowland area.
Banda *et al*. (2016)	Constructed DRI by using the PCA.	Results indicated that over 62% of households in the study area were not resilient, leading to them being vulnerable to the adverse effects of dry spells

Source: Author compilation of similar studies (2018).

2.14. Summary

The literature revealed that in the Sub-Saharan Africa, the frequency of dry periods has been increasing over the past years, with more countries (including South Africa) critically affected. Meteorological drought, agricultural drought, hydrological drought and socio-economic drought were identified as the different categories of drought with each leading to the occurrence of the other. The impact of drought includes environmental, socio, economic and food security impacts. Agricultural drought has a massive impact on vulnerable communities especially smallholder farmers or households, as food production is affected (reduced). This threatens the livelihoods of these communities as they are faced with unfamiliar circumstances or situations. The discussion has demonstrated that farmers respond differently to agricultural drought as they do not have similar and equivalent resources or assets. This study with small modification, will make use of Agricultural Drought Resilience Index (ADRI) to investigate resilience of smallholder famers and the consequence of drought resilience on the welfare of farming households in the Northern Cape, South Africa, A Principal Components Analysis (PCA) was used to construct the ADRI, Probit model to determine the factors that affect the resilience of households to agricultural drought and Stochastic Production Function to determine the effect of drought resilience on the welfare of small-holder livestock farming household.

Chapter 3 : Methodology

3.1 Introduction

The purpose of this chapter is to introduce the research method and the empirical techniques applied in this study. The chapter starts with a description of the area where the study was conducted (the Northern Cape).

3.2 Study area

The Northern Cape is by far the largest province located in the North-Western corner of South Africa. The surface area of the Northern Cape is 372 889 km² of land which comprises 30.5% of the total land area of the country, with a population of 1.2 million people – which is the smallest population when compared to other provinces. Kimberley is the capital city of the Northern Cape and Upington is one of the important towns (centre of the karakul sheep and dried-fruit industries). The province has five district municipalities namely Frances Baard (12 800 km²), John Taolo Gaetsewe (27 300 km²), Namakwa (126 900 km²), Pixley Ka Seme (103 500 km²) and ZF Mgcawu (102 500 km²). Figure 3.1 shows all the district and local municipalities around the Northern Cape.

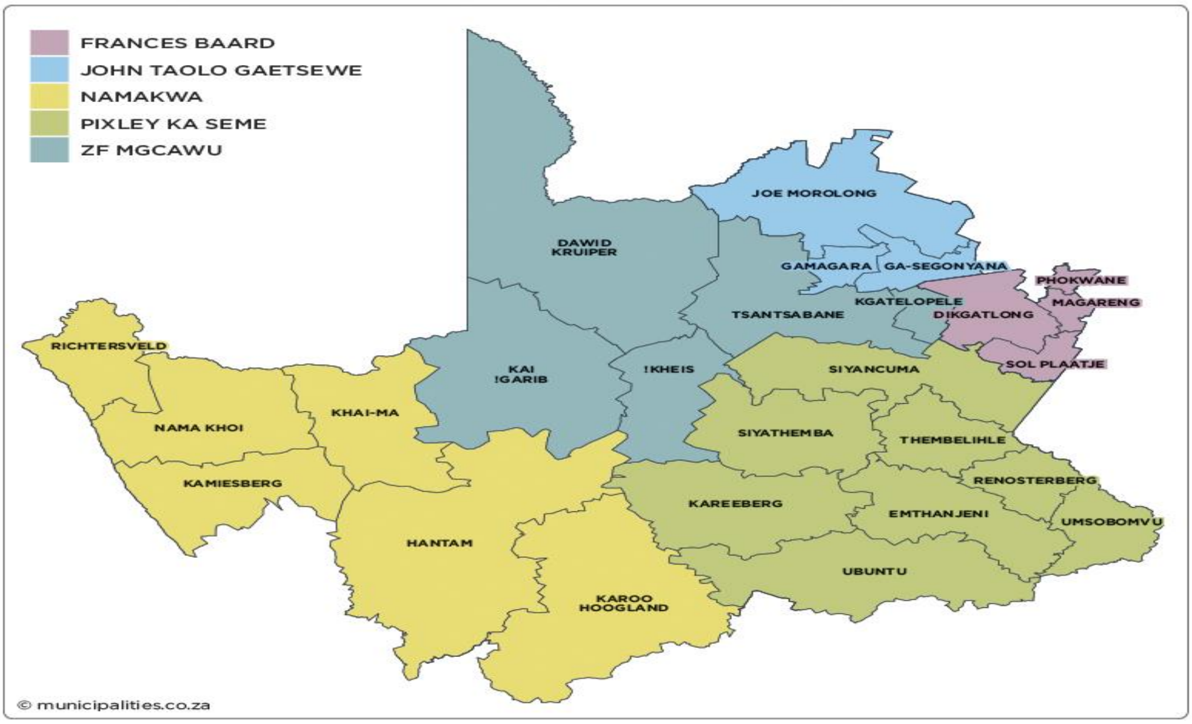

Figure 3-1: Northern Cape Province
Source: Frances Baard (2018): http://francesbaard.gov.za/our-regions/

The study was conducted in Frances Baard District Municipality, which is the smallest district located in the Eastern portion of the Northern Cape Province (see figure 3.2). The district accounts for only 3.4% of its geographical area, but accommodates the largest proportion of the province's population with 30,85 persons per square km. Frances Baard District Municipality is comprised of four local municipalities which are Dikgatlong (2 377.6 Km²), Magareng (1 541.6 km²), Phokwane (833.9 km²) and Sol Plaatje (1 877.1 km²). Setswana, Afrikaans, English and IsiXhosa are the dominant languages in the district (Frances Baard, 2018). Frances Baard district municipality was selected because it was declared a disaster zone, with more livestock smallholder farmers and has the potential to produce adequate livestock as compared to crops.

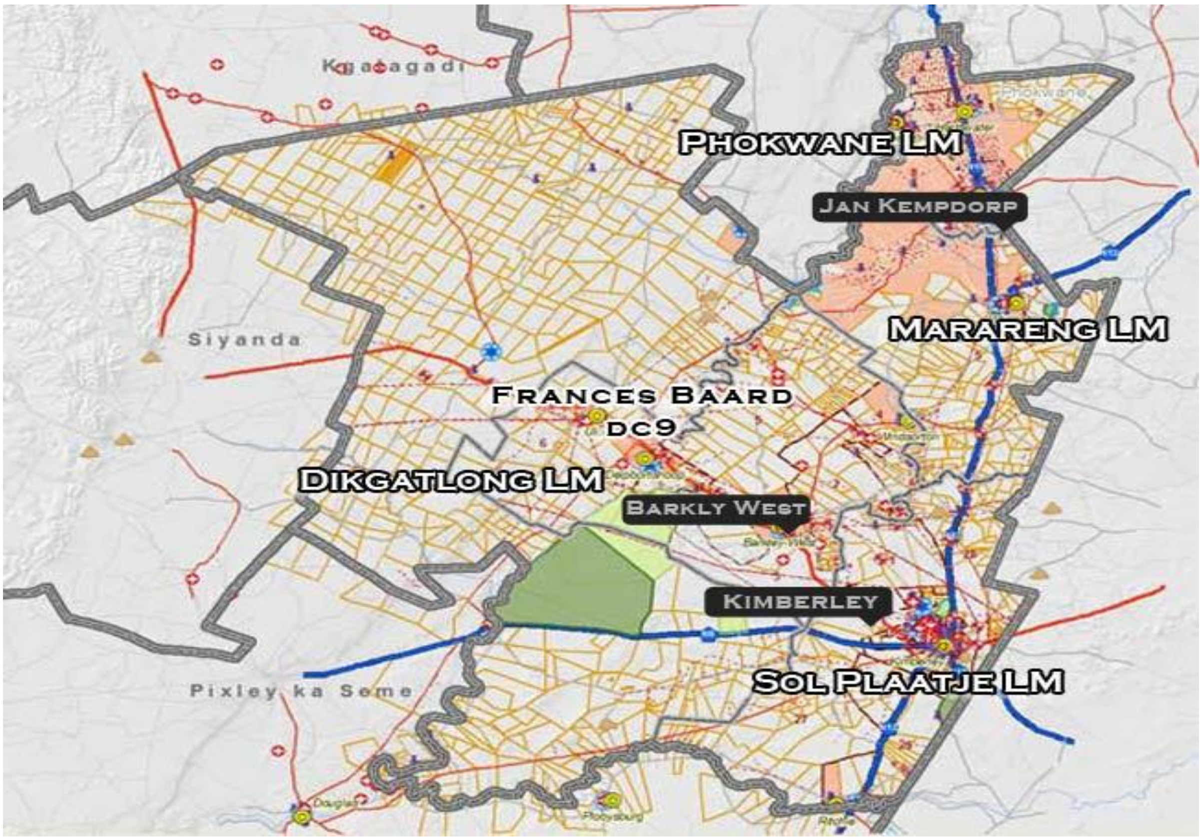

Figure 3-2: Frances Baard district municipality
Source: FBDM (2018).

Table 3.1 presents the number of households and population per local municipality of Frances Baard District Municipality. Sol Plaatje had the largest number of households (72 012) and population (255 351) when compared to the other local municipalities within Frances Baard. The major reason for this could be that Kimberley which in the largest city in the district municipality, falls under Sol Plaatje local municipality.

Magareng had the least number of households (6 970) and population (24 059) within the district municipality.

Table 3-1: Number of households and population per local municipality

Municipality	Number of households	Population
Dikgatlong local	14 751	48 164
Magareng local	6 970	24 059
Phokwane local	19 597	60 168
Sol Plaatje local	72 012	255 351
Total	**113 330**	**387 741**

Source: Author compilation based on FBDM data (2018).

3.2.1 Climate

The Northern Cape weather is usually that of semi-desert and desert areas and it is normally a hot and dry region, with fluctuating temperatures and normally low rainfall. The annual rainfall varies between 50 mm and 400 mm with an average annual rainfall of 202 mm over the province. However, the evaporation levels exceed the annual rainfall. The Northern, Eastern and Central parts of the province receive rain primarily from December to February (summer months). Namaqualand, portions of Boesmanland and small areas of the Green Kalahari form part of the western areas of the province, which receive rainfall from April to September (during winter months) (SA-V, 2018).

In the interior of the province, the average temperatures range between 34°C and 40°C in the afternoon during the month of January. In most parts of the province temperatures often top the 40°C mark during summer. Temperatures in the Orange River area are as high as 48°C in summer. Average day temperatures are mild (approximately 22°C) during winter (especially in June and August), with night temperatures often dropping below 0°C. In the mountainous areas of Sutherland, snow often falls in winter; this town lies at an altitude of 1 500 meters above sea level and is one of the coldest settlements in southern Africa with winter temperatures often being between -6 to -9°C (SA-V, 2018).

3.2.2 Agricultural production

The Orange River Valley, particularly in Upington, Kakamas and Keimoes has fertile agricultural land (grapes and fruit are cultivated intensively). The Karoo depends on sheep farming, while the karakul-pelt industry is one of the most essential in the Gordonia district of Upington. The Vaalharts Irrigation Scheme near Warrenton produces wheat, fruit, peanuts, maize and cotton. The province employs more than 40 000 people in the agricultural sector and more than 15 000 people were involved in subsistence farming annually (Stats SA, 2018).

Figure 3.3 presents the distribution of agricultural households involved in specific activities for 2016. As shown in the figure, approximately 48 300 households were involved in agriculture during the year 2016 in the Northern Cape (Statistics South Africa (Stats SA), 2016). A large number of these households were engaged in animal production (74.9%), while other households were engaged in crop production (15%) and mixed farming (10%). Households in the Northern Cape practice agriculture in their backyards, farmland and communal land.

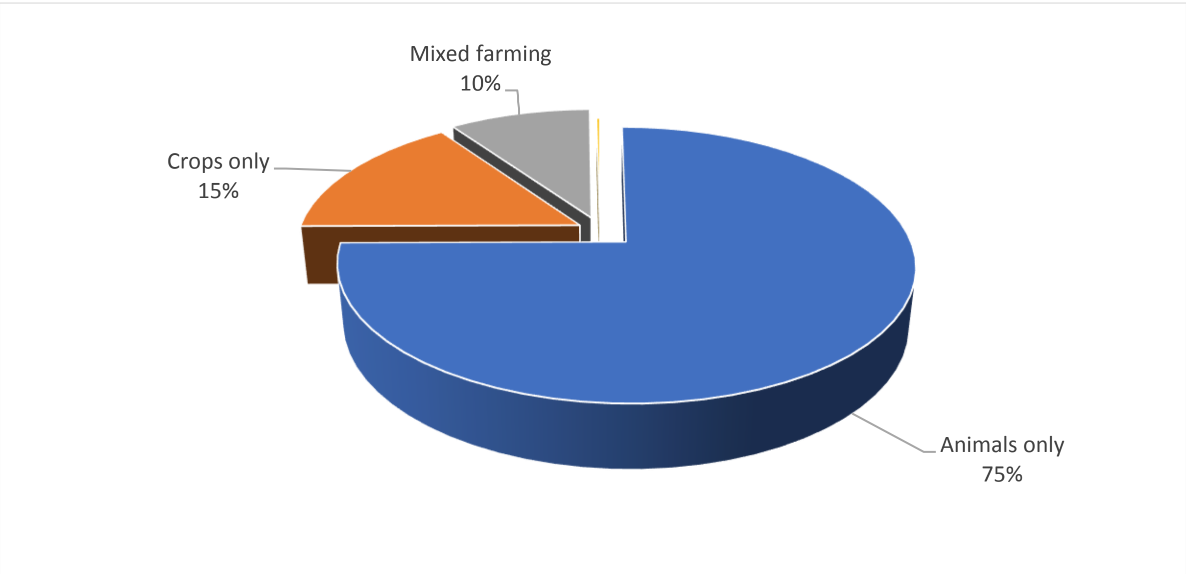

Figure 3-3: Distribution of agricultural households involved in specific activities for 2016
Source: Author compilation based on Stats SA data (2016).

Agriculture and mining remain the anchor sectors in the Frances Baard district. Agricultural production in the districts is made up of predominantly field crops followed by animal products; animal and horticulture sub-sectors specifically focusing on wheat, fruit, peanuts, maize, cotton, olives, cattle, game farming, viticulture, fishing and vegetables (Frances Baard, 2018).

3.3 Research approach & design

Research design refers to the entire process of research from conceptualizing a problem to writing the report, research questions, collecting data, analysis and interpretation (Creswell, 2007). McMillan and Schumacher (2010), defined research design as a method that describes the procedures for conducting the study, including when, from whom and under what conditions data will be obtained with the aim of specifying the plan for generating empirical evidence that will be used to answer the research questions. Research design can be in a form of qualitative, quantitative or a mixture of both methods known as mixed method research design. For the purpose of this research, a mixed approach was used. In a mixed approach, the researcher uses both qualitative and quantitative methods to analyse data. According to Tashakkori and Creswell (2007) as cited by Doyle, Brady and Byrne (2009), mixed method refers to research in which the researcher collects and analyses data, integrates the findings and draws inferences using both qualitative and quantitative approaches or methods in a single study.

3.3.1 Research approach

The interviews were conducted in Frances Baard District Municipality from the four local municipalities, which are Dikgatlong, Magareng, Phokwane and Sol Plaatje (please refer to the questionnaires in Appendix). Currently, there are no records showing the number of smallholder livestock farmers in the district. So, the number of smallholder farmers that were assisted during the 2015/2016 will be used as the population to determine the sample size. According to the Department of Agriculture Northern Cape (2018), there were 868 smallholder livestock farming units in the Frances Baard District Municipality that were assisted from all four local municipalities. Table 3.2 presents the number of farmers assisted during the 2015/2016 drought per local municipality, share of farmers and number of samples per each local municipality.

Table 3-2: Number of farmers who received assistance from government and sampling procedure

Local Municipality	No. of farmers	Share of farmers	No. of sample
Dikgatlong	347	40%	83
Magareng	119	14%	29
Sol Plaatje	263	30%	62
Phokwane	139	16%	33

Source: Northern Cape Department of Agriculture (2018) and Author calculations

The sample size of 207 smallholder farmers was the total of subjects who were willing to participate in the conducted questionnaire. Cochran's sample size formula for continuous data was used to determine the sample of 207.

$$N_o = \frac{t^2 * pq}{d^2} \quad \text{.......... (3.1)}$$

Where:

N_o= Sample size

t = value for the selected alpha level (indicates the level of risk the researcher is willing to take so that the true margin of error may exceed the acceptable margin of error)

pq= estimate of variance = 0.25 (maximum possible proportion (0.5)*1-maximum possible proportion (.5) produces maximum possible sample size)

d = acceptable margin of error for proportion being estimated = .05 (error researcher is willing to take) (Cochran, 1977; Bartlett *et al*., 2001)

If this formula is applied to the study and an alpha level of 1.65 (0.10), estimated variance of 0.5 and an error level of .05 were used, the formula would look as follow:

$$N_o = \frac{(1{,}65)^2 * (0.5)(0.5)}{(0.05)^2} \quad \text{.......... (3.2)}$$

$$N_o = 272$$

Resulting in a sample size of 272 respondents. Note that, if the sample size exceeds 5% of the population, the correctional formula of Cochran (1977), expressed as Equation 2, should be used to calculate the final sample size (Bartlett, et al., 2001)

$$N_1 = \frac{N_0}{1 + \frac{N_0}{population}} \quad \text{.......... (3.3)}$$

Thus, 5% of this value will be 303. The correctional formula will be used and a sample size of 272 is more than what is required for the study.

$$N_1 = \frac{272}{1 + \frac{272}{868}} \quad \text{.......... (3.4)}$$

$$N_1 = 207$$

3.3.2 The sampling Technique

A multiple-stage sampling technique was used to select respondents for this study. Alvi (2016) referred to multiple-stage sampling as a technique where two or more probability techniques are combined, used when the elements of population are spread over a wide geographical region. Although multiple-stage sampling was used, subjects included in the sample were selected to meet specific criteria. The respondents had to meet the following criteria to be included in the sample:

- Have had to be from one of the four local municipality in Frances Baard District
- Be a smallholder farmer producing livestock (cattle, sheep or goats).
- Be willing to participate.

3.3.3 Data collection

Data was collected to evaluate the farmers' knowledge and views on resilience and drought. A questionnaire or survey was developed to be able to conduct interviews, as an interview was chosen as a method of collecting data. Surveys may be used for descriptive, explanatory and exploratory research. A survey is information collected from different individuals or groups, where the investigator selects a sample of subjects and administers a questionnaire or conducts interviews to collect data (McMillan and Schumacher, 2010). In this study the information was collected through personal interviews.

The researcher, with assistant researchers, conducted the interviews. One of the advantages of conducting interviews is that there will be less errors as the researcher or researchers is or are able to explain what is expected from that specific question if the respondent does not understand what is required. This design was chosen to meet the objectives of the study. Interviews were conducted from July to September 2018 in Frances Baard District Municipality in the Northern Cape. The researchers met smallholder farmers, for interviews, at their farms, training sessions and conferences, with the assistance of extension officers from the Department of Rural Development and Agriculture from the four local municipalities.

3.3.4 Data analysis

After the data was collected, it was captured on Excel and it was cleaned immediately after capturing. SPSS 23 and StataSE 14 packages were used for all statistical analysis. Statistical Package for Social Sciences (SPSS) was used to analyse data collected for this study. SPSS 23 and StataSE 14 are computer or Window-based programs that can be used to perform data entry and analysis and to create tables and graphs. The programs can handle large amounts of data and can perform all of the analyses covered in the text and much more. Data is captured in a file which is translated to the SPSS 23 or StataSE 14 programs and is used to generate tabulated reports, charts, and plots of distributions and trends, descriptive statistics, and complex statistical analysis.

3.4 Conceptual framework

According to Walsh-Dilley, Wolford and McCarthy (2013), resilience framework focuses on understanding and promoting the capacity of local communities to respond, negotiate and transform shocks in such a manner that disturbances do not initiate a downward spiral and may even provide opportunities for improvement. The conceptual framework was adopted from the work of Mbae (2014), who based his research on the principle that factors that make farming households resilient to drought must first be identified, understood and strengthened. Figure 3.1 below shows the conceptual framework, which provides the factors that make farming households resilient to drought.

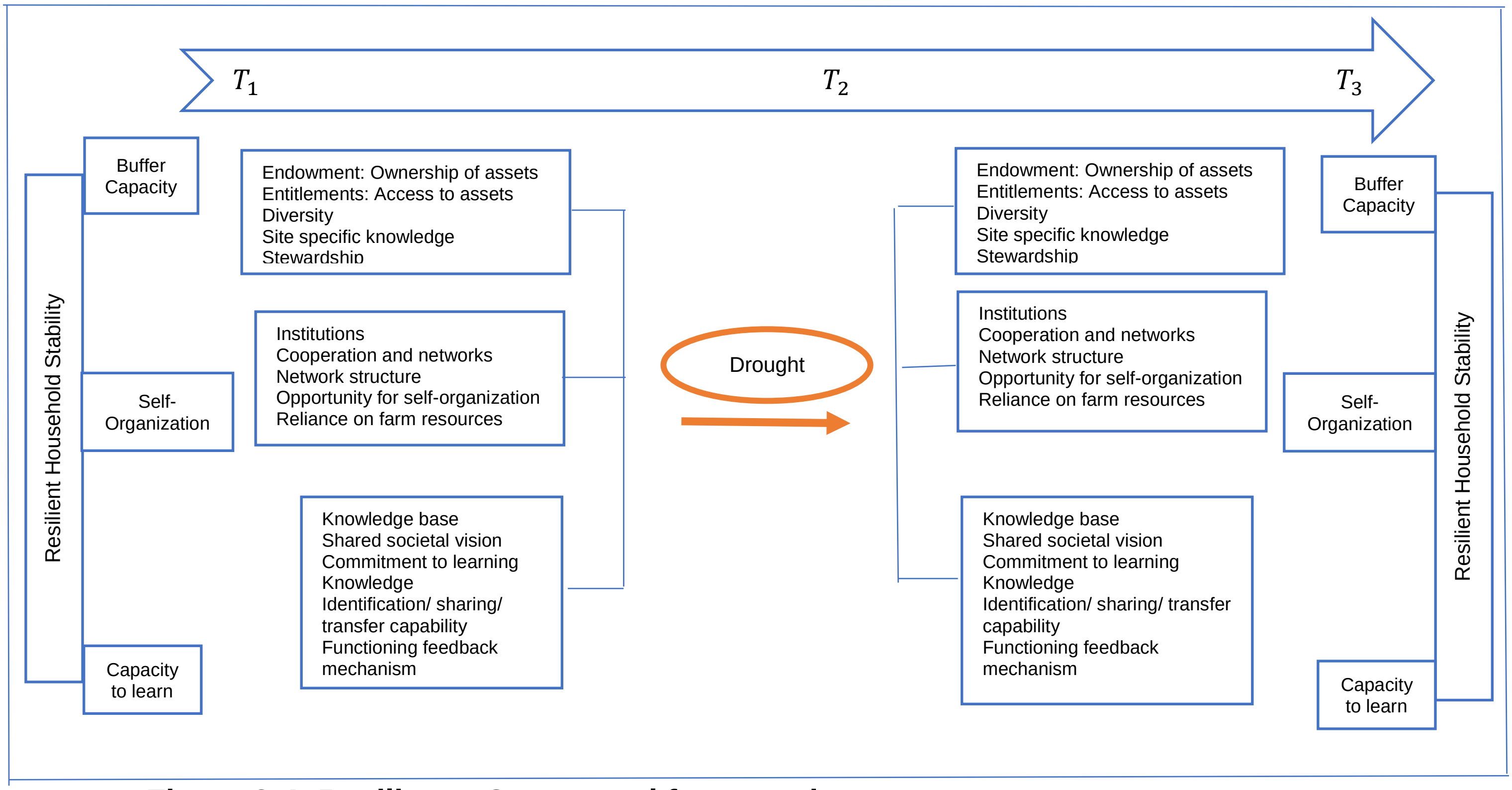

Figure 3-4: Resilience Conceptual framework
Source: Adopted from Mbae (2014).

Figure 3.4 presents the factors that make farming households resilient to drought. This conceptual framework highlights the three attributes which can be decomposed into various proxy indicators and are usually identified as, namely: buffer capacity, self-organization and capacity for learning (Mbae, 2014). According to Resilient Alliance (2010) as cited by Mbae (2014), buffer capacity has been described as the amount of disturbance a system can absorb and still retain the same structure, function, identity, and feedback on function and structure. The indicators are: endowment (ownership of assets), entitlements (access to assets), diversity, site specific knowledge and stewardship. Self-organization highlights indicators such as institutions, cooperation and networks, network structure, opportunity for self-organization and reliance on farm resources. Capacity to learn includes factors such as knowledge base, shared societal vision, commitment to learning, knowledge, identification or sharing or transfer capability and functioning feedback mechanism.

3.5 Empirical model for estimating resilience of a farming household

Principal Component Analysis (PCA) was used to construct the Agricultural Drought Resilience Index (ADRI). PCA is used when there are sets of continuous variables and is a dimension-reduction tool that is used to reduce a large set of variables to a small set that still contains most of the information in the large set. This is a multivariate analysis technique that regularly begins with data involving a substantial number of correlated variables. Four variables were aggregated to PCA to develop ADRI. These variables are as follows: livestock production produced by smallholder farmers in a normal year without agricultural drought ($W_{ny}L_{ny}$), livestock produced with agricultural drought (drought year) ($W_{dy}L_{dy}$), the number of months a household consumes food produced by the household in a normal year (without agricultural drought) ($W_{cny}C_{ny}$), and the number of months a household consumes food produced by the household in a bad year (with drought) ($W_{cdy}C_{dy}$). Each component of the equation is a weighted linear combination of the variables. The Principal Component Analysis model that was used to construct the Agricultural Drought Resilience Index was:

$$ADRI = W_{ny}L_{ny} + W_{dy}L_{dy} + W_{cny}C_{ny} + W_{cdy}C_{dy} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.5)}$$

Where:

ADRI represents the Agricultural Drought Resilience Index;

$\boldsymbol{W_{ny}L_{ny}}$: The weight of livestock production in a normal year multiplied by the actual number of livestock produced;

$\boldsymbol{W_{dy}L_{dy}}$: The weight of livestock production in a drought year multiplied by the actual number of livestock produced;

$\boldsymbol{W_{cny}C_{ny}}$: Weight for the number of months a household remains with meat in a normal year multiplied by the actual number of months a household remains with meat in a good year; and

$\boldsymbol{W_{cdy}C_{dy}}$**:** Weight for the number of months a household remains with meat in a drought year multiplied by the actual number of months a household remains with meat in a bad year.

All variables are expected to correlate positively with drought resilience. This is because an increase in any one of the variables was expected to be associated with an improvement in the well-being of the farming household.

3.5.1 Determining the factors that affect small-holder farming households' resilience to agricultural drought

To evaluate the factors that determine the resilience of households to agricultural drought in the Northern Cape, a Probit regression was employed. To determine whether a farming household is resilient or not to agricultural drought, ADRI which was developed by using Principal Component Analysis was used. This method was used by Banda (2015) to identify determinants of household resilience to dry spells and drought in Malawi. The drought resilience function is specified as:

$$Y_i = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 \ldots \ldots \ldots + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.6)$$

Y is the dependent variable, α is the parameters to be estimated, X is the independent variables and μ is the error term.

The probit regression model that was used to identify determinants of resilience was:

$$R_i = \alpha_0 + \alpha_1 Age + \alpha_2 Gender + \alpha_3 MStatus + \alpha_4 Funding + \alpha_5 Relatives + \alpha_6 Credit + \alpha_8 CCLL + \alpha_9 GovAss + \alpha_{10} TSource + \alpha_{11} NAss + \alpha_{12} Nlive + \alpha_{13} Oassets + \alpha_{14} CStrategy + \alpha_{15} AStrategy + \alpha_{16} ESupp + \alpha_{17} GOVI + \alpha_{18} FEXP + \alpha_{19} EDUC + \alpha_{20} DR + \alpha_{21} Sus + \alpha_{22} HM + \alpha_{23} RSupp + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.7)$$

Table 3.3 presents the description of the variables to be employed in the probit model and the expected sign.

Age

The age of the household head is an important factor that affects the decision of the farming household. Younger and older farmers do not think or do things the same way. Younger farmers may enhance their resilience better when compared to older farmers. This is mainly because younger farmers may adapt more easily to change and try new methods during dry periods.

Gender

In the past, households were headed by males. Some households interviewed were female-headed households. Gender plays an important role in decision- making; males may come up with different methods to survive during drought, while females do not try other methods. As a result, males may be more resilient to agricultural drought as compared to females.

Table 3-3: Description of variables used in the Probit model and expected sign

Variable	Description	Expected Sign
Dependent Variable		
Resilience	1 if the household is resilient and 0 if otherwise	
Explanatory variables:		
Age	Number of years	+
Gender	0 if Female and 1 if male	+
Marital Status (Mstatus)	1 if Single, 2 if Married, 3 if Widowed, 4 if Divorced, 5 if Separated, 6 if Other	+
Funding	Family savings =1, Borrowings=2, and Other=3	+/-
Remittances	1 if Yes, 0 if No	+/-
Credit	1 if Yes, 0 if No	+
Community Collaboration (CCLL)	1 if Yes, 0 if No	+/-
Government Assistance (GovAss)	1 if Yes, 0 if No	+
Other Water Sources (Tsource)	1 if Yes, 0 if No	+/-
Neighbour Assistance (NASS)	1 if Yes, 0 if No	+/-
Number of Livestock (Nlive)	Number of livestock	+/-
Other Assets (Oassets)	Number of other assets	+/-
Co-operative (COOP)	1 if Yes, 0 if No	+
Coping Strategy (CStrategy)	1 if Migrate, 2 if Ask for food, 3 if Sell livestock, 4 if Look for a job, 5 if Lessee of part of the farm, 6 if Other	+
Adaptive Strategy (AStrategy)	1 if Search for breeds that resist drought, 2 if Diversify farm activities, 3 if Livelihood diversification, 4 if Adopt conservation agriculture, 5 if Other	+
Enough Support (ESupp)	1 if Yes, 0 if No	+/-
Government Interest (GOVI)	1 if Yes, 0 if No	+
Farming Experience (FEXP)	Number in years	+
Education (EDUC)	1 if No education, 2 if Primary education, 3 if Secondary education, 4 if Tertiary	+
Drought Response (DR)	Sell livestock =1, Buy more livestock=2, Stop production=3, Sell assets=4, Other=5	+
Sustaining Natural Resources (Sus)	1 if Yes, 0 if No	+
Household Members (HM)	Number of members	+
Relative Support (RSupp)	Amount in Rands (ZAR)	+

Explanation of each variable that was employed in the Probit model is explained below:

Marital Status

Marital Status of the household head is an important characteristic that may affect resilience of affected families. It is expected that household heads that are married can be more resilient compared to others. If spouses of household heads are interested and involved in the daily activities of the farming household, the spouse of the household head may assist in decision-making during dry periods (drought). According to the researcher's knowledge, so far most researchers have not used marital status as a variable that determines the farmers' resilience. In this study, it was hypothesised that marital status would have a positive correlation to resilience of a farming household.

Household sources of income

Household sources of income is an important characteristic that may affect resilience of the farming household. It is expected that households that have different sources of funding for their farming business can either be resilient or not, depending on how they spend their money during dry periods. Households that are affected and have more funds to respond to agricultural drought, can be expected to be resilient, while those that do not have enough funds to respond are more likely to be less resilient to adverse effects of agricultural drought. Therefore, it is expected that funding could carry a positive or negative sign in the results.

Remittances

Immediate family members living outside the household play an important role for each household. Farming households can ask for assistance such as money to buy feed or help with the management of livestock from relatives during dry periods. Most people interviewed have relatives around Kimberley, other provinces, most specifically the Free State, North West and Gauteng and with a few having relatives residing in other countries, such as Zimbabwe. However, not all respondents receive monetary or managerial assistance from their relatives.

Credit

Access to credit during dry periods is very important, because the farmer gets an extra source of income although they will have to pay it back. Smallholder farmers become very vulnerable during agricultural drought to a point where they end up selling their livestock at a lower price resulting in lower profits. Smallholder farmers do not easily receive credit from financial institutions, because they do not have enough security.

Households that are affected and have access to credit can be expected to be resilient, while those that do not have access to credit are more likely to be less resilient to adverse effects of agricultural drought. Therefore, it is expected that credit could carry a positive sign in the results.

Community Collaboration

Community resilience refers to the capability to anticipate risk, limit impact, and bounce back rapidly through survival, adaptability, evolution and growth in the face of turbulent change (Eachus, 2014). Most communities hardly collaborate; this makes it difficult to determine the resilience of these communities. Resilient communities include those farming households that are able to withstand agricultural drought, with the knowledge and resources to respond and recover from agricultural drought. Enhancing resilience is considered critical in reducing the negative impact of drought or to mitigate drought vulnerabilities. Resource exchange and effective communication among community members (farmers) forms part of components of community resilience.

Government Assistance

Assistance from the government is an important characteristic that may affect resilience of the farming household to agricultural drought. Government plays an important role, especially in assisting smallholder farmers since there are few role players involved in smallholder farming. Smallholder farmers already receive assistance from government. The type of assistance that smallholder farmers receive from the government includes extension services (regular farm visits), training and land. During the 2015/2016 drought, smallholder farmers received coupons to buy feed from the government. However, not all farmers were assisted. Although smallholders receive assistance from the government, the government still need to put more effort into assisting these farmers.

Other Water Sources

Water plays a significant role in agricultural production. Animals depend highly on water for survival. Most farms are located far from rivers and there are no dams available on the farms; this means that there should be other water sources such as taps, boreholes and wells on the farm. It is expected that households whose farms have other water sources besides a river, can either be resilient or not depending on how the households manage the water during dry periods. However, grass for grazing is mostly affected when compared to water. It was thus, expected that other water sources could carry a positive or negative sign in the results.

Neighbour Assistance

Assistance from neighbours is an important characteristic that may affect resilience of affected families. It is expected that farming households that receive assistance from their neighbours (other farmers) can be more resilient when compared to those farming households that do not receive assistance from their neighbours. Farmers can assist each other by allowing the other farmer to access water or let livestock of the other farmer graze together. In this study, it was hypothesised that neighbour assistance would have a positive correlation to resilience of a farming household.

Number of Livestock

The number of livestock the farming household has is a very important characteristic because it can affect the household wealth of the smallholder farmer. A household that has a larger number of livestock that are ready to be sold, is more likely to have less problems during dry periods as it will be easy to sell some and still be able to feed the remaining number of livestock. This, however, comes with a cost of requiring more feed and more land as compared to a smallholder with less livestock.

Other Assets

Any asset the farming household is in possession of is an important characteristic. A household that is in possession of more assets that can be easily converted into cash is more likely to be resilient to agricultural drought because it can sell some of the assets to be able to survive by buying feed and ensuring they have enough water access during the period of agricultural drought. The other assets most farming households own include ducks, horses and implements such as a garden spade.

Co-operative

A farming household that is part of a co-operative can easily absorbs the adverse effects of agricultural drought. Members of a cooperative can share information or knowledge, buy feed in bulk, then share (they can even get discounts) and let their livestock graze together. Farming households that are part or member of a co-operative can enhance their resilience to agricultural drought easily. The study expected that the variable co-operative is positively correlated to household resilience to agricultural drought.

Coping Strategy

Strategies that a farming household apply during dry periods is a very important characteristic because it can help to come up with new methods to be resilient to agricultural drought if past strategies did not work out. A farming household that has applied more strategies over the past is more likely to have lesser challenges during dry periods than a farming household that does not do anything when faced with agricultural drought. In this study, it was hypothesised that a coping strategy would have a positive correlation to resilience of a farming household.

Adaptive Strategy

Adaptive strategies of the farming household may be a very important variable affecting the resilience of farming households to agricultural drought because these are the other measures the farming household undertakes during dry periods to try to survive or when affected in terms of food production. Some of the strategies the farming households apply when food production is affected during dry periods include searching for breeds that resist drought, diversify farm activities, diversify their livelihood or even adopt conservation agriculture. In this study, it was hypothesised that farming households that adopt any of the strategies mentioned above will enhance their resilience to agricultural drought.

Enough Support

Support from different institutions or organizations is an important characteristic of the farming household because if agricultural drought occurs and lasts for a very long time (more than a year), the different organizations can help to smooth the production of affected farming households by providing funds to buy feed and medicines during the tough times. The variable enough support means support that the farming household receives during dry periods from different agricultural stakeholders such as government, agricultural companies or financial institutions. Farming households that receive enough support from these institutions or organizations are expected to be resilient to agricultural drought when compared to those farming households that do not receive enough support.

Government Interest

Interest of government to agricultural drought in the study area is an important characteristic for the farming household because although government can provide assistance during dry periods, government may not be interested in what is going on within the study area; for example, not checking up on the smallholder farmers how they feed their livestock after giving them coupons to buy feed. An interested government will try to do research on ways that smallholder farmers can adopt to enhance their resilience to agricultural drought or other shocks, outsource more funding for smallholder farmers during dry periods or provide more drought training on how to survive during dry periods without having to sell the livestock. In this study, it was hypothesised that farming households with an interested government will enhance their resilience to agricultural drought better when compared to those farming households that have a government that is not interested.

Farming Experience

The number of years the household head has been involved in farming is an important characteristic for the farming household because the longer the farmer has been involved in farming will mean he/she have better management skills and the possibility of being exposed to agricultural drought more than once is very high. The number of years the farmer has been involved in farming also influences the decisions that the farmer makes. Farming household heads that have more years of experience in farming are expected to be resilient to agricultural drought when compared to those farming household heads with only a few years of experience in farming because they can apply all the methods they have applied in the past when faced with agricultural drought and even try new methods.

Education

The level of education of the household head is an important characteristic in determining the resilience of farming households. According Jiri, Mafongoya and Chivenge (2017), education increases the probability of adapting to climate change as it is associated with being open-minded and the ability to embrace positive change. However, the results showed that the educational level of the household has no significant influence on adaptation to climate change. This study hypothesised that education is one of the variables that affects resilience of a farming household to agricultural drought.

Drought Response

The way in which the farming household responds to agricultural drought is very important because the decision the farming household head makes during this time will affect the production, other farming activities and non-farming activities. Moreover, the decision taken by the farmer can either lead to the farmer to stop farming or continue with farming even after the study area starts receiving normal rainfall. When faced with agricultural drought the farmer can respond by selling some of his or her livestock, buying more livestock, stopping production, selling some assets or finding other ways such as spending less on non-farming activities (not paying school fees and buying less food). It is expected that the decision the farming household head makes when responding to agricultural drought can either enhance his or her resilience or not, depending on how the household head handles the decision made during dry periods. It was thus, expected that drought response could carry a positive sign in the results.

Sustaining Natural Resources

Sustaining natural resources such as water, can assist when faced with agricultural drought because there will be enough water for the animals to drink and to water the plants; this means that each farmer will be able to plant their own feed. This variable was based on the farmers' perception regarding sustaining natural resources on how this can assist during dry periods. This study hypothesised that sustaining natural resources is one of the variables that affects resilience of a farming household to agricultural drought.

Household Size

The number of members a farming household has is an important characteristic because it can affect the spending expenditure and labour. A farming household that has more family members that work of the farm is more likely to have less challenges in terms of labour during dry periods when compared to a household with a smaller number of household members. Members of the farming households can assist in decision-making when faced with agricultural drought. Some farming households interviewed, especially those with a few household members employ someone to take care of the livestock; this increases the operating expenses of the farming household, while a farming household with more members can take turns and do not spend on labour. It is expected that the number of members a household has can enhance the resilience of a farming household.

Relative Support

The amount of money (Rands) a farming household receives from relatives is an important characteristic, because when a farming household faces agricultural drought, they can use the money to buy feed or medicine as the government takes time to assist smallholder farmers during dry periods. It is expected that a farming household that receive financial assistance from relatives will be more resilient to agricultural drought compared to those farming households that do not receive any financial assistance from relatives. It was thus, expected that relative support could carry a positive sign in the results.

3.5.2 Determine the effect of drought resilience on the welfare of smallholder livestock farming households

A Stochastic Production Function (SFA) was used to determine the effect of agricultural drought resilience on the welfare of smallholder farmers in the Northern

Cape. The Stochastic Production Function model has been applied and modified by different researches (Wan and Battese (1992); Battese and Coelli (1995); Banda (2015); Nyam (2017)). SFA was firstly proposed independently by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). According to Sarafidis (2002) as cited by Nyam (2017), to estimate the frontier function in a given sample, SFA mainly makes use of the maximum likelihood estimation technique. There are different functional forms, like linear models, semi-log models, trans-log and the Cobb-Douglas. The trans-log production function was used because its functional form provides a better fit for the data when compared to the others. The trans-log production function model takes the form:

$$InY_i = \alpha_0 + \sum_{n=1}^{N} \alpha_n \, InX_n + {}^1\!/_2 \sum_{n=1}^{N} \sum_{m=1}^{M} \alpha_{mn} \, Inx_n Inx_m + v_i - u_i \ldots\ldots\ldots\ldots\ldots\ldots \quad (3.8)$$

The trans-log production function model that was used to determine the effect of agricultural drought resilience on the welfare of small holder farmers was:

$$Y_i = \alpha_0 + \alpha_1 Ha + \alpha_2 Labour + \alpha_3 Feed + \alpha_4 Other\ Costs + \alpha_5 ADRI + \nu_1 + \mu_2 \ldots\ldots \quad (3.9)$$

Where:Y_i: represents the livestock output for the farming household; Ha: is the actual amount of land (ha) used by farming households in producing livestock; Labour is the amount of labour (number of hours per person) used by farming household in producing livestock; Feed is the actual amount of feed (Kg) bought by the farming household during a drought year; Other costs is the amount of Rands (ZAR) used in a drought year for other farming activities apart from purchasing farming inputs; agricultural drought resilience index represented the drought resilience index for household; α_0 denotes the constant term while denotes α_1 is the coefficients of the parameters to be estimated for each household; v_i represents a symmetric two- sided normally distributed random error that accounts for the random effects beyond the farmer's control, u_i represents the asymmetric non-negative random-error component that measures technical inefficiency.

3.6 Summary

This chapter outlined the methodological approach used in the study. The main objective was to determine the resilience of smallholder farmers in the Frances Baard District Municipality, Northern Cape. The Northern Cape is one of the driest provinces in South Africa. After the 2015/2016 drought, which was severe, it was important to determine the resilience (how do smallholder farmers survive during dry periods) of smallholder farmers to agricultural drought as the province is already dry. Resilience needed to be examined to ensure that effective policies and meaningful interventions are developed for these farming households by the government and other agricultural stakeholders. Research findings and results of this study will be discussed in the following chapter.

Chapter 4 : Results and Discussion

4.1 Introduction

This chapter presents the research results and discussions from the data collected to determine the resilience of households to agricultural drought in the Northern Cape. Different statistical packages were used to analyse important findings, so that policies can be implemented by the government and policy makers. Firstly, this chapter will present results from the descriptive statistics, followed by results from Principal Component Analysis to construct the Agricultural Drought Resilience Index for the first objective, Probit model results to determine the factors that affect the resilience of farming households. Lastly, this chapter will also show the impact of ADRI on the welfare of smallholder farmers.

4.2 Descriptive statistics

4.2.1 Socio-economic characteristics of the respondents

This section of the chapter presents and discusses the results of the demographics of the respondents for both resilient and non-resilient small-holder farmers for all the municipalities. Table 4.1 presents the socioeconomic characteristics of all the farming households interviewed. For decision-marking (it can be financial or managerial), gender plays an important role especially in farming. The results from the study indicate that the majority of the farming household heads were males. The results show that male-headed households comprised 81%, while 19% of households were headed by females. These findings indicate that males in the farming households interviewed are the decision makers. Jiri, Mafongoya and Chivenge (2017) found that 61.9% of the farmers who have adapted to climate change were males.

Marital Status of the household head is an important characteristic. Approximately 67% of the respondents both resilient and non-resilient smallholder farmers indicated that they were married. During the interviews, spouses of household heads showed interest and seemed involved in the daily activities of the farming household. Moreover, the spouse of the household head assists in decision-making during dry periods (drought). About 20% of the respondents indicated that they are single, while others are widows (11%) and divorced (2%). Household heads that are married will make better decisions during dry periods as their partners can assist in decision-making.

Employment status of household heads is another important socio-economic characteristic that needs to be analysed. Farming household heads that are formally employed may be resilient to agricultural drought, because they have access to funds (for example, personal loans and can use their monthly salary). About 144 household heads (70%) reported farming as their main occupation in the study area, while 63 household heads (30%) reported that they are formally employed. Out of 207 households interviewed, approximately 30% of the household heads indicated that farming is their second occupation, while 2% of the household heads are self-employed. The remaining 140 farmers indicated that they do not have a secondary occupation. Approximately 38% of the farmers are pensioners and 30% are unemployed. Farmers use their pension money for the farm operations and during dry periods it will be hard for those farmers to be resilient as they do not have enough funding.

Funding is crucial for any farming business. Unlike commercial farmers, smallholder farmers do not have access to credit. The majority (50%) of the participants indicated that they use their family savings to operate their farm business, while 45% of the participants use other forms of funding such as monthly salaries, pension money, sales of livestock, other business and money from piece jobs. The rest of the participants use family savings and other sources (2%), borrowing from others (2%), and borrowing and other sources (1%). Farmers using their savings mean that during dry periods they will become more vulnerable as there would not be enough funds. About 82% of the farming household heads are not involved in any other business besides farming, while the remaining (18%) of the farming household heads own other business such as taverns and spaza shops. A farming household that is engaged in other business will enhance their resilience to agricultural drought as funds from the other business can assist during dry periods.

Table 4-1: Socio-economic characteristics of the farming household

Variable	Socio-economic	Frequency	Valid percentage	Cumulative Percentage
Gender	Female	39	18.8	18.8
	Male	168	81.2	100.0
Marital Status	Single	41	19.8	19.8
	Married	139	67.1	87.0
	Widowed	23	11.1	98.1
	Divorced	4	2.0	100.0
Main Occupation	Farmer	144	69.6	69.6
	Formally Employed	63	30.4	100.0
Secondary Occupation	Self-Employed	4	1.9	1.9
	Pensioner	78	37.7	39.6
	Unemployed	62	29.9	69.5
	Farmer	63	30.5	100.0
Funding	Family Savings	104	50.2	50.2
	Borrowing from others	5	2.4	52.6
	Borrowings and Other sources	5	2.4	55.0
	Family Savings and Other Sources	4	1.9	56.9
	Other Sources	89	43.1	100.0
Other Business	No	170	82.1	82.1
	Yes	37	17.9	100.0

Source: Author based on Survey (2018)

Table 4.2 presents the descriptive statistics of the farming households interviewed from the selected district. As shown in the table below, the average age of the household head is 55 years, the youngest household head was 21 years old and the oldest was 89 years old. Younger farmers will enhance their resilience to agricultural drought when compared to the older farmers. According Jiri, Mafongoya and Chivenge (2017), younger household heads tend to adapt easier to climate change than older household heads. The study reported that the farming household had an average of 5 members. Household members can assist in terms of labour, if the household head is busy with other things. Education is an important factor that affects the farmers' perception in terms of resilience. The average number of years of formal schooling for the respondents was approximately 8 years, with some farmers not receiving any form of formal education and the most educated farmers spent 16 years being educated. Most farmers start farming at an early age or grew up in households that practices farming (substantial farming) or work on a farm. Farming experience of the household head ranged from 1 to 40 years. The household head's farming experience was calculated at an average of 12 years. Having more years of farming experience means there is a high possibility that the farmer had experienced agricultural drought. This means that the farmer may try other methods to survive or use past strategies during dry periods.

Smallholder farmers rely on family labour, but not completely on family labour. On average, the farming households interviewed from the Frances Baard District Municipality spend 6 hours on the farm daily. The maximum hours spent on the farm was 10 hours where farmers indicated that they get to the farm at 7 am or at 5 pm, while the minimum hours spent on the farm is 0, because most of the farming households interviewed were farming on communal land and some farmers will form a group and employ someone who will take care of the livestock. However, some farmers would go to the farm to check the progress on the farm. Finally, the results show that farming households with remittances, more so that it seems regular with a monthly average of R317.83 monthly. This is a significant contribution to household income.

Table 4-2: Descriptive analyses of the farming households

Variable	N	Min	Max	Mean	Std. Deviation
Age	207	21	89	55.41	13.899
Education	207	0	16	8.05	4.41
Farming Experience	207	1	40	11.75	7.74
Hours spent	207	0	10	5.66	3.00
Support Rand value	207	0	16000	317.83	1 304.96

Source: Author based on Survey (2018)

4.2.2 Resources available for farming household

4.2.2.1 Land tenure for the farming household

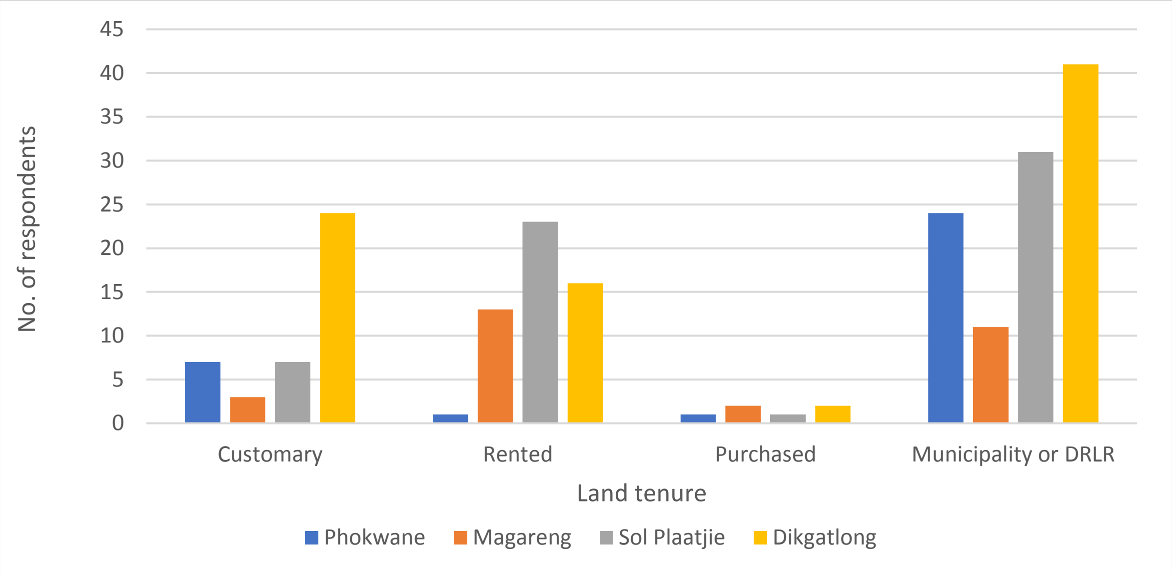

Figure 4-1: Land tenure for the farming household
Source: Author based on Survey (2018)

Figure 4.1 demonstrates the land tenure of farming households per municipality. Majority of the farmers from Phokwane (24), Sol Plaatjie (31) and Dikgatlong (41) municipalities indicated that the land (communal land) they are using for farming belongs to the Department of Rural Development and Land Reform or the Municipality. Since farmers do not own the land, they do not have access or full property rights; for example, there is a certain portion of the farm they are not allowed to use. If farmers had full access of the land, they would reserve certain portions to graze on during dry periods. The highest number of farmers interviewed who mentioned that they are renting the farm, are from Sol Plaatjie (24), Dikgatlong (16) and Magareng (13). In Magareng municipality, most of the farmers are renting the land when compared to the other forms of ownership. Farmers that mentioned customary use (Phokwane (7), Magareng (3), Sol Plaatjie (7) and Dikgatlong (24)) are those farmers that farm on one hectare (backyard farming), but still produce good quality livestock for the market. Fewer (6) famers from all the local municipalities which accounts for 2% have indicated they purchased the land used for farming. This shows that smallholder farmers are still lacking resources, while they have the potential to produce an adequate number of livestock. For livestock production, natural grazing plays a crucial role which requires more land. The government has to intervene, so that these smallholder farmers can be assisted and enabled to grow.

4.2.2.2 Access to water by farming households

Water is an important resource for livestock production. The majority (118) of the farmers are far from rivers, while the remaining (89) are closer to the river for all local municipalities. However, even though some farmers may be close to the river, they do not have access to the water, because they do not have water rights. About 201 farmers mentioned that they have access to other water sources. This number also includes the number of farmers that are close to the river, excluding 6 farmers that do not have access to other water sources, meaning they get water from the river.

Figure 4.2 shows the different types of water sources that smallholder farmers use on their farmers. As presented in figure 4.2, boreholes (49%) are the main source of water supply in most farms. Although farmers have boreholes on the farms, not all boreholes are operating. Sometimes farmers have to fetch water from their households to the farm, which leads to extra production costs (petrol used for water transportation). Other sources of water supply can either be taps or canals (30%). Farming households that use taps are those farming on a one hectare (backyard farming) and canals for farmers located in a communal land. While the rest use wells (18%), lakes (1%) and none (2%) meaning they use water that is directly from the river.

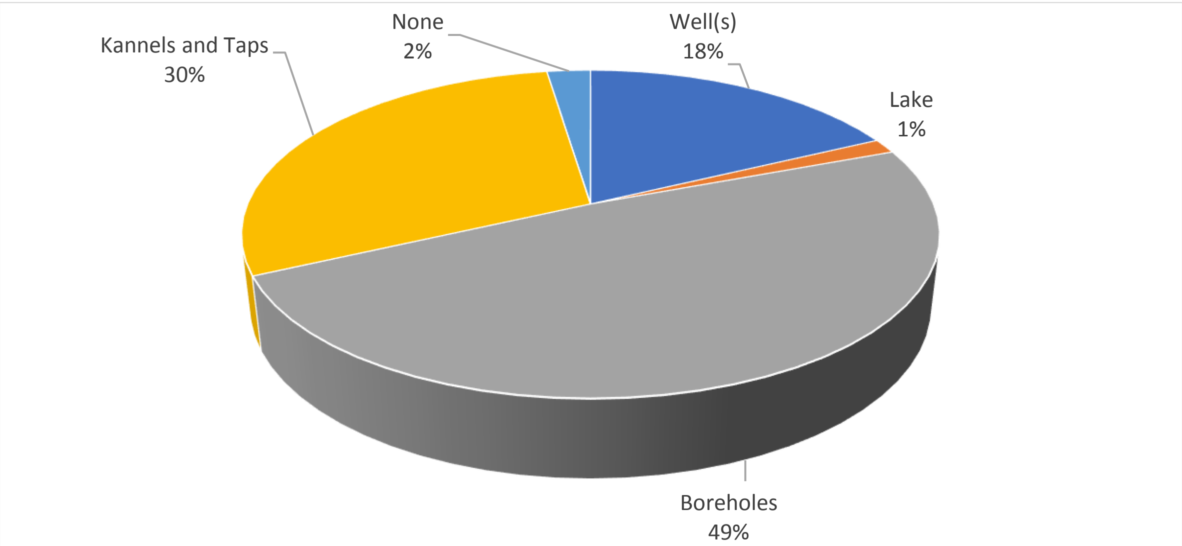

Figure 4-2: Household water sources
Source: Author based on Survey (2018).

Figure 4.3, 4.4., 4.5 and 4.6 presents the some of the types of water sources used by smallholder farmers for their livestock from Frances Baard District Municipality.

Figure 4-3: Livestock drinking water (Granspan)
Source: Author (2018)

Figure 4-4: Cattle drinking water (Granspan)
Source: Author (2018)

Figure 4-5: Well (s)at the dumping site farm
Source: Author

Figure 4-6: Sheep next to a borehole (Dikgatlong)
Source: Author (2018)

4.2.3 Assets owned by the farming households

Table 4.3 illustrates the number of assets owned by the farming households interviewed, excluding cattle, sheep and goats. Most farming households in the Frances Baard District Municipality own non-agricultural assets when compared to agricultural assets. Farming households own agricultural assets such as tractors, hand hoes, chickens and pigs, while other assets include horses and ducks. The percentage of smallholder farmers from all the local municipalities that own land are Dikgatlong (60%), Phokwane (18%), Magareng (13) and Sol Plaatjie (9%). Dikgatlong was the highest mainly because most smallholder farmers were from the local municipality. Dikgatlong (50%) had the largest number of smallholder farmers owning tractors when compared to Phokwane (25%), Sol Plaatje (13%) and Magareng (13%). Farming households have indicated that they do not have access to assets such as tractors, because they are expensive, and government give certain communal farms. Another reason may be that most of these farming households do not plough. Smallholder farmers from Sol Plaatje (42%) owned more pigs followed by Magareng (28%) then Phokwane (16%) and Dikgatlong (13%). Dikgatlong (44%) had the largest number of smallholder farmers owning hand hoes when compared to Sol Plaatje (35%), Phokwane (14%) and Magareng (7%), farmers indicated that since they do not have tractors they use hand hoes to plant their crops. Chickens are were part of the agricultural assets that smallholder farmers own with Dikgatlong farming owning 38% followed by Sol Plaatje (33%), Phokwane (17%) and Magareng (11%). Smallholder farmers interviewed have indicated that chickens are some of the assets they sell when faced with agricultural drought.

Table 4-3: Number of Assets owned by different farming households

	Phokwane	Magareng	Sol Plaatjie	Dikgatlong
Land	8	6	4	27
Tractors	4	2	2	8
Bakkies	19	17	44	50
Axes/Knives	29	27	156	166
Hand hoes	14	7	36	45
Wheelbarrow	26	36	60	84
Hosepipe	31	37	67	80
Radio	31	38	65	95
TV	37	45	82	106
Bed	111	118	229	287
Chairs	174	282	552	625
Chickens	325	198	621	714
Pigs	57	98	147	45
Other	69	29	30	151

Source: Author based on Survey (2018)

4.2.3.1 Agricultural Activity per municipality and number of livestock

Agriculture is important for food production and food security. Figure 4.7 shows the type of agricultural activity the farming household is involved in. Since the study was based on livestock farmers, the majority of the farmers from all municipalities were producing livestock only, while others are engaged in both livestock and crop production. Magareng had the largest percentage (97%) of farmers involved in livestock farming, followed by Sol Plaatjie (90%), Dikgatlong (83%) and Phokwane

(52%). Phokwane has the largest number of respondents engaged in mixed farming compared to the other municipalities.

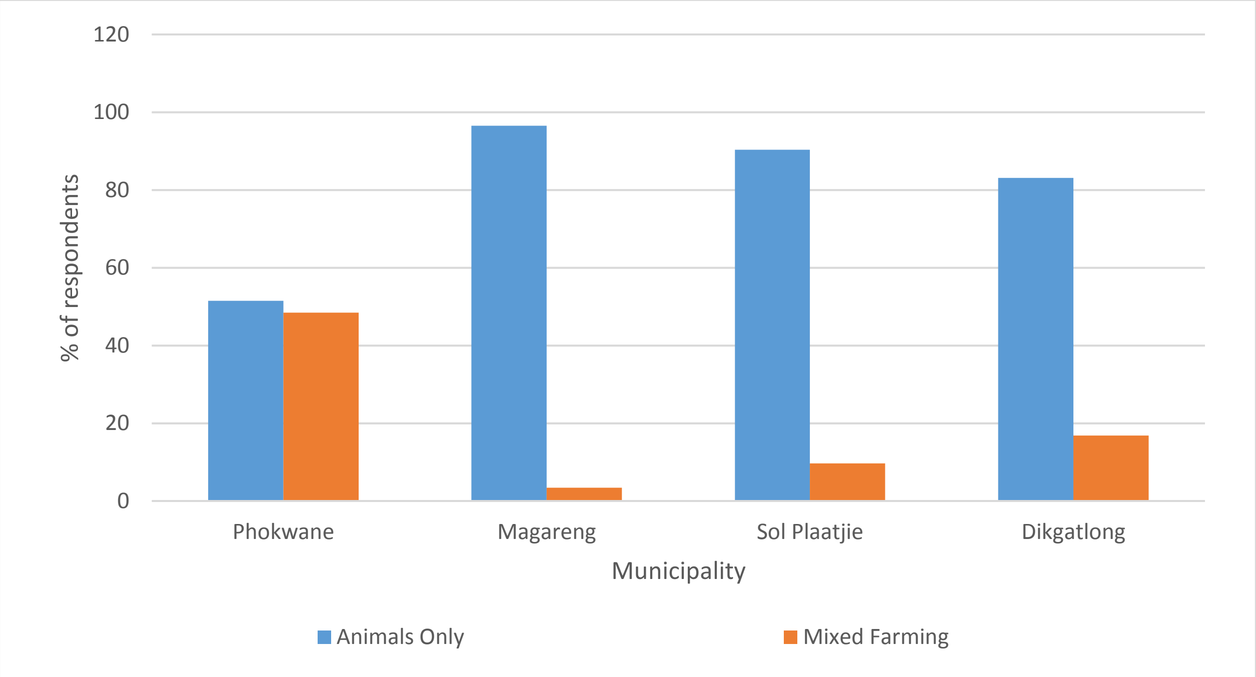

Figure 4-7: Livestock activity per municipality
Source: Author based on Survey (2018)

Approximately 48% of the respondents from Phokwane are engaged in both livestock and crop production, because most of farming households are farming in the backyard. The types of crops these farmers produce include fruits (mostly citrus) and vegetables, see figure 4.8, 4.9, 4.10 and 4.11 for the different crops produced. The crops produced are 100% fully used for household consumption, especially during agricultural drought where some farming households cannot afford to buy meat.

Figure 4-9: Vegetables planted (Sol Plaatjie)
Source: Author

Figure 4-8: Communal Farm (Magareng)
Source: Author (2018)

Figure 4-11: Planted land (Granspan)
Source: Author

Figure 4-10: Land preparation for planting
Source: Author

4.2.3.2 Number of livestock

Table 4.3 indicates the number of livestock per municipality. Phokwane had the largest number of sheep (316); Magareng had more goats (582); Sol Plaatjie (1584) and Dikgatlong (1961) had the largest number of cattle when compared to sheep and goats.

Table 4-4: Number of livestock per municipality

Municipality	Cattle	Sheep	Goats
Phokwane	260	316	262
Magareng	489	86	582
Sol Plaatjie	1584	676	799
Dikgatlong	1961	1363	1306
Total	**4294**	**2441**	**2949**

Source: Author based on Survey (2018)

Farmers sell their livestock at market centres (auctions), farm gates, sell as a group and around the community (including funerals, stokvels and households). Farmers believe they get a better price (they are able to determine their own price) when they sell around the community when compared to taking their livestock to auctions, because prices are determined by the weight at auctions. Figure 4.12 shows an auction in Hartswater, where some of the smallholder farmers market their livestock. Figure 4.13 shows livestock kept in a holding area at auction ready to be sold.

Figure 4-13: Auction in Hartswater
Source: Author (2018)

Figure 4-12: Livestock to be auctioned in the holding area
Source: Author (2018)

4.2.4 Farming households and Drought

4.2.4.1 Drought impact on livestock

Grass for grazing and water are the most affected during the periods of agricultural drought. About 99% of the farmers mentioned that they experience agricultural drought, while the rest (1%) indicated they do not experience agricultural drought. The farmers that do not experience agricultural drought are based in Magareng (Nazerec farm) where it is close to two rivers and the grass is good for grazing even in dry periods. The majority (54%) of the farming households indicated that when drought occurs, it lasts for the whole year. While the remaining mentioned it lasts for a month (19%) and about 27% of the farmers said it lasts for 4 to 6 months. Farmers that indicated agricultural drought lasts for a month are those farmers that cannot differentiate between normal, below and above-rainfall.

About 70% of the farming households from all the municipalities mentioned that drought is becoming more frequent, followed by 18% of the farming households mentioning they do not see any difference and 12% of the farmers think that drought is becoming less frequent. Each year, the Northern Cape is dry during winter periods; this makes it hard for farmers to differentiate between dry winters and agricultural drought. When agricultural drought occurs, it has a major impact on the production of livestock. Approximately 94% of the farmers indicated that agricultural drought has an impact on their livestock, while the remaining 6% indicated that agricultural drought does not have any impact on their livestock production.

Figure 4.14 illustrates the type of impact agricultural drought has on livestock production. Majority (40%) of the farmers indicated agricultural drought can lead to poor animal health. There are certain medicines that farming household buy during dry periods. However, not all farmers can afford. Poor animal health can lead to loss of livestock or loss of weight (leading to decrease in prices). About 27% of the farmers said that agricultural drought can lead to loss of livestock and about 10% indicated they are forced to sell their livestock at lower prices (decline in prices). The remaining indicated loss of livestock, poor animal health and decline in prices (13%) and loss of livestock and poor animal health (10%) as the types of impacts agricultural drought have on their livestock.

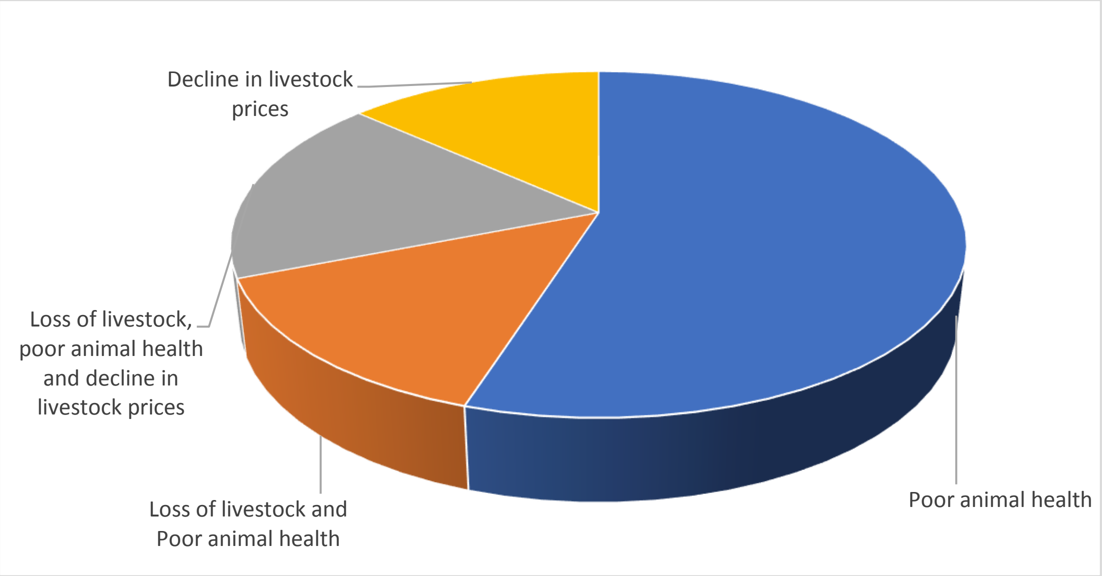

Figure 4-14: Drought impact on livestock
Source: Author based on Survey (2018)

4.2.4.2 Vulnerability to drought by livestock farmers

Figure 4.15 shows the vulnerability of farmers to agricultural drought for the different municipalities. Farming households from all the municipalities (Magareng (69%), Sol Plaatjie (61%), Dikgatlong (67%) and Phokwane (70%)) have rated themselves under "very high" when it comes to vulnerability, because they end up being stressed due to poor animal health, selling their livestock at lower prices, less grazing and increasing prices of farming inputs (feed and medicines). Fewer farmers from all the municipalities (Magareng (8%), Sol Plaatjie (2%), Dikgatlong (3%) and Phokwane (0%)) have indicated that they are not vulnerable to agricultural drought.

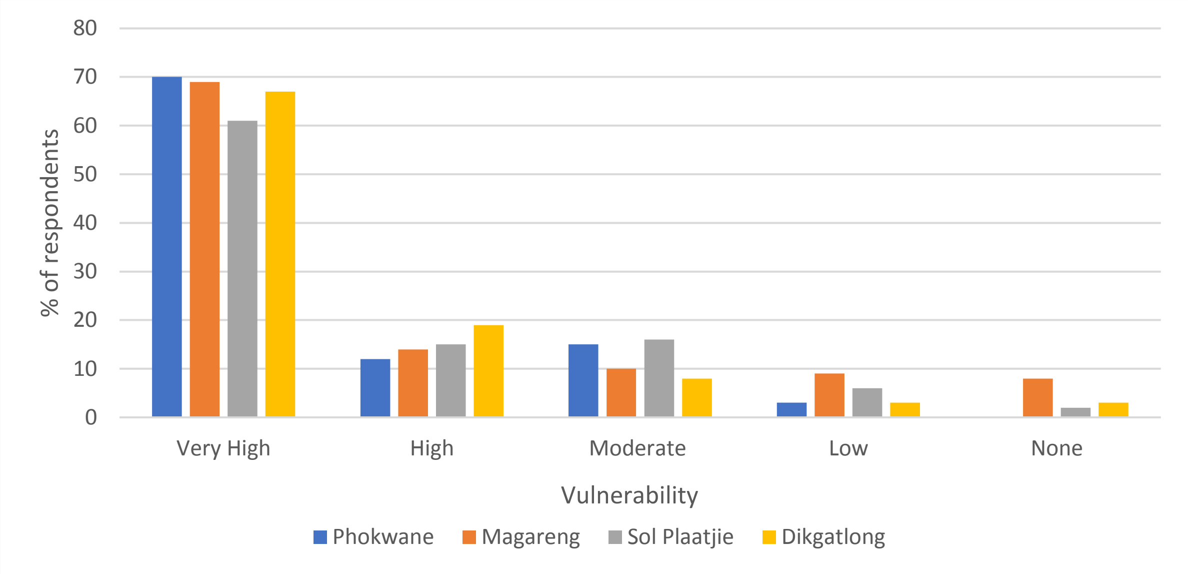

Figure 4-15: Vulnerability of households to agricultural drought
Source: Author based on Survey (2018)

4.2.4.3 Coping Strategies

No matter how bad the situation can be, farmers try to find ways to survive during dry periods. Figure 4.16 illustrates the coping strategies of farmers during agricultural drought. Majority (55%) of the farming households indicated that they sell some of their livestock to be able to feed the remaining animals during agricultural drought. This also reduces production costs such as feed and medicines. Approximately 34% of the farmers said they look for other ways to survive such as buying feed, stop production or ask help from the government for that specific period. The remaining look for jobs (6%) and ask for food (5%) from neighbours.

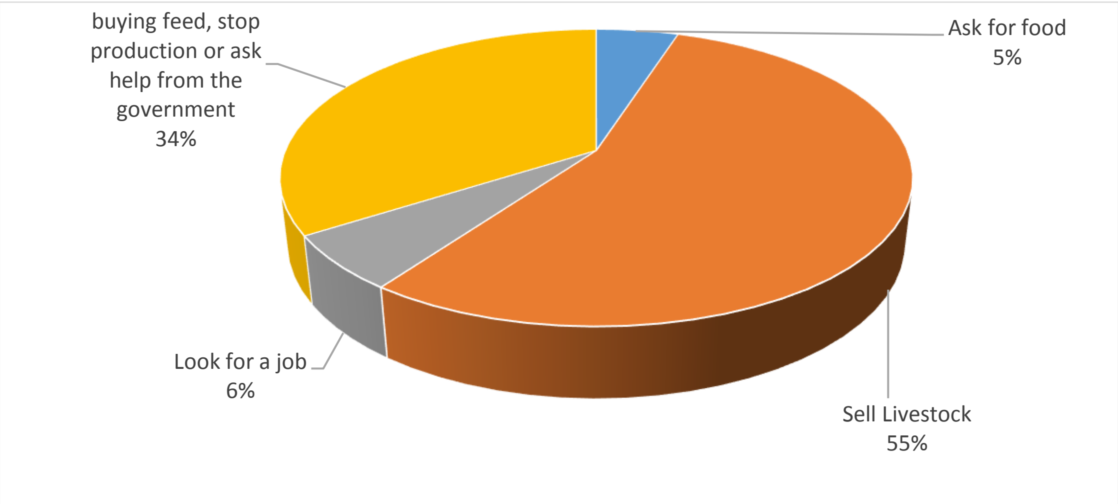

Figure 4-16: Coping strategies
Source: Author based on Survey (2018).

4.3 Results from the different empirical models

This sub-section of chapter 4 presents all the results from all the empirical models which are Principal Component Analysis, Probit Model and the Stochastic Production Function model for three objectives of the study. This sub-section starts by looking at the Principal Component Analysis.

4.3.1 Principal Component Analysis-Estimating the Agricultural Drought Resilience Index (ADRI)

Table 4.5 shows the correlation matrix of variables utilized when constructing ADRI. The highest correlation exists (0.585; 0.884) between Production of livestock in Normal year and Production of livestock in a drought year and Months household consume food in a drought year and Months household consume food in a normal year. This result was expected due to variables that highly correlated measuring the same construct. The first two variables (PLNY and PLDY) are indicators of production and the other two variables (MHCNY and MHCDY) indicators of consumption.

Table 4-5: Correlation matrix for variable used to construct the ADRI

	PLNY	PLDY	MHCNY	MHCDY
Production of livestock in Normal year (PLNY)	1			
Production of livestock in Drought year (PLDY)	0.585	1		
Months household consume food in normal year (MHCNY)	0.067	0.126	1	
Months household consume food in drought year (MHCDY)	0.084	0.012	0.884	1

Source: Author Estimation (2018).

In order to assess whether the data is suitable or not for PCA, the Bartlett's test of sphericity was conducted with the aim of testing the hypothesis that the variables used in PCA were not inter-correlated. Table 4.6 indicate the results of the Bartlett's test of sphericity. The results show that the null hypothesis is: the inter-correlation matrix is an identity matrix and the reduction of variables rejected since the inter-correlation matrix did not drive from a population. Because the inter-correlation and the correlation did result from a sampling error, the variables are suitability correlated to warrant the application of PCA.

Kaiser-Meyer-Olkin (KMO) was the second measure used to decide either PCA appropriate or not. KMO is a measure of sampling adequacy. Based on the results, the value of KMO is 0.549 which falls above the threshold value of 0.5. Consequently, allowing the data to be suitable for PCA, a greater value of KMO indicates that the degree of common variable among the variables is very large. This implies that application of PCA will lead to the components accounting for a fair amount of variance. As a result, the data set used met all the requirements for both KMO and Bartlett's test of sphericity and was considered to be suitable for dimension reduction using PCA.

Table 4-6: Results of the Bartlett's test of sphericity

Bartlett test of sphericity	
Chi-square	644.86
Degree of freedom	21
P-value	0.0000
Kaiser-Meyer-Olkin measure of sampling adequacy (Determinant of the correlation matrix)	0.549

Source: Author Estimation (2018)

Table 4.7 depicts the result of un-rotated PCA. Every variable is standardized to have a zero mean and a variance of one as shown in Table 4.7. The total variance to be explained is 5 for all three variables used. A useful variable must account for more than one unit of variance or must have an Eigen value of greater than one, because a variable can only account for one unit of the variance. Approximately 33% of the total variance is explained by the first principal component, while the second and the third is 24% and 21% respectively of the total variance. As a result, this is considered to be fair enough to use for more analysis.

Table 4-7: Results of un-rotated PCA (N=207; Component 3)

Component	Eigen value	Proportion	Cumulative
1	2.304	0.329	0.269
2	1.672	0.239	0.523
3	1.433	0.205	0.667

Source: Author Estimation (2018).

To choose the variable in constructing the ADRI, components were compared to a priori expectations. It is very important to obtain Eigen vectors, so that the variable to be used can be selected. Table 4.8 presents the value for the intersection of each variable and component that represents Eigen vector or component loadings. The component meets the expected signs and it will be utilized to construct the ADRI.

Table 4-8: Eigen vector from PCA

	Component 1	Component 2	Component 3
Production of livestock in Normal year	0.722	0.56	0.223
Production of livestock in Drought year	0.097	-0.599	0.591
Months household consume food in normal year	0.009	-0.051	-0.691
Months household consume food in drought year	0.019	0.028	0.009

Source: Author Estimation (2018)

The ADRI was constructed using equation 3.3 in Chapter 3 and the results in Table 4.8:

$$\text{ADRI} = 0.722 * \text{Production of livestock in Normal year} + 0.097 * \text{Production of livestock in Drought year} + 0.009 * \text{Months household consume food in normal year} + 0.019 * \text{Months household consume food in drought year} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(4.1)}$$

The formula shown in equation 3.3 in Chapter 3 and 4.1 applied to the data (207 Survey sample household respondents) to generate ADRI. Table 4.9 presents the ADRI for the Frances Baard District Municipality. The average household resilience index was -6.31; this means that farming households in the Frances Baard District Municipality are not resilient to agricultural drought. Approximately 91% (189) of the farming households interviewed were not resilient to agricultural drought, while the remaining 9% (18) of the farming households were resilient to agricultural drought. The next section of this chapter determines the factors that affect smallholder farming households' resilience to agricultural drought.

Table 4-9: Summary statistic for ADRI for Francis Baard District Municipality

	N	Mean	Stand. Dev.	Min	Max
ADRI	207	-6.31	6.90	-2.43	6.69
ADRI > 0	18	0.51	1.87	0.14	6.69
ADRI < 0	189	-7.00	6.88	-2.43	-0.008

Source: Author Estimation (2018)

4.3.2 Results from the Probit model

The independent contribution of each variable to variations in the response or dependent variable is measured by the coefficient. To determine the significance of each explanatory variable in terms of its influence to the response variable, P-values are used. Table 4.10 illustrates the results of the Probit regression model for the variables employed. Seventeen variables were employed in the model and only six of these explanatory variables were significant, which are: Gender, Credit, GovAss, COOP, EDUC, RSupp.

Table 4-10: Factors that influences the farming household's resilience to agricultural drought

ADRI	Coefficient	Std. Err.	P-value	Margin Effect	P-value
Age	0.001	0.015	0.529	0.001	0.529
Gender	-0.731	0.428	0.088*	-0.084	0.083
Mstatus	0.123	0.300	0.682	0.014	0.682
Funding	0.088	0.198	0.658	0.010	0.658
Relatives	-0.301	0.396	0.447	-0.035	0.444
Credit	1.038	0.498	0.037**	0.119	0.033
COMMUNITYCOLLABORA-TION	-0.442	0.424	0.298	-0.051	0.296
GVMENT	-1.341	0.794	0.091*	-0.154	0.088
Tsource	0 .145	0.199	0.467	0.017	0.467
NASS	-1.482	0.969	0.126	-0.170	0.126
Nlive	0.001	0.002	0.553	-0.050	0.553
Oassets	-0.438	0.417	0.293	-0.102	0.292
COOP	-0.886	0.509	0.082*	-0.016	0.076
Cstrategy	-0.143	0.127	0.260	0.003	0.259
Pknowledge	0.021	0.122	0.808	-0.018	0.808
ESUPP	-0.155	0.472	0.742	-0.018	0.742
GOVI	1.111	0.784	0.156	0.128	0.152
FEXP	0.002	0.023	0.932	0.000	0.932
EDUC	-0.365	0.204	0.073*	-0.042	0.067
DR	-0.042	0.104	0.686	-0.005	0.686
Sus	-0.543	0.494	0.272	-0.062	0.267
HM	-0.078	0.068	0.251	-0.009	0.247
RSUPP	0.774	0.439	0.078*	0.0890	0.073
Constant	1.823	1.821	0.317		

***** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10%**

Likelihood Ratio Chi-Square (LR chi2) (23) = 33.01, Prob > chi2 = 0.0808, Log likelihood = -44.649302, Pseudo R2 = 0.2699

Source: Author Estimation (2018)

Resilience of a farming household to agricultural drought is affected by the gender of the household head. Gender has a negative impact on resilience and is significant at 10% level. These results suggest farming headed by males were more likely to be less vulnerable to agricultural drought when compared to farming households headed by females. However, the findings do not agree with Andersen and Cardona (2013); Banda (2015), Banda *et al*. (2016) and Jiri, Mafongoya and Chivenge (2017), who found that gender had a positive but insignificant effect on resilience of a farming household to agricultural drought.

Education was found to be significant at 10% and negatively related to household resilient to agricultural drought. These results show that educated farmers are very likely to enhance their resilience to agricultural drought. An increase in the respondents' years of formal education by 1, results in 0.374 reduction of the farming household resilience. This was consistent with the findings of Andersen and Cardona (2013) who have indicated that education have a very small, barely significant effect on resilience. This is not in line with the findings of Jiri, Mafongoya and Chivenge (2017) who have found that the education level of the household head had no significant influence on the adaptation to climate change. The value of 0.043 on the marginal effect for the variable education means that up to a certain point, for any one year decrease in the educational level of the household head, the probability of the household becoming resilient to agricultural drought decreases by 0.043, holding all other factors at their mean values. This could be because the more educated you are, the more you get to learn different things.

Relative support has a positive impact on resilience and is significant at 10% level. These results suggest that farming households that receive financial support from immediate family members living outside the household tend to be more resilient to agricultural drought when compared to households that do not receive financial support from relatives. A household may have immediate family members living outside the household, but not receive any financial support. The marginal effect coefficient of 0.087 implies that an increase in the amount (in Rands) received from immediate family members living outside the household, results in a corresponding increase in the probability of a household enhancing its resilience by 0.087. The more the farming household receives financial support from relatives, increases its chance of being resilient to agricultural drought. This finding is consistent with Andersen and

Cardona (2013) and Banda (2015) who determined that households that receive financial support from relatives tend to be more resilient compared to those not receiving any financial support.

The coefficient of the variable credit was found to be significant at 5% and positively correlated with the resilience of households to agricultural drought. These results suggest that farming households with access to any form of credit are more likely to enhance their resilience to agricultural drought when compared to those farming households that do not have access to credit. The results of the marginal effect on the variable credit for the farming household suggest that up to a certain point, for an increase in one access of credit or any other funding of the farming household, the probability of the farming household becoming resilient to adverse effects of agricultural drought increases by 0.119, holding all other factors that affect resilience at their means.

The variable co-operative has a negative effect on the resilience of a farming household to agricultural drought and it was significant at 10% level. This implies that respondents that are part or member of a co-operative are most likely to be resilient to agricultural drought. Farmers that are part of a co-operative are able to assist each other (allowing livestock to graze on each other's farms and if the other farmer does not have access to water, they can share), sharing of information or knowledge and being able to buy feed in bulk. This was consistent with Keil *et al*. (2008) who found that the number of village organizations a household is involved in positively influences its resilience in Central Sulawesi, Indonesia. The value of 0.101 on the marginal effect for the variable co-operative means that up to a certain point, for one decrease in the number of co-operatives a farming household head is involved in, the probability of the household becoming resilient to agricultural drought decreases by 0.101, holding all other factors at their mean values.

Government assistance was also found to be significant at 10% and negatively correlated to households resilient to agricultural drought. These results show that farming households that receive assistance from the government during dry periods are very likely to be resilient. According to the farming households that were interviewed, during the 2015/2016 drought, they received assistance from the government (coupons to purchase feed) depending on the number of livestock the farmer had. However, farmers argued that this was not enough as agricultural drought lasts for a longer period of time and although the government assisted it was very late already; some farmers had already started losing or selling livestock.

The results of the marginal effect on the variable government assistance for the farming household suggest that up to a certain point, a decrease in the respondent's assistance from the government by 1, results in 0.156 reduction in the chances of a farming household to enhance its resilience to agricultural drought. Government assistance can also include informing communities about weather predictions (for example the 2015/2016 drought was announced before it occurred), provide livestock management training during agricultural drought periods and regular farm visits by extension officers. Jiri, Mafongoya and Chivenge (2017) argued that access to extension information significantly affects the farmers' decision to adapt to climate change. This means that farming households with government assistance (extension officers) are expected to be more resilient to agricultural drought due to better livestock management during this period.

4.3.3 Resilience impact on the welfare of the farming households

Table 4.11 below presents the results of the impact of resilience to the welfare of the farming households. The results were obtained by running the Stochastic Production Function model. The results indicated that feed cost, other farming operational costs and labour were significant. Analysis on each variable will be presented in the next section.

Table 4-11: Impact of resilience on the welfare of households

Variable	Coefficient	z	P-value
Land T	-699,964	-1,63	0,103
FeedC	0,248	2,53	0,012***
OFOC	1,763	7,84	0,000***
InLabour	1632,788	1,93	0,054**
ADRI	1561,626	0,84	0,402
Constant	-928,551	0,00	0,998

***** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10%**

Wald chi2 (5) = 135.63, Log likelihood = -2109.8002, Prob > chi2 = 0.0000

Source: Author Estimation (2018).

Welfare of smallholder farmers is measured by the income from their livestock production. It was found that the amount spent on buying feed significantly affect the welfare of smallholder farmers. Feed costs were significant at 1% and positively correlated to the welfare. The results suggest that an increase in the amount of feed cost by 1 unit, increases the possibility of the welfare of the farming households by 0.248. This means that farming households that spend much money in buying feed for their livestock are more likely to improve their welfare as compared to those who spend less on feed.

For the farming households to receive good prices when they sell their livestock, they need to feed to be able to get good body mass. During dry periods, less grass is available for grazing as agricultural drought has a huge impact on the grass, so this means that farmers to get good weight for their livestock; they need to spend more on feed. The findings were in line with Banda *et al*. (2016). The study revealed that the amount of seed used in maize production significantly affects the welfare of a farming household, although it was seed because the study was focusing on crops.

There is a significant positive effect of other farming operational expenses on the welfare of the farming household, in simple terms as the farming household spends more on other expenses such as medicine and water it will result in the farmer's welfare increasing. This is supported by the coefficient value of 1.763, showing that it is more likely that the welfare will increase as the amount of other expenses increases. Animals tend to be weak during dry periods, meaning they are easily affected by numerous diseases.

There is a positive relationship between labour and welfare. The coefficient of 1632,788 indicates that as the number of hours spent on the farm increases, it is more likely that the welfare of the farming household will increase. This means that the more the farmer, household members or the employer spends time on the farm, they can easily notice if there is something wrong with the livestock; for example, during dry periods animals need extra care.

Land Tenure and Agricultural drought resilience index were found insignificant. This could be as a result that most of the farmers farm on communal farms which are owned by the municipality or Department of Rural Development and Land Reform; they do not have to pay any loans, its only rent which is paid annually. Agricultural drought resilience index is insignificant, because during dry periods most farmers do not have any plan apart from selling their livestock to be able to buy feed. This is not in line with Banda *et al*. (2016); the authors have found that with a positive drought resilience index, farmers are more likely to have improved welfare as compared to their counterparts who have lower drought resilience.

4.4 Summary of the chapter

This chapter presented the descriptive and empirical results of the resilience dynamics for Dikgatlong, Magareng, Phokwane and Sol Plaatje, Frances Baard District Municipality in the Northern Cape. The results have shown that only 9% of the households were resilient to agricultural drought, while the remaining 91% of the farming households were not resilient to agricultural drought. The majority of the farming household heads indicated farming as their main occupation, with most farmers being pensioners and others unemployed. The study results clearly show that gender, educational level, financial support from relatives, being part of a co-operative, institutional support and government assistance affect the resilience of a farming household to agricultural drought. The study further shows that feed cost, other farming operational expenses and labour have a significant impact on the farming households' welfare, whereas land tenure and ADRI were insignificant.

The next chapter, Chapter 5, provides the summary of the result, which recommends and concludes the overall study.

Chapter 5 : Conclusion and Recommendations

5.1 Introduction

Chapter 5 is the last chapter of this study. The chapter presents the summary of the results and contribution, conclusion and recommendations and lastly the limitations of the study. The chapter starts by summarising the results and contribution of the study.

5.2 Summary of the results and contribution

Interviewed households from the Frances Baard District Municipality mostly were male-headed households and only a few were headed by females. The average age of smallholder farmers that participated in this research were 55 years old, with an average of 5 members in the household. The average number of years of formal schooling for the respondents was about 8 years, with some farmers not receiving any form of formal education and the most educated farmers spent 16 years in formal education. On average, farmers would spend 6 hours on the farm. Farming was considered to be the main occupation of most farming household heads interviewed, while other household heads were formally employed, and farming was their second occupation.

The study found that most of the farming household heads are either pensioners or unemployed individuals. For daily farm operations, farmers make use of the family savings, monthly salaries, pension money, money received after selling livestock, other business and money from piece jobs. Due to a lack of security or collateral, smallholder farmers from Frances Baard District Municipality do not have access to credit even during dry periods. Taverns and informal shops were identified as the other businesses farming households are engaged in, other than farming.

Smallholder farmers from the selected district farm on communal land which is owned by the municipality or the Department of Rural Development and Land Reform, rented, purchased and customary land. Although most smallholder farmers lack rivers adjacent to their farms, they access water from boreholes, cannels and taps, wells and lakes, with most of them involved in livestock farming only. However, Phokwane had the largest number of smallholder farmers engaged in mixed farming compared to the other municipalities. These farmers plant crops such as fruits and vegetables which are mainly used for own consumption, especially during dry periods as some cannot afford to buy meat. Farmers from all local districts experience agricultural drought, which leads to poor animal health, decline in livestock prices and loss of livestock. As a result, most farmers tend to be stressed during dry periods. To be able to survive during dry periods, smallholder farmers sell their livestock to be able to survive or stop production.

Furthermore, the study found that from the 207 farmers interviewed only 18 farmers were resilient to agricultural drought, while the remaining 189 were not resilient to agricultural drought. The study results clearly show that gender, educational level, financial support from relatives, being part of a co-operative, institutional support and government assistance affect the resilience of a farming household to agricultural drought. Moreover, feed cost, other farming operational expenses and labour have a significant impact on the farming households' welfare, whereas land tenure and ADRI were insignificant.

The study contributed to existing literature by constructing Agricultural Drought Resilience Index (ADRI) and used it to determine the factors that affect the resilience of faming households and the impact of agricultural drought resilience on the welfare of smallholder farmers' households in the Northern Cape. These findings will help policy makers and stakeholders to improve current or formulate future strategies and policy interventions that will boost smallholder farmers' resilience to agricultural drought. Furthermore, smallholders had the opportunity to learn from the study during data collection.

5.3 Conclusion and Recommendations

This sub-section of the study presents the conclusions and recommendations that were drawn from this research. This sub-section starts by looking at the conclusion.

5.3.1 Conclusion

This study developed an agricultural drought resilience index to measure the resilience of smallholder farmers to agricultural drought from four different local municipalities Dikgatlong, Magareng, Phokwane and Sol Plaatje (Frances Baard District Municipality) in the Northern Cape. The findings regarding the resilience of farming households to agricultural drought in the Northern Cape were that most households were not resilient; this was showed by only a few farming households being resilient to agricultural drought. A total of 189 (91%) farming households were non-resilient and vulnerable to agricultural drought, and only 18 (9%) were resilient. The study revealed that gender, educational level, financial support from relatives, being part of a co-operative, institutional support and government assistance are the significant factors that determines the resilience of a farming household to agricultural drought.

Furthermore, during dry periods farming households sell their livestock to be able to feed the remaining livestock. During the 2015/2016 drought, farmers received coupons from the government to purchase feed. However, this initiative did not help much as most farmers had already started selling and losing (due to death) their livestock. Based on the findings of this study, resilience of farming households to agricultural drought is a broad issue that needs comprehensive intervention. The recommendations as mentioned in 5.3.2 should be taken into consideration to enhance the resilience of farming households to agricultural drought.

5.3.2 Recommendations

This section sets out recommendations for policymakers that might contribute to enhancing the resilience of smallholder livestock farmers in the Frances Baard District Municipality. This study investigated the resilience of farming households to agricultural drought among smallholder farmers from the four selected municipalities, namely Dikgatlong, Magareng, Phokwane and Sol Plaatje of the Frances Baard District Municipality in the Northern Cape. It was found that farming households in the selected municipalities are not resilient to agricultural drought. This means that the government and policymakers should come up with effective responses to address enhancing resilience to agricultural drought and development among smallholder farmers from selected municipalities. The following recommendations can be made, based on the findings of this study.

The government should try to find ways in which they can help smallholder farmers to have easy access of water**.** The Northern Cape is one of the driest provinces in South Africa, with an annual rainfall of 202 mm. Most parts of Frances Baard District Municipality do not have any rivers or dams close by, most smallholder farmers use wells, boreholes or solar technology to pump water. One of the disadvantages of using solar is that when there is no sun, smallholder farmers are unable to pump water. In Granspan, which falls under Phokwane municipality, smallholder farmers struggle with water even in a normal year (without drought) as the livestock drinks water from wells that are provided by the municipality. However, sometimes this water is not good for animals as some people pour chemicals such as Temik Poisoning into the water, which can be very harmful to livestock as it can lead to loss of livestock (death). The government and stakeholders within the livestock industry should come up with a way in which smallholder farmers have easy access to water during both normal and dry seasons and of providing smallholder farmers with camps.

Another recommendation is to create fodder planting programmes to assist farmers especially in dry periods. The Northern Cape is the largest province in South Africa, with the smallest population. As a result, not all land is used, so this means there is enough land that can be used for planting crops such as lucern or barley, etc. Most respondents mentioned that if the government could provide them with land (own farms) and implements like tractors so they can plant their own feed, it will help them get through drought. However, this can be very challenging as there are many smallholder farmers and the province is already dry so they may struggle with adequate water to implement this initiative.

The government should try to identify those areas or regions where it will be easy to plant and for the crops to grow, then plant fodder (sorgum, lucern or barley) for different groups of smallholder farmers to use to feed their livestock; some of the feed can be stored so that it is available during dry periods. This will not only help smallholder farmers to survive during dry periods, but more jobs will be created through this initiative. During the 2015/2016 drought smallholder farmers received assistance from the government. However, by the time smallholder farmers were assisted, some had already stopped farming. As part of government assistance, smallholder farmers should be the first people to receive assistance during dry periods by providing them with feed and medicines. Both respondents who have benefited and those who did not benefit from this initiative, believe that if government can provide feed and medicines during dry periods, it will really assist them to get through dry periods.

The results showed that access to credit is one of the factors that affect the resilience of a farming household to agricultural drought. Most of the smallholder farmers do not have access to credit. The government, agricultural private organisations and financial institutions should develop Agricultural Drought Insurance with low premiums, which smallholder farmers will be able to pay**.** This will allow them to have extra funds during dry periods and be able to enhance their resilience to agricultural drought. The government should provide regular training**.** Training is already provided by the government for the smallholder farmers, but not all the smallholder farmers have access to these training sessions. Training providing information such as livestock management during dry periods can assist, as smallholder farmers end up selling some of their livestock to be able to buy feed for the remaining livestock. Some of the livestock struggle to grow or end up not surviving during dry periods due to the farmers' lack of knowledge on what medicines or feeds should be used during drought periods. Furthermore, the government should try to come up with co-operatives for all the smallholder farmers in the district. Already most smallholder farmers are located on communal farms, so to group these farmers to form co-operatives will be easy. Smallholder farmers tried to develop co-operatives among themselves, but most failed.

5.4 Limitations of the study

The objectives of this research were achieved. However, there were some unavoidable limitations. Firstly, most respondents speak Afrikaans and understand a little bit of Setswana, making communication between the researcher and the respondents difficult. So, it was hard to explain the questionnaire to the respondents. Secondly, some farmers were not interested. There are many livestock smallholder farmers in the Northern Cape (Frances Baard District Municipality), although they are not on record. However, most farmers were not interested in participating in the study, because they felt they will not benefit from the study and it is a waste of time. Lastly, political issues on the farms made it difficult to collect data. Most of the farms in the Northern Cape are communal farms (owned by the government or municipality). Sometimes, when interviewing the farmers, they started talking about political issues, for example, the government is accused of not giving enough land, water rights; or fighting for leadership among farmers on the farm. Most of these issues were very sensitive and the researcher could not address them. However, the researcher tried to explain that what she is doing is for academic and policy implementation purposes.

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APPENDIX

UNIVERSITY OF THE FREE STATE
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YUNIVESITHI YA FREISTATA

UFS·UV
NATURAL AND AGRICULTURAL SCIENCES
NATUUR- EN LANDBOUWETENSKAPPE

RESILIENCE OF HOUSEHOLD'S TO AGRICULTURAL DROUGHT IN THE NORTHERN CAPE, SOUTH AFRICA

This questionnaire was developed by Ringetani C Matlou, from the University of the Free State, Department of Agricultural Economics. The purpose of this questionnaire is to investigate factors that affect smallholder and emerging farming households' resilience to agricultural drought and its effect on their welfare. The findings will provide a guide to policy formulation that will increase long-term resilience (be able to respond, absorb and recover) to agricultural drought for smallholder and emerging farmers. The questionnaire is divided into different sections. The information provided will be used by the University of the Free State to inform government and policy makers. Please note that, in terms of section 17 of the STATISTICS ACT 6 OF 1999, your information will not be disclosed to anyone except the parties mentioned above. The selection purpose was done randomly to participate in the study, you are free not to participate in the study.

HOUSEHOLD IDENTIFICATION

Date of interview:	
District:	
Village:	
Name and Surname of respondent:	
Respondent Tel no.:	
Questionnaire No.	

1. SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

1.1 How old is the household head (Age):	
1.2 Gender:	Female=0 and Male=1
1.3 Marital Status:	Single=1, Married=2, Widow=3, Divorced=4, Separated=5 and Other=6:
1.4 Educational level (years spent at school)	
1.5 What is the main occupation of the household head? Does the head have the second occupation?	
1.6 How long have you been farming/ farm experience?	
1.7 Where do you get funding for your farm business?	Family savings=1, Borrowings=2, and Other=3
1.8 Is there any other business the household is doing besides farming? If yes, please specify.	No=0 and Yes=1

1.9 How many household members are you staying with?		
1.10 How many members stay in the following age group categories?		
1.10.1 Age group	Male	Female
<18 years old	(1)	(1)
18- 49 years old	(2)	(2)
>50 years old	(3)	(3)
1.11 Does the household have any relatives staying in cities or towns, other provinces or international? (Specify the number of people)	No=0 and Yes=1	
1.12 Did these members send any support to Households over the past 1 or 2 year(s)? (Specify the last you received assistance)	No=0 and Yes=1	
1.13 What kind of support did the household receive with equivalent of Rand value?		

2. TYPES OF RESOURCES

2.1 How many hectares do you have?	
2.2 Land Ownership	Customary=1; Rented=2; Purchased=3, Other=4
2.3 Does the household have any river close by? What is the shortest distance? How is the availability of water?	No=0 and Yes=1 ______km Seasonal=0 and Perennial=1
2.4 Does the household have other source of water? What are they? What is the distance from the household?	No=0 and Yes=1 Well(s)=1, Lake=2, Borehole=3, Other (specify)=5 _____km
2.5 Is there a dambo land close by? What do you use the land used for?	No=0 and Yes=1 Grazing=1, Planting crops =2, Other=3

3. LIVESTOCK PRODUCTION/FARMING ACTIVITIES

3.1 What agricultural enterprise are you involved in? How many ha are allocated for rain-fed agriculture and irrigation?	Animals only=1, Crops only=2, Mixed Farming=3, Other=4 Rainfed: Irrigation:
3.2 Please specify the number of livestock you have?	Cattle: Sheep: Goats:
3.3 What do you do with livestock produced? (If both please specify the % for each)	Own Consumption=1, Sales=2, Both=3
3.4 Do you buy livestock (breeding, etc.)?	No=0 and Yes=1

3.5 How do you feed your animals?	Buy feed=1, Natural grazing=2, Other=3
3.6 Are there any animals ready to be consumed or sold? If yes, how many? If not, why not?	No=0 and Yes=1
3.7 In a normal year, how much do you spend on feed monthly? How many kg's and number of bags do you buy?	
3.8 How much do you spend on animal health monthly, and on casual labourers?	Medicine: R Veterinary costs: R Casual labourers: R
3.9 What other costs do you incur?	
3.10 Where do you sell your livestock (market)?	Farm gate=1; market centre=2; Formal marketing groups=3; Other=4
3.11 How many household members spend full time on the farm (labours)? Please specify the number of hours spent. Are they all permanent employees? How much do you pay each employee?	
3.12 How many days does it take to prepare for mating? How many labourers do you use during mating? How many days and hours do they spend?	
3.13 How many labourers do you use during animal birth and lactation period?	
3.14 In the normal year, how long does it take the livestock to be ready? and How many months does the livestock that your household produces last in stock?	
3.15 In the drought, how long does it take the livestock to be ready? and How many months does the livestock that your household produces last in stock	

4. CONSUMPTION AND EXPENDITURE

4.1 How many kg's of meat (livestock- sheep, goat and cattle) does your household consume per month under normal situation on average?	
4.2 How many kg's of meat (livestock- sheep, goat and cattle) does your household consume per month under drought on average?	
4.3 At what price did you buy livestock last year? From their production in the normal year? And drought period?	

4.4 During the drought period, how long does it take your household before to exhaust stock?	
4.5 How do you respond when you are faced with drought periods in the middle of a farming season?	Sell livestock=1, Buy more livestock=2, Stop production=3, Sell assets=4, Other=5

5. HOUSEHOLD RESOURCE ENDOWMENT

Which one of the following assets does the household own?

Type of asset	No. of assets available (Rand value)	Would you sell the asset during drought to survive?
Land		No=0, yes=1
Cattle		No=0, yes=1
Sheep		No=0, yes=1
Tractors		No=0, yes=1
Bakkies		No=0, yes=1
Axes/knives		No=0, yes=1
Hand hoes		No=0, yes=1
Wheelbarrow		No=0, yes=1
Hose pipe		No=0, yes=1
Radio		No=0, yes=1
Television		No=0, yes=1
Bed		No=0, yes=1
Chairs		No=0, yes=1
Goats		No=0, yes=1
Chickens		No=0, yes=1
Pigs		No=0, yes=1
Others (specify)		No=0, yes=1

6. AGRICULTURAL DROUGHT, RESILIENCE AND KNOWLEDGE ASSESSMENT

6.1 Are you part of a co-operative?	No=0 and Yes=1
6.2 If yes, how do you benefit from the co-operative? If not, why are you not part of any co-operative?	
6.3 Do you normally experience agricultural drought in your community?	No=0 and Yes=1

When was the last time drought occurred/ Specify the drought years in order of priority.	
6.4 How is the frequency (occurrence) of agricultural drought over the past 5 years? How long does drought last (period)? Do you think droughts are becoming more or less frequent? How did previous drought affect your social activities/ psychological stress?	 Week=1, Month=2, Year=3, Other=4 More=1; No difference=2; Less=3; Other=4
6.5 Does drought have any impact on your herd? If yes, what is the impact?	No=0 and Yes=1 Loss of livestock=1; Poor animal health=2; Decline in livestock prices=3; Other=4
6.6 How did drought influence your cattle herd? Please indicate number of livestock.	Normal year Drought year Cows R Heifers F Steers Bulls
6.7 How did drought influence your sheep flock? Please indicate number of livestock.	Normal year Drought year Ewes R Ewes Young Lamb Ram
6.8 How did drought influence your goat flock? Please indicate number of livestock	Normal year Drought year Does R Ewes Doelings/bucklings Buck
6.9 How many livestock did you buy?	Normal year Drought year Cattle Sheep Goat
6.10 How many numbers of livestock are in a feeding system and recovery of natural grazing?	
6.11 How many livestock did you consume or sell?	Normal year Drought year Cattle Sheep Goat
6.12 What are the feed costs that you normally incur during the period of drought? What other costs do you incur?	

6.13 Besides livestock, how did drought affect your farm? Which other part/another part of your farm is affected? How would you rate your farming operation's level of drought vulnerability?	 Very high=1, High=2, Moderate=3, Low=4, None=5
6.14 Over the past years, how has your household adjusted itself to agricultural drought?	Stopped farming=1, Produce less livestock=2, Sell livestock=3, Sell Assets=4, Obtain credit from the bank=5, Other=6
6.15 How do you get information on weather forecasts?	Newspaper=1; Radio/TV=2; Friends=3; Social Media=4; Other=5
6.16 How do you respond to this?	Stopped farming=1, Produce less livestock=2, Sell livestock=3, Other=4
6.17 When you have prior knowledge that there will be drought, what measures does your household take (coping strategies)?	Migrate=1, Ask for food=2, Sell livestock=3, Look for a job=4, Lessee part of the farm=5, Other=6
6.18 Do you prepare for drought periods/Are you always ready for drought? How prepared do you consider yourself to deal with drought?	No=1 and Yes=1 High=1; Medium=2; Low=3
6.19 During the drought period, how is your household affected in terms of food production (adaptive strategies)?	Search for breeds that resist drought=1, Diversify farm activities=2, Livelihood diversification=3, Adopt conservation agriculture=4, Other (specify)=5
6.20 Is there enough support to improve farming practices during dry periods? If yes, what are they?	No=0 and Yes=1
6.21 Do you receive any assistance from the neighbours and community during drought periods? What kind of support? How does it assist household access to food?	No=0 and Yes=1
6.22 What is the role of a social network in drought reduction? What are the institutional capability coordinating activities to respond to the impacts of drought in the community? Do institutions help you reorganize so as to effectively cope with drought? In your community, do you collaborate in drought mitigation? (please specify in which way) Is your community actively involved in drought risk reduction planning? (please specify in which way)	 No=0 and Yes=1 No=0 and Yes=1 No=0 and Yes=1
6.23 Do you have any insurance? If yes, do you receive any cash during drought periods?	No=0 and Yes=1

6.24 Do you receive any assistance from the government during drought periods?	No=0 and Yes=1
6.25 If yes, what kind of assistance do you get?	Food=1, Financial=2, Farm inputs (incl. feed) =3, Other=4
6.26 In the past, did government successfully support you through the drought? If yes, please specify what they did.	No=0 and Yes=1
6.27 Is government interested in drought issues and impacts in your area? (Please specify what they have done to show they are interested). Is there any form of training to provide you with knowledge and skills on how you can effectively take charge of drought? (how long?)	No=0 and Yes=1 No=0 and Yes=1
6.28 Does government inform you of national/regional drought policies or initiatives that may impact your community? (If yes, what are these policies?)	No=0 and Yes=1
6.29 Do you think to sustain natural resources such as water will benefit the community during drought periods? In what way?	No=0 and Yes=1
6.30 What policies do you think can be implemented so that smallholder and emerging farmers can adjust to agricultural drought?	

HOUSEHOLD FOOD SECURITY ACCESS SCALE MEASUREMENT TOOL

No.	Questions	Options	Response
1.	Did you have a concern that some member of your family will not have an adequate amount of food in the last month?	0=no (go to Question 2); 1=yes(answer b. below)	
b.	How frequently did it show?	1= seldom (once or twice last month); 2=occasionally (1 to 10 times last month); 3=frequently (many times in the last month)	
2	Were some family members not capable to have the types of food they desire because of no money in the last month?	0=no (go to Question 3);1=yes (answer b. below)	
b.	How frequently did it show?	1= seldom (once or twice last month) ; 2=occasionally (1 to 10 times last month);3=frequently (many times in the last month)	
3a	Were some family members had to consume the inadequate selection of food due to no income in the last month?	0=no (go to Question 4);1=yes (answer b. below)	
B	How frequently did it show?	1= seldom (once or twice last month); 2=occasionally (1 to 10 times last month);3=frequently (many times in the last month)	
4a	Were some family members forced to consume the varieties of food they did not need to consume because of no income to buy the other kinds of food in the last month?	0=no (go to Question 5);1=yes (answer b. below)	
B	How frequently did it show?	1= seldom (once or twice last month); 2=occasionally (1 to 10 times last month);3=frequently (many times in the last month)	

5a	In the past four weeks, were some household members forced to eat the kinds of food that they did not want to eat because of lack resources to obtain other types of food.	0=no (go to Question 6);1=yes (answer b. below)	
B	How frequently did it show?	1= seldom (once or twice last month); 2=occasionally (1 to 10 times last month);3=frequently (many times in the last month)	
6a	Were some household members forced to consume less meals per day as there was not an adequate amount of food in the last month?	0=no (go to Question 7);1=yes (answer b. below)	
B	How frequently did it show?	1= seldom (once or twice last month);2=occasionally (1 to 10 times last month) 3=frequently (many times in the last month)	
7a	Were some household members forced to go for 24 hour without having a meal as there was not sufficient food in the last month?	0=no (questionnaire is finished;1=yes (answer b. below)	
B	How frequently did it show?	1= seldom (once or twice last month);2=occasionally (1 to 10 times last month);3=frequently (many times in the last month)	

Thank you for participating in this questionnaire.