The impact of drought in the South African agricultural sector and the skills implications

by

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Declaration

By submitting this assignment electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third-party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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Summary

The objective of the study was to assess the skills gap and training needs of farmers and key professionals in South Africa's agricultural sector in terms of drought management. A total of 192 semi-structured questionnaires were administered to assess farmers' skills gaps and training needs in the dry agroecological zones of the Free State, and the Cape provinces (i.e., Eastern, Northern, and Western Cape) of South Africa. Findings revealed that the main socioeconomic impacts of drought among farmers were reduced household food security (80% of participants) and increased levels of poverty (≥ 60%) regardless of farmer typology. For subsistence and small-scale commercial farmers, loss of farm income (85% and 80%), increased livestock mortalities (72% and 65%) and pest and disease incidences (65% and 56%) were identified as the main economic impacts, respectively. Reduced water availability (85% subsistence and 80% small-scale commercial farmers), grazing land deterioration (68% subsistence and 64% small-scale commercial farmers) and loss of vegetation were perceived as the main environmental impacts. Irrespective of farmer type, supplementary feeding (71% of participants), selling livestock (55%) and use of appropriate stocking rates (43%) were the main agricultural coping strategies during drought. Ordinal regression marginal effects results showed that age and sex negatively influenced the ability of farmers to cope with impacts of drought, while level of education, source of income and access to agriculture extension services had a positive influence ($P \leq 0.05$). Regardless of farmer typology, respondents generally lacked agricultural drought management skills, such as drought monitoring, and early warning systems (86%), and water management (75%) skills.

A follow-up survey was conducted in the same provinces by administering 55 semi-structured questionnaires to key professionals (i.e., agricultural extension and disaster management officers) to identify their skills gap and training needs. About three-quarters of key professionals reported that the main impact of drought on them was work overload. Drought-related challenges included shortage of resources (62% extension officers) and lack of a comprehensive drought management policy (62% drought management officers). Most extension and disaster management officers possessed professional and support skills such as human emotional intelligence (71% and 54%, respectively), personal and public relations (71% and 85%), community mobilisation (74% and 77%), and leadership (71% and 62%). Drought preparedness planning was the most dominant drought management skill possessed by more than

half of the key professionals. Extension and disaster management officers' training needs included geographic information systems (GIS) and remote sensing (50% and 46%), early warning systems and forecasting (43% and 38%), and recovery and rehabilitation (50% and 23%), respectively. Therefore, tailor-made models of educating key professionals are required to increase agricultural sector resilience to drought and adaptation to environmental, social, and economic changes. It was recommended that the government should invest and provide support in disaster management strategies and policy implementation, particularly disaster and extension services with disaster response programs that improve long-term farmer competencies of drought preparedness and mitigation.

Keywords: Agricultural extension officers, small-scale commercial farmers, disaster management officers, drought management, skills gap, subsistence farmers.

Opsomming

Die doel van die studie was om die vaardigheidsgaping en opleidingsbehoeftes van boere en sleutel professionele persone in Suid-Afrika se landbousektor in terme van droogtebestuur te assesseer. Altesaam 192 semi-gestruktureerde vraelyste is geadministreer om boere se vaardigheidsgapings en opleidingsbehoeftes in die droë landbou-ekologiese sones van die Vrystaat, en die Kaapse provinsies (d.w.s. Oos-, Noord- en Wes-Kaap) van Suid-Afrika te bepaal. Bevindinge het aan die lig gebring dat die belangrikste sosio-ekonomiese impak van droogte onder boere verminderde huishoudelike voedselsekuriteit (80% van deelnemers) en verhoogde vlakke van armoede (≥ 60%) was, ongeag die boertipologie. Vir bestaans- en kleinskaalse kommersiële boere is verlies aan plaasinkomste (85% en 80%), verhoogde veevrektes (72% en 65%) en plaag- en siektevoorvalle (65% en 56%) as die belangrikste ekonomiese impakte geïdentifiseer, onderskeidelik. Verminderde waterbeskikbaarheid (85% bestaans- en 80% kleinskaalse kommersiële boere), weidingsgrondagteruitgang (68% bestaans- en 64% kleinskaalse kommersiële boere) en verlies aan plantegroei is as die belangrikste omgewingsimpakte beskou. Ongeag die tipe boer, was aanvullende voeding (71% van deelnemers), verkoop van vee (55%) en die gebruik van gepaste vee (43%) die belangrikste landbouhanteringstrategieë tydens droogte. Ordinale regressie-marginale effekte resultate het getoon dat ouderdom en geslag die vermoë van boere om die impak van droogte te hanteer negatief beïnvloed het, terwyl vlak van onderwys, bron van inkomste en toegang tot landbouvoorligtingsdienste 'n positiewe invloed gehad het ($P \leq 0.05$). Ongeag die boertipologie, het respondente oor die algemeen 'n gebrek aan landbou-droogtebestuursvaardighede, soos droogtemonitering, en vroeë waarskuwingstelsels (86%), en waterbestuur- (75%) vaardighede.

'n Opvolgopname is in dieselfde provinsies gedoen deur 55 semi-gestruktureerde vraelyste aan sleutel professionele persone (d.w.s. landbouvoorligtings- en rampbestuurbeamptes) te administreer om hul vaardigheidsgaping en opleidingsbehoeftes te identifiseer. Ongeveer driekwart van belangrike professionele persone het gerapporteer dat die grootste impak van droogte op hulle werkoorlading was. Droogteverwante uitdagings het 'n tekort aan hulpbronne (62% voorligtingsbeamptes) en 'n gebrek aan 'n omvattende droogtebestuursbeleid (62% droogtebestuursbeamptes) ingesluit. Die meeste voorligtings- en rampbestuursbeamptes beskik oor professionele en ondersteuningsvaardighede soos menslike emosionele

intelligensie (onderskeidelik 71% en 54%), persoonlike en openbare betrekkinge (71% en 85%), gemeenskapsmobilisering (74% en 77%) en leierskap (71% en 62%). Droogtegereedheidsbeplanning was die mees dominante droogtebestuursvaardigheid waaroor meer as die helfte van die sleutel professionele persone beskik het. Voorligtings- en rampbestuursbeamptes se opleidingsbehoeftes het geografiese inligtingstelsels en afstandswaarneming (50% en 46%), vroeë waarskuwingstelsels en vooruitskatting (43% en 38%), en herstel en rehabilitasie (50% en 23%) ingesluit , onderskeidelik. Daarom word pasgemaakte modelle van die opvoeding van sleutelprofessionele persone vereis om die landbousektor se veerkragtigheid teen droogte en aanpassing by omgewings-, maatskaplike en ekonomiese veranderinge te verhoog. Daar is aanbeveel dat die regering moet belê en ondersteuning bied in rampbestuurstrategieë en beleidsimplementering, veral ramp- en voorligtingsdienste met rampreaksieprogramme wat langtermynboerebevoegdhede van droogtevoorbereiding en versagting verbeter.

Sleutelwoorde: Landbouvoorligtingsbeamptes, kleinskaalse kommersiële boere, rampbestuursbeamptes, droogtebestuur, vaardigheidsgaping, bestaansboere.

This thesis is dedicated to my family, particularly my late father, and brother.

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List of Acronyms and Abbreviations

AgriSA – Agriculture South Africa

AgriSETA – Agriculture Sector Education Training

ARC – Agricultural Research Council

DALRRD – Department of Agriculture, Land Reform and Rural Development

DCGTA – Department of Cooperative Governance and Traditional Affairs

FAO – Food and Agriculture Organisation

GIS – Geographic Information System

IDC – Industrial Development Corporation

IDD – International Disaster Database

NDMC – National Disaster Management Centre

NRF – National Research Fund

SAWS – South African Weather Services

THRIP – Technology for Human Resources Industry Programme

UNSDGs – United Nations Sustainable Development Goals

Chapter 1 – General Introduction

1.1 Introduction

Drought is a complex phenomenon that can affect society and the natural environment in a number of ways, including short-term reduced agricultural production, social tensions, and environmental degradation (Lottering et al., 2021). Over 410 major droughts were recorded globally between 1980 and 2008 affecting 53.5 million people annually (Lottering et al., 2020). In 2015, Africa suffered US$2.4 billion in economic damage, with Southern Africa incurring economic damages of up to US$354 million (Bahta, 2021). The impact of drought on the agricultural sector are greater when compared to other sectors owing to its reliance on water availability (Matlou et al., 2021). This is particularly so in Africa where agriculture has a huge social and economic footprint with close to two-thirds of the population in sub-Saharan Africa being smallholder farmers who rely on rainwater for either crops or animal production. In this region, agriculture accounts for 60% of employment and is central to food and nutrition security, and rural development (Matlou et al., 2021).

South Africa is the 30th driest country in the world (Pili & Ncube, 2022). Thus, the occurrence of drought puts the long-term sustainability of the agricultural sector in the country under immense pressure (Bahta & Myeki, 2021). Widespread droughts were recorded in South Africa for much of the 20th century (Lottering et al., 2020); in fact, since 1900, 19 of those years have been classified as dry years (Fanadzo et al., 2021). The drought of 2015-16 was one of the worst droughts in recent years, and it resulted in a decline of 8.4% in agricultural production and the country's national livestock herd decreased by 15% (Vetter et al., 2020). The International Disaster Database (IDD) quantified the economic damage of the drought to be R3.3 billion, with 2.7 million households affected (Zhou et al., 2022). The knock-on effects of this drought resulted in 31 000 direct job losses (Agri SA Research, 2019). The recurrence and frequency of droughts in South Africa will have dire consequences, especially with the projected population expected to reach 82 million by 2035 (Strydom & Struweg, 2016). In order to ensure food and nutrition security because of drought occurrences, the country needs sustainable approaches to drought management.

Drought management in the South African agricultural sector is overseen by the Department of Agriculture, Land Reform, and Rural Development (DALRRD) in collaboration with the Department of Cooperative Governance and Traditional Affairs (DCGTA), specifically the National Disaster Management Centre (NDMC) (Vogel et al., 2010; Liebenberg, 2015). The NDMC is a critical drought advisory body with regards to early warning system planning, stakeholders' initiation and facilitation, and the establishment of research institutions, whereas the former is mainly tasked with the dissemination of drought information, education, technologies, and program implementation in farming communities and the agricultural sector (Liebenberg et al., 2015). Hence, the role of these key professionals, particularly, agricultural extension and disaster management personnel in the sustainability and development of the agricultural sector in the face of recurring droughts cannot be overstated.

In South Africa, there is significant literature regarding the impacts of drought on agriculture (Mare et al., 2018; Talanow et al., 2021; Archer et al., 2022). However, most of these studies concentrated on the drought impacts on specific farmer types, either subsistence, small-scale or large commercial farmers, and not on drought's implications on agricultural skills for the entire sector. Other researchers focused on agricultural drought management in South Africa (Baudoin et al., 2017; Andersson et al., 2020; Meza et al., 2021). Information on the negative impacts of drought on agricultural losses and food availability is usually part of the drought narrative, but questions related to skills gap and training needs of farmers and key professionals in South Africa's agricultural sector in terms of drought preparedness and mitigation remain unanswered or are even decoupled from routine drought risk assessments. Drought skills assessment could facilitate greater drought resilience and equip farmers with the necessary skills needed to cope and be able to mitigate the negative impacts of droughts (Ruwanza et al., 2022). Such an assessment is important in the identification of key professionals' knowledge gaps in drought management, which could guide with designing re-training programs to develop new competencies in managing climate risk and enhancing the resilience in the agricultural sector. In addition, it enables policymakers to formulate suitable policy interventions on agricultural drought management.

1.2 Problem statement

Despite many years of disaster relief assistance from the South African government, there is consensus that drought assistance has been ineffective, poorly coordinated, and untimely (Baudoin & Ziervogel, 2017). Presently, there is no clarity on the government supported drought disaster preparedness and mitigation measures due to instability of policies and lack of cooperation or collaboration among different stakeholders (Mare et al., 2018). As drought is a recurrent feature in the agricultural sector, it is important to evaluate the preparedness and level of skills of farmers and key professionals in the agricultural sector in South Africa. Drought risk management skill competencies of farmers and key professionals in the sector are little known, and it is important to investigate their capabilities. This information will contribute to a pool of knowledge and literature on the impact of drought in the South African agricultural sector and skill implementation. The results of this study will enable identification of the skills gap in the monitoring and early warning, risk impact assessment, and mitigation and adaptation preparedness and mitigation of drought in South Africa. This prompts government and private sector to implement programmes that develop drought resilience, mitigation, and preparedness, and allow for future development of efficient strategies to manage drought. As a result, drought resilience will be improved especially in communities where there are low adaptive capacities, high levels of poverty and lack of safety nets.

1.3 Objectives of the study

The objective of the current study was to assess the impact of drought in the South African agricultural sector and the skills implications. The specific objectives were to:

1. Identify the skills gap and training needs of farmers in the agricultural sector with respect to drought management in South Africa, and
2. Investigate the skills gap and training needs of key informants in the agricultural sector with respect to drought management in South Africa.

1.4 Study questions

1. What are the skills gaps and training needs of farmers in the agricultural sector in terms of drought management in South Africa?
2. What are the skills gaps and training needs of key informants in the agricultural sector in terms of drought management in South Africa?

1.5 Null hypothesis

The null hypothesis tested were:

1. The skills gap and training needs of subsistence farmers and small-scale farmers in the South African agricultural sector with respect to drought management are similar.
2. The skills gap and training needs of agricultural extension officers and disaster management officers in the in the South African agricultural sector with respect to drought management are similar.

Chapter 2 – Literature Review

2.1 Introduction

Globally, the sustainability of the agricultural sector is under threat from climate variability and climate-associated threats such as droughts (Vogel & Olivier, 2019). Droughts account for 8% of global natural disasters, with 25% occurring on the African continent (Baudoin et al., 2017). They are risk multipliers, causing additional risk and human security issues such as land loss, persistent poverty, displacement and migration, and competition for increasingly scarce natural resources (Omotayo & Zikhali, 2019). Droughts have had a significant impact on the agricultural sector in South Africa, as well as disastrous consequences for the economy, the environment, and millions of people (Elum et al., 2017).

The South African agricultural sector is dualistic and divided into commercial and smallholder sectors (AgriSETA, 2016). The smallholder sector is further sub-divided into small commercial (i.e., emerging) and subsistence sectors (Zwane, 2019). The agricultural sector has approximately 40 000 commercial farmers, 220 000 emerging farmers, and more than 2 million subsistence farmers (Talanow et al., 2021). It employs about 880 000 people, with 91 % of them being unskilled (Stats SA, 2017). Drought risk in these sectors varies according to their historical background, with subsistence farmers being more vulnerable followed by small commercial farmers and large-scale commercial farmers (Meza et al., 2021). Coordination between role players such as policymakers and skilled professionals (i.e., particularly disaster managers, extension workers, researchers, farmers, and the private sector) is required for the country to be able to manage drought events (Warner et al., 2017). Against this background, the objective of this chapter is to discuss the impact of drought and the skills implications among farmers and key professionals in the agricultural sector with respect to drought management in South Africa.

The following is the literature review chapter's outline: Firstly, a discussion of the impact of drought on South Africa's agricultural sector. Following that, an examination of the skills implications of the drought's impact and finally, a summary of the chapter.

2.2 Drought impact on the South African agricultural sector

Droughts of varying severity are common in South Africa, and they have been declared on numerous occasions in the country's northern, western, and southern regions over the last century (Jordaan et al., 2019). Despite studies focusing on impact of drought on agriculture (Caleni, 2017; Masipa, 2017; Rakgwale & Oguttu, 2020), South Africa remains vulnerable to drought due to an over-reliance on dryland farming and a lack of drought management skills in the agricultural sector (Kom et al., 2020). Drought has a greater destructive impact in communities rife with poverty and underdevelopment (Caleni, 2017). Figure 2.1 shows some of the impacts of drought on South Africa's agricultural sector from 2000 to 2018. There was major reduction in the volume index of field crops, horticulture, and food production between 2005-2006 and 2015-2016. Field crop production had the greatest decline in both periods, while horticultural, animal and food production had a significant decrease in 2015-2016. These trends correspond to the years when South Africa declared drought to be a national disaster.

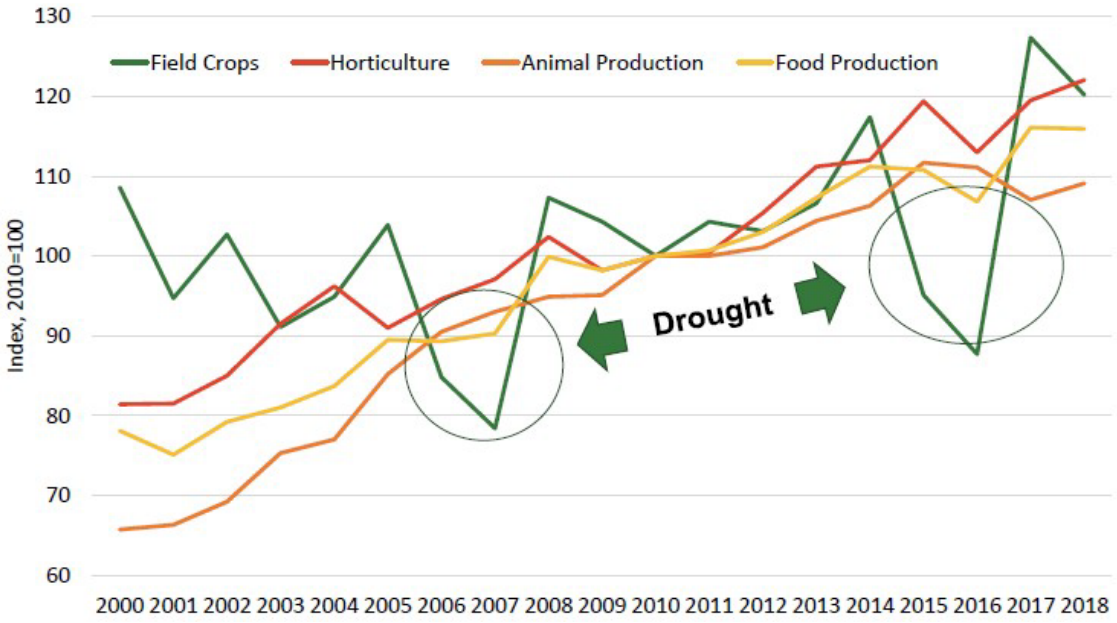

Figure 2.1:Volume index of agricultural production in South Africa. Source: Agri SA, 2019

2.2.1 Impact of drought on socio-economic aspects

Drought has an impact on agricultural arable land availability (Masipa, 2017; Thornton et al., 2020). Farmers use this land for food production, specifically crop production, which is the backbone of rural agricultural economics (Mdungela et al., 2018). Subsistence farmers are disproportionately affected during droughts due to socioeconomic issues such as water scarcity, food price increases, loss of income, loss of employment, increased poverty, food insecurity, and malnutrition (Ngcamu & Chari, 2020). Lottering et al. (2020), estimated that between 2003 and 2005, a rural population of approximately 700 000 people were affected by drought as water sources dried up and, crops and livestock died. The majority of these farmers lacked access to financial institutions and resources, as well as knowledge and managerial skills (Ashraf et al., 2020). One of the impacts of drought is that farmers either temporarily or permanently abandon their businesses, migrating to other regions in search for better job opportunities (Kom et al., 2020). Coincidently, during the droughts of 2004-2006 and 2009-10, South Africa experienced high internal migration rates of approximately 2.3 million people, accounting for 5% of the country's population (Mastrorillo et al., 2016).

Drought pressures cause mental health (anxiety and depression) issues in farmers (Agri SA Research, 2019). For example, a farmer in the Vosburg area of the Northern Cape was diagnosed with depression after losing 400 sheep and 450 springboks in the 2015-16 drought, which he described as the worst he had ever witnessed in 45 years of farming (AgriSA, 2016). Droughts reduce farm revenues, limiting farm financial cash flow by increasing operational costs. As of June 2019, the South African agricultural sector had a total debt of R125 billion (Agri SA, 2019). Figure 2.2 depicts trends in agricultural debt, farm assets, and debt as a percentage of assets. The total agricultural farm debts, assets, and debt as a percentage of assets increased between 2011 and 2016, with drought being a major contributor to the debt total.

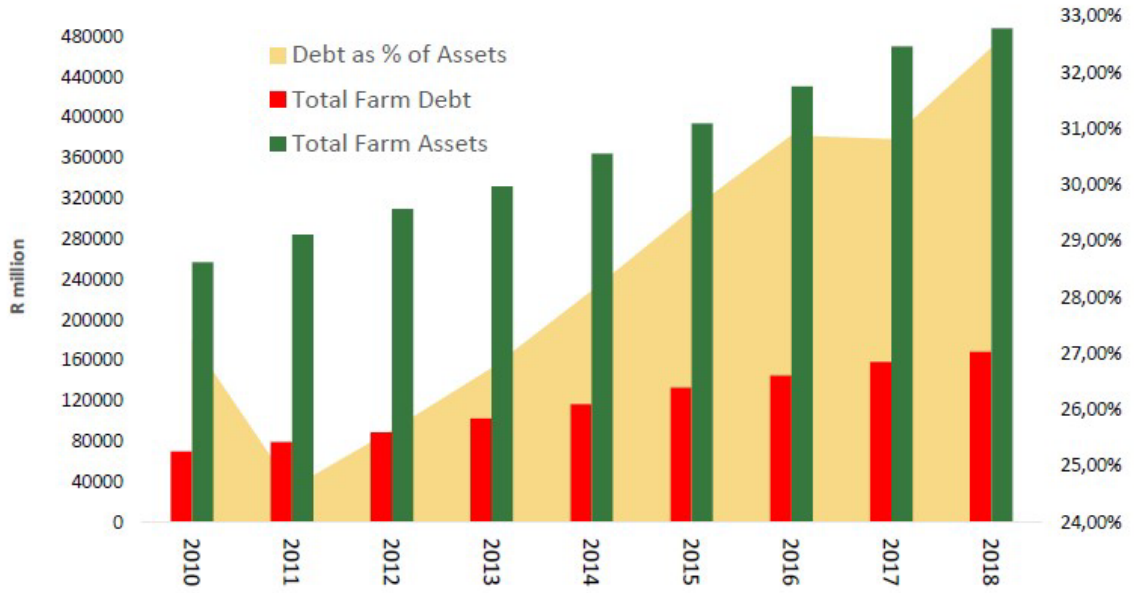

Figure 2.2: Agricultural debt, farm assets, and debt as a percentage of assets. Source: Agri SA, 2019

Approximately 70% of farmers interviewed in an AgriSA survey in 2015 indicated financial difficulties, and 50% indicated the need to retrench workers due to the prolonged drought conditions (AgriSA, 2016). According to Araujo et al. (2016), 2 000 permanent and seasonal jobs were lost in the wine industry in 2016, and agricultural income was reduced by R37 million. Due to decreased sugar cane production caused by the drought, the Sugarcane Growers Association lost 6 500 seasonal jobs (AgriSA, 2016). Drought also had an impact on businesses that purchase agricultural products and services such as feeds, machinery, fertilisers, seeds, livestock, financial institutions, and other chemicals (Agri SA Research, 2019). For instance, the South African Agricultural Machinery Association reported in 2016 that annual sales of tractors and combine harvesters fell by 11% and 30%, respectively (AgriSA, 2016). Seed producers suffered losses because of the drop-in seed sales, and these seed stocks had to be disposed of because they were no longer viable for resale in the following production season. The drought's knock-on effect increased retail prices in 2016 (Stats SA, 2020) as a case of super maize meal (i.e., milled maize grain), a staple food for most South Africans, increased by 41% for a 5 kg bag (Agri SA, 2020).

2.2.2 Impact of drought on crop production

Crop production, particularly field and horticultural crops, contributes R69 billion and R70.5 billion in gross income, respectively (Stats SA, 2020). The horticultural sector, through the packaging, processing, distribution, and retail industries, is critical to the long-term viability of the South African agricultural value chain. Drought reduces soil fertility, which is necessary for crop production, nutrient provision for crop growth, carbon storage, and water cycle regulation (Tilman et al., 2020).

The horticultural sector covers 330 000 hectares of farmland in South Africa. Wine and table grapes, deciduous fruits, citrus, and potatoes cover 98 000, 81 000, 68 000, and 54 000 hectares, respectively (AgriSA, 2017). The 2015-2016 drought reduced the pome fruit industry by 9%, resulting in a loss of R898 million, and the stone fruit industry lost R458 million (Hortgro, 2019). In a typical year, the South African stone fruit industry produces 1.4 million cartons for export; however, only 420 000 cartons of nectarine and 235 000 cartons were exported in 2015-2016 (Agri SA Research, 2019). Citrus growers in Mpumalanga province saw crop volume decline, while navel orange growers in the Eastern Cape province saw fruit splitting due to drought related high temperatures (Hortgro, 2017). Drought caused 50 to 80% fewer onions and potatoes to be planted in the Ceres region in 2019, resulting in losses of around R40 million and affecting seasonal workers' wages (Symington, 2019). Drought and high temperatures in the Western Cape province impacted the quality of grapes and wine (Araujo et al., 2016). As a result of the impact of drought over the years, the grape planted area has drastically reduced. Figure 2.3 depicts the gradual decline of vineyards in the Klein Karoo between 2014 and 2018 because of a severe multi-year drought. As shown, the land area under the Klein Karoo vineyard has declined at a rate of 3% per year.

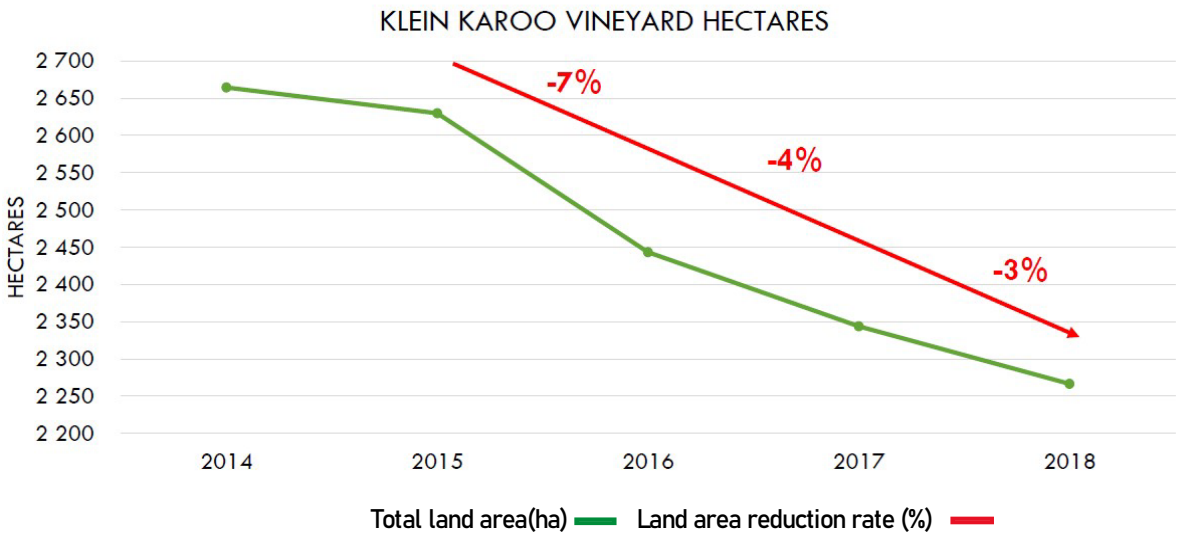

Figure 2.3: Trends in planted total land area in the Klein Karoo vineyard. Source: Hortgro (2019)

The field crops sector accounts for 30% of South Africa's total gross agricultural production (AgriSA, 2017). Maize and wheat are the most widely grown field crops in South Africa, accounting for approximately 250 million hectares and 592 552 hectares of planted area per year, respectively (AgriSA, 2016). During the 2015-16 drought, an estimated 1.95 million hectares of maize were planted, the lowest amount of maize planted since 1928 (Schulze, 2016). To meet domestic demand, approximately 3.30 million tonnes of maize had to be imported in the second half of 2016 (Schreiner et al., 2018). In 2016, South Africa imported 1.85 million tonnes (60%) of wheat to meet its domestic consumption of 3.14 million tonnes (AgriSA, 2016). As the drought continued, only 481 850 hectares of wheat were planted, compared to 2 million hectares in the 1970s (Agri SA Research, 2019). The quality of harvested barley was not malting grade and was only suitable for stock feed, resulting in low producer prices (AgriSA, 2016). Some farmers turned to cotton and fodder production as a backup (Agri SA Research, 2019), while others reported that the drought increased weed sprouting, which increased weeding labour costs by R2 000 per hectare (Elum et al., 2017). Drought also hastens disease transmission and insect invasion (Caleni, 2017). The fall armyworm outbreak is one example of a disease that presented new challenges in South Africa, affecting large tracks of vegetables and sweetcorn (Zwane, 2019).

2.2.4 Impact of drought on livestock production

The livestock sector contributes 48% to South Africa's total agricultural gross domestic product (Matlou et al., 2019). In South Africa, approximately 69% of land is suitable for extensive livestock farming, and the livestock sector accounts for approximately 53% of total agricultural land (von Bormann, 2019). Drought has a negative impact on the livestock production system by decreasing rangeland, feed crop production and livestock production, and increasing input costs and incidences of new emerging pathogenic and vector-borne diseases (Thornton et al., 2020). Subsistence farmers are the hardest hit by these impacts because livestock are a vital source of income and stability for them (Thornton et al., 2020). According to AgriSA (2017), in 1992, South Africa's drought caused grazing land depletion, lack of drinking water, and livestock loss. Most smallholder farmers in Limpopo's Vhembe district were forced to slaughter their livestock, which they then sold at lower prices (Mpandeli et al, 2017). During the 2015-16 drought, Eastern Cape, Kwa-Zulu Natal, and Western Cape provinces lost approximately 150 000, 40 000 and 30 000 cattle, respectively (Schreiner et al., 2018). Livestock slaughters increased by 8% as farmers battled to maintain their nuclei herd due to feed shortage and high fodder prices (Maré et al., 2016; Muthelo et al., 2019). Over a two-month period (November 2015 to December 2015), slaughter rates for red meat products increased by 12, 23, and 37% for pigs, cattle, and sheep, respectively (Mare et al,. 2018). Some farmers were forced to relocate their livestock to regions with better pastures (Mpandeli et al, 2017).

Commercial farmers were forced to make drought-related mitigation plans such as drilling boreholes, refurbishing existing water reservoirs, purchasing feed and hay, and cultivating fodder, further straining their already precarious financial positions (AgriSA, 2018). Extra feed (cultivating and purchasing grass, purchasing maize for feeding, and constructing a feedlot) and animal relocation to better rangeland cost an average of R186 000 per farmer and R4 500 per animal, respectively (Schreiner et al., 2018). Mare et al. (2018) discovered that the commercial national herd decreased by 14.4% between 2013 and 2016, while the cost of maintaining the nucleus herd increased by 177%. According to Vetter et al. (2020), investigations in the communal municipalities of uMzinyathi and uThukela indicated drought-induced livestock mortalities of up to 42% in cattle and 28% in goats. Furthermore,

following the 2015-16 drought, the percentage of households owning cattle fell from 55 to 46%, while goat ownership fell from 80 to 77% (Lottering et al., 2021). The study found that close to R100 million (9 635 cattle deaths) and R25 million (16 732 goat deaths) in value were lost in the 3 000 households of uMzinyathi and uThukela municipalities (Khowa, 2021). During drought periods, stock theft in communal areas along the Lesotho-South Africa border increased by 25 and 78% in the Free State and Eastern Cape communal farmers, respectively (Bahta et al., 2016).

According to Mare et al. (2018), the price of meat tripled during the 2013-16 drought, resulting in higher carcass prices and a decrease in livestock slaughter numbers at abattoirs. Prices for animal products increased by 2.6%, and milk production decreasing by at least 3% (Schreiner et al., 2018). In 2016, the poultry feed increased from R11.68 to R12.11 causing an increase in the average price per dozen of eggs, and a 4.5% increase in poultry meat (AgriSA, 2019). Moreover, poultry production fell by 10% in the first quarter of 2017, while the price per tonne rose by 9.3% compared to 2016 (African Farmers' Association of South Africa, 2019). Due to drought-related dry conditions, there was an outbreak of Foot and Mouth Disease in the first quarter of 2019, which halted beef exports (AgriSA, 2019). Extensive livestock production systems were replaced by intensive production systems in drought-prone provinces of South Africa. This was a necessary drought adaptation strategy for the farms to remain productive.

2.3 Drought implications on agricultural sector skills

There is strong consensus that the South African government has provided agricultural disaster relief assistance for many years, but that drought relief has been insufficient, and poorly executed (Baudoin et al., 2017). This is despite that South Africa has one of the world's leading drought risk management statutes (National Disaster Management Act, 2002). The challenge is not the drought itself, as it is a natural occurrence, but South Africa's reliance on drought risk crisis management (Liebenberg et al., 2015). Due to policy uncertainty and a lack of cooperation between different stakeholder groups, there is presently no consistency on government-supported drought preparedness and mitigation initiatives (Bahta, & Niekerk, 2018). Given the impact of droughts over the past two decades, South

Africa's major challenge appears to be a lack of skilled professionals who understand the drought management phenomenon (Bahta et al., 2016). According to AgriSETA (2018), there is a shortage of drought management competent agricultural skilled professionals such as agricultural scientists, technicians, engineers, research and development officers, extension officers, disaster management officers and consultants, with some positions deemed hard-to-fill.

The key drivers of change in the South African agricultural sector are the influence of global warming, climate change and drought, thus it is important to change to more sustainable production practices (AgriSA, 2020). According to the United Nations Convention to Combat Desertification (UNCCD) (2013), the three crucial pillars of drought risk resilience and mitigation are drought risk monitoring and early warning systems, vulnerability and risk assessment, and drought risk mitigation measures. Consequently, these components should be given priority while preparing and planning for droughts with stakeholders such as farmers, agricultural extension officers, disaster management experts, agriculturists, and the commercial sector. Agricultural drought management is evolving, and a well-planned approach is required now, as well as the development of national policies aimed at mitigating the effects (risks) of drought should be supported by improved data, research, skill development, and collaboration. Table 2.1 depicts the three pillars of drought risk management, and actions and skills required for the agricultural sector. As an example, drought vulnerability necessitates the use of an agricultural skilled professional who can map drought hotspots, risk profile vulnerable farmers, communities, or regions for drought impact, and assess their drought coping strategy skill set.

Table 2.1: Agricultural drought preparedness and mitigation action fields and skills

Drought monitoring and early warning systems	Drought vulnerability and risk assessment	Drought risk mitigation measures
• Drought situation assessment • Drought forecasting improvement • Access to reliable/ timely data • Awareness raising programmes • Identification and monitoring precipitation levels and weather condition through climatic parameters such as streamflow, groundwater levels, reservoir and lake levels, and soil moisture as well as a comprehensive • Assessment of current and future drought and water supply conditions • Incorporation of local indigenous knowledge systems into the information system	• Assessing risk profile of communities/ regions e.g., subsistence farmers, rainfed and irrigated • Agriculture condition of crops, livestock and environment • Finding reasons for vulnerability of the communities/ regions and mitigation measures to address these risks • Assessing severity of droughts potential impact • Mapping drought hotspots • Assessing the coping capacity of communities affected by drought	• Increase water supply • Decrease water demand • Water harvesting • Water sources protection • Development of water sources such as dams, and wells • Utilisation of groundwater reserve sources • Water rationing/allocation • Land and water resources balancing • Restoration of pastures • Enhancement of irrigation schemes • Implementation of Integrated Water Resources Management (IWRM) such as, mitigating upstream-downstream user conflicts, greater coordination between water users, communities, and sectors • Crop insurance • Management of livestock production within the landscape: relocation of herds, nomadic migration, use of special reserved areas • Conservation agriculture • Capacity building and policy • Diversification of farmer livelihoods through social protection, cash-transfer programs or improving access to markets and rural services

Source: United Nations Convention to Combat Desertification (2016)

2.3.1 Government, extension, and disaster management services

Drought events over the past decade have not only exposed the South African government, but also a lack of skills and competency in agricultural extension and disaster management personnel (Baudoin et al., 2017). Ngaka and Zwane (2018) argued that the uncertainties and complexity of drought in South Africa will force prospective agricultural extension and disaster management personnel to evolve and assume a variety of roles and competencies to address various agricultural needs. This will enable them to play critical roles in initiating drought-related change in the agricultural sector, as well as in improving farmers' drought-related knowledge, attitudes, skills, and resilience capabilities (Zikhali et al., 2020). These professionals will be expected to be innovative and skilled in the face of ever-changing drought and climate variability, necessitating constant re-training to improve personnel quality and foster a change in policy formulation, advisory and sustainable technical production skills, drought early warning system analysis skills, and regular access to new valuable information and technologies to improve farmers' and the agricultural sector adaptation capacities.

As shown in Table 2.1, in the face of climate change, agricultural drought risk management will require agricultural extension and disaster management personnel skilled in drought monitoring and early warning systems, drought vulnerability and risk assessment, and drought risk mitigation measures. Other skills required include human skills, emotional intelligence skills, conceptual skills, communication skills, green technology skills, and technical production skills (Ibeje & Ekwueme, 2020). This was supported by Ashraf et al. (2020) who argued that agricultural extension personnel should be knowledgeable in project planning, implementation, and evaluation, personal and public relations management and supervision, problem-solving, program planning and development, research, marketing, teaching information technology, and drought mitigation subject matter expertise such as conservation agriculture (crop rotation, zero tillage, soil mulching), and water harvesting.

It is critical to examine the state of agricultural sector support and extension advisory services in South Africa, which is in constant contact with farmers. Liebenberg (2015) provides an appraisal on the state of the South African Department of Agriculture extension and advisory services. The extension advisory services employ 2 155 people, with the provinces of the Eastern Cape, Limpopo, and Kwa-

Zulu Natal accounting for 30, 28, and 16% of the total, respectively, and the country has a shortage of 10 000 agricultural extension personnel owing to demographics and farming systems. Within that group, about 20% have a bachelor's degree or higher, 80% have a diploma or less, and 25% have completed technical training curricula since joining the civil service, with roughly 9, 11, 6, and 7% completing in-service skills training in communication, project management, computer literacy, and human management, respectively (Liebenberg, 2015). To address these disparities, the Department of Agriculture initiated programmes such as the Extension Recovery Programme and the National Extension Support Services, which were designed to revitalise and improve accountability and professionalism in extension services, with 3 200 agricultural extension personnel earning bachelor's degrees and technical skills (Liebenberg, 2015). As of 2019, AgriSETA had indicated that it will train 21 235 agricultural sector employees in different skills. Farmer support expenditure totalled R4.405 million per year, with the majority (55%) directed toward extension services, equating to roughly R4 000 per farmworker and R47 000 per commercial farmer (Baudoin et al., 2017). To tackle agricultural drought difficulties and their implications, South African government agencies and policymakers must adopt a proactive rather than reactive approach. Hence, additional capabilities in drought policy design, consulting, and advice are required for policymakers, legislators, advisers, and disaster management employees. To achieve this, more funding is needed for workforce development in drought monitoring and evaluation, situation assessment, and adaptation and mitigation skills programs.

2.3.2 Academic, research institutions and the private sectors

The Agricultural Research Council (ARC) and universities are tasked with promoting and developing human resources, research, and innovation in support of the agricultural sector (Liebenberg, 2015). They offer analytical, consultancy, and advisory services to the agriculture sector, as well as drought training interventions in South Africa (Zwane et al., 2015). The droughts events that have occurred have exposed the deficit in the quality of skills supply to the agricultural sector. To mitigate the impacts of drought, the ARC, in collaboration with universities and colleges, must invest in new competencies or skills through training and development, as well as research into modern

innovative suitable technologies and sustainable agricultural skills practices through AgriSETA, the National Research Fund (NRF), and training programs such as the Technology for Human Resources Industry programme (THRIP) (Zikhali et al., 2020). Another commendable innovation, the development of a drought-tolerant hybrid WE3127 and WE3128 maize variety, which enhanced yields in smallholder farmers in the provinces during the 2014-15 season (African Farmers' Association of South Africa, 2019).

Since the 2015-16 drought, more funds have been committed in skills development, with more than 190 students enrolled in 2018-19, compared to 50 in 2008-09 (Agri SA Research, 2019). In 2018-19, more than 54 students received Master of Science degrees and 24 received Doctoral degrees, with blacks accounting for 80% of the graduates (Ubisi et al., 2020). Universities have transformed drought research and development into official learning programmes curricula (AgriSETA, 2018) and the extension services programmes are offered by 5 institutions (3 universities and 5 colleges) and, short and postgraduate programmes in disaster management studies are also offered by 5 universities (Zikhali et al., 2020). Only 74 high schools and 24 universities and colleges in South Africa provide agriculture-related programmes (AgriSETA, 2020). Judging from the agricultural sciences 2% graduation and enrolment rate, and a young population of about 8 million in South Africa, more still need to be done through investment to address the skills gap in the agricultural sector particularly on the subject of agricultural drought management skills (AgriSETA, 2020).

Drought's various consequences have gradually led to the formation of private sector consulting firms offering agricultural services such as climate-smart agriculture, sustainability, technical production, and business management advice (Liebenberg, 2015). Several cooperative and commodity-based agricultural support organizations, such as AgriSA, which provides research, economic development, extension, and information sharing, demonstrate this (Elum et al., 2017). This is a departure from the usual reliance on agricultural experts from academic institutions and government, which has been criticised for making information and services difficult to obtain. Through its extension services, AgriSA has been at the forefront of disseminating drought information to its members and South Africa as a whole, as it recommends appropriate information and technological skills, sustainable agricultural skills, and strategies to its members at the highest professional standards to mitigate and

adapt to the impacts of drought. Acknowledging these organisations and the private sector for their drought management skills and knowledge is vital. Thus, their inclusion and participation in South Africa's national agricultural drought management planning must be prioritised.

2.3.3 Farmers and the farming community

Drought is threatening the productivity of South Africa's farming community, as they are the most vulnerable and severely affected (Fanadzo et al., 2021). The fundamental reason of high drought susceptibility is a lack of resources, knowledge, and skills for drought preparation, which is especially acute in resource-poor small-scale commercial and subsistence farmers. Therefore, farmers should be equipped with ecologically friendly agricultural techniques to create resilience capabilities to deal with future droughts and assure food security (Lottering et al., 2021). The government should strive to strengthen policies that promote farmers' progress in drought mitigation and coping strategy (Muthelo et al., 2019). Timely access to extension services will ensure that farmers are well-equipped with skills to prepare and mitigate drought (Schulze, 2016). To better deal with recurring droughts, farmers must be trained in drought management techniques such as drought monitoring and early warning systems, drought vulnerability and risk assessment, and drought risk mitigation (livestock management, water management, crop management, business management, rangeland management, and soil management) (Table 2.1).

One of the crop management skills that can be utilised by farmers is the use of drought-tolerant and hybrid drought-resistant crops (Kom et al., 2020). Crops such as sorghum have physiological water-conserving mechanisms that ensure less water is used whilst maintaining yields and production (Muthelo et al., 2019). The majority of farmers in South Africa, particularly small-scale commercial and subsistence farmers, adopt crop management practices such as crop rotation, mulching, and zero tillage (Rusere et al., 2019). These conservation techniques and approaches are advantageous for preserving soil structure, suppressing weeds and pathogens, and reducing crop water requirements (Ncube & Shikwambana, 2016). According to Ncube & Shikwambana (2016), subsistence farmers in the Karoo employed perforated holes on 2 litre plastic bottles buried into the ground in the centre of a

vegetable plot as a water conservation skill. Commercial farmers have used the development and maintenance of water facilities such as water abstraction reservoirs and dams to preserve water and mitigate drought (Schreiner et al., 2018). Water harvesting skills include the development of contours and ridges that improve the capture of runoff water, allowing it to accumulate and absorb into the soil, reducing runoff and protecting the topsoil from erosion (Caleni, 2017).

Livestock management skills are imperative for a livestock-producing farmer in South Africa. The farmer must be capable of managing pastures, assessing the situation, and making suitable preparations, plans, and judgments (Keesstra et al., 2018). For instance, if the pasture has been drastically reduced and there is less forage, a farmer should be aware of when to reduce the stocking rate and the subsequent relevant approach. Ncube and Lagardien (2014) identified a few skills that South African farmers in the Karoo region used, such as the construction of spreader banks for moisture conservation in pastures, rotational grazing, and the adoption of ecological principles to maintain rangelands and stocking rates based on rangeland carrying capacity. Chikwanha et al. (2021), reported water restriction and deprivation techniques, use of succulent feeds, and water stress alleviators, investments in water supply enhancement, efficient water accounting and auditing as livestock drought management coping strategies. Farmers should be knowledgeable about which cattle breeds are more resistant to drought conditions in their different locales. Ncube (2018), observed farmers in the drought-prone Karoo region of South Africa's Northern Cape utilising drought-resistant breeds such as Angora goats and Doper sheep and others had ventured into springbok and ostrich farming. Apart from these, supplementary feed and the creation of fodder banks can also be utilised to combat drought.

Above all, through extension services, farmers should have access to financial institutions such as the Industrial Development Corporation (IDC) and Land Bank. Farmers can get drought-related loans and business management expertise from these organisations. For example, during droughts, these institutions provide drought relief aid, concessionary disaster relief funds, and multi-peril and hail crop insurance (Zwane et al., 2015). The South African Weather Service (SAWS) disseminates drought early warning system information to help farmers to plan for drought ahead of time (Ndlovu et al., 2020). Farmers should be able to read applications like the Temperature Humidity and Enthalpy Heat Indices

through the SAWS, which allow them to monitor humidity and temperatures and inform on intensive system heat stress conditions, respectively (Baudoin et al., 2017).

2.4 Summary

The reviewed literature provides information on the skills gap of farmers and key professional's situation in drought management in South Africa's agriculture sector. Drought management in South Africa is based on crisis management, which is inefficient, slow, and poorly planned among relevant parties such as the Department of Agriculture, Disaster Management Centre, South African Weather Service, Agricultural Research Council, higher educational institutions, farmers' organisations, farmers, private sector, and financial institutions. The sector lacks critical skills in agricultural drought management due to low enrolments and graduations at higher education institutions specialising in drought management. To deal with the effects of drought, new skills such as sustainable agriculture, monitoring and early warning systems, vulnerability and impact assessment, and risk mitigation strategies are required. It is necessary to address the current situation of agricultural extension and disaster management staff in terms of drought preparedness and mitigation. As a result, the next chapter focuses on describing the methodology used in the assessment of the drought management skills of farmers and key professionals (agricultural extension, and disaster management personnel) in South Africa's agricultural sector.

Chapter 3 – Materials and methods

3.1 Introduction

This chapter provides an overview of the materials and methods used in the research study. The chapter begins with an overview of the ethical approval, then moves on to study sites and sampling procedures, data collection, and finally statistical analyses.

3.2 Ethical approval

The study received ethical approval from the Stellenbosch University Social, Behavioural and Education Research Committee (REC-2021-19116) as per the South African National Health Act 61 of 2003. Before data collection, study participants were required to sign consent forms, and their identities were kept confidential in accordance with the South African Protection of Personal Information Act 4 of 2013 (POPIA). All protocols relating to COVID-19 regulations were followed as outlined in the South African Disaster Management Act No. 27 of 2002, Amendment of Regulation issues in terms of Section 27(2). Gatekeeper permission letters to interview farmers and extension officers were obtained from DALRRD, whilst that for interviewing disaster management officers were obtained from the DCGTA-NDMC of South Africa.

3.3 Study sites and sampling procedures

Table 3.1 shows the environmental conditions, main agricultural activities and sample size of surveyed areas. A multi-stage purposive sampling method was used to select the provinces, districts, and local municipalities. These areas were selected based on aridity and recurrence of drought (drought prone). A rainfall-based aridity index was used to classify the provinces into “semiarid agroecological zone” indicating an area receiving annual rainfall ranging between 250 and 500 mm and “arid agroecological zone” receiving < 250 mm (Halimani et al., 2021; Maliva & Missimer, 2012). Based on this criterion, the targeted areas in the Free State and Eastern Cape provinces were classified as

“semiarid agroecological zone” whereas those in the Northern Cape, and Western Cape were classified as “arid agroecological zone” (Fig 3.1).

The research population of interest in the drought prone and dry agroecological zones in the targeted three Cape provinces and Free State province were subsistence, and small-scale commercial farmers followed by key professionals (agricultural extension and disaster management officers). Their selection was guarded by the Disaster Management Framework of 2005, which states the DALRRD, DCGTA, NDMC, and farmers as the main key stakeholders in agricultural drought risk management in South Africa (Vogel et al., 2010). "Subsistence farmer", is defined as a "farmer who produces for household food security and sale excess produce, while a "small-scale commercial farmer" is a "farmer that produces entirely for sale and profit" (DAFF, 2015). Figure 3.1a shows the provinces and districts surveyed, while Fig 3.1b and Fig 3.1c shows the local municipalities and local communities surveyed.

Table 3.1: Climatic conditions, and the main agricultural activities in the sampled areas

Province	District	Municipality	Land area (km²)	GPS coordinates	Ecological zone	Climatic conditions		Main agricultural activities	Farmers	Key professionals
						Annual rainfall (mm)	Mean annual temperature (^{O}C)			
Free State	Lejweleputswa	Tswelopele	6 524	28.0223° S, 25.9468° E	Semiarid	400 - 600	15 - 16	Crop production – maize; sunflower	27	6
	Xhariep	Letsemeng	9 828	29.3246° S, 25.0940° E	Semiarid	350 - 500	16 - 17	Livestock production – sheep; goat; ostrich	18	6
Northern Cape	Namakwa	Karoo-Hoogland	27 985	31.8438° S, 20.9030° E	Arid	100 - 200	17 - 18	Livestock production - sheep	20	5
	Pixley Ka Seme	Emthanjeni	11 388	30.6551° S, 24.0088° E	Arid	190 - 260	13 - 14	Livestock production – sheep; goat; game	27	5
Western Cape	West Coast	Matzikama	5 372	31.6125° S, 18.5226° E	Arid	30 - 260	17 - 18	Horticulture production and aquaculture – vegetables; grapes	9	6
	Central Karoo	Beaufort West	21 917	32.3529° S, 22.5841° E	Arid	150 - 235	17 - 18	Livestock production – sheep; goat	27	9
Eastern Cape	Chris Hani	Engcobo	11 046	31.6764° S, 28.0093° E	Semiarid	300 - 400	11 - 14	Subsistence livestock and crop production – cattle; sheep; goat; maize	32	7
	O.R Tambo	Nyandeni	2 474	31.5697° S, 29.1391° E	Semiarid	470 - 550	17 - 20	Subsistence livestock and crop production – cattle; sheep; goat; maize	32	11

Sources : https://en.climate-data.org/; Halimani et al. (2021).

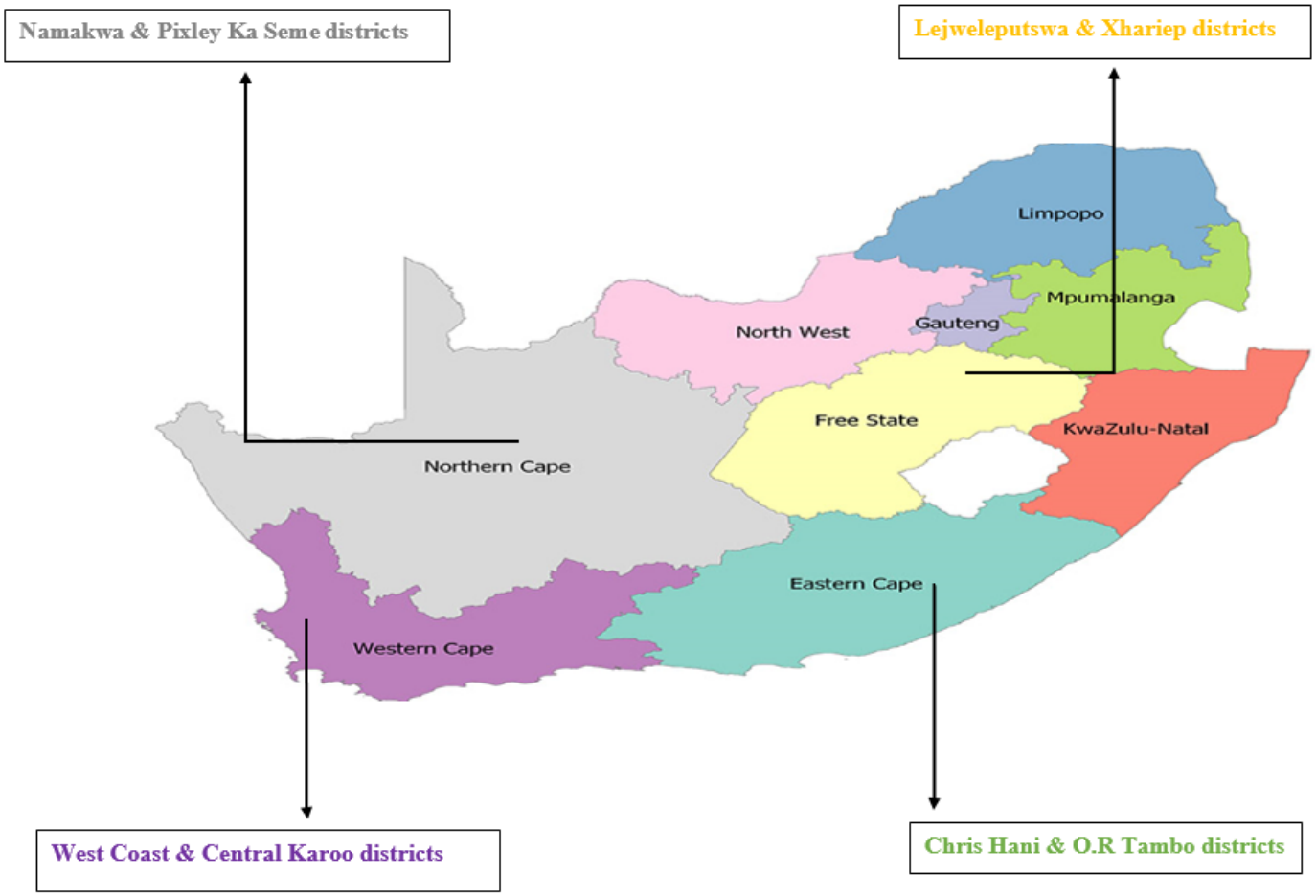

Figure 3.1a: Map of surveyed districts in the targeted provinces and districts of South Africa. *Source : //www.google.com/search ?q=SouthAfrica+province+district+municipality+map&rlz*

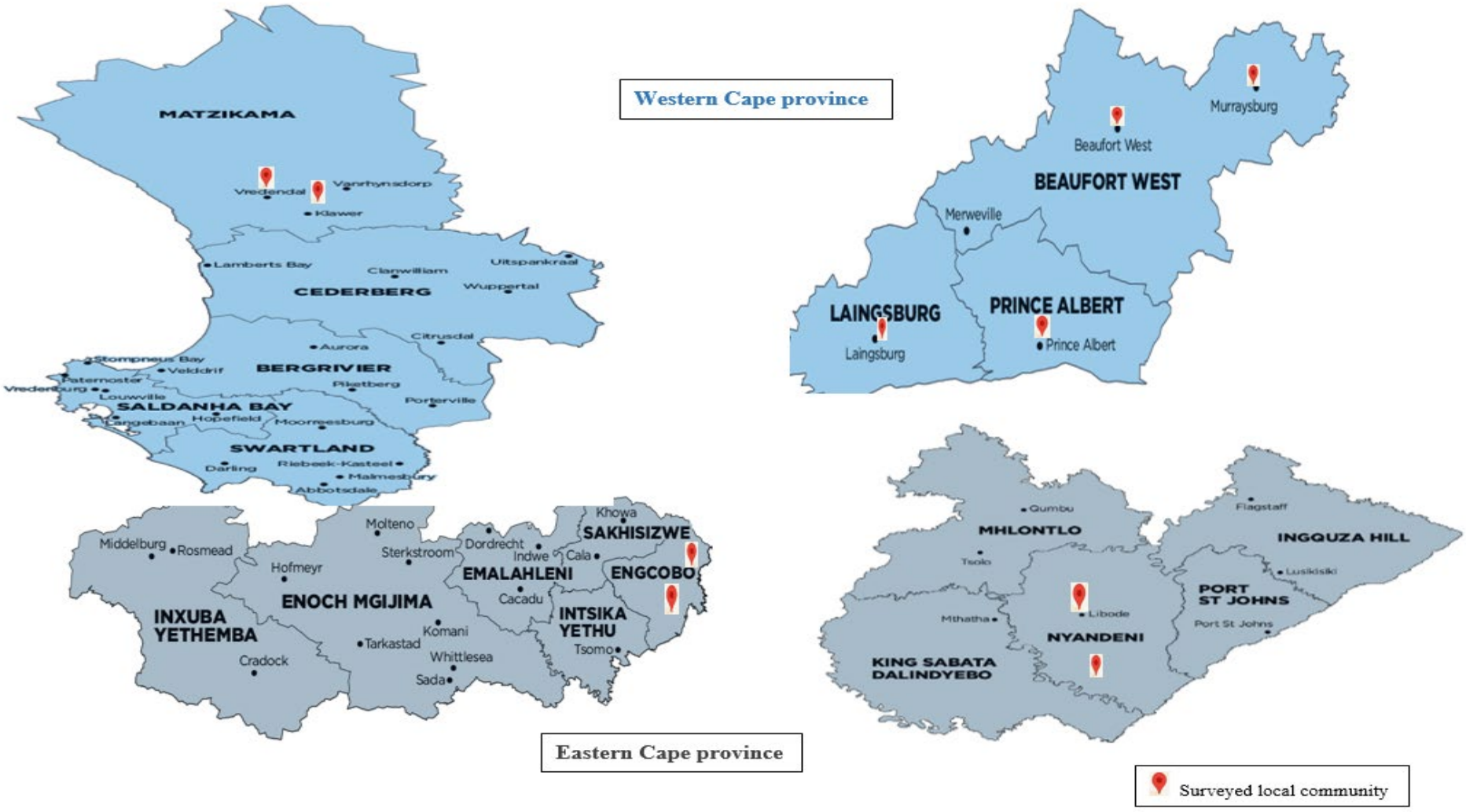

Fig 3.1b: Map of surveyed local municipalities and communities in the Western Cape, and Eastern Cape provinces. *Source : //www.google.com/search ?q=SouthAfrica+province+district+municipality+map&rlz*

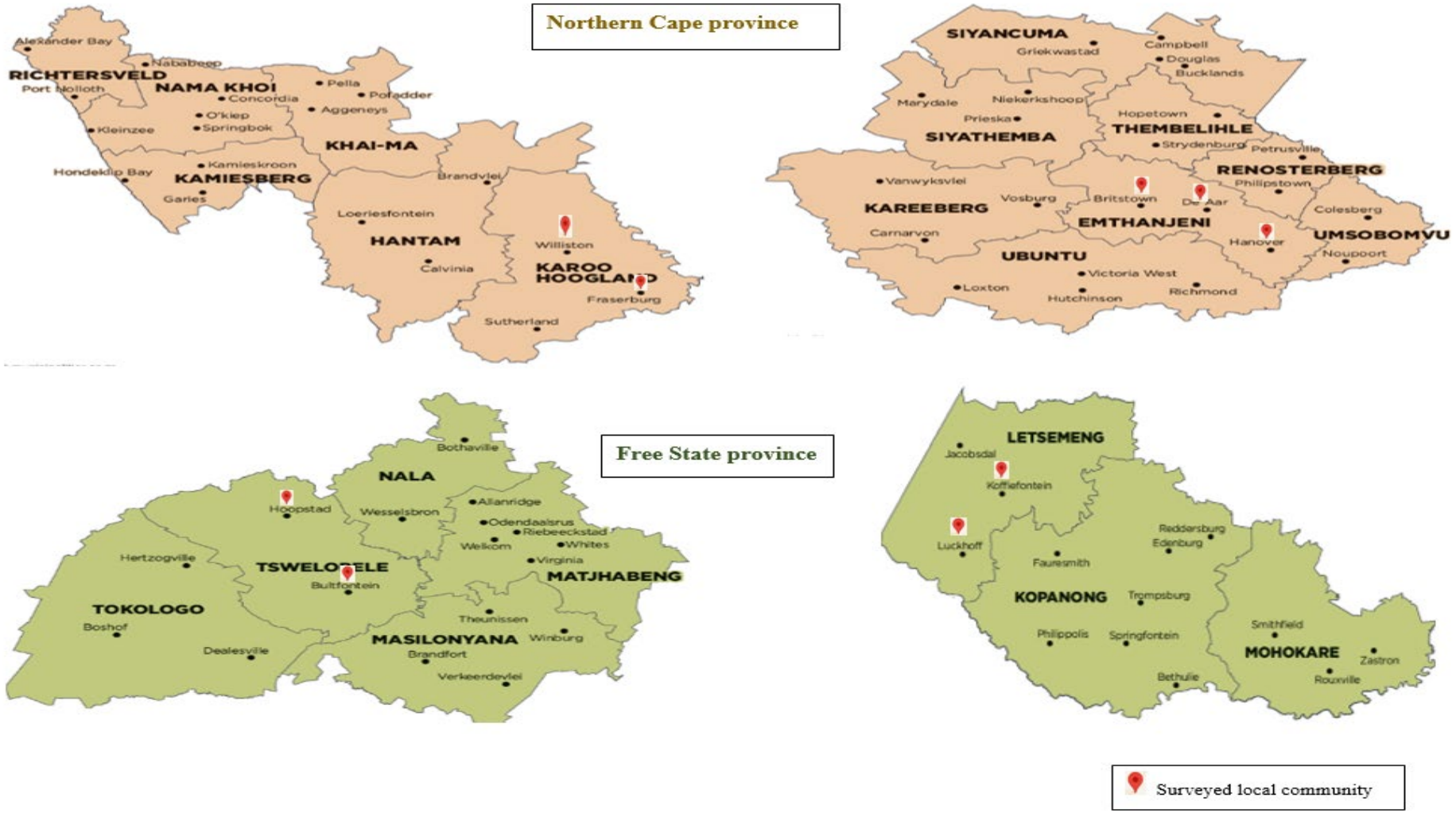

Figure 3.1c: Map of surveyed local municipalities and communities in the Northern Cape and Free State provinces. *Source ://www.google.com/search?q=SouthAfrica+province+district+municipality+map&rlz*

3.4 Data collection

In each targeted community, a list of farmers obtained from the local DALRRD extension support services were used as a sampling frame. Farmers were randomly selected from this list, but only those who were willing to take part in the study were interviewed. A total of 192 farmers were interviewed face-to-face between February and May 2022. Trained enumerators administered a pre-tested semi-structured questionnaire in the farmer's preferred local language (i.e., English, IsiXhosa, Sesotho or Afrikaans; Appendix 1). Questionnaires captured information on the farmers' socio-economic profiles, farm characteristics, farmers' perceptions of the impact of drought, and knowledge of drought management skills, and training needs. The following is an example of questions that were posed: "What impact did drought have on your farm, and how severe was the impact?" The farmer was asked to indicate the perceived impacts of the drought and rate its severity using a 5-point Likert scale (from neutral to very high). The questionnaire had a total of 67 questions and each farmer was interviewed for an average of 45 minutes. In addition to data collection, farm visits were conducted to observe the farmers' drought adaptation strategies.

For the key professionals, 32 extension and 13 disaster management officers were either interviewed telephonically or in-person using a pre-tested structured questionnaire in either English, IsiXhosa, Sesotho or Afrikaans. The questionnaire inquired about the demographic characteristics of key professionals, their perceptions of the impact of drought, professional support, and knowledge of drought management, skills and training needs (Appendix 2).

3.5 Statistical analyses

All data were analysed using SAS 9.4 (SAS Institute Inc. Cary, NC, USA). Descriptive statistics using PROC FREQ procedures were used to analyse farmers' and key professionals' socio-economic characteristics, and drought management skills. Flock/ herd size data were analysed using the general linear model procedure (PROC GLM) with the model fitting farmer typology and agroecological zone as the fixed effects and farmer within a given farm type or agroecological zone as the random effect.

The farmers' drought management skills and training needs were ranked using the Kruskal-Wallis test (NPAR1WAY procedure). An ordinal regression model (PROC LOGISTIC) was used to determine the factors influencing a farmer's ability to cope with the impacts of drought. The logit model fitted independent variables such as age, sex, education, farmer type, ecological zone, farm size, farming experience, source of income, access to extension services and agricultural training (Table 3.2). The forward selection model option embedded in PROC LOGISTIC was used to select independent variables that would be included in the final model. The model used was:

$$Log\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon$$

Where;

P = probability of a farmer's ability to cope with the impacts of drought;

β_0 = intercept;

$\beta_1, \beta_2 \ldots \beta_n$ = coefficients of independent variables;

$\chi_1, \chi_2 \ldots \chi_n$ = independent variables;

ε = random residual error.

The empirical specifications of the determinants underlying the binomial logit were based on current farmers' ability to cope with drought as follows:

$$\begin{aligned} Y_i(\text{Ability to cope with the impact of drought}) = {} & \beta_0 + \beta_1(\text{Age}) + \beta_2(\text{Sex}) + \beta_3(\text{Education}) \\ & + \beta_4(\text{Type of farmer}) + \beta_5(\text{Ecological zone}) + \beta_6(\text{Farm size}) \\ & + \beta_7(\text{Source of income}) + \beta_8(\text{Farming experience}) \\ & + \beta_9(\text{Access to extension services}) + \beta_{10}(\text{Agricultural training}) \end{aligned}$$

Where; β_0= Intercept and $\beta_{1\ldots}\beta_{10}$ coefficients. Marginal effects were developed to explain the effects of independent variables in terms of probabilities as follows:

$$x_1, \frac{1}{N}\sum_{i=1}^{N}\frac{\beta.p_i.(1-p_i)}{100}.$$

The marginal effects measured the effect of predictor variables on the probability of a farmer's ability to cope with the impacts of drought for a unit change in the independent variable. Probability (P) values ≤ 0.05 were deemed significant. For the key professionals, descriptive statistics were used to analyse demographic profiles, drought perceptions, and professional and support skills using PROC FREQ procedures of SAS.

Table 3.2: Description of independent variables used to create a logistic regression model for factors influencing the ability of a farmer to cope with the impacts of drought in South Africa

Independent variable	Description of an independent variable
Age	Age of the farmer [0 = Young (younger than 40), 1 = Adult, older than 40]. A few studies have established that older farmers tend to cope with drought than younger farmers (Muthelo et al., 2019; Nyam et al., 2021; Muroyiwa et al., 2022). According to Shikwambana & Malaza (2022) older farmers mostly tend to rely on experience and local indigenous knowledge when coping with the variability of climate. Therefore, older farmers are expected to have a greater influence on the farmer's ability to cope with drought.
Sex	Sex of the farmer (0 = Male, 1 = Female). Nowadays females just like male farmers have better access to networks, and experience in farming (Antwi-Agyei & Stringer, 2021). Therefore, females are expected to have a greater influence on the farmer's ability to cope with drought.
Educational level	Educational level of the farmer (0 = No formal education to primary education, 1 = Secondary and tertiary education). Low level of education is associated with marginalisation and poverty, therefore a low level of literacy among farmers increases drought impacts vulnerability (Muroyiwa et al., 2022). According to Muthelo et al. (2019), secondary and tertiary education is important for farmers to make informed decisions about drought adaptation strategies. Higher levels of education increase adoption of coping strategies. Therefore, secondary, and tertiary education is expected a greater influence on the farmer's ability to cope with drought than no formal and primary education.
Type of farmer	Type of farmer (farmer typology) (0 = Subsistence farmer, 1 = Small-scale commercial farmer). Commercial farmers mostly have more resources and technologies that enable them to put measures that combat the impacts of drought compared to subsistence farmers, who are strongly associated with food insecurity and poor livelihoods during drought periods (Muroyiwa et al., 2022). Thus, smallscale commercial farming is anticipated to positively influence farmers' ability to cope with drought.
Ecological zone	Ecological zone (0 = Semiarid, 1 = Arid). Farmers in arid areas have long periods of drought-associated water scarcity (Muthelo et al., 2019). Therefore, they have more experience with drought which positively influence their knowledge and coping strategies than farmers in less drought areas (Muroyiwa et al., 2022) Hence, farming in arid areas is more likely to positively influence farmers' ability to cope with drought.
Farm size	Farm size (0 = Less than 100 ha, 1 = More than 100 ha). Size of the farm is associated with farmers' economic viability, which usually influences the adoption of new technologies by farmers (Mapiye, 2022). Therefore, it is anticipated that a large farm size might positively influence a farmer coping with drought.
Farming experience	Farming experience of the farmer (0 = Less than 10 years, 1 = More than 10 years). Farming experience equips a farmer with more agricultural practical knowledge of their farms and an appreciation of the need to adopt mitigation strategies when faced with re-current droughts (Muroyiwa et al., 2022). Hence, a farming experience of more than 10 years is anticipated to determine farmers' ability to cope with drought.
Source of income	Source of income (0 = Farming income, 1 = Other income sources). Access to other sources of income act as stabilizers and buffers for a farmer when exposed to climatic risks such as drought (Mapiye, 2022). Therefore, access to other sources of income is expected to have a greater influence on the farmer's ability to cope with drought.
Access to extension services	Access to extension services of the farmer (0 = No access to agricultural extension services, 1 = Access to agricultural extension services). There is a strong relationship between the access of farmers to extension services with the adoption of new technology by a farmer (Muroyiwa et al., 2022). Consequently, access to information improves the chances of adopting coping strategies. Thus, access to extension services is expected to have a positive influence on a farmer's coping with drought.
Agricultural training	Agricultural training (0 = No agricultural training, 1 = agricultural training). Farming skills obtained through agricultural training have a positive influence on agricultural technical measures (Muthelo et al., 2019). This implies that farmers with agricultural training have farming skills that will more likely increase the chances of adoption of drought technical measures as a coping strategy. Thus, possession of some agricultural training is anticipated to influence a farmer's ability to cope with drought.

Chapter 4 – Results, Discussion, Conclusions and Recommendations

4.1 Results and discussion

4.1.1 Farmers' socioeconomic profile

Table 4.1 presents the socioeconomic profiles of the farmers who participated in the present study. Regardless of farmer typology, about two-thirds of the respondents were males. This expected result could be attributed to comprehensive labour obligations generally associated with men (Bareki & Antwi, 2017). Almost half of subsistence and one-third of small-scale commercial farmers were more than 60 years old indicating the dominance of adults in farming owing to possible retirement or retrenchment from urban employment (Goni et al., 2018). This could also be attributed to lack of youth's involvement in agriculture and their preference to emigrate to urban areas for less-labour intensive jobs (Fourie et al., 2018). About 55 and 72% subsistence and small-scale commercial farmers, respectively, had secondary and post-secondary education. These findings corresponds with Khuluvhe & Ganyaupfu (2022) who reported that about half of the South African population have at least a secondary educational qualification. More than 60% of small-scale commercial farmers and 48% of subsistence farmers had received agricultural training. The higher proportion of small-scale commercial farmers who have received some agricultural training suggests that they could have better exposure and understanding of new and improved agriculture management and production information than subsistence farmers (Mthi & Nyangiwe, 2018).

Almost 30% of small-scale commercial farmers had private land whereas most subsistence farmers (48%) relied on communal land. The bulk of subsistence farmers (70%) had fields of less than 50 hectares, and half of the small-scale commercial farmers had farms of more than 100 hectares. Such variations highlight the importance of tailor-making drought response strategies in line with farmer characteristic and reduce vulnerability to climatic conditions and unfavourable agricultural production outputs (Bareki & Antwi, 2017).

Irrespective of type of farmer, close to 90% of the respondents were full-time with over 70% of them having more than 10 years of farming experience. These differences could be attributed to the arrival of community members from surrounding farms and communities, and retirement or migration from urban to rural areas to focus on farming (Goni et al., 2018). Small-scale commercial farmers (55% of the respondents) had the most paid labour compared to subsistence farmers (35%), and this could be related to affordability and having multiple sources of income. Forty percent of farmer's income were from field crops and 65% from livestock sales, which were both primary sources of income. However, one-third of subsistence farmers received social grants and pensions as the main sources of income. As expected, majority of subsistence farmers (48%) were on communal land while half of small-scale farmers were either on private or leased land. This is because rural communities depend on communal lands for livelihoods sustainability especially when used for agricultural purposes (Lidzhegu & Kabanda, 2022). Regarding farm size, nearly 60% of subsistence farmers had small land sizes (≤10 ha) compared to over 80% of small-scale farmers who had large farms (≥100 ha). Land holdings in communal areas are generally small and a mainly used for subsistence purposes (Aliber & Hart, 2009).

Table 4.1: Demographic information of farmers (%) in the selected provinces.

Variable	Type of farmer		Overall (n=192)
	Subsistence (n = 120)	Small-scale commercial (n = 72)	
Sex			
Male	65.00	58.33	65.50
Female	35.00	41.67	37.50
Age (years)			
< 20	0.83	-	0.52
21-30	4.17	4.17	4.17
31-40	5.00	13.89	8.33
41-50	19.17	19.44	19.27
51-60	23.33	29.17	25.52
> 60	47.50	33.33	42.19
Level of education			
No formal education	16.67	13.89	15.63
Primary	28.33	13.89	22.92
Secondary	45.83	47.22	46.35
Tertiary	9.17	25.00	15.10
Agricultural training			
Yes	48.33	61.11	53.13
No	51.67	38.89	46.88
Land ownership			
Private/Own	5.83	29.17	14.58
Communal/ Tribal	48.33	30.56	41.67
Leased	25.00	20.83	23.44
Government	20.83	19.44	20.31
Farm size			
< 10ha	59.50	6.94	39.62
10-50ha	28.33	11.11	21.87
50-100ha	3.33	-	2.08
100-500ha	8.33	43.06	21.35
< 500ha	-	38.89	15.08
Farming experience			
< 1 year	1.67	-	1.05
2-5 years	0.83	9.44	4.06
5-10 years	25.00	16.67	21.88
10-20 years	36.67	26.67	32.92
< 20 years	35.83	47.22	40.09
Farming full-time/part-time			
Full-time	90.00	90.28	90.10
Part-time	10.00	9.72	9.90
Paid labour			
Yes	55.00	34.72	47.40
No	45.00	65.28	52.60

4.1.2 Farm agricultural activities

Half of the small-scale commercial farmers and two-fifths of the subsistence farmers surveyed resided in arid areas with over 75% of the former practicing livestock production. However, in semiarid areas 70% of small-scale commercial farmers practiced mixed farming compared to 80% of the subsistence farmers. Maize was the primary crop grown by 30% of the small-scale commercial farmer and 45% subsistence farmers, followed by vegetables at 20 and 25%, respectively. Horticultural crops were grown by 2% of small-scale commercial farmers. In addition to home consumption, 32% of subsistence farmers produced crops for sale, and only 4% for livestock feed. In contrast, 25% of the small-scale commercial farmers grew crops for feeding livestock in addition to sales.

Irrigation was reported by 15% of small-scale commercial farmers, and 8% of subsistence farmers. Of these, 14% were in arid areas with 12% in semiarid. The primary sources of irrigation water for crop production were dams and boreholes with 11% of small-scale commercial using both sources, and 2% for subsistence farmers. With respect to agroecological zone, almost an equal proportion of respondents used dams for irrigation in arid (7%) and semiarid (9%) areas. The use of boreholes as the source of livestock drinking water by small-scale commercial farmers was 20% versus 30% by subsistence farmers, which concurs with reports by Pili & Ncube (2022). This is despite the high costs associated with drilling boreholes. Boreholes are an integral source of water for livestock producers in the arid Karoo region (Halimani et al., 2021). Interestingly, boreholes used by subsistence farmers for drought impact mitigation were mostly drilled by DALRRD (Liebenberg, 2013).

Table 4.2 shows the size of livestock herds/flocks among subsistence and small-scale commercial farmers in the surveyed communities. Small-scale commercial farmers had larger flock sizes than subsistence farmers ($P \leq 0.05$). Generally, small-scale commercial farmers are profit-oriented and thus keep larger flocks or herds and implement different herd management practices characterized by pedigree breeds, advanced technology, rangeland management, and farmers' exclusive rights to grazing resources all of which contributes to increased animal production (Nyam et al., 2021). Additionally, the same author (Nyam et al., 2021) stated that farmers with larger herds of livestock are wealthier, have access to inputs, and use herding labour, which lowers mortality rates in drought-prone

areas. However, flock/ herd sizes in communal areas are often limited by feed scarcity due to degraded and often overgrazed rangelands (Pili & Ncube, 2022).

Farmers in arid areas had greater ($P \leq 0.05$) sheep and goat numbers than those in semiarid areas as the former tend to have smaller populations, but large tracts of lands, as opposed to farmers in semiarid areas. The large numbers of sheep and goats in arid areas were partly attributed to adaptation capabilities of small ruminants to the drier environments compared to large stock, (Bahta & Myeki, 2021). Additionally, better livestock and rangeland management skills of the farmers in arid areas could have contributed to the small ruminant numbers (Table 4.2).

Table 4.2: Livestock flock size (least square means ± standard error) in subsistence and small-scale commercial farmers in the selected provinces.

Livestock	Type of farmer		P value	Ecological zone		P value
	Subsistence farmers	Small-scale commercial farmers		Arid	Semiarid	
Cattle	7.5 ± 0.95	18.2 ± 8.81	0.1229	5.6 ± 1.23	15.9 ± 5.82	0.1283
Sheep	32.5 ± 4.46^{b}	160.2 ± 37.44^{a}	<.0001	143.1 ± 32.93^{a}	32.6 ± 4.41^{b}	0.0002
Goats	10.9 ± 1.49^{b}	37.3 ± 16.64^{a}	0.0440	39.4 ± 14.43^{a}	6.6 ± 1.00^{b}	0.0102

$^{a-b}$ Least square means with different superscripts in the same row are significantly different ($P \leq 0.05$).

Majority of farmers indicated meat (80% of the respondents) and live animal sales (93%) as the primary reasons for keeping livestock regardless of their type. Approximately half of the small-scale commercial farmers stated that they kept certain breeds of sheep and goats for wool and fibre, respectively. Other reasons for keeping livestock by subsistence farmers included ceremonies (40%), status (15%) and milk production (14%). Similar reasons were reported by Mapiye et al. (2009) and Halimani et al. (2021) for both small-scale and subsistence farmers-dominated areas.

The main breeds of cattle kept by subsistence farmers were non-descript crossbreeds (66% of the respondents), Nguni (25%), Bonsmara (6%) and Brahman (3%). For small-scale commercial farmers, the Bonsmara (58% of the respondents) was the dominant breed, followed by non-descript crossbreed (25%), Afrikaner (10%), Nguni (6%) and Limousine (1%). Farmers kept non-descript crossbreeds due to uncontrolled breeding, and their large frame sizes and heavy carcasses

(Nyamushamba et al., 2017; Chikwanha et al., 2021). The Nguni was largely kept by subsistence farmers as it is a hardy breed and adaptable to harsh environmental stressors (Kooverjee et al., 2022). On the other hand, the Bonsmara breed found to be predominant among small-scale commercial farmers (55%) is a local composite breed with efficiency under feedlot conditions, and tolerance to heat and ticks (Nyamushamba et al., 2017).

About 40% of the subsistence farmers had Merinos and Dorper sheep breeds while 18 and 35% of the respondents had crossbreeds and Meatmaster sheep breeds, respectively. Majority of small-scale commercial farmers (48%) had the Merino sheep breed, and a few had Dorper (32%), crossbreeds (14%), Van Rooy (4%) and Meatmaster (2%). Overall, the Dorper and Merino sheep breeds were expected to be the most common due to their comparable production efficiency (Mupfiga et al., 2022). Dorper (50% of respondents) was the dominant sheep breed in the arid areas whilst the Merino dominated the semiarid area (58% of the respondents). Farmers in arid areas prefer the Dorper breed due to their resilience and adaptability to a variety of environmental conditions, such as feed and water scarcity as opposed to the Merinos (Cloete et al., 2014; Traits, 2021).

The dominant goat breeds owned by subsistence farmers were crossbreeds (62% of the respondents), Boer goat (22%) and Angora goats (5%). Small-scale commercial farmers owned Boer (56% of the respondents), Angora (19%), crossbreeds (13%) and Alpine (4%) goats. Farmers in arid areas had crossbreeds (49% of the respondents), Boer (35%), Angora (12%), Saneen (2%) and Alpine (1%) goats. Semiarid areas farmers had crossbreeds (59% of the respondents), Boer (28%), and Angora (10%) goats. Overall, the most commonly reported goat breeds were crossbreeds (59% of the respondents) and Boer (34%) goats due to their adaptive characteristics (Pieters et al., 2009).

4.1.3 Farmers' perceptions on the impact of drought

Regardless of the type of farmer and agroecological zone, all the interviewees were familiar with the term "drought," defining it as lack of rainfall, and occurrence of higher-than-normal temperatures. Drought affected over 95% of respondents regardless of farmer type and agroecological zone. All of the farmers were affected by multi-year droughts since 2015 supporting an Agri-SA (2020)

report, that most farmers are yet to recover from the impacts of the 2015 drought. The finding that half of subsistence and small-scale commercial farmers did not anticipate the onset of the 2015 drought, and one-third were unprepared was expected considering that South Africa has been experiencing drought scenarios and farmers would have managed to establish drought coping mechanisms for possible future occurrences (Katiyatiya et al., 2022).

Subsistence and small-scale commercial farmers reported reduced household food security (~80 % of the respondents) and increased poverty (>60%) as major social impacts of droughts (Fig 4.1). Other social impacts, such as loss of employment, increased household tension and conflicts, increased migration, theft, and stress were higher among subsistence farmers than among small-scale commercial farmers (Fig 4.1) supporting previous findings that subsistence farmers and rural populations are the most vulnerable to drought (Ebhuoma et al., 2020; Muroyiwa et al., 2022). Similarly, according to Lottering et al. (2021), drought impacts resulted in increased levels of food insecurity, poverty, and malnutrition among subsistence farmers in uMsinga, KwaZulu-Natal. Due to drought during the past ten years, thousands of farmers (mainly young men) have moved from rural to urban areas in search for jobs (Vetter et al., 2020). Furthermore, Mathinya et al. (2022) stated that small-scale commercial farmers' poverty levels tend to rise during drought years due to debt default because they mostly rely on loans and debts to promote productivity.

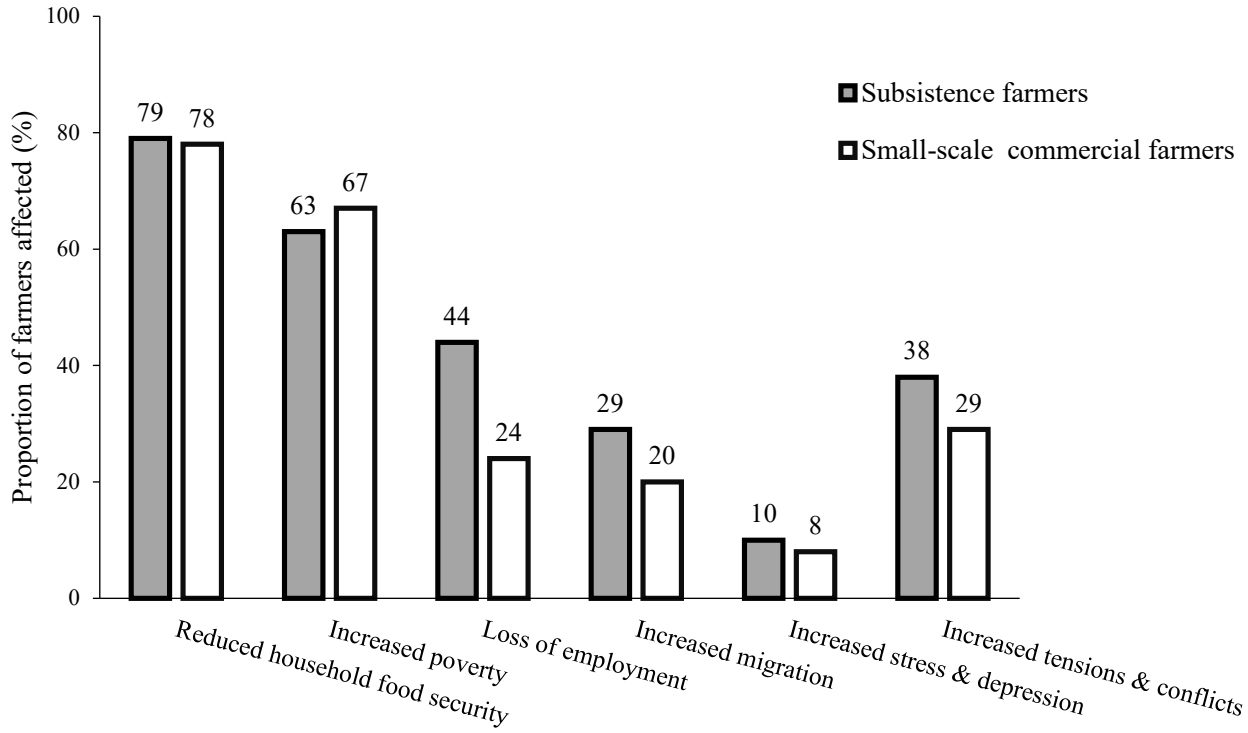

Figure 4.1: Percentage of subsistence and small-scale commercial farmers who experienced social impacts due to drought

Approximately 85% of subsistence farmers and 80% of small-scale commercial farmers reported farm income losses as the main economic impact of drought (Fig 4.2). This could be attributed to crop failure, unproductive livestock, lack of access to financial institutions and insurance, and limited farm business management skills (Bahta et al., 2016). During droughts, small-scale commercial farmers reported experiencing more livestock mortalities (72% of the respondents), pest and diseases prevalence (60%) than subsistence farmers (65 and 56%, respectively). These findings could be due to drought unpreparedness, and greater flock size of small-commercial farmers than subsistence farmers (Table 4.2). As a result, having large flocks improved the likelihood of increased livestock mortalities, parasites, and diseases. According to Mare et al. (2018), small-scale commercial farmers have higher mortality rates during drought seasons due to the high costs associated with managing a bigger flock or herd size. Furthermore, drought causes feed and veterinary product price increases, rendering livestock production unprofitable (Agri SA Research, 2019b; Schaub & Finger, 2020). Small-scale commercial farmers largely keep exotic breeds that are adapted for greater intensive production in addition to large

herds of animals. However, most exotic breeds do not fare well when there is drought occurrence (Matlou et al., 2021).

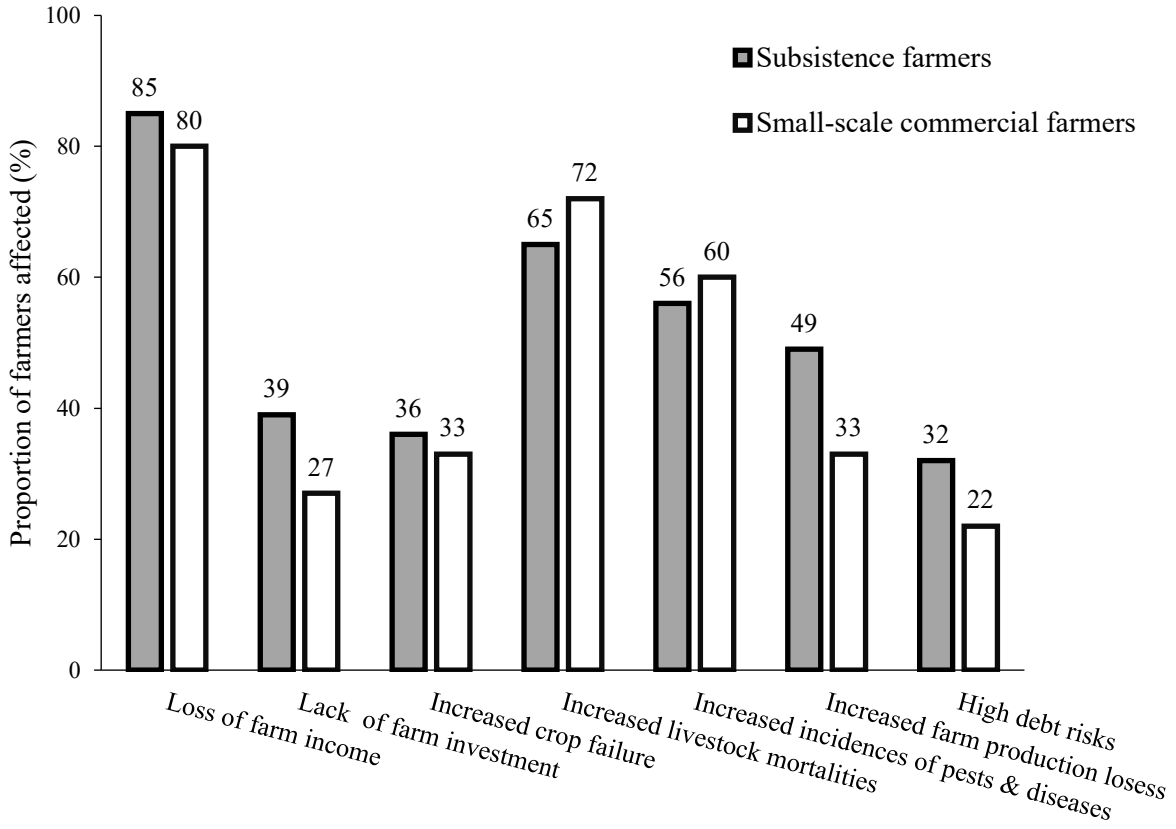

Figure 4.2: Percentage of subsistence and small-scale commercial farmers who experienced economic impacts due to drought

Environmental impacts were generally experienced more by subsistence farmers than small-scale commercial farmers (Fig 4.3). Reduced water availability was cited by 85% of subsistence farmers and 80% of small-scale commercial farmers as a major environmental impact during droughts followed by rangeland deterioration cited by 68% of subsistence farmers and 64% of small-scale commercial farmers. Similar to current findings, majority of respondents in uMsinga, KwaZulu Natal rated water scarcity and rangeland deterioration among the main environmental problems that affected them during droughts (Lottering et al. 2021). Vetter et al. (2020) reported that during the 2016 drought in KwaZulu-Natal, a high percentage of animal deaths were reported in areas with overgrazing and soil erosion. The

impacts of drought negatively impact crops, forage and animal production and subsequently affects farmers' livelihoods (Bahta & Myeki, 2022).

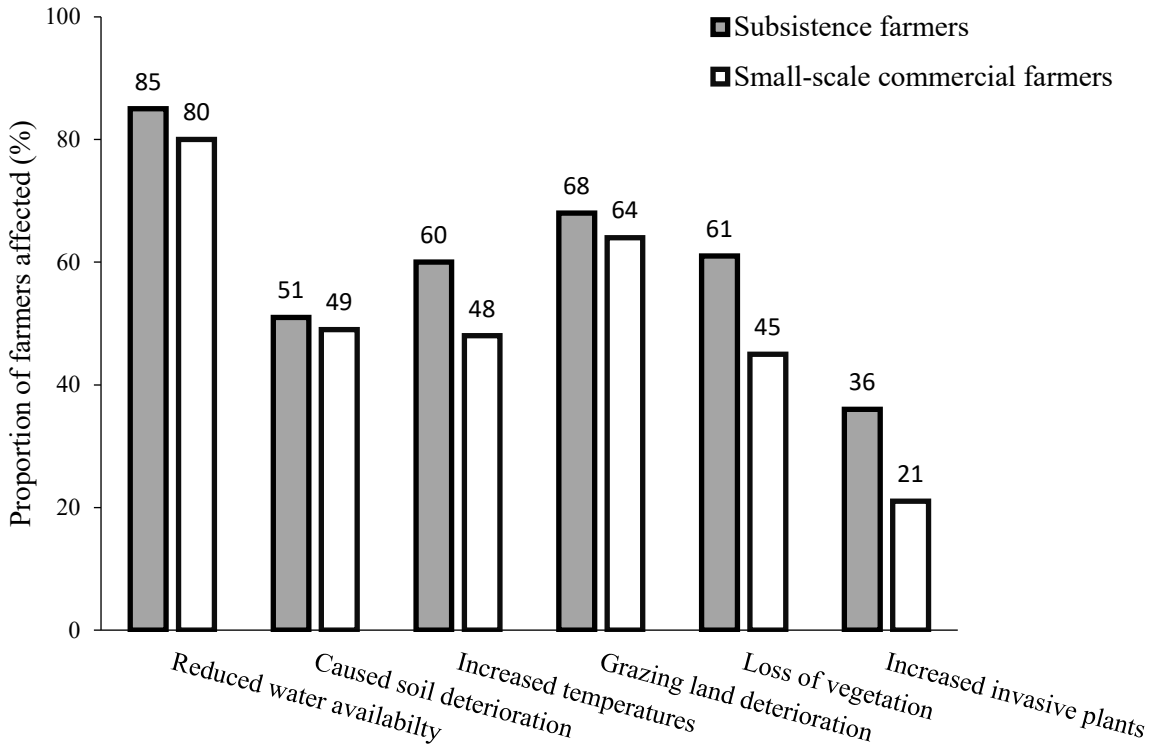

Figure 4.3: Percentage of subsistence and small-scale commercial farmers who experienced environmental impacts due to drought

4.1.4 Farmers' agricultural drought management skills

Table 4.3 shows the farmers' agricultural drought management skills. Farmers possessed drought management skills which included the use of appropriate stocking rates (43%), rotational grazing (39%), rangeland condition assessment (34%), supplementary feeding (71%), use of fodder banks (44%) and livestock selling (55%). However, there were more subsistence farmers who indicated that they had skills in the form of use of stocking rate, supplementary feeding, fodder bank than small-scale farmers. Mare et al. (2018) found similar results showing that livestock farmers' coping mechanisms include selling livestock earlier and cultivating crops such as Lucerne and maize to serve as fodder banks. More farmers in the arid areas indicated that they have skills in the form of use of stocking rate, rotational grazing, rangeland condition assessment, supplementary feeding, fodder bank

Table 4.3: Percentage of farmers with selected agricultural drought management skills in the selected provinces.

Drought management skill	Type of farmer		Agroecological zone		Overall (n = 192)
	Subsistence (n = 72)	Small-scale commercial (n = 120)	Arid (n = 83)	Semiarid (n = 109)	
Crop management					
Planting of drought-resistant varieties of crops	10.42	9.90	10.84	27.52	20.31
Introduction of cultivars with shorter growing	6.77	3.65	7.23	12.84	10.42
Changing planting and harvesting times	12.50	4.69	2.41	28.44	17.19
Crop rotation	13.02	6.25	7.23	71.56	19.27
Crop diversification	15.10	6.25	4.82	33.94	21.35
Introduction of legume cover crops	8.33	4.69	4.82	19.27	13.02
Reduced area planted	16.15	5.21	6.02	33.03	21.35
Water management					
Irrigation technologies and water scheduling	7.29	5.21	13.25	11.93	12.50
Water conservation techniques	20.83	11.46	27.11	35.78	32.29
Rainwater harvesting	13.54	14.58	21.69	33.03	28.13
Drilling boreholes	9.90	8.33	26.51	11.93	18.23
Protection of open water sources	15.10	5.73	19.28	22.02	20.83
Recycling of wastewater	6.77	10.42	9.64	22.94	17.19
Construction of storage tanks	19.27	9.38	27.71	29.36	28.65
Building dams for water storage	9.38	4.69	14.46	13.76	14.06
Soil management					
Zero/ minimum tillage	7.81	2.08	3.61	14.68	9.90
Mulching	14.58	6.77	4.82	33.94	21.35
Composting	15.10	7.81	3.61	37.61	22.92
Increased soil cover crop	14.58	6.77	6.02	33.03	21.35
Intercropping	15.63	4.17	2.41	33.03	19.79
Construction of contours and terraces	6.77	1.56	1.20	13.76	8.33
Leaving fields fallow	6.25	2.60	2.41	13.76	8.85
Integrated pest management	6.25	3.65	3.61	14.68	9.90

Drought management skill	Type of farmer		Agroecological zone		Overall (n = 192)
	Subsistence (n = 72)	Small-scale commercial (n = 120)	Arid (n = 83)	Semiarid (n = 109)	
Construction spreader channels to prevent soil	4.17	0.52	2.41	6.42	4.69
Rangeland management					
Use of appropriate stocking rates	28.65	14.06	62.65	27.52	42.71
Creation of paddocks	13.54	7.29	24.10	18.35	20.83
Rotational grazing	20.31	18.75	42.17	36.10	39.06
Night grazing	7.29	2.08	9.64	9.17	9.38
Rangeland assessment	21.88	12.50	45.78	25.69	34.38
Removal of invasive plant species	11.98	6.25	22.89	14.68	18.23
Irrigation of pastures and rangelands	6.25	1.56	10.84	5.50	7.81
Reseeding pastures and rangelands with improved	9.90	4.17	22.89	7.84	14.06
Livestock management					
Use of adapted breeds	25.00	12.50	55.42	23.85	37.50
Use of improved reproduction methods	9.90	7.81	28.92	9.17	17.71
Use of livestock genetic improvement techniques	8.85	5.73	19.28	11.01	14.58
Supplementary feeding	43.75	27.60	77.11	66.97	71.35
Use of fodder banks	27.60	16.67	50.60	39.45	44.27
Selling of livestock	35.42	19.27	73.49	40.37	54.69
Culling less reproductive animals	16.15	9.38	42.17	12.84	25.52
Relocation of livestock to areas with better	8.85	8.85	31.33	7.34	17.71
Water restriction and deprivation techniques	7.81	3.13	18.07	5.50	10.94
Use of water stress alleviators in drinking water	9.38	5.73	26.51	6.42	15.10
Vaccination against diseases and parasites	23.44	13.02	55.42	22.02	36.46
Business management					
Water accounting and auditing	5.73	4.17	13.25	7.34	9.90
Creation of an alternative low input system	5.73	4.17	13.25	7.34	9.90
Saved money for emergencies	14.58	12.50	37.35	19.27	27.08
Risk assessment and management	6.77	6.25	20.48	7.34	13.02

Drought management skill	Type of farmer		Agroecological zone		Overall (n = 192)
	Subsistence (n = 72)	Small-scale commercial (n = 120)	Arid (n = 83)	Semiarid (n = 109)	
Diversifying the farm	7.29	8.85	22.89	11.01	16.15
Insurance	7.29	4.17	15.66	8.26	11.46
Credit and borrowing from financial institutions	7.29	5.73	20.48	7.34	13.02

and selling livestock compared to semiarid farmers. This could be attributed to varying adaptation strategies that the farmers could have developed overtime due the known characteristics arid environments such as poverty, food insecurity, water scarcity and environmental degradation (Ndlovu et al., 2020).

Table 4.4 shows the socioeconomic factors that influence farmers' ability to cope with the impacts of drought. Ordinal regression marginal effects result show that farmers' ability to cope with drought was influenced by age, sex, education, the source of income, and access to agriculture extension services ($P \leq 0.05$). An increase in young farmers, males, level of education, farming income, and access to agricultural extension services increased the probability of coping with the impacts of drought ($P \leq 0.05$). Similar findings by Lottering et al. (2021), showed that socioeconomic characteristics such as age, sex, education, and income have an impact on the adoption of mitigation measures. According to Hassan et al. (2020), the level of education encourages the adoption of new technologies, higher levels of education considerably increasing a farmer's ability to improve drought adaptation strategies. Post-primary education is the most essential component in the adoption of new agricultural technologies since it helps a farmer receive and process information from agricultural extension and other types of media (Mthombeni et al., 2021). Bahta (2021) asserted that male farmers' participation in social networks such as farmers' associations increased their access to resources, making them more resilient to the impacts of drought. Khowa (2021) observed that there is a positive association between education level and age, as educated young farmers can easily obtain, comprehend, and apply agricultural drought coping strategies. Young farmers are more adaptable to new farming technologies and methods than older farmers (Vetter et al., 2020). Agricultural extension services are critical to gaining access to productive services information, new technologies, credit, and drought early warning systems (Afful, 2016).

Most subsistence farmers had more indigenous knowledge on drought than small-scale commercial, which concurs with Mathinya et al. (2022). According to Mathinya et al. (2022), the disparity in resource endowment pushes subsistence farmers to be inherently traditional, limiting new technology adoption. The majority of respondents in uMsinga, KwaZulu-Natal used indigenous knowledge of water conservation strategies such as rainwater harvesting and the use of wells, with remarkable success (Lottering et al., 2021). Some of these indigenous techniques are being adopted because they are less expensive, easily accessible, and widely available locally which suits the resource-limited subsistence farmers (Mugambiwa, 2018).

Table 4.4: Socio-economic factors influencing the ability of farmers to cope with the impacts of drought in South Africa

Variable	Margin	Standard error	t-value	P>|t|	[95% Confidence Interval]	
Age	-0.1821743	3.224921	2.20	0.0281	-0.2342588	-0.1300899
Sex	-0.1335256	2.452912	2.12	0.0343	-0.1717012	-0.0953500
Education	0.4406897	1.363367	-11.62	<.0001	0.3236932	0.5576861
Type of farmer	-0.0086452	1.339575	0.25	0.8019	-0.0111169	-0.0061735
Ecological zone	-0.1051853	2.818375	1.45	0.1468	-0.1352582	-0.0751123
Farm size	0.0107053	1.707678	-0.24	0.8074	0.0076446	0.0137661
Experience in farming	-0.0166425	1.013150	0.64	0.5230	-0.0214006	-0.0118843
Source of income	0.0922225	1.695813	2.11	0.0345	0.1185893	0.0658557
Access to extension services	0.0768560	1.509754	-1.98	0.0478	0.0548826	0.0988295
Agricultural training	-0.0268330	1.099098	0.95	0.3425	-0.0345047	-0.0191613

4.1.5 Farmers' drought management training needs

Table 4.5 shows the proportions of farmers with access to drought information, aid and training. The finding that 25% of subsistence farmers and 15% of small-scale commercial farmers had access to drought information, with extension agencies providing half of the information was not expected. This is because extension services are responsible for knowledge and information transfer to farmers including drought, weather and climate changes, educating them on decision making and promotion of agricultural development in the face of unpredictable environmental changes (Raidimi et al., 2019). The majority (74%) of subsistence farmers reported having indigenous knowledge on how to cope with impacts of agricultural drought. This is consistent with a previous study by Ubisi et al. (2020), who found that smallholder farmers in Nkomazi Local Municipality, Mpumalanga used indigenous knowledge to predict weather in preparation for the agricultural production season by observing animal behaviour, plants, atmospheric indicators, and human ailments. To mitigate the effects of climate change on their agricultural activities, local farmers in South Africa and Kenya used indigenous knowledge to predict seasonal weather and rainfall patterns, determine wind speed and direction, preserve grains for planting purposes, and implement various traditional farming support systems (Apraku et al., 2021). Seventy-six percent of subsistence farmers and

88% of small-scale commercial farmers were members of farmer networks, where knowledge and experiences were frequently shared indicating good and reliable communication channels that can be used to convey drought information to farmers (Rakgwale & Oguttu, 2020). Approximately 30% of subsistence farmers and 15% of small-scale commercial farmers had previously received government and farmer-organisation aid/ relief, either as cash handouts (15%), vouchers (55%), and/ or livestock feed (28%). This is in line with previous studies in the Eastern Cape and Free State provinces where farmers received different forms of assistance during drought (Ngaka, 2012). However, the turnaround time for the relief has been a constraint to agricultural production (Katiyatiya et al., 2022). One-quarter of small-scale commercial farmers and 15% of subsistence farmers reported receiving agricultural training in the previous ten years.

More than 84% of participants, both subsistence and small-scale commercial farmers stated that they require training in agricultural drought management. Lack of agricultural training affects the ability of farmers to formulate drought preparedness increasing their susceptibility to drought (Mniki, 2009). Training and education of farmers is paramount and positively contributes towards drought preparedness and reduces impacts of drought (Belle et al., 2017). Regardless of farmers' typology and agroecological zone, most farmers (75%) indicated workshops or seminars as their preferred method of training. The observed variations in training could be attributed to possible skills shortage among extension officers and drought management personnel emanating from weak research institutions linkages and lack of regular training, which is key in knowledge and skills development among farmers (Raidimi et al., 2019).

Table 4.5: Percentage of farmers with access to drought information, aid, and training in the surveyed areas

Variable	Type of farmer		Overall (n = 192)
	Subsistence (n = 120)	Small-scale commercial (n = 72)	
Access to drought information			
Yes	39.17	41.67	40.10
No	60.83	58.33	59.90
Sources of drought information			
Government extension services	0.83	-	0.52
Farmers' organizations	4.17	4.17	4.17
Community leaders	5.00	13.89	8.33
Indigenous Knowledge	19.17	19.44	19.27
Print/ Visual media	23.33	29.17	25.52
Possess indigenous knowledge			
Yes	74.17	33.80	59.03
No	25.83	66.20	40.97
Access to farmers' networks			
Yes	75.83	87.50	80.21
No	24.17	12.50	19.79
Received drought relief/aid			
Yes	46.67	40.28	44.27
No	53.33	59.72	55.73
Source of relief/aid			
Government extension services	53.33	0.11	33.37
Farmers' organizations	1.67	59.72	0.23
Community leaders	0.83	4.17	0.21
Neighbours/Family	44.17	35.00	66.19
Kind of assistance			
Advisory	55.83	69.01	59.65
Farming tools	4.17	-	0.03
Medication and vaccines	1.67	-	0.01
Funds	1.66	16.90	0.07
Feed	36.67	14.08	40.24
Received agriculture drought-related training in the past 10 years			
Yes	15.00	25.00	18.75
No	85.00	75.00	81.75
Need drought management training			
Yes	90.83	84.72	88.54
No	9.17	15.28	11.46
Best way to be trained			
Workshops/Seminars	75.83	79.17	77.08
Print /Visual media	24.17	20.48	22.92

Table 4.6 depicts the agricultural drought management skills required by farmers. Drought monitoring and early warning systems (86%) were identified as the most critical drought management skills required by farmers irrespective of their type and ecological zone. This is mostly because these approaches could be prohibitively expensive for most farmers to acquire. A study of local early warning systems for drought in Limpopo by Andersson et al. (2020) found that farmers had weak early warning systems and were unaware of South African Weather Service (SAWS) forecasts but relied on indigenous forecast indicators to direct their farming activities. Drought monitoring techniques such as remote sensing are not only expensive for most farmers (Khapayi & Celliers, 2016) but difficult to understand (e.g., the web-based tool, FruitLook) even by an average farmer (Bonthuys, 2017; Mensah et al., 2018). Water management skills were ranked second in importance irrespective of farmer type and agroecological zone ($P \leq 0.05$). This could be attributed to water being an essential natural resource in agriculture. Water management skills contributes towards building resilience against drought impacts and the economic growth and development (Nhemachena et al., 2020). They assist farmers in making autonomous changes such as changes in the timing of planting dates, changes in crop varieties, and crop mixes in response to changing rainfall patterns and seasonal changes in growing conditions (Nhemachena et al., 2020). Farmers ranked crop production, livestock management, and soil management lower because there are skills that most indigenous knowledge focuses on and their solutions are readily available, affordable, and simple to apply to a farmer's local environment (Lottering et al., 2021).

Table 4.6: Drought management skills required by farmers in South Africa

	Rank (mean rank) [a]					
Drought management skill	Subsistence	Small-scale commercial	Sig	Arid	Semiarid	Sig
Drought monitoring and early warning systems	1 (5.35)	1 (5.32)	*	1 (4.80)	1 (5.74)	*
Vulnerability and risk assessment	3 (12.71)	5 (9.09)	*	6 (10.76)	5 (11.26)	*
Crop production	5 (13.71)	7 (11.37)	*	5 (10.24)	6 (14.18)	*
Water management	2 (9.34)	2 (8.18)	*	2 (8.36)	2 (9.32)	*
Soil management	8 (22.25)	8 (13.15)	*	8 (15.47)	8 (16.65)	*
Rangeland management	4 (13.00)	3 (8.186)	*	4 (10.08)	4 (10.55)	*
Livestock management	7 (14.45)	6 (9.15)	*	3 (9.15)	7 (14.91)	*
Business management	6 (14.09)	4 (8.56)	*	7 (11.16)	3 (9.68)	*

[a] The lower the rank, the greater the importance of the skill, *Significance at $P \leq 0.05$

4.1.6 Key professionals' demographic and socioeconomic characteristics

Table 4.7 shows the demographic profiles of the key professionals in the agricultural sector. Nearly half of the key professionals (agricultural extension and disaster management officers) were females. The equal representation of sex in the total number of key professionals was not expected. This is in contrast to previous researchers (Carelsen, 2020; Zikhali et al., 2020) who reported that there were more male extension officers in most South African provinces. For the past decade the DALRRD agencies such as Agriculture Sector Education Training (AgriSETA) and private organisations have been on the drive to promote the girl child through agricultural-related educational bursaries, which has seen an increase of females in the sector (Afful, 2016). The DALRRD has also been on a major drive to increase the number of agricultural extension workers from 2 492 to 10 000 more agricultural extension workers by 2024 (Ntombela, 2020). These initiatives will further contribute towards addressing gender disparities in state agricultural extension services which may reduce hunger and food insecurity, particularly among poor rural subsistence farmers (Antwi-Agyei & Stringer, 2021).

Majority of agricultural extension and disaster management officers (80%) were between the ages of 30 and 60 years. Almost 12% of agricultural extension officers were PhD holders, 24% had a master's degree, and 35% either had an honours or bachelor's degree. In contrast, Oladele (2015), reported that 3% of agricultural extension officers in North West province had certificates, 41% had diplomas, 15% had degrees, 20% had Bachelors of Technology, 10% had Master in Agrarian Studies, Master of Tech, and Doctoral in Technology. More than half of disaster management officers had a master's degrees, with the remainder holding honours degrees or lower. Approximately 75% of agricultural extension officers and 70% of disaster management officers had more than 5 years of work experience. Over 80% of agricultural extension officers worked directly with subsistence farmers, which could be attributed to issue of resource-limitation by subsistence farmers, hence rely on government extension services for information and farming necessities (Carelsen, 2020). According to Raidimi & Kabiti (2019), government agricultural extension services are the primary support system available to smallholder farmers, ensuring rural economies agricultural production and food and nutrition security through regular dissemination of new information and technology. This is done in collaboration with stakeholders such as disaster management officers who advise and coordinate resources for relevant research and training programs (Andersson et al., 2020).

Table 4.7: Key professionals' (%) demographic and socioeconomic characteristics in four selected provinces of South Africa

Variable	Key professionals		Overall (n=55)
	Extension officers (n = 42)	Disaster management officers (n = 13)	
Sex			
Male	48.00	46.15	49.09
Female	52.00	53.85	50.91
Age (years)			
21-30	14.28	7.69	12.73
31-40	42.86	30.77	40.00
41-50	33.33	23.08	30.91
51-60	9.52	38.46	16.36
Level of education			
PhD degree	11.90	-	9.09
Master's degree	23.81	53.85	30.91
Honours degree	26.19	7.69	21.82
Bachelor's degree	16.67	15.38	16.36
Diploma	19.05	23.08	20.00
Certificate	2.38	-	1.82
Experience			
< 1 year	4.76	7.69	5.45
2-5 years	21.43	23.08	21.82
5-10 years	30.95	53.85	36.36
10-20 years	38.10	15.38	32.73
< 20 years	4.76	-	3.64

4.1.7 Key professionals' perceptions on impact of drought

As anticipated, all the agricultural extension and disaster management respondents were familiar with the term "drought". Carelsen (2020), argues that most drought management officers have knowledge of drought, however, the main issue is their lack of competencies on the subject and poor organisation from their respective institutions. Agricultural extension workers advised small-scale commercial (38% of respondents), and subsistence farmers (62%), while 85% of disaster management officers advised the local DALRRD and municipalities on policy matters.

Agricultural extension officers work with mixed farmers (68% of respondents), livestock farmers (14%) and 5% advice field crop and horticulture farmers. Almost 80% of agricultural extension officers disseminate information on farm management (71%), health (livestock and crop disease and pests; 62%), marketing (60%) and drought management (50%) to farmers. Farmers are provided with drought

management information during information days (40%), and face-to-face communication (20%), either every week (26%), every month (19%), or every three months (28%). About 15% of agricultural extension officers also distribute inputs including seeds, fertilizer, pesticides, and feedstock to farmers. Almost half of disaster management officers were involved in drought planning, while 62% were involved in developing and organising drought management plans at the local municipal level.

Table 4.8 shows the effects and challenges of drought on key agricultural professionals' performance. Work overload during the drought affected 46% of agricultural extension officers and 67% disaster management officers. Belay and Abebaw (2004) reported that the effectiveness of agricultural extension officers was linked to qualification, motivation, commitment, and responsiveness to the ever-changing social, economic, and political environment. It has, however, been observed that South Africa's agricultural extension services overburdens officers with top-down policy objectives that are often beyond their capabilities and available resources, which results in low morale among agricultural extension officers (Jordan & Koinis, 2014). South Africa's agricultural extension officers advise over 2.3 million rural households and 3200 commercial farmers, with a large governmental extension to farmer ratio of 1:850 and a non-governmental sector extension to farmer ratio of 1:1034 impeding efficient farmers advisory services (Koch & Terblanche, 2013). With regards to disaster management, one or two district disaster management officers advise a local municipality and the DALRRD under the respective district, which overburdens them.

Over two-fifths of agricultural extension officers had larger areas to cover and were having difficulties in advising farmers during drought. Lack of resources (62% of the respondents), farmer illiteracy (54%), and farmers' reluctance to adopt new technologies (54%) were among the challenges reported by of agricultural extension officers. Lack of finance and related activities, inadequate infrastructure, and a lack of a comprehensive drought management policy were among the major difficulties experienced by disaster management officers (62%). Disaster management officers plan, organize, coordinate, and implement measures to mitigate agricultural drought at the national, district municipality, and local municipality levels. They are also responsible for other natural disasters such as floods, earthquakes, and cyclones, the magnitude of which often constrains available resources (Baudoin et al., 2017). Some areas that require the services of these personnel have poor accessibility, such as roads and mobile phone network in the Eastern Cape, this is often exacerbated by the province's large government

agricultural extension to farmer ratio of 1:1500 (Molieleng et al., 2021). Remote locations with poor road conditions result in high transportation costs and impede movement efficiency (Lottering et al., 2021). The resources available to cover all of these natural disasters are insufficient to reach all those in need of agricultural and drought information (Jordan & Koinis, 2014). Disaster management is considered a scarce skill in South Africa (AgriSETA, 2020; Katiyatiya et al., 2022). A fifth of the agricultural extension and disaster management officers proposed increased government funding for programs, stakeholder collaboration and coordination as potential solutions to drought challenges. This is likely to contribute towards the development of agricultural extension officers, which will have multiplier effects in the areas they service (Afful, 2016).

Table 4.8: Effects of drought and challenges faced by key professionals during droughts (%) in four selected provinces.

Variable	Extension officers (n = 42)
Effects	
Work overload (increase in work)	45.95
Increased area to cover	43.24
Difficulty in advising farmers	43.24
Distress and anxiety	40.54
Low morale	29.73
Poor welfare	13.51
Challenges	
Lack of resources	62.17
Illiteracy among the farmers	54.05
Farmers' resistance to adopt improved technologies	54.05
Lack of appropriate technology	40.54
Lack of farmers' cooperation regarding training/field	40.54
Lack of support staff	27.03
Communication problems	27.03
Shortage of transport to farms	24.32
Erosion of the functional system of agricultural	21.62
Lack of training opportunities	21.62
Variable	Disaster management officers (n = 13)
Effects	
Work overload (increase in work)	66.67
Increased area to cover	33.33
Difficulty in advising the relevant departments	33.33
Low morale	33.33
Poor welfare	33.33
Challenges	
Lack of finance and related activities	61.54
Limited infrastructure	61.54
Lack of comprehensive drought management policy	61.54
Inadequate research	46.15
Environmental sustainability issues	15.38
Reliance in retaliatory response approach	7.69
Climate changes issues	7.69

4.1.8 Key agricultural professionals' professional and support skills

Table 4.9 shows the proportion of key agricultural professionals who had professional and administrative skills. Most agricultural extension officers (71%) had crop production skills while 77% of disaster management officers had disaster management skills. All disaster management officers had computer and information technology skills, 84% had personal and public relations skills and 76% had community mobilisation, planning and development skills. Over 71% of agricultural extension officers were proficient in human emotional intelligence, personal and public relations, and leadership which is supported by Terblanché's (2008)'s earlier findings. These are the skills required of extension officers to maintain positive relationships with farmers. Oladele (2015) identified personal management, communication skills, interpersonal skills, and education skills as necessary competencies for extension and disaster management officers. The specific development of agricultural extension officers' leadership and organisational skills aids in the effective development and motivation of farmers and stakeholders (Ngaka, 2012).

Table 4.9: Proportion (%) of key professionals with professional and administrative skills in four selected provinces

Variable	Key professionals		Overall (n=55)
	Extension officers (n = 42)	Disaster management officers (n = 13)	
Professional skills			
Crop production	71.45	7.69	56.38
Soil management	47.38	7.69	38.00
Livestock production and health	40.48	7.69	32.65
Agricultural economics	38.09	3.30	29.87
Agricultural engineering	31.91	-	24.36
Aquaculture	28.57	-	21.82
Sustainable agriculture	33.33	-	25.45
Meteorology	21.43	-	16.36
Disaster management	57.14	76.92	61.82
Support skills			
Human and emotional intelligence	71.43	53.85	67.27
Personal and public relation	71.43	84.62	74.55
Leadership	71.43	61.54	69.09
Community mobilisation	73.81	76.92	74.55
Planning and development	66.67	76.92	69.09
Rural development	54.76	23.08	47.27
Marketing	52.38	15.38	43.64
Computer and information technology	38.10	100	29.09

4.1.9 Key professionals' drought management knowledge and skills

Table 4.10 presents the drought management skills' competency of key professionals. Approximately 57% of agricultural extension officers and 76% of disaster management officers interviewed reported that they had experienced challenges in managing drought-related disasters. More than half of disaster management officers had education and awareness, early warning systems, monitoring and evaluation, and preparedness planning as their main skills in managing drought disasters. Agricultural extension officers reported preparedness planning (50%), and adaptation and mitigation (48%) as their main drought management skills. In contrast, Afful (2016) reported that South African agricultural extension officers lack technical competencies in climate variability issues to support smallholder farmers' crop production. However, Zikhali et al. (2020) stated that agricultural extension officers in Limpopo were competent in climate-change mitigation strategies but were hampered by lack of resources to develop farmers in the province. Additionally, Tadesse (2018) concluded that disaster management personnel require competencies in technology transfer, information exchange, networking, management, and professional linkages for proper disaster risk management.

Table 4.10: Key professionals' drought management skills (%) in four selected provinces

Drought management skills	Key professionals		Overall (n= 55)
	Extension officers (n = 42)	Disaster management officers (n = 13)	
Preparedness planning	50.00	53.85	50.91
GIS and remote sensing	28.57	7.69	23.64
Early warning systems	38.10	53.85	41.82
Data interpretation and analysis	30.95	23.08	29.09
Monitoring and evaluation	40.48	53.85	43.64
Forecasting	38.10	15.38	32.73
Education and awareness	38.10	61.54	43.64
Vulnerability and impact assessment	35.71	53.85	40.00
Recovery and Rehabilitation	30.95	46.15	34.55
Adaptation and mitigation	47.62	30.77	43.64

Table 4.11 shows that training in drought disaster management skills was required by 92% of disaster management officers and 88% of agricultural extension officers. Workshops and seminars were the preferred training method by agricultural extension and disaster officers (>50%). Only 15% of disaster management officers and 24% of agricultural extension officers preferred part-time drought disaster management training. For extension officers, preparedness planning (52%), interpreting and analysing information (52%), adaptation and mitigation (50%), recovery and rehabilitation (50%), and GIS and remote sensing (50%) were ranked as the most important drought disaster management training needs. Disaster policy formulation (54%) and GIS and remote sensing (46%) skills were the most important skills training needs for drought disaster management officers.

Table 4.11: Proportion (%) of key professionals who require specific drought management training in four selected provinces

Drought management skills' needs	Key professionals		Overall (n = 55)
	Extension officers (n = 42)	Disaster management officers (n = 13)	
Preparedness planning	52.38	30.77	47.27
Forecasting	42.86	38.46	41.82
Monitoring and evaluation	40.48	38.46	40.00
Policy making	16.67	53.85	25.45
Education and awareness	42.86	30.77	40.00
Information interpretation and analysis	52.38	38.46	49.09
Vulnerability and impact assessment	42.86	38.46	41.82
Adaptation and mitigation	50.00	38.46	47.27
Recovery and rehabilitation	50.00	23.08	43.64
GIS and remote sensing	50.00	46.15	49.09

4.2 Key findings

It was discovered that drought management in South Africa is based on ex-post impact management and has been severely hampered by lack of skilled human capital (agricultural extension and disaster management officers). The agricultural sector is currently hampered by lack of higher education institutions specialising in agricultural drought management, and low enrolment and graduation rates, as well as an

aging skilled labour force. Drought impacted both small-scale commercial and subsistence farmers, resulting in decreased household food security, increased poverty, and income loss. A few of both types of farmers were found to be proficient in drought coping skills such as the use of appropriate stocking rates, rotational grazing, rangeland condition assessment, supplementary feeding, and livestock selling, but the majority of them were limited in drought preparedness and mitigation skills. The main drought management skills that were limited in both types of farmers were mitigation monitoring and early warning systems, as well as water management skills. To improve the farmers' ability to cope with drought, factors such as the farmers' sex, age, education level, primary source of income, and access to agriculture extension services must be taken into consideration. Key informants were found to be limited in GIS and remote sensing, early warning systems and forecasting, and recovery and rehabilitation. Notably, agricultural extension officers were limited in GIS and remote sensing, data interpretation and analysis, recovery and rehabilitation, adaptation and mitigation, and recovery and rehabilitation. Disaster management officers were limited in GIS and remote sensing, forecasting, data interpretation and analysis, and adaptation and mitigation.

4.3 Recommendations

The main recommendations made following findings of the current study were:

- Ongoing drought management skills training is required for farmers and key agricultural professionals, notably agricultural extension workers who have frequent interaction with farmers.
- The South African government and non-governmental organisations must enhance the extension farmer ratio to improve farmers' access to extension staff. This improves farmers access to timely drought assistance, information, and adaption strategies and technology.
- Incorporation and designing of agricultural drought management short courses for key professionals and other relevant key stakeholders, this facilitated by organisations such as AgriSETA who are mandated for agricultural training and education in South Africa. This helps to produce professionals who are environmentally sensitive and skilled.
- Development and/ or implementation of agricultural drought management policies that enable all stakeholders to be proactive and participate in the drought management process, hence eliminating the crisis risk management, top to bottom approach, riddled with bureaucracy and bottlenecks.

4.4 Conclusions

All farmers, irrespective of typology and agroecological zone had limited skills in businesses, soil, crops, water, and rangelands management. Most farmers had no access to drought information and required drought management training. The major drought management skills required by farmers regardless of typology and agroecological zone were drought monitoring and early warning systems, and water management. Extension officers require training on preparedness planning, interpreting, and analysing information, adaptation and mitigation, recovery and rehabilitation, and using GIS and remote sensing whereas disaster management officers require training on disaster policy formulation, GIS and remote sensing. These drought management skills could aid the resilience of the agriculturalists sector and impact on drought management policy formulation in South Africa.

4.5 Further research

Based on the current study's findings, future research into the development of a framework that will serve as a tool for assessing farmers' drought sensitivity and how farmers deal with the effects of drought would be important. This could aid farmers and agricultural professionals by serving as a guideline in agricultural drought management. More research to identify the major stakeholders in the agriculture sector in terms of drought management is important. The identification of these important stakeholders will be critical in bringing a discussion on the topic of agricultural drought management and identifying and resolving difficulties that impede stakeholder collaboration. Finally, research to chronicle indigenous knowledge of drought preparedness and mitigation is indispensable. There is concern that some of this vital information is being lost, particularly in the black African community, where the bulk of the younger generation is avoiding agriculture due to problems such as drought.

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Appendix 1: Farmers' Questionnaire

A SURVEY ON THE IMPACT OF DROUGHT AND SKILLS IMPLICATIONS IN THE SOUTH AFRICAN AGRICULTURAL SECTOR

Note: The objective of this study is to determine the skills gap and training needs of farmers in the agricultural sector with respect to drought management in South Africa. Any information you provide will be strictly confidential and only used for this research. Information provided in this survey will not be directly attributed to you and will only be used for descriptive and analytical purposes.

Consent is given. YES ☐ NO ☐
If the answer to this question is "NO", do not proceed with the interview.

Farmer's Name (Optional): _____

Farmer's Consent signature: _____

Farmer's Contact details: _____

Province: _____

Enumerator Name: _____

District: _____

Date: _____

Municipality: _____

GPS coordinates (Optional): _____

Questionnaire Number: _____

SECTION A: FARMER'S DEMOGRAPHIC AND FARM PROFILE

1. **What is your sex?**
   1= Male ☐ 2= Female ☐ 3= Prefer not to say ☐

2. **What is your age group?**
   1= < 20 years ☐ 2= 21-30 years ☐ 3= 31-40 years ☐ 4= 41-50 years ☐
   5= 51-60 years ☐ 6= > 60 years ☐

3. **What is your highest level of education?**
   1= No formal education ☐ 2= Primary ☐ 3= Secondary ☐ 4= Tertiary ☐

4. **What type of a farmer are you?**
   1= Largescale commercial ☐ 2= Commercially oriented Smallholder ☐
   3= Subsistence smallholder ☐

5. **What type of land ownership do you hold?**
   1= Private/Own ☐ 2= Communal/ Tribal ☐ 3= Leased ☐
   4= Government ☐ 5= Other (Specify) _____

6. **How long have you practised farming in this area?**
   1= < 1 years ☐ 2= 2-5 years ☐ 3= 5-10 years ☐ 4= 10-20 years ☐ > 20 years ☐

7. **What is the size of your farm?**
   1= < 10ha ☐ 2= 10-50ha ☐ 3= 50-100ha ☐ 4= 100-500ha ☐ 5= > 500ha ☐

8. **Do you practise farming Full-time/Part-time?**
   1= Full-time ☐ 2= Part-time ☐

9. **What kind of workforce do you have?**
   1= Permanent labour ☐ 2= Seasonal labour ☐ 3= Family labour ☐ 4= None ☐

10. **Do you have paid labour?** 1= YES ☐ 2= NO ☐

11. **If YES, how many employees do you have?** _____

12. **What type of employees do you have?**

Type	Number
1. Unskilled	
2. Semi-skilled	
3. Skilled	
4. Highly skilled	

13. **Do you have any formal training in any agricultural production system?**
    1= YES ☐ 2= NO ☐

14. **If YES, specify** _____

15. **What are your sources of income?**

Source of income	**Rank**
1. Field crop sales	
2. Horticultural sales	
3. Livestock sales	
4. Salary	
5. Pensions	
6. Social grants	
Others(specify): _____	

SECTION B: CHARACTERISATION OF THE FARM

16. **What is your farm's main agricultural activities?**
    1=Livestock ☐ 2= Field crops ☐ 3= Horticulture ☐ 4= Livestock & Field crops ☐ 5= Livestock & Horticulture ☐ 6= Field crops & Horticultural ☐ 7= All of the above ☐

17. **What kind of horticultural/field crops do you produce on your farm?**

Type of horticultural/field crop	**Rank**	**Hectares**
1.		
2.		
3.		
4.		

18. **What are your reasons for growing these horticultural/field crops?**

_____
_____
_____
_____

19. **What is the source of water for your crops (if any)?**
1= Dam irrigation ☐ 2= Borehole 3=Irrigation ☐ 4= Rainfed ☐
5= Other (Specify) _____

20. **Of the total of land, how much land is under,** Irrigation _____**Ha** and Rainfed _____**Ha**?

21. **Q59**

Livestock Specie **1. Being the most important**	**Total Number**	**Breeds**	**Rank the species**
1. Cattle		a.	
		b.	
		c.	
		d.	
2. Sheep		a.	
		b.	
		c.	
		d.	
3. Goats		a.	
		b.	
		c.	
		d.	
4. Pigs		a.	
		b.	
		c.	
		d.	
5. Chickens		a.	
		b.	
		c.	
		d.	
Other (specify), _____		a.	
		b.	
		c.	
		d.	

22. **What are your reasons for keeping the above-mentioned livestock?**

Use	**Rank**	**Use**	**Rank**
1. Meat		6. Sales	
2. Milk		7. Dowry	
3. Draught power		8. Ceremonies	
4. Fibre (wool/mohair)		Other (specify)	
5. Status			

23. **What type of water sources do you use for your livestock?**
1= Borehole ☐ 2= River ☐ 3= Dam ☐
4= Other (Specify) _____

24. **Do you keep any farming records?**
1= YES ☐ 2= NO ☐
25. **If YES, what kind of records do you keep?**

1= Yield and production record ☐ 2= Farm Diary Record ☐ 3= Annual valuation record ☐ 4= Profit and loss record ☐ 5= Other (Specify) _____

26. **What has been your farm's average Livestock/ Horticulture/ Field crops yield per year for the past five years?**

Horticulture production

_____
_____
_____

Field crop production

_____
_____
_____

Livestock production

_____
_____
_____

27. **Does your crop and/or livestock yield vary annually?** 1= YES ☐ 2= NO ☐

28. **If YES, what might be the reasons for the production variations (if any)?**

_____
_____
_____
_____

SECTION C: DROUGHT IMPACT ON THE FARM

29. **Are you familiar with the term "drought"?**
1= YES ☐ 2= NO ☐

30. **If YES, what is your understanding of drought?**

_____
_____
_____

31. **What do you think causes drought?**
1= Lack of rainfall ☐ 2= High temperatures ☐ 3= Human activities and erosion ☐
4= Climate change ☐ 5= Other (Specify) _____

32. **Have you experienced any severe drought(s) at your farm?**
1= YES ☐ 2= NO ☐

33. **If YES, specify the year(s) you experienced drought in the past 10 years**

_____
_____

34. **How serious was(were) the drought(s)?**
1= Very severe ☐ 2= Severe ☐ 3= Moderately severe ☐ 4= Not severe ☐

35. **Did you face any challenges during drought years on your farm?**
1= YES ☐ 2= NO ☐

36. **If YES, what are the challenges?**

_____
_____
_____
_____

37. **What impact did the drought have on your farm and how severe was the impact?**

Social impacts	**Tick**	**Indicate the extent of the effect**				
		Very high	High	Moderate	Low	Neutral
Reduced household food security						
Caused loss of employment						
Increased poverty						
Caused human migration						
Increased stress and education						
Increased tensions and conflicts over communal natural resources						
Other(s) (Specify) _____						

Economic impacts	**Tick**	**Indicate the extent of the effect**				
		Very high	High	Moderate	Low	Neutral
Decreased farm income						
Reduced farm investments						
Caused crop failure						
Increased livestock mortalities						
Increased pests and diseases						
Increased farm production losses						
Increased debts and risk						
Other(s) (Specify) _____						

Environmental impacts	**Tick**	**Indicate the extent of the effect**				
		Very high	High	Moderate	Low	Neutral
Reduced water quantity and quality						
Caused deterioration of soil productivity						
Increased average environmental temperatures						
Caused deterioration of grazing pastures						
Caused loss of vegetation						
Increased plant invasions						
Other(s) (Specify) _____						

SECTION D: FARMER'S DROUGHT ADAPTATION SKILLS AND KNOWLEDGE

38. **Did you foresee any signs/ indicators of drought before it started?**

1= YES ☐ 2= NO ☐

39. **If YES, what methods did you use to foretell that drought was coming?**

_____
_____
_____

40. **Were you prepared to cope with drought?**

1= Yes ☐ 2= No ☐ 3= Cannot remember ☐

41. **If YES, what steps did you take in preparation for the drought?**

_____
_____
_____
_____

42. **How did these steps help you to minimize the impact of drought?**

_____
_____
_____
_____

43. **What drought management skills do you use at your farm and to what extent have they been effective? indicate by a tick.**

Crop management	**Tick**	**Indicate the extent of the effectiveness**				
		Very high	H	Moderate	Low	Neutral
Planting of drought-resistant varieties of crops						
Introduction of cultivars with shorter growing seasons						
Changing planting and harvesting times						
Crop rotation						
Crop diversification						
Introduction of legume cover crops						
Reduced area planted						
Other (Specify) _____						

Water management	**Tick**	**Indicate the extent of the effectiveness**				
		Very high	High	Moderate	Low	Neutral
Irrigation technologies and water scheduling e.g. drip irrigation						
Water conservation techniques						
Rainwater harvesting						
Drilling boreholes						
Protection of open water sources						
Recycling of wastewater						
Construction of storage tanks						
Building dams for water storage						
Other (Specify) _____						

Soil management	**Tick**	**Indicate the extent of the effect**				
		Very high	High	Moderate	Low	Neutral

Zero/ minimum tillage						
Mulching						
Composting						
Increased soil cover crop						
Intercropping						
Construction of contours and terraces						
Leaving fields fallow						
Integrated pest management						
Construction spreader channels to prevent soil erosion						
Other (Specify) _____						

Rangeland management	**Tick**	**Indicate the extent of the effect**				
		Very high	High	Moderate	Low	Neutral
Use of appropriate stocking rates						
Creation of paddocks						
Rotational grazing						
Night grazing						
Rangeland assessment						
Removal of invasive plant species						
Irrigation of pastures and rangelands						
Reseeding pastures and rangelands with improved grasses						
Other (Specify) _____						

Livestock management	**Tick**	**Indicate the extent of the effect**				
		Very high	High	Moderate	Low	Neutral
Use of adapted breeds						
Use of improved reproduction methods						
Use of livestock genetic improvement techniques						
Supplementary feeding						
Use of fodder banks						
Selling of livestock						
Culling less reproductive animals						
Relocation of livestock to areas with better pastures						
Water restriction and deprivation techniques						
Use of water stress alleviators in livestock drinking water						
Vaccination against diseases and parasites						
Other (Specify) _____						

Business management	**Tick**	**Indicate the extent of the effect**				
		Very	High	Moderate	Low	Neutral
Water accounting and auditing						
Creation of an alternative low input system						

Saved money for emergencies						
Risk assessment and management						
Diversifying the farm						
Insurance						
Credit and borrowing from financial institutions						
Other (Specify) _____						

44. **What drought management skills were most effective on your farm?**

Drought management skills
1.
2.
3.
4.
5.
6.

45. **Are there any drought management skills that were passed to you by the elders in your family or community (indigenous knowledge)?** YES☐ NO ☐

46. **If YES, what are they?**

_____
_____
_____

SECTION E: FARMER'S TRAINING NEEDS ON DROUGHT

47. **Do you get drought management information in your area?**
1= YES ☐ 2= NO ☐

48. **If YES, what are your sources of drought management information?**
1= Government Extension services ☐ 2= NGO ☐ 3= Community leaders ☐
4= Indigenous Knowledge ☐ 5= Radio/ Television/ Print media ☐
6= Other (Specify) _____

49. **Do you get any assistance during the drought periods?**
1= YES ☐ 2= NO ☐

50. **If YES, who assists you?**
1= Government extension services ☐ 2= NGO ☐ 3= Farmer organisation ☐
4= Politicians ☐ 5= Community leaders ☐ 6= Neighbours/ Family ☐
6= Other (Specify) _____

51. **What kind of assistance did you get?**

_____

52. **How helpful is the assistance in alleviating the effects of drought?**
1= Excellent ☐ 2= Very Good ☐ 3= Good ☐ 4= Poor ☐

53. **Do you share drought experiences with other farmers?** 1= YES ☐ 2= NO ☐

54. **If NO, why?**

_____
_____
_____
_____
_____

55. **If YES, how do you share your drought experiences with other farmers?**
1= Farmer group meetings ☐ 2= Field days ☐ 3= Farm-farmer visits ☐
4= Networking e.g. cell phones ☐ 5= Print media ☐
6= Other (Specify) _____

56. **How effective has sharing drought experiences with other farmers solved drought challenges?**
1= Very effective ☐ 2= Effective ☐ 3= Slightly effective 4= No effect ☐

57. **Have you received any drought-related agricultural training in the last ten years?**
1= YES ☐ 2= NO ☐

58. **If yes, from whom did you receive the training?**
1= Government Extension services ☐ 2= NGO ☐ 3= Farmer organisation ☐
5= Politicians ☐ 6= Community leaders ☐ 7= Neighbours/ Family ☐
8= Other (Specify) _____

59. **What kind of drought management training did you receive?**
1= Crop management ☐ 2=Water management ☐ 3= Soil management ☐
4=Rangeland management ☐ 5= Livestock management ☐ 6= Business management ☐

60. **Can you specify the drought management training?**

_____

61. **Were there any follow-ups to check if you were implementing the training knowledge?**
1= YES☐ 2= NO ☐

62. **If YES, how many times did they follow up?**
1= Once ☐ 2= Twice ☐ 3= More than Three times ☐

63. **How effective was the training in solving drought challenges?**
1= Very effective ☐ 2= Effective ☐ 3= Slightly effective 4= No effect ☐

64. **What would you suggest are the best ways to get people in your farming community to learn about drought management?**

_____
_____
_____
_____

65. **What drought challenges and opportunities do you see in the future of your farm?**

_____

_____

_____

66. **Do you have any specific skills you would like to be trained on to cope with droughts in the future?**
1=YES ☐ 2= NO ☐

67. **If YES, what are they?**

Skill	Rank
1.	
2.	
3.	
4.	
5.	

Appendix 2 : Key agricultural professionnels' questionnaire

A SURVEY ON THE IMPACT OF DROUGHT IN THE SOUTH AFRICAN AGRICULTURAL SECTOR AND SKILLS IMPLICATIONS

Note: The objective of this study is to determine the skills gap and training needs of key professionals in the agricultural sector with respect to drought management in South Africa. Any information you provide will be strictly confidential and only used for this research. Information provided in this survey will not be directly attributed to you and will only be used for descriptive and analytical purposes.

Consent is given. YES ☐ NO ☐
If the answer to this question is "NO", do not proceed with the interview.

Name (Optional): _____	**Consent signature (Optional):** _____
Contact details: _____	**Province:** _____
Enumerator Name: _____	**District:** _____
Date: _____	**Municipality:** _____
GPS coordinates (Optional): _____	**Questionnaire No:** _____

SECTION A: DEMOGRAPHIC PROFILE

1. **What is your sex?**
   1= Male ☐ 2= Female ☐ 3= Prefer not to say ☐

2. **What is your population group?**
   1= African ☐ 2= White ☐ 3= Coloured ☐ 4= Indian ☐
   5= Other (Specify) _____

3. **What is your age group?**
   1= < 20 years ☐ 2= 21- 30 years ☐ 3= 31-40 years ☐
   4= 41-50 years ☐ 5= 51-60 years ☐ 6= > 60 years ☐

4. **Who is your employer?**
   1= Government ☐ 2= Non-Governmental Organisation ☐ 3= Private ☐
5. **Can you please specify the above response?**
   _____

6. **What is your employment status?**
   1= Fulltime ☐ 2= Part-time ☐ 3= Volunteer

7. **What is your highest educational level?**

Academic level	Granting institution	Academic level	Granting institution
1. PhD degree		4.Bachelor's degree	
2.Master's		5. Diploma	

3.Honours		6. Certificate	

8. **What is your occupation/job?**
   1= Agricultural Extension ☐ 2= Crop production ☐ 3= Livestock production ☐
   4= Meteorology ☐ 5= Disaster Management ☐ 6= Other (Specify) _____

9. **What is your major occupational/job responsibility/duty?**
   1= Administration ☐ 2= Supervision ☐ 3= Research ☐ 4= Teaching ☐
   5= Extension ☐ 6= Veterinary ☐ 7= Other (specify) _____

10. **Can you please specify the above response?**
    _____

11. **How long have you been in this occupation/job?**
    1= < 1 years ☐ 2= 2-5 years ☐ 3= 5-10 years ☐ 4= 10-20 years ☐ > 20 years ☐

SECTION B: DROUGHT IMPACT ON THE AGRICULTURAL SECTOR

12. **Are you familiar with the term "drought"?**
    1= YES ☐ 2= NO ☐
13. **If YES, what do you think causes drought?**
    1= Lack of rainfall ☐ 2= Poor farming practices ☐ 3= High atmospheric temperatures ☐
    4= Erosion and human activities ☐ 5= Other (Specify) _____
14. **What are the main types of farmers you work with?**
    1= Commercial farmers ☐ 2= Emerging small-scale ☐ 3= Subsistence farmers ☐

15. **What is your role in the agricultural sector?**
    1= Extension ☐ 2= Research ☐ 3= Supply inputs ☐ 4= Policy making ☐
    5= Other (Specify) _____

AGRICULTURAL EXTENSIONISTS QUESTIONS

16. **Which type of farmers do you provide extension services?**
    1= Livestock farmers ☐ 2= Field crops farmers ☐ 3= Horticulture farmers ☐ 4= Fruits farmers ☐ 5= Mixed farmers ☐ 6= Other (Specify) _____

17. **What information do you disseminate to farmers?**

Information	**Tick**	**Information**	**Tick**
1. Nutrition		6. Breeding	
2 Health (diseases and pests)		7. Marketing	
3.Rangeland management		8. Agro meteorology	
4.Farm management		9 Drought management	
5. Agribusiness		10. Other (Specify) _____	

18. **Do you disseminate drought management information to farmers?**
    1= YES ☐ 2= NO ☐

19. **If YES, how do you disseminate drought management information to farmers?**
    1= Information days ☐ 2= Face to face ☐ 3= Farmer to farmer ☐ 4= Radio/Television ☐
    5= Cell phones ☐ 6= Internet/websites ☐ 7= Community leaders ☐
    8= Farmers' organisations ☐ 9= Other (Specify) _____

20. **How frequently do you disseminate the drought information to farmers?**
    1= Weekly ☐ 2= Monthly ☐ 3= Quarterly ☐ 4= Yearly and above

21. **If NO, explain why?**

    _____

    _____

22. **Have you been affected by drought?**
    1= YES ☐ 2= NO ☐

23. **If YES, how have you been affected?**

Effects	Tick	Effects	Tick
1. Work overload		5. Poor welfare	
2. Increased area to cover		6. Distress and anxiety	
3. Difficulty in advising farmers		7. Other (Specify)	
4. Low morale		_____	

24. **What challenges do you face as an agricultural extensionist during the drought?**

Challenges	Tick
1. Lack of resources	
2. Erosion of the functional system of agricultural extension	
3. Lack of training opportunities	
4. Lack of support staff	
5. Illiteracy among the farmers	
6. Farmers' resistance to adopt improved technologies	
7. Communication problems	
8. Shortage of transport to farms	
9. Lack of appropriate technology	
10. Lack of farmers' cooperation regarding training/field days	
11. Other (Specify) _____	

25. **What are the possible solutions to the challenges you mentioned above?**

    _____

    _____

    _____

AGRICULTURAL RESEARCHERS' QUESTIONS

26. **If you do research, what type of research do you do?**

Type of research	Tick	Type of research	Tick
1. Livestock		7. Extension	
2. Field crops		8. Agricultural engineering	
3. Horticulture		9. Sustainable agriculture	
4. Fruits		10. Agro meteorology	
5. Farm management		11. Disaster management	
6.Agricultural economics		12. Other (Specify) _____	

27. **Do you research on drought management?** 1= YES ☐ 2= NO ☐

28. **If YES, what type of drought management research do you conduct?**

Type of research	Tick	Type of research	Tick
1. Preparedness planning		5. Vulnerability and impact assessment	
2. Forecasting		6. Adaptation and mitigation	
3. Monitoring and evaluation		7. Recovery and Rehabilitation	
4. Education and awareness		8. Policy making	
9. GIS and remote sensing		10. Data interpretation and analysis	

29. **Do you disseminate your research findings?** 1= YES ☐ 2= NO ☐

30. **How do you disseminate your research to farmers?**
1= Extension officers ☐ 2= Community leaders ☐ 3= Face to face ☐ 4= Cell phones ☐
5= Publications/ Print media ☐ 6= Radio/Television ☐ 7= Internet/websites ☐
8= Farmers' organisations ☐ 9= Educational institutions ☐
10= Other (Specify) _____

31. **Have you been affected by drought?** 1= YES ☐ 2= NO ☐

32. **If YES, how have you been affected?**

Effects	Tick	Effects	Tick
1. Technical research impediments		5. Reduced funding	
2. Discontinuation of research		6. Low morale	
3. Difficulty in publishing quality work		7. Other (Specify)	
4. Farmers not co-operating			

33. **What challenges do you face as an agricultural researcher during the drought?**

Challenges	Tick
1. Lack of funding and resources	
2. Lack of motivation	
3. Inadequate number of extension officers to implement research findings	
4. Illiteracy among the agricultural sector	
5. Resistance to adopt improved technologies	
6. Lack of support from policy makers	
7. Other (Specify) _____	

34. **What are the possible solutions to the challenges you mentioned above?**
_____
_____
_____

35. **If you supply inputs, specify the type of inputs you supply?**
1= Seeds ☐ 2= Fertilizers ☐ 3= Pesticides ☐ 4= Feedstock ☐ 5= Loans and credit ☐
6= Veterinary chemicals drugs ☐ 7= Farm equipment and machinery ☐
8= Other (Specify) _____

36. **Do your agricultural inputs contribute to drought management?** 1= YES ☐ 2= NO ☐

37. **If YES, explain how do your agricultural inputs contribute towards drought management?**

_____

_____

_____

38. **How do you disseminate the information about your inputs to farmers?**

1= Extension officers ☐ 2= Community leaders ☐ 3= Face to face ☐ 4= Cell phones ☐

5= Print media ☐ 6= Radio/Television ☐ 7= Internet/websites ☐ 8= Farmers' organisations ☐

9= Other (Specify) _____

39. **Have you been affected by drought?** 1= YES ☐ 2= NO ☐

40. **If YES, how have you been affected?**

Effects	**Tick**	**Effects**	**Tick**
1. Decreased sales		5. Increased water supply shortage	
2. Decreased revenue and income		6. Debt increase	
3. Reduced and shortage of stock		7. Other (Specify) _____	
4. Distress and anxiety			

41. **Did you receive any assistance during the drought?**

1= YES ☐ 2= NO ☐

42. **If YES, who assisted you?**

1= Government ☐ 2= Financial institutions ☐ 3= Non-governmental organisations ☐

4= Community leaders ☐ 5= Individuals ☐ 6= Other (Specify) _____

43. **What type of assistance did you receive?**

_____

44. **What challenges do you face as an agricultural input supplier during the drought?**

Challenges	**Tick**
1. Lack of funding and resources	
2. Limited infrastructure to reach farmers	
3. Low demand of inputs	
4. Lack of latest market information and technologies	
5. Limited business knowledge	
6. Lack of government support	
7. Inconsistent policies	
8. Other (Specify) _____	

45. **What are the possible solutions to the challenges you mentioned above?**

_____

_____

_____

POLICY MAKERS AND ADVISORS' QUESTIONS

46. **What type of agricultural policies do you make?**

_____

_____

47. **Do you contribute to drought management policy?** 1= YES ☐ 2= NO ☐

48. **If YES, explain how do you contribute to drought management policy.**

_____

_____

49. **What policies are currently in place to ensure effective drought management?**

_____

_____

50. **What challenges do you face as an agricultural policymaker during the drought?**

Challenges	**Tick**
5. Lack of finance and related activities	
2. Limited infrastructure especially in the small-scale farmers	
3. Reliance in rain fed agriculture	
4. Inadequate research	
5. Climate changes issues	
6. Lack of comprehensive land policy especially on land redistribution	
7. Environmental sustainability issues	
8. Other (Specify) _____	

51. **What are the possible solutions to the challenges you mentioned above?**

_____

_____

_____

SECTION C: PROFESSIONAL AND SUPPORT SKILLS

52. **What agricultural professional skills do you have and how competent are you in the skills? Indicate by a tick.**

Professional skills	**Tick**	**Indicate your level of knowledge on the skill**				
		Very high	High	Moderate	Low	Neutral
Crop production						
Soil management						
Livestock production and health						
Agricultural economics						
Agricultural engineering						
Aquaculture						
Sustainable agriculture						
Meteorology						
Disaster management						
Other (Specify) _____						

53. **What support skills are you competent at? How knowledgeable (competent) are you in the skills indicate by a tick.**

Supportive Skills	**Tick**	**Indicate your level of knowledge on the skill**				
		Very high	High	Moderate	Low	Neutral
Human and emotional intelligence						
Personal and public relation						
Leadership						
Community mobilisation						
Planning and development						
Rural development						
Marketing						
Information and computer technology						
Other (Specify) _____						

SECTION D: DROUGHT MANAGEMENT SKILLS AND KNOWLEDGE

54. **Do you possess drought management skills?** 1= YES ☐ 2= NO ☐

55. **If YES, what drought management skills do you possess? How competent are you in the skills? Indicate by a tick.**

Drought	**Tick**	**Indicate your level of knowledge on the skill**				
		Very high	High	Moderate	Low	Neutral
Preparedness planning						
GIS and remote sensing						
Early warning systems						
Data interpretation and analysis						
Monitoring and evaluation						
Forecasting						
Education and awareness						
Vulnerability and impact assessment						
Recovery and Rehabilitation						
Adaptation and mitigation						
Other (Specify) _____						

56. **Where did you obtain the above-mentioned drought management skills?**

Level of institution	**Tick**	**Granting institution**
1. University		
2. College		
3. Private institute		
4. In-service		
5. Other (Specify) _____		

57. **If you do not possess drought management skills, do you want training on drought management?**

1= YES ☐ 2= NO ☐

58. **If YES, which areas of drought management do you want to be trained in?**

Area	**Tick**	**Area**	**Tick**
1. Preparedness planning		7. Vulnerability and impact assessment	
2. Forecasting		8. Adaptation and mitigation	
3. Monitoring and evaluation		9. Recovery and Rehabilitation	
4. Policy making		10. GIS and remote sensing	
5. Education and awareness		11. Other (Specify)	
6.Information interpretation and analysis		_____	

59. **How do you want to be trained?**

1= Workshops ☐ 2= Seminars ☐ 3= Conferences ☐ 4= Mentorships ☐ 5= Part time study ☐
6= Full time study ☐ 7= Other (Specify) _____