COPING AND ADAPTATION STRATEGIES FOR AGRICULTURAL WATER USE DURING DROUGHT PERIODS

Report to the

WATER RESEARCH COMMISSION

by

Bongani Ncube

Cape Peninsula University of Technology

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Obtainable from:
Water Research Commission
Private Bag X03
GEZINA, 0031

Orders@wrc.org.za or download from www.wrc.org.za

The report emanates from a project entitled *Coping and adaptation strat*egies for agricultural *water use during drought period*s (WRC Project K5/2602)

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EXECUTIVE SUMMARY

Background

The Water Research Commission Project K5/2602 entitled "Coping and adaptation strategies for agricultural water use during drought periods" was commissioned by the Water Research Commission (WRC) in 2016. The main objective was to conduct a desktop review in the nine provinces of South Africa, with a view of identifying the current knowledge on drought and occurrence, the ways in which the government is managing the drought both at national and provincial level, including Early Warning Systems, Climate Advisory Services, and Indigenous Knowledge Systems. The research was also aimed at reviewing drought coping and adaptation strategies in dryland cropping systems, irrigation, livestock and mixed systems. It was aimed at identifying potential strategies that can be adopted by South Africa, including strategies from Sub-Saharan Africa and other regions. Additionally, the review was to identify policy and research gaps, and make recommendations of what should be done in South Africa under current drought conditions, and future droughts, including the suggestion of a national drought response strategy for agricultural water use in South Africa.

Rationale

South Africa recently experienced one of the worst droughts in history, with provinces such as the Western Cape still threatened with serious water shortages. The situation threw the country into pandemonium as the water scarcity debate took centre stage with every sector looking for ways of conserving water. Agriculture is one of the industries that was hardest hit by the drought. Agriculture uses more than 60% of fresh water, and most of this water is used in irrigation (NWRS, 2004). Therefore, the drought had the most devastating impacts on the agriculture industry because of the effects on the food production chain. It is important to note that the agricultural sector is one of the most sensitive sectors in the country. Currently South Africa like many other countries in the region lacks a targeted or harmonised drought response for agriculture. Building farmer resilience is seen as a key strategy in helping communities instead of the current responses to immediate crises (IRIN, December 2015). There is need to invest in building farmer resilience and ability to cope and adapt to droughts. Coping and adaptation strategies for agricultural water use during drought are currently scattered in different departments and sectors. Every province has its own drought response strategy, and in some provinces the drought plans are almost obsolete. Drought effects also affect the farmers differently and the response strategies largely fail to recognise this, e.g. the more vulnerable subsistence and smallholder farmers are usually the hardest hit because they lack funding, have limited access to technology and also low adaptive capacity during uncertainty periods. There is therefore an urgent need to review the country's drought response strategies

for the agricultural industry and come up with a basket of options that farmers can adopt during drought

Aims of the Review

1. Review of the current knowledge of drought and drought occurrence in South Africa, including the review of current drought polices and strategies, national and provincial response strategies.
2. Review of drought coping and adaptation strategies in dryland cropping systems, irrigation, livestock and mixed systems across the country.
3. Identify policy and research gaps, and make recommendations of what should be done in South Africa under current drought conditions, and future droughts. Suggest a national drought response strategy for agricultural water use in South Africa.

Methodology

The Cape Peninsula University of Technology undertook the project. The project was divided into three deliverables linked to the three aims. A number of Water Research Commission (WRC) projects that cover various facets of drought were reviewed. These include the most recent WRC Project K5/2084 entitled 'Insights into indigenous coping strategies to drought for adaptation in Agriculture: A Karoo scenario' and WRC Project K5/2152 entitled 'Planning for adaptation: Applying scientific climate change projections to local social realities.' Additionally, a number of drought studies and reports on drought in Southern Africa and Sub Saharan Africa were also reviewed in the context of South Africa. A number of published articles were also used in compiling the review.

Review Findings

Definition of Drought

The first part of the report includes definitions, types and categories of drought, South African climate according to provinces, occurrence in South Africa, and the response to it by the provinces. It was revealed that definition of drought is not a one-size-fits-all. However, a general definition was identified as shortage of rainfall over a long period. In South Africa, it is defined as the shortage of rainfall for a prolonged period in which normal needs of the users are not met. It was noted that drought is a regular, recurrent, normal and natural phenomenon in South Africa. Drought, though, is regarded as a different phenomenon compared to other climatic hazards like floods. It is difficult to determine when drought starts and ends, and its impacts are not easily measured since they extend to social, economic, natural and environmental aspects.

This review identified eight types of drought: seasonal drought, periodic drought, disaster drought, false drought, premature drought, prolonged drought, green drought and financial drought. Four basic categories of drought were identified as: meteorological drought, agricultural drought, hydrological drought and socio-economic drought.

South African Climate

It has to be noted that identifying information about the climate of South Africa according to provinces was difficult; neither did it yield adequate results. Nevertheless, information available indicated that South Africa is characterised by average annual rainfall of 500mm, and that it receives well below the world's average rainfall of 860mm. Rainfall is unevenly distributed across the country and is unpredictable and unreliable. Agricultural activities consume about 60% of South Africa's water resource. South Africa lacks endowment with ground water due to underlying hard rock formations and groundwater aquifers. It was revealed that Free State has highest water storage capacity and Gauteng the lowest. On the same note, South Africa ranks ninth in the Southern African region amongst the lowest in water storage capacity.

Drought Impacts in South Africa

Generally, drought impacts could be categorised into agricultural, economical, socio-economic and environmental. Reports show that the current drought being experienced in South Africa has already impacted severely on agriculture, socio-economic and the economy. Although it was difficult to measure impacts of drought per province due to lack of relevant information, nationally, it had been reported that significant livestock mortalities and crop failure had occurred during period 2014-16. This resulted in increase in maize imports, affecting negatively on the economy of the country. Environmentally, water volumes in dams, lakes and rivers declined significantly, leading to a serious water crisis in South Africa. Drought effects last longer even after drought, posing a serious challenge on the socio-economic aspect of people's lives. In South Africa, cost of food was revealed as a major challenge, especially for the rural, smallholder farmers. Reports showed an increase in the cost of basic food basket by October 2015, and predictions showed that the cost would be 25% more, implying dire consequences for food security. Workforce retrenchments and closure of small town businesses, unemployment of social instability was reported already in 2016.

Drought Occurrence and Response

There was limited drought information available in order to determine the pattern of its occurrence in South Africa, specifically on the drought spanning from 2014-2016. Attempts were made to review drought occurrence according to each province. Some provinces did not have reasonable amount of information in order to determine how they were experiencing drought. However, it was revealed that Northern Cape and Western Cape received a total range of rainfall from 0-50mm in 2014-15. Drought was declared as disaster in different provinces at different times due to the minimum requirements for declaration of disaster.

It was revealed that the South African government has the mandate to manage drought in order to protect its people, with the involvement of farming communities, the private sector and civil society. A comprehensive drought management plan, embedded in the National Disaster Management Act was identified, reviewed and analysed. The National Drought Management Plan, which was developed as stipulated by the Disaster Management Act (DMA) No. 57 of 2002, provides a framework for Provincial Drought Management Plans in South Africa. Each province is required to draft a Drought Management Plan according to its needs. However, the fact that the National Drought Management Plan was last revised in 2005 is worrying. There were areas in the National Drought Management Plan that were unclear. This was seen as problematic because it was argued to trickle down to the implementers of the plan at provincial level. Some few challenges including lack of finances, capacity and proper monitoring and evaluation are assumed to be emanating from the plan.

Efforts to identify provincial Drought Management Plans were fruitless, except for Western Cape and Northern Cape. This review could not conclude the reasons for non-existence of these documents since the review focused on information available. However, drought management in South Africa remains reactive rather than proactive, regardless of the existence of sound, drought management policy. At national level, huge amounts of money that has since been injected into drought mitigation strategies that are not even well structured, coordinated and monitored. Drought mitigating measures identified include borehole drilling, fodder provision, movement of cattle heads to state-owned land, and dam restrictions. Implementation of the policy remains a challenge in most of the provinces. Regardless of the tireless efforts towards drought management in South Africa, findings show a lack of coordination, monitoring and management of national and provincial government strategies.

The review also identified some of the limited efforts that were made by the private sector and civil society in assisting drought management. Operation Hydrate and Awqaf SA, in partnership with the Department of Water and Sanitation, Agri-SA, in partnership with Shoprite, Shell and Standard Bank are some of the organisations that were identified to have been involved in drought mitigation.

Early Warning Systems

Drought mitigation components, i.e. Early Warning Systems (EWSs) and Indigenous Knowledge Systems (IKSs) were reviewed and discussed in depth. The review sort to understand the role of EWSs in South Africa; how they are being implemented; and the challenges faced. Findings show that EWSs play a significant role in mitigating drought effects; if managed effectively. However, EWSs in particular, have been found to be ineffective if used without consideration of the social environment in which the end-users of forecast information operate, especially the poor emerging, smallholder and subsistence farmers. Nevertheless, this phenomenon is not unique for SA, since it is common in southern Africa and large parts of the world. It was found out that, poor African farmers operate under many limiting social environment factors, that if climate information is divorced and used in isolation, it would not yield much results. There was, therefore, need to assess the social environment and identify the factors that would hinder effective use of EWSs. If done, it is foreseen as potentially informing drought management policies, culminating in successful mitigation of drought effects in future.

Indigenous Knowledge Systems

The review sought to determine the extent to which indigenous coping strategies were being perceived, valued and adopted by farmers during drought periods in South Africa. Findings show that indigenous coping strategies are valuable, sustainable and affordable ways of managing drought. IKSs are perceived as playing a very important role in managing drought, particularly as a mitigating measure. Few studies on indigenous drought management strategies were identified, making it difficult to generalise the findings. It is clear from the review, farmers need to be supported and assisted, to use effectively, their local knowledge on coping and adapting to drought. However, IK alone could never be sufficient to manage drought, unless complemented with scientific knowledge.

Conclusions

Review findings reveal that there is little known about drought occurrence in SA. In some provinces, only the information on when drought was declared as disaster could be found. There is no information on the severity or impacts of drought. On the same note, no reports could show what strategies were implemented in these provinces in order to mitigate drought effects. Challenges were faced in implementing the National Drought Management Plan (NDMP), including lack of finances, capacity and expertise. Arguably, it can be concluded that effective drought management implementation in SA is far from being realised.

Regardless of the resources that have been used to develop and transform the policy post-apartheid, huge sums of money continue to be injected in fruitless drought relief aid. There are limited reports that show proper drought management strategies that have and are being implemented to tackle drought in the provinces of SA. Reports have shown that in fact, the government has assisted farmers with fodder and other ways of mitigating drought. Nothing is there to show that the planning that was done years ago in terms of managing drought has yielded results.

There are no reports of the evidence of monitoring and evaluation of the provincial drought management plans by the responsible persons at the national level. It was noted that some provinces had no DMPs and no follow-ups were made to ensure that this was rectified. Although the lack of capacity, funds, and structures at provincial/local government have been cited as obstacles to implementing the NDMP, there are no reports that indicate what was done in order to implement the NDMP. It is also understood that the lack of clarity on the roles and responsibilities of stakeholders imply that no one ensures that the policy is being implemented accordingly. EWS were reviewed in general, and in particular, the SA, Southern Africa and Sub-Saharan Africa. EWSs have been found to be a promising tool for drought mitigation. However, in the African continent, the implementation and effective use of EWS has been hampered by many other factors characterising the resource poor, smallholder and subsistence farmers. Nevertheless, governments have continued to issue early warning information to the people through the responsible institutions, in the case of SA, the South African Weather Services (SAWS). It was also revealed that dealing with drought by the use of EWS is compromised by the social environment in which many of the African smallholders are operating. Providing early warning information in isolation is argued to be ineffective, considering that the farmers in question face many challenges. Poverty is complex, hence the manifestation of many forms of it due to the stresses that accompany climate change. Climate forecast information could be argued to disadvantage the poor farmers who depend on farming for their survival, due to lack of access, interpretation, and use of such information for decision-making. When they turn to local knowledge without support with scientific information, the farmers are limited and eventually become desperate and frustrated.

IK has been found to be another useful tool for drought coping, adaptation and mitigation. However, research has shown that there is a lack of interest by governments to acknowledge, adopt, and formalise IK. It can be argued that IK coping strategies are the only option for those poor farmers that lack access to scientific knowledge, although the extent to which IK can be used successfully without complementing it with scientific knowledge, for example, EWS is very small. Ultimately, this kills the enthusiasm for the farmers to adopt scientific knowledge, resulting in lack or limited success by the producers of climate information to communicate it to the farmers.

Effective drought management is a result of proper planning, culminating to adequate preparedness. Drought relief can only be applied when all efforts have been exhausted to avoid or mitigate effects of droughts. Although drought is inevitable in SA, given the comprehensive drought management policy in place, implementing the mitigating and adaptation strategies could go a long way in addressing drought before it affects people, the rural poor in particular. Drought relief, if not managed or coordinated properly, has potential to create dependence on the government by the rural poor. Farmers need to be empowered in order for them engage in drought management efforts, making decisions on themselves and managing their own activities.

Recommendations for Future Research

It is evident that many aspects of drought still require further research in order to understand the drought phenomenon. However, the research itself is not useful, unless its findings are translated into action. Of importance to emphasise is an investigation on the livelihoods of smallholder farmers in SA. These farmers are surrounded by a myriad of challenges that need the government and other stakeholders to understand if ever they are to manage drought effectively. Unless and until this is done, it will remain a dream for smallholder farmers to achieve their goals of contributing to food security and having food on the table for their families. However, it would be improper and unfair to blame the government only, about the failures of all other stakeholders in managing drought. The government has the responsibility, with the support of all other stakeholders, to protect its people from the risk and effects of drought. It must oversee the activities of other stakeholders, of course, being flexible to give a reasonable degree of freedom and independence, so that it would not become an obstacle for development. The role of the NGOs, in this instance, in drought management, is yet to be clear. An investigation is needed in order to determine the level and extent to which NGOs in SA have contributed to drought management, the challenges that they face, successes and the lessons learnt overtime. NGOs are potentially effective, if interested in drought management, to effect change. This is because they operate amongst the people and find it easier to reach out and influence change. This could work well also, in collaboration with the IKSs so that they could get the support they need to improve the use of IK and at the same time adopting new technologies.

It is important to acknowledge that SA has been able to develop a sound drought management policy. The national government has also taken strides in providing drought relief to its people. However, the extent to which relief has been received and has addressed the rural poor, smallholder farmers is yet to be revealed. It can also be concluded that there is limited research on drought in general, and on its occurrence and management in SA. No monitoring and evaluation are being done on the implementation and effectiveness of programmes for drought management. Therefore, it is difficult to determine to what extent has the implementation of NDMP gone and is achieving its purpose.

Both IKSs and EWSs are critical in addressing drought in SA, and should not be used in isolation. On the same note, the context and environment in which these are provided should be conducive. This means that a holistic approach should be taken into consideration when using these tools of drought mitigation, including the social context in which different farmers operate, particularly the resource poor farmers.

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LIST OF ABBREVIATIONS

AD	Agricultural Drought
ADMP	Agricultural Drought Management Plan
ADRMP	Agricultural Disaster Risk Management Plan
ARC	Agricultural Research Council
BFAP	Bureau for Food and Agricultural Policy
CAS	Climate Advisory Services
COGTA	Corporative Governance and Traditional Affairs
DAFF	Department of Agriculture, Forestry and Fisheries
DEWIS	Drought Early Warning and Information Systems
DEWS	Drought Early Warning Systems
DMA	Disaster Management Act
DMC	Disaster Management Centre
DMP	Drought Management Plan
DWS	Department of Water and Sanitation
EC	Eastern Cape
EWS	Early Warning Systems
FAO	Food and Agriculture Organization
FS	Free State
IK	Indigenous Knowledge
IKFs	Indigenous Knowledge Forecasts
IMTT	Inter-Ministerial Task Team
IVIS	Integrated Value Information Systems
JOC	Joint Drought Operation Committee
KZN	KwaZulu Natal
MEC	Member of the Executive Council
MHEWS	Multi Hazard Early Warning System
NC	Northern Cape
NDMA	National Disaster Management Centre
NDMC	National Disaster Management Centre
NGOs	Non-Governmental Organisations
NW	North West
PPP	Public Participation Programme
SA	South Africa
SAWS	South African Weather Service
SCFs	Seasonal Climate Forecasts

UNISDR	United Nations International Strategy for Disaster Risk Reduction
WC	Western Cape
WRC	Water Research Commission
ZDM	Zululand District Municipality

CHAPTER 1: CURRENT KNOWLEDGE OF DROUGHT AND DROUGHT OCCURRENCE IN SOUTH AFRICA

1.1 INTRODUCTION

It is argued that no definition of drought is all-inclusive (Van Zyl, 2006). However, droughts can be defined as shortage of precipitation over an extended period (Rouault and Richards, 2003). A drought could also result from a decrease of water availability to substantially below the normal condition for a certain place and time, typically associated with a period of below-average rainfall (Mwendera, 2016). The simplest definition is any unusual dry period, which results in a shortage of water (Van Zyl, 2006). Rainfall deficiency is therefore the trigger, but it is the shortage of useful water in the soil, in rivers or reservoirs, which creates the hazard.

A drought in South Africa is a prolonged, abnormally dry period when there is insufficient water for users' normal needs (Van Zyl, 2006). Agriculture suffers first and eventually everyone feels the impact. In South Africa's climate, drought is a regular and recurrent feature (Rouault and Richards, 2003). This notion is supported by Mwendera (2016), who submitted that indeed, the drought which is currently devastating parts of the country is a recurrent characteristic feature of South Africa's highly variable climate and weather extremes. Droughts are a frequent occurrence in South Africa's arid and semi-arid rangelands (Vetter, 2009). Additionally, a drought is also regarded as a normal phenomenon in South Africa), and is a natural phenomenon, which cannot be prevented (Mokwenyane 2015).

Drought is unlike other natural hazards, such as floods, in that there is often no well-defined start and end (Mwendera, 2016), and is different from the rapid-onset environmental hazards (Van Zyl, 2006). It is called a 'creeping' hazard because droughts develop slowly and have a prolonged existence, sometimes over several years (Van Zyl, 2006). Because of the creeping nature of drought, its effects accumulate slowly over a substantial period. Therefore, the onset and end of drought is difficult to determine and scientists and policy makers often disagree on the basis, that is, the criteria for declaring an end to drought (Wilhite, Sivakumar and Pulwarty, 2014). Unlike most hazards, drought can be difficult to recognise, especially in the early stages, and it is defined in terms of effects rather than causes. Furthermore, it is important to view any water shortage in relative terms of need rather than in absolute rainfall amounts (Van Zyl, 2006). Droughts are not confined to areas of low rainfall any more than floods are confined to areas of high rainfall, and drought should always be viewed in the context of a specific climatic regime and the associated demands for water (Van Zyl, 2006).

The total average annual available surface water in South Africa is 49 200×10^6 m^3, including the inflow from Lesotho and Swaziland, and of this, 25% is economically harnessed as usable yield (Mukheibir, 2005). Agriculture is by far the largest user of water. Urban and rural requirements make up 25% and 4% water use respectively, while agriculture and forestry together use two thirds of the available water resources (Mukheibir, 2005). Agriculture in South Africa is said to be predominantly rainfed (Mwendera, 2016). However, according to the Food and Agriculture Organisation (FAO) estimates of 2012, only about 13% of total cropland is equipped for irrigation, of which an estimated 95% is actually irrigated, and agricultural water withdrawals amount to just 15% of total renewable water resources (Mwendera, 2016). The country's rainfall and river flows are variable, erratic and seasonal; droughts occur frequently and agricultural yields are often constrained by insufficient water (Mwendera, 2016). Water is indeed the factor that most limits agricultural development in the country, with more than 50% of South Africa's water already used for agricultural purposes (Mwendera, 2016).

1.1.1 Objectives of the chapter

The main aim of the chapter was to review the current knowledge of drought and drought occurrence in South Africa, including the review of current drought polices and strategies, national and provincial response strategies. The first part of the review looks at South Africa's drought polices and strategies, including national and provincial strategies. This also includes early warning systems (EWS) and climate advisory services. A number of Water Research Commission (WRC) projects have been published covering various facets of drought. These projects have also been reviewed, the most recent projects being the WRC Project K5/2084 entitled 'Insights into indigenous coping strategies to drought for adaptation in Agriculture: A Karoo scenario' and WRC Project K5/2152 entitled 'Planning for adaptation: Applying scientific climate change projections to local social realities.' This information has was compiled to show what is already available and how the information is implemented. There is also a number of drought studies and reports on drought done in Southern Africa and Sub Saharan Africa which were also reviewed in the context of South Africa.

1.1.2 Context of the review

A desktop review was conducted with the objective of assessing the current available knowledge about drought in South Africa and its occurrence. The review included the existence, implementation, effectiveness, and monitoring of drought policies and/or strategies by the South African government. The four basic categories and types of drought were reviewed, with focus on agricultural drought, with the aim of determining how much was known about drought in agriculture and how it affected South African farmers and their activities, with special attention to the current drought.

All the nine provinces of South Africa were reviewed in terms of climate, drought occurrence/patterns, drought policies and strategies. In the case where policies or strategies to mitigate drought impacts existed, there was further consideration of how effective they were and how they were being implemented and managed. On the same note, the review aimed at determining the extent to which the national and provincial governments were prepared in the event of drought occurrence. Additionally, the study sought to identify gaps in the current policies and/or strategies for management of drought, and to recommend possible solutions for the future.

In order to fully determine drought occurrence or patterns, the presence/absence of government policies/strategies to assist farmers coping with drought, and the effectiveness of these; the study took into consideration the period from 1994 when the country changed government to 2013. The current drought period, that is, 2014-2016, was reviewed separately. The objective was to determine how drought as a phenomenon in South Africa has or is being perceived, documented, tackled and managed, especially the current drought, which has become severe over the years. However, the drought of the period 1992-93 and its impacts can never be underestimated, neither can it be ignored, that although the country was going through political instability, there was a government in place. Governments are understood to be the vanguards of all aspects of development. It is to be noted that, though, the focus was on national and government departments' strategies and/policies, a consideration was also made of the indigenous knowledge systems, including research institutions and non-governmental (NGO) strategies to mitigate drought.

1.2 DEFINING DROUGHT

1.2.1 Categories of drought

There are four basic categories of drought, namely meteorological, agricultural, hydrological and socio-economic droughts (Mwendera, 2016). Figure 1 illustrates the drought categories.

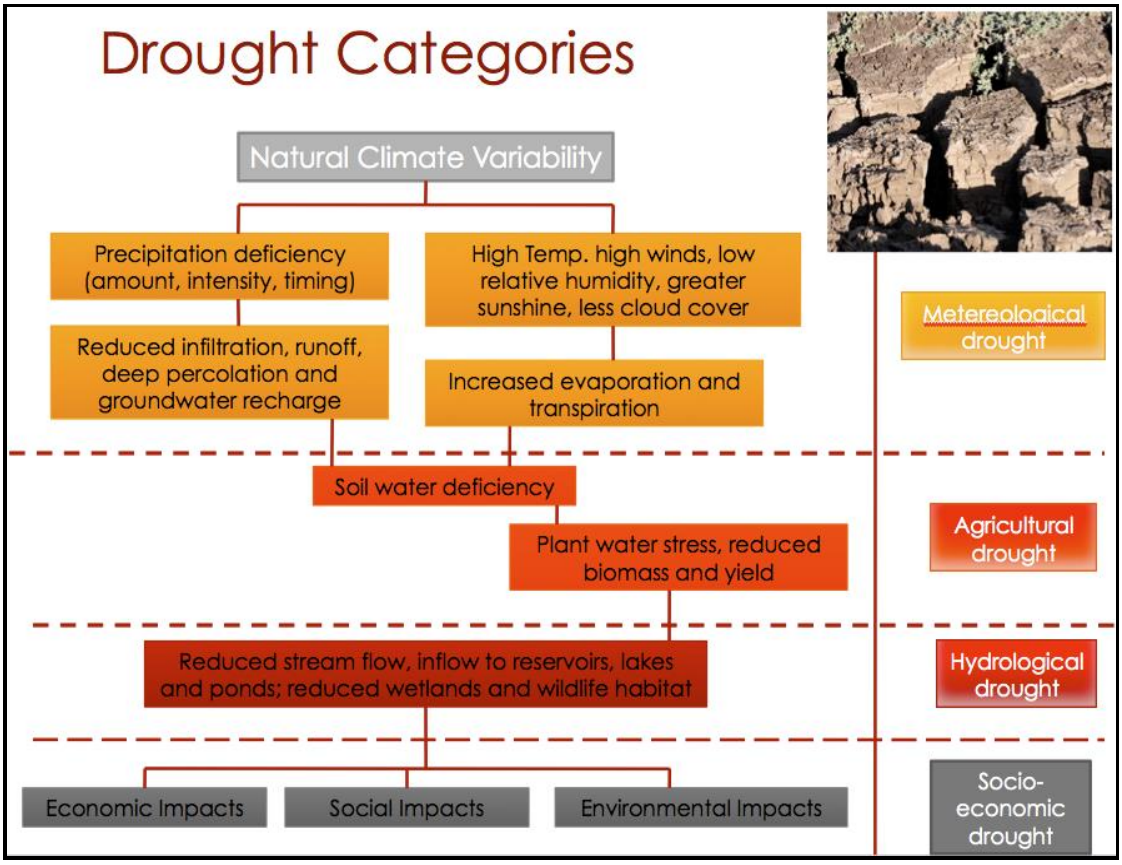

Figure 1: Categories of drought (Extracted from Jordaan, 2012)

Meteorological drought

The South African Weather Service (SAWS) defines drought based on the degree of dryness in comparison to "normal" or average amounts of rainfall for a particular area or place, and the duration of the dry period; a deviation from normal measured rainfall could indicate a meteorological drought (Van Zyl, 2006). SAWS normally monitor meteorological droughts.

Hydrological drought

Hydrological drought refers to deficiencies in surface and sub-surface water supplies, occurring when natural stream flow or ground water levels are sufficiently reduced (Backeberg and Viljoen, 2011). Therefore, hydrological drought tends to be measured by relating a shortfall of water supply to water demand when reduced precipitation endures over an extended period, a decline of surface and sub-surface water will be detected (Van Zyl, 2006). Hydrological drought is even further removed from the deficiency of precipitation since it is normally defined in terms of the departure of surface and sub-surface water supplies from some average condition at various points in time (Wilhite *et. al.*, 2014).

Agricultural drought

Agricultural drought occurs after meteorological drought, but before the hydrological drought (Backeberg and Viljoen, 2011). In respect of an irrigation drought, this definition is instrumental for drought planning because agriculture is usually the first economic sector to be affected by drought. Therefore, agricultural drought refers to a situation when the amount of water in the soil no longer meets the needs of a particular crop.

Socio-economic drought

Socio-economic drought deals with drought in terms of supply and demand of goods and services (Jordaan, 2012). The physical water shortage starts to affect people; and the ripple effect can therefore be traced through economic systems and agricultural droughts link various drought characteristics to agricultural impacts. The focus is mainly on precipitation shortages, differences between actual and potential evapotranspiration, and soil water deficits (Jordaan, 2012). The elapsed time when precipitation deficiencies are actually detected in other components of the hydrological system causes impacts of drought to be out of phase with other impacts in the economic sector. This explains why drought impacts should not just be studied when they happen during a period of water scarcity, but also while they linger when drought conditions no longer exist (Backeberg and Viljoen, 2011).

1.2.2 Types of drought

Seasonal drought

This is a predictable drought and an annual event, for example, a dry winter in a summer rainfall region, or a dry summer in a winter rainfall region (Van Zyl, 2006). Other seasons may also be much drier than normal. Where overgrazing prevails, a seasonal drought may be mistaken for a severe drought, which qualifies for assistance (Van Zyl, 2006). Seasonal droughts do not qualify for assistance unless the preceding seasons were disastrously dry**.**

Periodic drought

This drought occurs at more or less regular intervals and is largely the result of normal fluctuations in rainfall below the expected average. Overgrazing aggravates such droughts. Periodic droughts are also those that must be provided for in the form of veld and fodder reserves (Van Zyl, 2006).

Disaster drought

Although there is no single all-encompassing definition for a disaster drought that would satisfy all perceptions, rainfall is a factor that determines the incidence and severity of such a drought (Van Zyl, 2006). Disaster droughts tend to develop gradually in grazing lands, usually from chronic lower rainfall over many months and seasons. In crop production areas a disaster drought could occur over the short term, such as when the soil has already reached an advanced stage of drying out, followed by little or no rain. Disaster droughts are not predictable and occur at uneven intervals of years. The incidence of disaster droughts is low, usually only once in 15 or more years. A major aggravating factor in disaster drought is overstocking. This leads in a progressive deterioration of veld quality and quantity. Disaster droughts could last very long, but usually end within 12 to 36 months. In the paper presented to Drought

Policy in the Republic of South Africa, 1989drought in South Africa was defined as occurring at 70% of normal rainfall. It becomes a disaster or severe drought when two consecutive seasons experience 70% or less rainfall. A disaster drought also implies that an area qualifies for State relief schemes, is associated with abnormally low rainfall conditions over more than one season and a marked reduction in agricultural production concomitant with a high risk (Jordaan, 2012).

False drought

This type of "drought" occurs when rainfall is normally below the long-term average, but because of overgrazing the veld and fodder, supply becomes prematurely depleted, giving the impression of a prevailing drought. In some instances, false droughts have been declared as disaster droughts (Jordaan, 2012).

Premature drought

This type of drought occurs when a chronic dry situation is so aggravated by overgrazing that a disaster drought is prematurely declared. In many instances, adjoining farms may differ widely as to the intensity of a drought result of veld management practices and the exploitation of grazing capacity (Jordaan, 2012).

Prolonged drought

A drought situation can be prolonged for months where high stock numbers are maintained. This results in a more or less chronic food shortage even after rain has fallen. Plants become severely damaged. It is also possible that areas, which have been declared drought stricken do not recover after moderate rainfall. After a few months, the drought could be even worse (Jordaan, 2012).

Green drought

Green drought occurs when excessive grazing pressure is maintained in semi-dry periods. This causes food shortages even though the vegetation appears green and soil moisture reserves are favourable, or where natural causes such as rain showers during a drought promote a short spell of green growth, but not enough for breaking the drought. A green drought can also occur where insects severely attack plants and deplete the fodder to such a degree that it takes on the appearance of a drought situation. There is thus a shortage of fodder in spite of favourable circumstances. The most common pests are locusts, Karoo caterpillar and the commando caterpillar (Van Zyl, 2006)

Financial drought

Farmers exert pressure to obtain financial assistance in order to improve cash flow. Therefore, a region is sometimes declared drought stricken even though a drought does not prevail. (The declaration of such a region as a disaster drought area has a negative effect on the interpretation of rainfall records because a drought is indicated when it does not exist.)

1.3 SOUTH AFRICAN CLIMATE AND DROUGHT OCCURRENCE

South Africa is regarded as a water-stressed country, with an average annual rainfall of 500mm (Mukheibir and Sparks, 2003). Other reports indicate that the country's average annual rainfall is 450mm per year, well below the world's average of 860mm, while evaporation is also comparatively high (Benhin, 2006). Rainfall is unevenly distributed across the country, with humid subtropical conditions in the east and dry, desert conditions in the west. Only 10% of the country receives an annual precipitation of more than 750mm and 50% of South Africa's water resource is used for agricultural purposes (Benhin, 2006). It is estimated that about 65% of South Africa receives less than 500mm per year (Ngaka, 2012). In general, rainfall is highly unpredictable and reliable. The natural availability of water across the country is variable, and rainfall displays strong seasonality (Mukheibir and Sparks, 2003).

There are also no large or navigable rivers in South Africa and the total flow of all rivers in the country combined amounts to approximately 49,200 million m^3 per year, which is less than half of that of the Zambezi River (Benhin, 2006). It has been reported by many authors that South Africa is also poorly endowed with groundwater resources, as most of it has underlying hard rock formations, which, although rich in minerals, do not contain any major groundwater aquifers, which could be used on a national scale (Benhin, 2006). Groundwater has an important role to play in rural water supplies, but few major groundwater aquifers exist that can be utilised on a large scale due to high salinity in most parts of the country (Mukheibir and Sparks, 2003). It is estimated that about 5 400 million cubic meters of water a year could be obtained from underground sources (DWAF, 1994). When compared with other nations on the globe, South Africa has very low water storage capacity. The average water storage capacity in South Africa is the ninth lowest within the Southern African region (Mwendera, 2016). Within the country, the Free State Province has the largest water storage capacity of 5 669.6 m^3/capita while Gauteng Province has the lowest water storage capacity of 8.7 m^3/capita (Mwendera, 2016). Benhin, (2006) further noted that South Africa is expected to be among the worst water scarce countries by 2025. Given the temperatures and rainfall patterns, two main farming seasons are identified in the country, that is, the summer season from October/November to March/April and the winter season from April/May to August/September. The central and eastern parts of the country receive summer rainfall, whilst the south-western part of the country is a winter rainfall region (Van Zyl, undated). Table 1 summarises provincial climate in South Africa

Table 1: Climate information from selected provinces

Province	**Climate**
Northern Cape	Characterised by vast arid and semi-arid plains, and covered with grass in the Kalahari and low shrub in most of the province. Most of the province receives summer rainfall whilst a narrow strip along the West Coast receives winter rainfall (Jordaan, 2012). Annual mean precipitation for the province is 200mm with only 20mm per annum in the far west and up to 540mm in the east of the province (Jordaan, 2012). Northern Cape is the driest province in South Africa (Benhin, 2006). The Northern Cape is characterised by a harsh climate with minimal rainfall and prolonged droughts (Mukheibir, 2003). The area's arid climate is accompanied by high evaporation and the mean annual precipitation ranges between 20 mm on the west coast to approximately 300 mm on the eastern side (Mukheibir, 2003).
Eastern Cape	Climate is highly varied. The west is dry with sparse rain during winter or summer, with frosty winters, and hot summers in the north. The Eastern Cape is the only one of South Africa's nine provinces to have all seven of its biomes or ecological zones, within its boundaries
Western Cape	The Western Cape, the second driest province, receives mainly winter rainfall, and has warm dry summers. It has a Mediterranean climate (South Africa.com, 2016)
KwaZulu Natal	KwaZulu-Natal is the wettest province in the country (Benhin, 2006); The rainfall also varies considerably, from 500 mm to over 2 000 mm/a.Climatologically it is classified as a summer rainfall region (Dube and Jury, 2003).

1.4 IMPACTS OF DROUGHT ON AGRICULTURE

Quantifying the impacts of drought is a socio-economic problem and it is indeed intricate (Garanganga, 2011). Wilhite *et. al*. (2014) added that, quantifying the impacts and providing disaster relief is a far more difficult task for drought than for other natural hazards, since these impacts can filter through economies and the environment for months, years and even decades. These characteristics of drought have hindered development of accurate, reliable, and timely estimates of severity and impacts (i.e., drought early warning and information systems) and, ultimately, the formulation of drought preparedness plans and drought policies. Additionally, the impacts of drought are, at times, enormous and result in economic and environmental impacts as well as personal hardship (Wilhite*, et. al.*, 2014). Similarly, in qualitative terms, drought has affected the South African economy, agriculture, environment, social life and hydrology. Although the focus is on agricultural effects, the effects on other aspects of development can never be understated. The effects are interlinked and difficult to mention in isolation, hence they are discussed below, accordingly.

1.4.1 Agriculture

Crop failure and death of livestock

Most droughts result in widespread crop failure, livestock deaths, consequently loss of draught power for the ordinary farmers. The South African agricultural sector recorded a decrease of 12.6% in the third quarter of 2015 (Brink, 2016). Significant livestock mortalities were reported in KwaZulu-Natal, Limpopo, North West and the Free State Agri-Western Cape, 2016). South Africa's first maize production forecast estimated the 2015 harvest to be the worst in 8 years, with a drop of 21% relative to the average of the last 5 years and 32% down on 2014's year bumper crop (Drought Report, 2015). The United Nations Office for the Coordination of Humanitarian Affairs (OCHA, 2016) reported that the expected commercial maize crop for 2016 was 29.1 per cent less than for 2015, which was also a drought year and that the expected total maize imports for 2016/17 stood at 3.65 million tonnes. The 1991/1992 drought is still ranked as the worst natural disaster in South Africa, which resulted in approximately 70% of crops failing and maize had to be imported into the country (Mniki 2009).

It was noted that, in horticulture it is difficult to assess drought impacts as they vary according to producer, area, and the conditions under which they are produced. However, generally, there was a notable decrease in yield and size of fruits like pome and stone, and decreased yield in table and wine grapes, and the quality of citrus fruit was also poor (Bureau for Food and Agricultural Policy (BFAP) and IVIS, 2016).

1.4.2 Environment

Droughts in most cases result in general environmental degradation, and the problem is more pronounced in cases of inappropriate land use patterns. Soils in drought-hit areas have been left 'exhausted' and will be very costly to restore to their optimal production potential (Garanganga, 2011). There are limited reports of how droughts have affected the environment in most parts of South Africa.

1.4.3 Hydrological

Some rivers, dams and lakes either dry out or water volumes shrink thereby paralyzing the fish, hydro-electric power generation, and recreation industries (Garanganga 2012). Reports show that there was a growing water crisis in the Republic of South Africa, with an average dam level (as of 30 May 2016) of approximately 54 per cent – 22 per cent, less than the same period in 2015 (OCHA, 2016).

1.4.4 Industry

The general welfare of society is usually affected adversely by the advent of each drought (Garanganga, 2011). Agreeably, Van Zyl (Undated) noted that outcomes associated with a drought event, particularly an extreme event, are also tightly coupled to other societal elements, for example, economic changes, conservation and land care practices, rural livelihoods, agricultural practice, and most of all on food security. Income transfers from urban to communal areas become more common; population movement to urban centres increases leading to urban overcrowding, increase in crime and poor health and nutrition become common occurrences (Garanganga, 2011). As noted by Latham (2016), in South Africa, it is the cost of food in an economic downturn that has been the immediate effect.

However, hidden from view is a growing social crisis as farmers retrench their workforce and the new class of black commercial farmers has been rocked by the drought, and small towns reporting business closures, growing unemployment and social instability (Latham, 2016). The depreciation of the rand had a strong correlation on the landed price of fertiliser and oil-based products, resulting on year-on-year increase of 11 per cent on fertiliser and 10 per cent on fuel (Latham, 2016). While short-term solutions are being crafted, the drought will not only affect the next production season, but might also have long-term financial and debt implications for farm businesses. There were already efforts to facilitate grain imports and identify external supply sources (Makube, 2016).

Crop production has been adversely affected by dry conditions. As shown by some reports, 83% of South Africa's maize, 53% of the country's wheat crop and 73% of sugarcane are produced under dry land (Briefing of the Standing Committee, 2016). It was indicated that with reduced production volumes, South Africa might become a net importer of food and this will negatively affect the trade balance (Makube, 2016). The author added that, sectors such as maize and sugar, which would normally contribute to the sector's positive trade balance, would shift to a negative net trade position in 2016, following estimated more than 5 million tons of grains such as maize and wheat that had been imported. This implies loss of revenue for both the country and the agricultural sector. It was highlighted that sugar production was already well below normal levels in 2015 and was projected to remain at similar levels for the second consecutive year in 2016, representing a 28% reduction from the normal harvest in 2014 (BFAP and IVIS, 2016). Unlike the crop sector where production declines in a drought year, beef production tends to increase; as producers cull due to poor or insufficient grazing and high feed costs (BFAP Drought Policy, 2016). Notably, commercial beef slaughters had already increased by 8% year on year in 2015, rising almost 18% above the 5-year average (BFAP Drought Policy, 2016).

1.4.5 Socio-economic impacts of drought

Loss of income

The poverty trap small scale farmers find themselves in is made worse by each drought that strikes, and this has adverse implications on the farmers' ability to maintain and/or improve soil fertility (Garanganga, 2011) through purchase of fertiliser. Drought results in the farmers being unable to service loans. Also affected are the input providers, who usually record lower sales and are left with unsold stock and heavy financial losses (Brink, 2016). This notion was supported by Makube, (2016), who highlighted that the reduced production volumes and planted areas in the case of grains and oilseed crops would result in serious financial losses for input suppliers due to lower demand for seed, fertilizers, pesticides and herbicides. On the same note, at a food manufacturing level, the shortage of grains and higher prices would result in higher production costs.

Crop failure results in farm labour lay-offs, increased farm debt and farm closures and affects households that depended on the agricultural sector (Mniki, 2009). It was estimated that during the 1991/2 drought, 50 000 jobs were lost in the agricultural sector, with a further 20 000 in related sectors, affecting about 250 000 people (Mniki 2009). According to the Reserve Bank of South Africa, the loss of GDP during the 1992 drought was approximately 1.8 per cent, representing US$ 500 million (Pretorius & Small 1992). The figures for the current drought have not been quantified, but indications show high losses.

Threat to household food security

It was reported that, in October 2015, the cost of a basic food basket in South Africa, was already 14% more than the average household's monthly income (Bio Watch, 2016). Due to the drought, the National Agricultural Marketing Council predicted that a basic food basket would cost 25% more, with dire consequences for food security (Fact Sheet Food Crises, 2016). SAWS reported that with a recorded annual total rainfall of 403 millimetres, 2015 represented the driest year for South Africa since 1904 (Briefing of the Standing Committee, 2016).

Famine

Famine is the most serious potential outcome of drought although the linkage is not simple. Drought is the most important environmental hazard in semi-arid regions for two reasons. First, a low mean annual rainfall is associated with high variability. It is the lack of rainfall reliability, rather than rainfall amounts in these areas, from season-to-season or year-to-year, which creates uncertainty about the available water supplies and leads to drought hazards. Second, the duration of drought is longer in the drier lands. In wetter areas, a rainfall deficit is likely to persist for a few months only. General household welfare impacts of water scarcity, forced migration, and health implications (Hassan and Backeberg, 2010) are profound.

1.5 CURRENT KNOWLEDGE OF DROUGHT

1.5.1 Current knowledge of drought in South Africa's agricultural sector

Reports indicate that the frequency and impacts of natural disasters in the farming community in South Africa has significantly increased, and the most common type of disaster is drought (Ngaka, 2012). The Minister of Water and Sanitation noted that the water sector was facing considerable challenges, which include climate change, lack of rainfall, ageing and poor maintenance of infrastructure in some areas, water leaks, water pollution, illegal water connections, alien and invasive species, heat wave, etc. (Mokwenyane, 2015). The Minister noted that the current El Nino was perhaps the worst in history. The last worst drought was experienced in 1992/3. The Republic of South Africa was reported to be experiencing one of the worst droughts ever recorded due to two consecutive below average rainfall seasons since early 2015 (OCHA, 2016). However, drought could be experienced in various ways, especially in South Africa where the water resource is scarce. Table 2 shows drought occurrence in each province, as indicated by few relevant reports that were found.

Table 2: Occurrence of drought in South Africa by province (2014-2016)

Province	Drought Occurrence
North West	The country experienced the signs of a new round of El Nino, with the onset of the current drought in the North West province in 2013, which was subsequently declared as a disaster on 29 July in the same year (Mokwenyane 2015). Due to the deteriorating drought conditions in 2016, the North West was declared as a disaster area again on 24 July 2015 (Mokwenyane, 2015). Dam storage levels decreased by 14% (Anonymous, 2015).
Eastern Cape	If provincial dam storage levels were compared to values for the same point in time in 2014, the values decreased in all provinces except the Eastern Cape where it was 1% higher (Anonymous, 2015).
Northern Cape	The province received total rainfall ranging from 0-50mm (Mokwenyane, 2015)
Limpopo	Drought was declared as a disaster in Limpopo on 4 November 2015 (Mokwenyane, 2015).
Western Cape	The province received total rainfall ranging from 0-50mm (Mokwenyane, 2015). The high value of a decrease of 30% for Western Cape is probably associated with rains arriving late during the winter season (Anonymous, 2015).
Kwa-Zulu Natal	KwaZulu-Natal declared drought as a disaster on 12 December 2014 (Mokwenyane, 2015). Northern KwaZulu-Natal, where Biowatch works with smallholder farmers, has experienced severe drought since 2014, prompting the KZN Cabinet to declare some districts as emergency disaster areas in January 2016 (Bio Watch, 2016). The water levels of dams in the area have fallen dramatically. By March 2016 the Jozini Dam was only 47% full – compared to 61% full at the same time in 2015 – and the Hluhluwe Dam had dropped to only 18%. Half of the total water available in these catchments is used for irrigation, and an amount equivalent to half of irrigation use is lost in stream flow reductions (Fact Sheet Water Crisis, 2016) The extent of drought in KZN is well depicted by how far the water storage trend for 2016 was falling below the medial storage trend for past thirty years (Drought report, 2005). Water storage situation in the Usuthu-Mhlatuze water management area was at its lowest point (about 61%) for past thirty years, and far below the 30-year Median Storage Trend (Anonymous, 2015).
Free State	In Free State, drought was declared as a disaster on 4 September 2015 (Mokwenyane, 2015)
Mpumalanga	In Mpumalanga was at an advanced stage of preparation for the declaration of drought as a disaster, which would be completed soon (Mokwenyane, 2015).

It was reported that the lower than normal rainfall eastwards in June indicated that the drought could intensify in KwaZulu-Natal, Mpumalanga, Limpopo and some other parts of North West (Anonymous, 2015). The drying trend seemed to have started to manifest during the summer season of 2012/13 and had been intensifying ever since in all the summer rainfall regions, which includes dominant parts of all the provinces except for Western Cape (Anonymous, 2015). The seasonal climate forecasts provided by the SAWS heightened high probabilities of below-normal rainfall for the start of the summer season (Anonymous, 2015). This was expected to continue throughout summer with relatively small chances of above normal rainfall for localised areas in early to mid-summer. This suggests a strong possibility of the dry conditions persisting, which may lead to a long-term drought (Anonymous, 2015). A combination of the delayed onset of the season and a poor mid-season rainfall pattern at critical stages of maize development, led to unfavourable expectations for regional maize production (Anonymous, 2015).

There was limited information on how drought has or has been occurring in the different provinces of South Africa. However, it is difficult to conclude that there is no such information on record, although efforts to obtain such were unsuccessful largely. In an attempt to secure information, provincial offices were written emails requesting for any documentation on drought. At the same time, it could be that, since drought and its effects has been reported to be difficult to assess, information could take longer than anticipated to be documented. The little information that was found report the current and the 1992/3 droughts, implying that where drought has not been reported, it has not been occurring. This is not the case with South Africa, where drought has been reported as a recurrent and normal phenomenon. The only question could be the extent to which it has occurred over time.

1.5.2 National and Provincial Drought Strategies/Policies

In South Africa, drought management is the responsibility of national, provincial and local government, farming communities, the private sector and civil society (Department of Agriculture, 2005). The Minister of Water and Sanitation acknowledged that, as government, they were fully conscious of the responsibility they bore to mitigate droughts' economic and social impact on the country and its people, taking into account that water is a scarce resource in South Africa (Mokwenyane, 2015).

National Disaster Management Centre

A National Disaster Management Centre (NDMC) was established in 2006, following stipulations of the Disaster Management Act (DMA) No. 57 of 2002, which provided the framework for disaster management, including drought disaster in the country (Hassan and Backeberg, 2010).

The Drought Management Plan

The process of drafting the Drought Management Plan (DMP) was initiated during the 1991/1992 drought, and was published in 2005. Its legislative framework covers

- Prevention and reduction of disasters
- Mitigation
- Preparedness
- Response
- Rehabilitation
- Interventions

The draft was followed by development of the Agricultural Disaster Risk Management Plan (ADRMP) and the Agricultural Drought Management Plan (ADMP) as mandated by the DMA (Hassan and Backeberg, 2010). As noted in other reports, public policy in the water and agriculture sectors has seen major shifts since 1994 that has helped to address many of the problems regarding drought management in South Africa (Hassan and Backeberg, 2010). Various government policy papers advocate for a new approach and strategy in managing drought which emphasizes a shift towards a more proactive approach that adopts risk reduction rather than the reactive drought relief strategy of the past (Hassan and Backeberg, 2010).

The Department of Agriculture

In the 1990s, South Africa implemented major changes in policy related to agriculture, land use and drought. The Department of Agriculture proposed the following priority areas and programmes for addressing drought and drought management:

- increased awareness and preparedness by way of a national drought plan;
- reduction of risk to droughts through appropriate research plans;
- establishment of mitigation plans;
- recovery and development programmes - post-drought;
- implementation of education, training and information plans;
- risk management, with a strong emphasis on an insurance-based solution, which can be applicable to the agriculture sector as a whole (Mukheibir, 2003)

The Department of Water and Sanitation

It is important to note that drought management cannot be complete without the involvement of the water sector. Water needs to be properly managed before, during and after drought. The South African water sector went through a major reformation after the 1994 elections, culminating into a series of documents and principles to guide the water management and development of South Africa. These principles guided the intensive programme of work involving the minister and other political leaders, and other government departments. They organized user groups and South Africans in a process of consultation, research and synthesis (Mukheibir, 2003). One of the results was a new national water act, which was approved in 1998, as well as progress to integrating these concepts with other policies, such as drought, disaster and agriculture.

South Africa's National Water Act (Act 36 of 1998) states that its purpose is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways that take into account, among other things, management of floods and droughts (Mukheibir, 2003). For achieving this purpose, the act would establish suitable institutions and ensure that they have appropriate community, racial and gender representation

The National Disaster Management Act

It tasks all spheres of government, in collaboration with civil society, to undertake to protect people, infrastructure and other national assets from the impact of disasters (RSA, 2002). It is therefore, the duty of government to plan for climate change adaptation and mitigation to reduce the vulnerability of people, infrastructure and other national assets to climate change.

Limited research has been conducted to determine what local governments in South Africa have or are doing to pursue these goals. In 2008, the South African National Disaster Management Centre, therefore, commissioned research into the measures taken by local municipalities in anticipation of and in response to climate change (Tempelhoff, e*t. al.*, 2012). Regardless of the limited research to determine the efforts of government departments to mitigate drought effects, it is reported that government has implemented a number drought relief schemes to mitigate drought effects in the South African agricultural sector, as part of a national effort to assist affected farmers (Ngaka 2012). However, some reports note that the post-1994 period was characterised by the withdrawal of government from the agricultural sector in the sense that farmers since then had to operate completely in a free market environment, and that included the reduction of subsidies, tax relief schemes and easy finance to farmers (Jordaan, 2012).

The approach toward farmers was also mirrored in government's approach to drought relief where commercial farmers were left to fend for themselves. Some effort was made, however, to support poor emerging and subsistence farmers who received some drought relief in the form of government loans, with government security from Land Bank and animal feed and fodder (Van Zyl, 2010). However, farmers needed proper early warning and reliable early warning mechanisms and data to make informed decisions (Jordaan, 2012). Government could not avoid its responsibility to provide proper early warnings and continued research in support of the agricultural sector. The historical and current distrust between the government and the agricultural sector slowed down the implementation of a streamlined drought policy with clear guidelines and contingency plans for disaster drought prevention, mitigation and relief (Jordaan, 2012).

The White Paper on Disaster Management

A new approach to disaster management was adopted in a white paper on disaster management and the ensuing Disaster Management Act (Act 57 of 2002). The act is administered by the Department of Provincial and Local Government. Unlike previous policies that focused mainly on relief and recovery efforts, this act highlights the importance of preventing human, economic and property losses, and avoiding environmental degradation. This new approach aims to:

- create an environment for effective disaster management;
- promote proactive disaster management through risk reduction programmes;
- improve the ability to manage disasters and their consequences;
- promote integrated and coordinated disaster management through partnerships with stakeholders and cooperative relations between government departments;
- ensure adequate financial arrangements;
- promote disaster management training and community awareness

1.6 DROUGHT RESPONSE IN SOUTH AFRICA

1.6.1 National Government Drought Policies/Strategies

The national government provides a framework for drought management strategies to all provincial governments. These provinces must then develop their own programmes depending on their specific needs. The Disaster Management Act 57 states that each province is charged with the responsibility of preparing a disaster management plan for the province as a whole, coordinating and aligning the implementation of its plans with those of other organizations of state and multinational role-players and regularly reviewing and updating its plan (Republic of South Africa 2003). Likewise, each metropolitan and each district municipality is responsible for establishing and implementing a framework for disaster management in their municipalities aimed at ensuring an integrated and uniform approach to disaster management in their respective areas. These relief measures should, however, be seen as the exception and not be implemented on an on-going basis (Mukheibir, 2005). However, the national government does not necessarily neglect its responsibility of overseeing that these have been done and at times, intervening at its own capacity when need arises.

It can be argued that effectiveness of the government programmes leaves a lot to be desired. Ngaka (2012) argues that despite many years of drought relief assistance from the government, studies show a consensus amongst analysts that drought assistance has been ineffective, poorly co-ordinated and untimely. It is argued that too much attention in research is given to the risk and coping mechanisms and too little to the impact of these mechanisms (Jordaan, 2012). This makes it difficult to conclude whether little work has been done to manage drought or information is still beyond reach. However, the few articles that have been found and reviewed present a daunting task since they lack coordination. It is difficult to determine the work done, the recipients, time and the extent to which the problem was addressed.

In 2008/09, the government purchased and supplied fodder at subsidised rates, depending on whether the farmer was categorised as small, medium or large-scale (Ngaka, 2012). It also provided for the repair of water infrastructure, that is de-siltation of earth-dams and repair of boreholes, for communal farmers or farmers sharing common property such as land (Ngaka, 2012).

1.6.2 The 2014-2016 Government Drought Response Experience

Although a reasonable amount of information describes government efforts on mitigating drought, relevance was the most challenging issue. Many reports lack information on what has been done to assist drought stricken farmers. It was difficult to generalise these findings across all the nine South African provinces because some of them have almost zero information available. However, some few reports were identified and analysed. It was reported, that the national government allocated R1-billion in the 2016 budget to drought relief measures, including, the distribution of animal feed, moving cattle herds, transporting potable water and drilling boreholes (Bio Watch, 2016). The Department of Water and Sanitation spent R500 million on emergency and short-term interventions to mitigate the effects of the drought in drought-stricken provinces. Dam operating rules were applied to thirty-five dams; four systems had restrictions applied with regard to the mandatory restrictions on domestic and agricultural use. The provinces included KwaZulu-Natal, Free State, North West, Mpumalanga, Limpopo, Western Cape, Eastern Cape and Northern Cape. The interventions include among others, Water Conservation and Water Demand Management (WCDM), through War on Leaks, surface water resource management, optimized operation of the Vaal River System, groundwater resource management, carting of water through a fleet of motorized tankers, provision of static storage tanks and storage reservoirs.

While these measures saved lives at that moment, many farmers were still be unable to carry the losses, and relief was unlikely to reach most of the two-and-a-half million smallholders whose livelihoods depend on farming (Bio Watch, 2016). The Department of Agriculture, Forestry and Fisheries provided livestock feed and alternative grazing on available state farms and R226 million had been reprioritised and allocated. It facilitated and supported the revolution of credit facilities challenges due to crop failure with Land Bank and other development financial institutions. Additionally, the government promised to monitor the food prices through the Food Price Monitoring Committee under the National Agricultural Council to inform appropriate measures to maintain food security; strengthen climate change adaptation programmes developed for the sector and coordinate interdepartmental food and nutrition security interventions to mitigate the effects of drought on farmworkers and rural communities (Department of Agriculture, November 2016).

The Department of Rural Development and Land Reform (DRDLR) announced that livestock from worst affected regions in five provinces would be relocated to “state-owned land”, where there was still better pasture (Bio Watch, 2016). In the North West the department reported that it would allocate 200 000 ha to be made available for communal farmers and was busy doing field assessments and infrastructure needs and water assessments and possibility of establishing feedlots. It is important to note that these are reports with some promises that are not known when and how they were fulfilled. Money was allocated to municipalities and provincial departments to distribute to the drought stricken farmers accordingly. However, it is not clear whether there was follow up to determine whether the relief reached the intended clients.

The Department of Cooperative Governance and Traditional Affairs wrote to all the mayors in the country to take various actions to respond to the drought situation. These actions included, among others, following the guidance of the Department of Water and Sanitation regarding the introduction of water restrictions, monitoring adherence to water restrictions and application of penalties where necessary; prioritisation of the repair of water leaks, and the promotion of water-efficient technologies, rainwater harvesting, and use of grey water for irrigation (Bio Watch, 2016). It is unfortunate that government seemed to under-estimate the dire consequences of failure to manage water by its citizens, well before, during and after drought. It cannot come as a foreign practice to use water sparingly for South Africans, given its climate, which is well known to be prone to droughts. Hence, it is argued that the preparedness of the government for drought leaves a lot to be desired.

The cost of developing contingency plans to adapt to water shortages and mitigate droughts is relatively small compared with the potential benefits (Mukheibir and Sparks 2003). Of importance to note from the few drought management strategies implemented is the absence of adequate planning towards agricultural drought effects mitigation. Hassan and Backeberg (2010) note that apart from few recent examples in Agricultural Drought (AD) management, such as the subsidy to encourage stock reductions among drought management strategies in South Africa, livestock producers, few changes have been made in economic policy to manage drought in South Africa. They added that, even the incentive to reduce stocks and lower the pressure on grazing resources, and pastureland leaves out livestock farmers who are not located in drought disaster proclaimed areas. In addition, crop farmers are largely excluded from AD management programs. For example, a huge gap remains in developing instruments and institutions that would enable sufficient numbers of crop farmers to participate in yield and weather insurance markets that currently attract a handful of commercial crop farming enterprises in South Africa (Hassan and Backeberg, 2010).

Hassan and Backeberg (2010) noted that formal agriculture insurance and drought insurance in particular have been inaccessible to poor farmers in the developing world in general and in South Africa in particular. This needed urgent attention in South Africa, as small farmers who were farming in very marginal environments could benefit from self-insurance options and off-farm employment opportunities. This was supported by Brink (2016), who cited that in 1992-93, drought-relief was available and state guarantees were used to write off carryover debt and afford farmers an opportunity to make a new start. This current drought starting from 2013 seems to have caught the government unprepared to deal with the impacts. There are no risk and disaster programmes in place to secure and reinforce the production base of the agricultural sector, and it is feared that there is going to be a negative long-term impact because South Africa does not have a safety net for farmers (Brink, 2016). Farmers tend to use their own reserves to leverage additional credit in order to cope with drought, thereby exhausting these reserves and the credit cycle continues, as they would need finance to cater for their production cost for the coming year (Brink, 2016).

Economic policy instruments for the promotion of sustainable farming, water and land use practices are also not well exploited to induce desirable longer-term adaptations to drought in South Africa (Hassan and Backeberg, 2010). For instance, no policies and programs provide incentives or subsidy schemes to promote adoption of more efficient water use technologies, such as sprinkler and drip irrigation methods among other water-saving farming practices. On the contrary, it appears that most recent agricultural development efforts plan for further expansions in relatively more water-intensive crops and land use options (Hassan and Backeberg, 2010).

It is reported that, in 2015, many farmers were unable to obtain adequate input financing for the current production season because of the liquidation of some input financing companies and because of the high risks of lending money to struggling farmers, especially taking into account possibility of further interest rate increases (Brink, 2016). Reports note that fodder prices had increased dramatically and the availability of fodder was being hampered by the drought, resulting in even more emergency slaughtering or selling of animals and lower prices for these farmers (Brink, 2016). However, the government encourages farmers to slaughter their animals as early as possible, ideally at the onset of drought to avoid wastage by buying fodder. This could work as a coping strategy for farmers would not afford to buy fodder, but at the same time minimising on loses. On the other hand, the latter coping strategy is not without its own challenges and could be the reason why many farmers find it difficult to take the advice. Taking into consideration the issue of continuity, if the farmer sells or slaughters his total herd, or even most of it, it means that he loses his genetic base, which was developed over a long period (Brink, 2016).

The Inter-Ministerial Task Team (IMTT) was also concerned about issues such as the poor monitoring, reporting and evaluation of the impact of the response and intervention process and non-expenditure and delayed implementation of grant programmes to address service delivery issues (Ministry for Cooperative Governance and Traditional Affairs (COGTA, 2016)),. It seems this is not unique to South Africa, it has been argued that responses to drought by governments throughout the world are generally reactive, poorly coordinated and untimely, and that they are typically characterized as “crisis management” (Wilhite and Pulwarty, 2005). In addition, the provision of drought relief or assistance to those most affected has been shown to increase vulnerability to future drought episodes by reducing self- reliance and increasing dependence on government and donor organizations. Thus, it is imperative that emergency relief be provided in such a manner that it provides a safety net for those elements of society that are most vulnerable while promoting self-reliance and the principles of a national drought policy based on the concept of risk reduction (Wilhite *et. al.*, 2014).

1.6.3 Provincial Strategies/Policies

Provincial governments have been provided with a framework by the national government, in which they must develop policies suitable for their own purposes. Provinces are expected to develop drought coping strategies that suit their province. However, it has been found that the national policy framework, in most provinces, has remained at this level and has not trickled down to the intended users. During this review, efforts were made to search for documents at the provincial government websites to determine what has been done. Some provincial departments had no such information. The Minister of Corporative Government admitted, citing that some provinces were not availing resources on time for immediate response intervention measures and instead relies on national government (COGTA, 2016). Arguably, it could be that there are some plans for mitigating drought but have not been uploaded on provincial websites or any other platform with easy access by the public.

1.6.3.1 North West

It was noted that farmers in the arid Northern Cape were fully aware of the climate limitations in the province and farming practices were adapted through many years of experience to fit the climate profile of the region (Jordaan, 2012). Any assistance to farming communities would be in accordance with the Disaster Management Framework. In order for farming communities to qualify for this assistance, they should have applied prevention and mitigation strategies, for example, the planting of drought-tolerant crops, de-stocking and the use of available insurance products (Jordaan, 2012). The farmers should have also followed good farming practices; and utilised early warning information in their planning, and must report their drought damages to their local authorities and advisory services (Department of Agriculture, 2005). This implies that government would have done its duty to prepare farmers for drought beforehand, failure of which farmers would not shoulder the blame on themselves.

The government of South Africa declared the District Municipalities of Frances Baard, John Taolo Gaetsewe, Pixley ka Seme, Namakwa & ZF Mgcawu as drought disaster areas on 29 January 2016. Subsequently, a number of interventions have been implemented to mitigate the effects of drought in the Northern Cape Province. Eight (8) municipalities benefited from the drought relief interventions implemented in the province, namely Hantam, Kammiesberg, Richtersveld, Ubuntu, Kareeberg, Emthanjeni, Thembelihle and Mier. The interventions include technical assessments and assistance with boreholes. Six (6) boreholes had been refurbished, eighteen (18) newly drilled and 115 were fully operational.

The Department of Water and Sanitation (DWS) had since 2010 to 2013, installed 1237 rainwater harvesting tanks. Subsequent to that, the towns of Griquastad benefited from 150 rainwater tanks, Loeriesfontein 88, Mier 56, Douglas 69 and Kareeberg 20. The department had also provided static storage tanks at strategic locations and the carting of water by tankers to severely drought stricken areas. Water tankering to critically affected communities is procured by DWS, municipalities, community based organisations (CBO's) and Non-Governmental Organisations (NGO's) as an emergency measure to deal with the drought situation. Ten (10) tankers had been allocated and the allocations are determined and based on a needs assessment and business plans submitted. Although tankers have already been procured, due to the increasing severity of the drought, it was expected that further tankers would be required.

The department was working towards securing more funds to support this growing need. Water restrictions were continuing in Brandvlei, Loeriesfontein, Williston, Vanwyksvlei, Victoria West and Loxton. Medium term solutions for the department include among other things domestic rainwater harvesting, conducting a hydro-census on groundwater utilization to facilitate future good groundwater management, and to integrate groundwater and surface water use. Long-term plans include the construction of new dams and reservoirs, reviewing all state-owned reservoirs operating rules, and finding long-term solutions to Acid Mining Drainage (Department of Water and Sanitation, April 2016).

1.6.3.2 Kwa-Zulu Natal

Water and Sanitation Deputy Minister Pamela Tshwete visited the Zululand District Municipality (ZDM), communities to engage with residents on drought related issues. The Department of Water and Sanitation during the 2015/16 financial year provided R39 693 000.00 drought relief funding to the Zululand District Municipality (ZDM), under which eDumbe Local Municipality falls. About 12039 households from eDumbe benefited from this water tankering intervention. Interventions in the area also involve drilling, testing, and equipping of three boreholes, installation of two JoJo tanks and construction of a pipeline in town. Costs of this intervention were estimated at R908 049.00. The intervention was still on going. In response to the persistent drought, the KZN Regional Office together with KZN Cooperative Governance & Traditional Affairs Department formed the ZDM Joint Drought Operation Committee (JOC) as one of initiatives to manage and mitigate the drought impact in the affected areas. About R17 million from its MIG funded rudimentary projects in the new financial year, i.e. 2016/17, to fund new additional drought interventions (Department of Water and Sanitation, July 2016).

The Deputy Minister of Water and Sanitation, together with other designated people led a public participation programme (PPP) in eDumbe, KZN. It was highlighted that water access backlog within the district stood at 32%. The JOC is comprised of various stakeholders including local municipalities, other government departments, non-governmental organizations, etc. Through the guidance of the JOC, various short-term projects, focusing on ground water management, spring protection, fixation of leaks, implementation of water restrictions to ensure sustainability or stretch the available water resources were looked at (Department of Water and Sanitation, July 2016).

1.6.3.3 Free State

The DWS Regional Head for the Free State, Dr Tseliso Ntili, established a team after rising concerns that the Vals River that feeds Moqhaka Local Municipality might be running dry due to minimal rainfall. The team came up with short and medium-term solutions that would assure the supply of water to the three towns, namely Kroonstad, Steynsrus and Viljoenskroon. These solutions included supplying Jojo tanks, water tankering, drilling new boreholes and refurbishing existing boreholes, plugging leaks and re-using effluent, amongst others. Long-term solutions would also be tabled by the team (Department of Water and Sanitation, May 2016).

1.6.3.4 Mpumalanga

Rolling of Drought Relief Programme for all drought-stricken Mpumalanga farmers by the Department of Agriculture, Rural Development, Land and Environmental Affairs Provincial Cabinet evoked section 41 of the Disaster Management Act, and declared the drought experienced in the province as a disaster. The MEC pronounced that the department had allocated R33 million, which would be used for the provision of fodder, salt and water tanks to the areas, which required immediate relief aid. The hardest-hit farmers were encouraged to visit their nearest regional agriculture offices to get assistance and to apply for the drought relief programme (Department of Agriculture, November 2016).

What are regarded as provincial governments strategies are actually national government interventions in various provinces. It can be concluded that the implementation of provincial government drought strategies has been slowed down at their level, and has cost the intended beneficiaries. However, it can also not be questioned whether the provincial government officials have the capacity to execute the policies and to what extent they could do so. It is evident that the issue of political will could be a play, therefore, making the issue complex and sensitive.

A snapshot at the above few “provincial” governments’ strategies/programmes that were implemented support the argument that government of South Africa has not translated its policies into a reality that could benefit farmers who have suffered great loss due to devastating drought across the country. Some of the implemented programmes did not directly benefit the farmers, they were reported as they were delivered to give a clearer view that focus had shifted from assisting farmers to cope with drought. This is not surprising, as alluded to earlier, although there was a paradigm shift in the approach in which government would manage drought, this has not materialised, at least for farmers. Most farmers are poor, and when drought strikes without them being prepared and receiving relevant assistance, it exacerbates poverty and further marginalises them since the majority entirely depend on subsistence farming for survival.

1.6.4 Drought response from other stakeholders

As mentioned earlier, the government does not work in isolation in addressing the drought crisis. It was reported that the Department of Water and Sanitation (DWS) continues to collaborate with the private sector and other sectors of the South African community in efforts to relieve the impact of the current drought on affected communities countrywide. In the latest collaboration effort, the DWS continued the grand partnership with Operation Hydrate and Awqaf SA (Department of Water and Sanitation, July 2016). This collaboration would result in the drilling of 67 new boreholes, symbolizing the 67 Minutes of volunteerism expected from every South African in recognition of Mandela Month. The investment towards this effort stood at R10 million. The Minister of the DWS, Ms Nomvula Mokonyane, in appreciating this continued partnership, indicated that civil society was continuing to collaborate with government and this made them proud. Mr Yusuf Abramjee, speaking on behalf of Operation Hydrate and Awqaf SA, indicated that the NGOs and their partners would continue in their work to keep up the spirit of Ubuntu (Department of Water and Sanitation, July 2016). In this partnership, the government would identify where the need of water is. It implies that the government has once again assumed its responsibility to spearhead development in every aspect of its people. However, it is believed that NGOs commonly work closer with people, and have the ability of understanding people better. It would be more efficient if they were given independence to assist people as they see fit.

In 2015, Agri SA established a Drought Disaster Relief Fund, to relieve the severe drought conditions, which hit South Africa in the last two quarters of 2015 and during the first quarter of 2016. Wimpy SA conducted a promotion in support of the Drought Fund where proceeds from all funky cappuccinos sold would go to farming communities in need (Agri SA, 2016). However, this promotion was limited in certain branches, therefore, not reaching all affected communities.

AgriSA, in partnership with Shoprite, brought relief to farming communities across the country, which were mostly affected by the drought, through its #ActForChange Fund (AgriSA, 2016). The fund was launched following requests by consumers who want to make a difference in communities affected by natural disasters such as the recent droughts, as well as in the communities experiencing serious challenges such as poverty and food scarcity (AgriSA, 2016). As part of on-going relief efforts, on 12 May 2016, Shoprite and AgriSA delivered food parcels to 150 impoverished farming families in the community of Jozini in the Umkhanyakude District in KwaZulu-Natal (AgriSA, 2016). Additionally, Agri Roodeplaat and the AgriSA Hope Grass Project in collaboration with Kwanalu also distributed fodder to farmers in the Makhathini Flats Community.

Standard Bank has been involved with various initiatives (such as operation Hydrate) to cushion the devastating impact of the drought, and has since, via its Agribusiness unit, contributed a significant amount to the drought relief fund managed by AgriSA, as an attempt to keep the farmers in business and on the land, contributing to food security (AgriSA, 2016). As the farmers in the summer rainfall regions prepare for the next production season, Standard Bank will, within the framework of the relevant regulatory environment in which it considers lending, assist its agricultural clients on a case-by-case basis. The bank will take cognizance of the impact of the drought on every specific case and exploring all avenues and alternatives to keep farming businesses going (Agri SA, 2016).

Shell donated R1 million to AgriSA's Drought Relief Fund, directed at supporting farmers in Springbok and surrounding communities in the Namaqualand region of the Northern Cape (AgriSA, 2016). Niemann, Shell General Manager Sales, Commercial Lubricants, acknowledged that although government has contributed a significant amount toward drought relief, the public sector could not address this dire situation alone and additional support from the private sector was crucial.

1.7 EARLY WARNING SYSTEMS

1.7.1 Types of Early Warning Systems

An Early Warning System (EWS) is a system of data collection that facilitates the detection and monitoring of disasters in order that action can be taken to reduce the effects of the disaster in some way (Monnik, 2016). This data should be collected and disseminated to the intended recipients in a timely and meaningful manner so they can prepare for the impending hazard and minimise the effects. Early warning systems aim to reduce vulnerability and improve response capacities of people at risk, thus, governments maintain EWS to warn their citizens and themselves about impending hazards, resulting for example, from health, geologic or climate and weather-related drivers (Wilhite, Sivakumar and Pulwarty, 2014). In order for EWS to be effective, they should address four key elements as defined by the United Nations International Strategy for Disaster Risk Reduction (UNISDR). The components of effective EWS include

a) Risk identification

b) Monitoring and warning system

c) Warning dissemination

d) Response actions (Monnik, 2016)

Effective drought early warning systems must integrate precipitation data with other data such as stream-flow, snowpack, groundwater levels, reservoir and lake levels, and soil moisture in order to assess drought and water supply conditions (Wilhite *et. al.*, 2014). For most locations, drought forecasting and early warning is still a linear process based on a “sender–receiver” model of risk communication. It is more effective to design drought early warning and information systems (DEWIS) that rely on multiple physical indicators and climatic indices in combination with social indicators (Wilhite *et. al.*, 2014). Effective DEWIS are an integral part of efforts worldwide to improve drought management and preparedness and must be the foundation of mitigation plans and a national drought policy (Wilhite, *et. al.*, 2014).

1.7.2 Early Warning Systems in South Africa

South Africa has a number of, and is in the process of developing more, EWS for different sectors and different weather-related hazards (Environmental Affairs Report, undated). SAWS is the legally mandated institution, as per the Weather Service Act (Republic of South Africa 2001), responsible for weather and climate forecasting and the issuing of severe weather-related alerts (Environmental Affairs Report, undated). SAWS has adopted the Multi-Hazard Early Warning Systems (MHEWS), which makes use of multiple monitoring systems and meteorological, hydrological and climate information to prepare for and respond to multiple weather-related hazards (Environmental Affairs Report, undated). The SAWS Severe Weather System disseminates early warning information to affected communities about potentially damaging weather events (e.g. heavy rain, heat waves and cold weather). SAWS has collaborated with a number of research institutions and government departments to develop a number of other EWS, work is underway to improve EWS in South Africa in order to improve the communication and dissemination of information at the local municipality and community level (Environmental Affairs Report, undated).

Effective Drought Early Warning Systems (DEWS) have high potential in making a contribution towards tackling the cycle of droughts, by way of providing timely, relevant and comprehensible information on impending droughts (Masinde, 2014). Successful DEWS in turn rely on weather forecasting systems, but implementation of such systems in many African countries is hampered by among other things, inadequate coverage by weather stations (Masinde, 2016). Farmers are further hampered by very poor utilisation of the Seasonal Climate Forecasts (SCFs), mostly because the content, format and dissemination channels used do not address the farmers' needs; hence they continue to rely on their local/indigenous knowledge forecasts (IKFs) to derive critical cropping decisions (Masinde 2014).

The Drought Management Plan seeks to reduce the impacts of droughts by providing information management, monitoring and evaluating systems for the early warning of droughts (Ngaka, 2012). Another example of a drought EWS is the Umlindi system developed by the Agricultural Research Council (ARC), which provides information on drought conditions based on the interpretation of satellite and climate data. The SAEWS aims to be an integrated, end-to-end EWS, right down to community level, incorporating all four elements of an effective EWS and involving all stakeholders (Poolman, undated). Gaps in the implementation of EWS in South Africa

Information is disseminated to the Disaster Management Centre (DMC) and public prior and during events via internet, email, telephone, television, newspapers, radio, local disaster managers (Poolman, undated). However, there is lack or limited institutional knowledge on how to secure funds, and municipalities do not budget for Disaster Risk Reduction (DRR) programmes (CSIR, 2014).

Reports show that, despite the existence of South African National Disaster Management Center (NDMC), the uptake of EWS remains slow (CSIR, 2014). It was added that provincial offices of Department of Agriculture, Forestry and Fisheries (DAFF) remain incapacitated and constrained because of the lack of structure and defined roles for individuals (Anonymous, 2014). Botha *et al*. (2011) found that 50% of local municipalities in South Africa lacked the disaster management structures, while 68% of local and 25% of district municipalities did not have disaster management advisory forums (CSIR, 2014).

Dissemination of warnings to all levels of society remains a challenge (Department of Environmental Affairs, Undated,). Effective dissemination of warnings to all levels of society are still a problem and need significant support and participation with other structures, including disaster management, media and other role players (Poolman, undated). The Minister of Corporative Government, Mr Van Rooyen, admitted in his speech, “Our people do not have much information”. He added that there should be increased communication of drought-related information to all communities. Jordaan, (2012), argued that, in addition to the accuracy of forecasts, the challenge is of communicating the forecasts and early warnings in such a way that they reach all farmers and stakeholders. Few farmers understood the methodology used to illustrate the forecasts in the first place and the communication channels used for seasonal forecasts were not as effective as the communication channels used for daily and weekly forecasts (Jordaan, 2012). Meteorological drought is the first indicator of drought and is usually a region-specific expression of precipitation’s departure from normal over some period of time (Backeberg and Viljoen, 2011).

However, weather forecasts, although they could be largely reliable, they can never be fully trusted. According to Jordaan, (2012), one cannot value the accuracy of meteorological forecasts, which is an indication of drought early warning from one year’s forecasts and blame the weather service for poor forecasting, but the vagueness of the forecasts gives some perspective on the scepticism of farmers regarding the meteorological forecasts available (Jordaan, 2012). It is argued that farmers do not adjust their management practices sufficiently according to the meteorological forecasts since they have little trust in current forecasts (Jordaan, 2012).

It is evident that government assistance might be reaching a few, fortunate smallholder farmers. The commercial farmer has no place in the drought relief programmers. However, in terms of access to early warning systems and any other resource that enhance farmer decision making in terms of drought, the commercial farmers are better positioned. Reports show that the sources used to communicate agricultural related information are almost beyond reach by the poor, rural, smallholder farmers (Jordaan, 2012). While this is the situation, it is understood that farmers who would qualify for soft loans or any other forms of drought relief were those that would have adhered to the requirements of the National Disaster Management Act. This poses a serious challenge for the poor farmers who might have missed most of the information as it is availed.

The delivery and uptake of information is limited in most communities, and by most stakeholders. It is argued that there is need for the development of tools that can translate information to end users (CSIR, 2014).

1.7.3 INDIGENOUS KNOWLEDGE AND DROUGHT

Indigenous/traditional knowledge (IK) is described as the knowledge of an indigenous community, accumulated over generations of living in a particular environment (Masinde and Bagula, 2012). It is traditional cultural knowledge that includes intellectual, technological, ecological and medical knowledge. Johnson (1992) defined indigenous knowledge as a body of knowledge built up by a group of people through generations of living in close contact with nature. This knowledge is established where people have survived for a very long time and have become familiarised with their surroundings. Indigenous Knowledge Systems, in South African context, refer to bodies of knowledge embedded in African philosophical thinking, and social practices that have evolved over thousands of years (Maferetlhane, 2012). The Cabinet approved the Indigenous Knowledge Systems Policy in 2004, which provides a broad basis for the recognition, understanding, integration and promotion of Indigenous Knowledge resources within South Africa (Maferetlhane, 2012).

Reports show that there has been a sharp increase in publications in the area of indigenous knowledge in Africa, especially in South Africa, where tens of research projects are funded through the National Research Foundation (Loubser 2005). Despite this encouraging trend, publications in the category of weather/droughts/climate-variation prediction are still rare, and specifically, studies on agriculture and environment are minimally represented as compared to other categories like culture (Masinde and Bagula, 2012). Generally, publications on IK on drought/weather management in Africa reveal that communities in Africa use more or less common approaches to predicting drought and weather (Masinde and Bagula, 2012). They observe the changing seasons, lunar cycles, natural environment, like behaviour of animals/birds and the appearance of certain plants (Alcock, 2010, Masinde and Bagula, 2012, Ncube and Lagardien, 2015,). Like modern weather forecasters, IK also involves studying meteorological parameters such as air temperature, cloud colour and direction, and wind direction (Masinde and Bagula, 2012). It has been noted that researchers today concur that indigenous knowledge and modern science complement each other. In order to develop sustainable strategies, it is therefore important to take into account of, and learn from, what local people already know and do, and to build on this.

1.7.4 Indigenous drought coping and adaptation strategies

According to the study carried out by Ncube and Lagardien (2015), farmers in the Karoo region were using local known strategies to cope and adapt to droughts and have been doing this for many years. After heeding to the indigenous drought indicators, for example the ones that have been discussed, farmers attempt to prevent, manage and cope with drought impacts, including water shortage management. Strategies that have been used to manage water shortages include planting and irrigating small areas, to use as little water as possible (Ncube and Lagardien, 2015). On adaptation, farmers harvest water from the mountains, drill boreholes, and construct stock dams to conserve water (Ncube and Lagardien, 2015), like methods reported in Zimbabwe where farmers were harvesting water from rooftops and diverting water from natural springs into tanks (Shumba, 2001). This ensures that farmers have a substantial amount of water stored up, and in case of a drought, the stored water would be able to sustain them for about five months depending on the volume of the tank.

Farmers in Karoo purchase lucerne from others to supplement their feed for animals. As an adaptation strategy, long-term storage of lucerne is also considered; by planting of saltbush, Prosopis and Agave is done to provide animals with alternative feed species. Farmers also slaughter or sell their animals, leaving the breeding herd so that the business can continue. Some market their livestock early before their quality is affected by drought (Ncube and Lagardien, 2015). Drought-resistant herd and low-input systems are also adopted to adapt drought in the long term. For fruit producers, producers grew short-season cash crops to improve cash flow and change systems to alternative high value crops and enterprises (Ncube and Lagardien, 2015)

To mitigate the effects land degradation, farmers grazed their animals alongside the roads, or migrated animals to areas with more grass and they imported fodder from other regions (Ncube and Lagardien, 2015). Medium term strategies included rotational grazing, and pen feeding, treating animals with natural plants, traditional animal disease management, building of weirs and slots to provide long-term erosion control and construction of contours across slopes to conserve soil (Ncube and Lagardien, 2015).

1.8 CONCLUSION AND RECOMMENDATIONS

The review shows that South Africa is a dry country that is prone droughts. A closer look at the provinces shows that they experience drought differently, according to climate. The country is currently experiencing suffering a severe drought. However, the amount of information available at the time of this review did not reflect the severity of drought experiences by the South African agricultural sector; neither did it reflect the work done by the government to mitigate drought effects. The limited information available shows that, the government of South Africa understands and acknowledges its mandate to manage drought. This is evidenced by the existence of good policies and strategies to assist its people to cope with drought. However, it remains, that, comparing policies and what has implemented, drought management for farmers is far-fetched. Despite the holistic approach that the government established and desires to embark on, it is evident that the drought management focus has remained reactive rather than pro-active.

A review of some reports that highlight the complexity of dealing with drought effects in most of the countries worldwide, it is evident that South Africa is not an exception. Therefore, it can be argued that there is need to invest in planning for drought prevention measures than to spend more than what is adequate on mitigating drought effects. It is a real test of willingness on the part of South African government to invest in preventing drought in the agricultural sector. Great commitment and political will is required by the government to implement drought policies. According to Szöllösi-Nagy, 1999), drought planning is the action taken by individual citizens, industry and the government in advance to mitigate impacts and conflicts arising from droughts.

This could include planning for water storage since generally; water storage provides a mechanism for dealing with drought, which, if planned and managed correctly, increases water security, agricultural productivity and climate change/ variability adaptive capacity (Mwendera, 2016). Building dams with large storage capacity is one of the strategies governments use to match water demand with stored supply, and for security against the risk of drought (Mwendera, 2016). One of the indicators of water resources deployment is the water storage capacity, which is the amount of water stored in reservoirs per capita (Mwendera, 2016). Improved water resource management and water storage capacity make the economy more resilient to external shocks, such as rainfall variability and drought, and thus provide a stable and sustainable base for increased food and industrial productivity and production to maintain economic growth and development (Mwendera, 2016).

People must also be empowered through educational programmes so that they understand risks and ways of mitigating and avoiding drought. Farmers need to own their strategies, rather than depending entirely on the government to rescue them. There is need to complement science with other knowledge that reduce vulnerability to drought effects, such as resource management, indigenous knowledge and communication of scientific information. It is recommended that focus should be on both the improvement of government response to drought emergencies and on greater attention to reducing risks associated with drought occurrences. Makube (2016) suggests that the government should focus on supporting farmers with feed, production and labour subsidies in order to keep them on the land, improving irrigation infrastructure to ensure increased production and sustainability of supplies, encouraging diversification to ensure alternative sources of income and exploring crop insurance programmes that can act as safeguards for producers in the future.

CHAPTER 2: DROUGHT COPING AND ADAPTATION STRATEGIES

2.1 INTRODUCTION

There are a number of reasons why drought response is ineffective in South Africa and the region. There is limited understanding of the scientific basis of droughts, the definition, monitoring, impacts, prediction. Drought knowledge is scattered in in departments and there are experts involved in various aspects of drought management. Understanding the historical frequency, duration and spatial extent of drought could assist planners in determining the likelihood and potential severity of future droughts. At the same time, successful experiences in adopting comprehensive and active approach across various sectors in dealing with droughts should be widely shared and the capacity to apply such approaches built and developed where needed. The need to efficiently use water during drought has become critical for the agriculture industry. A number of strategies such as supplementary irrigation through dryland rainwater harvesting have been tried and proved to substantially improve water usage and crop productivity (Biazin et al., 2011) during droughts. To ameliorate the impacts and effects of drought on the veld it is essential that special attention should be given to the timely implementation of necessary precautionary measures and drought management practices (Booysen and Rowswell, 1983). However, this information is not readily available to farmers. There is a lack of timely and coordinated approaches for responding to drought; farmers receive assistance which usually arrives too late for most farmers after they have already lost their crops and livestock (Ncube and Lagardien, 2015).

This chapter covers the second aim of the project which is a review of drought coping and adaptation strategies in dryland cropping systems, irrigation, livestock and mixed systems. The chapter defines vulnerability, and then gives a brief history of drought in South Africa. Selected coping and adaptation strategies adopted in other countries are then outlined. Finally, the report then identifies strategies that have been adopted in South Africa during the past and current drought.

2.2 DROUGHT VULNERABILITY

According to Patrick (2003), vulnerability to drought is complex, yet essential to understand to be able to design drought preparedness and mitigation strategies, relief policies and programs. The further states that response options available to less prosperous households or societies are very low. Poverty and vulnerability are not the same, two households or societies may have similar levels of poverty but different levels of vulnerability, for example, one household or society may be primarily dependent on just one or two forms of income generation, such as mono-cropping for exports, while another may depend on diversified livelihoods. Both groups can have the same level of income, yet, when they are both exposed to a shock such as a drought, the former will likely become poorer than the later because there is a greater exposure to risk and/or because they have fewer response options.

Most definitions of vulnerability contain a common thread (Wilhelmi and Wilhite, 2002). They all agree that vulnerability shows the degree of defencelessness of society to a hazard, which could vary either as a result of variable exposure to the hazard or because of coping abilities. Coping abilities according to Downing and Bakker (2000) include protection and mitigation. Selvarajan et al. (2002) define vulnerability as the extent to which a natural or social system is susceptible to sustaining damage from climate change. Downing (1991) defines it as an aggregate for a given population or region of underlying factors that influence exposure to famine and a predisposition to the consequences of famine. Adger (2000) describes social vulnerability as the exposure of groups or societies to stress resulting from the impacts of environmental change. Social vulnerability generally consists of disruption to livelihoods and loss of security.

Binayak (1996) on the other hand defines vulnerability from two perspectives: the first perspective is the 'risk-centric view' whereby vulnerability is typically defined as variability in the living standard caused by consumption or income shocks, the second is 'right-centric view' whereby vulnerability is said to be caused by lack of social and political rights. Both views are important when considering the implications of vulnerability for drought reduction. The common understanding of the above definitions is the expression of susceptibility to hazards, either as a result of varying exposure to hazards or because of variations in the ability to cope with its impacts.

Selvarajan et al. (2002) also believe that vulnerability has two sides: an external side of risks shocks to which an individual or household is subjected and an internal side, which is defencelessness, meaning a lack of means to cope without damaging loss. Dow (1993) gives vulnerability factor as characteristics of the environment, individuals, and society. These contributing factors include economics, technology, social relations, demographics and health, biophysics, individual perception and decision-making and institutions.

Factors such as economics, technology, and infrastructure are better understood, while individual and societal factors are more difficult to understand and conceptualized. Vulnerability has damaging effects on livelihoods and not just life and property; the most affected people are those that find it hardest to reconstruct their livelihoods following the disaster (Wilhelmi and Wilhite, 2002). The authors state further that vulnerability is closely correlated with human infrastructure and socio-economic conditions, and as a rule, the poor suffer more from hazards than the rich, although poverty and vulnerability are not always correlated. Drought vulnerability varies for different individuals and nations. In developing countries, drought vulnerability constitutes a threat to livelihood, the ability to maintain productive systems and healthy economics; while in developed economies, drought poses significant economic risks and costs for individuals, public enterprises, commercial organisations and governments (Downing and Bakker, 2000). The degree to which a population can be affected by drought depends largely on various response or coping options available to them, or their degree of vulnerability, which in turn can be decreased by adequate pre-drought planning and mitigation of effects during the event or the lack of it.

The combination of environmental and economic changes is altering the context under which farmers in southern Africa cope with climate vulnerability (Leichenko and O'Brien, 2002). In order to be able to design successful strategies for drought preparedness and mitigation, there is a need to understand who is vulnerable and why they are vulnerable. Such examination can point to structural and socio-economic issues which present societies with difficult choices between consumption today and investment in crisis for the future.

South Africa has struggled to effectively plan for and to deal with the impacts of drought in farming systems. The reasons for this are both historical and also related to planning and the socio-economic environment. Before assessing the coping and adaptation strategies that are adopted in farming, it is important to present a brief history of drought in South Africa

2.3 HISTORY OF DROUGHT IN SOUTH AFRICA

The story of drought in South Africa began as far back as the 1800s a number of drought events were noted in the country and continue to be recorded. Van Zyl and Vogel, 2009 report in the Farmers Weekly Magazine that serious drought spells occurred in the 1800s, these periods includes 1812-1815; 1817-1819; 1827-1829; 1834-1838; 1844-1862; 1866-1869; 1876; 1887-1888 as well as 1896 and 1898. The authors also state further that in the last century, a major drought occurred during 1904-1908; 1912-1916; it was recorded that the drought of 1919 was a very severe one, the record continued from 1922-1924; 1926-1928; 1930-1933; 1935-1938; 1960s; 1970s; 1980s and 1990s.

2.3.1 Drought experiences during early 1800

There are limited official reports on impacts and associated responses to early drought in the first decade of the 19th century. Reports on drought records showed negative impacts on farming activities and large numbers of livestock mortality were reported. Coping mechanisms included moving animals to areas with better grazing and water availability. van Zyl and Vogel (2009) report that apart from the drought severity itself, there were other factors that significantly added to suffering from drought effects by farmers. These factors included lack of clear official institutional responses to drought. Human resource-use behaviour; including land-use practices severely impacted on vegetation change which ultimately heightened the drought impacts on the farmers.

2.3.2 Drought in South Africa from 1900 to 1950

This period was groundbreaking in the history of agriculture and understanding of the great drought problem in South Africa. According to van Zyl and Vogel (2009), the period saw researchers bringing about valuable research results about droughts as well as suggestions for policies on drought management, some of which are regarded as still suitable today. Various investigations on drought impacts on agriculture and the economy were undertaken during this period.

van Zyl and Vogel (2009) also highlight various committees or reports of committees which were commissioned by the government to look into best possible by which losses as a result of drought could be reduced or avoided. Such committees include:

select committee on drought, rainfall and soil erosion (June 1914), Union of South Africa interim report of the drought investigation commission (1922), final report of the drought investigation commission (1923), national provision against drought (1941), phase relief scheme (1946) and the report of the fodder bank committee (1949). Some of the reports gave the main factors causing drought losses as the kraaling of stock; inadequacy of drinking water facilities, the destruction of vegetation and resulting soil erosion which in turn led to diminishing efficiency of the rainfall. The key areas of concern by the drought investigation commission included overstocking which was very prevalent throughout the country, extreme seasonal variations.

Efforts during this period constituted the first official attempt at a systematic and coordinated analysis of the fundamental shortcomings on farming. Public attention was directed at problems of soil erosion and drought, which were seen as threats to South Africa's progress which was essential to adapt farming systems. It was also concluded that certain interacting factors heightened drought impacts in South Africa, and these included soil erosion and animal diseases.

2.3.3 Drought in South Africa from 1950 to 1980

The drought spells of the 1960s and 1980s emerged as key periods of persistent drought spells in the latter half of the 19th century. van Zyl and Vogel (2009) stated that the years of consecutive drought were observed in various areas including the North-Western Cape, northern areas of the country, Transvaal, and the Free State. In March 1961, the Department of Agriculture's Technical Services appointed a committee to enquire into the Feeding of Animals in times of drought. Supplementary research and extension services were necessary for the guidance of farmers in th efficient feeding of animals in times of drought, planning and management measures to prevent and/or alienate the adverse effect of drought, methods of providing fodder for use during periods of drought; on farms, from other sources, with attention to the possibility of efficient utilization of feeds, such as maize, Lucerne hay, as well as the conservation, storage and the distribution of supplies of fodder. During these periods, van Zyl and Vogel (2009) state that it was mandated that if a farmer had followed a correct farming practices as stipulated by the government and never the less fallen a victim to drought, the new Department of Agricultural Finance would be ready at all times with a drought relief fund out of which assistance could be given. This was to enable the farmer to move his stock to suitable grazing and back or to buy fodder for the animals.

In the 1960s, a number of surveys on the drought situation were carried out in several parts of the country. As a result of such surveys; a comprehensive memorandum was prepared and submitted to the Agricultural Advisory Council and the Minister of Agriculture. The result of the investigations confirmed some problems of farm units that were also a symptom of what was occurring in the rest of the country, which paved way for the legislation on the subdivision on Agricultural Land in 1970.

On 7th May 1966, the state President appointed the Commission of Enquiry into Agriculture (Marais Commission) to lay down the basic principles for healthy farming systems in the republic (both economic and biological), to determine in what respects, branches, and regions the farming systems fell short and why, as well as to specifically investigate and make recommendations in respect of the reconstruction of agriculture in regions particularly subjected to drought conditions and to report thereon interim. This commission gave an interim report in 1968 with recommendations on a wide range of matters including many pertaining to drought. They considered just like former commissions, that droughts of shorter or longer-term duration were a characteristic and inevitable phenomenon, which would be expected to occur with certainty over large parts of the republic at least once in five years.

2.3.4 Drought in South Africa from 1980s to 1990s

According to van Zyl and Vogel (2009) in the 1980s and 1990s, there was an increase in drought occurrences and experiences which became more regional when it came to reporting on drought impacts. In the early 1980s, the declaration of drought was based on the criteria such as rainfall over three seasons, veld condition, availability of water for stock, stock condition/deaths and availability of fodder to be purchased with a disaster drought being declared if rainfall over two consecutive seasons was 70% or less the average main precipitation of the area concerned (Baloyi, 2010).

The 1982/1983 and 1991/1992 droughts were the most severe meteorological droughts of the 20th century in Southern Africa. In the 1991-92 droughts, 70% of the crops failed. It was estimated that half of the population in the affected area was at risk of malnutrition, and other related health problems (Monnik, 2000). As a result of drought in the 1980s, the agricultural sector suffered a great deal, during these periods, an estimated R3 billion debts escalated from an emergency assistance to the agricultural scheme (van Zyl and Vogel, 2009). Pre-1990 drought policy was directed primarily at stock farmers according to Monnik, (2000) because stock farming was considered to be best adapted to the highly variable rainfall conditions in South Africa.

Relief aid tended to favour the poor and climatically marginal areas. Van Zyl and Vogel (2009) stated that drought of the late 1980s and early 1990s resulted in government bailing out farmers with large sums of money through the Agriculture Department. This led to the beginning of a change in policy direction, at this time; the government decided that no future financial aid would be made to Agricultural Producers. There was a shift in paradigm in 1994 (Walters, 1993; Monnik, 2000; O'Meagher *et al.,* 1998), this resulted from a change in the political dispensation, the disaster aid, especially drought assistance was to be revised to make way to develop a more proactive response to the drought phenomenon; this was reflected in the 1995 White Paper on Agriculture which has the following, "Agricultural production and practices would be organised in such a manner to improve national as well as household food security. Drought will be recognised as a normal phenomenon in the agricultural sectors and it will be accommodated as such in farming and Agricultural Financing Systems. The Government should not support measures that soften the negative impacts on farm incomes caused by poor risk management, as this will cause farmers to use high-risk methods which could endanger resource conservation, farming systems, which make provision for drought as a normal phenomenon in South Africa should be developed. In addition, the Government should, therefore, support the full spectrum of production systems and practices, from urban food garden and small-scale production for household income and food security to large-scale production systems, which can add considerably to national food security. And lastly, in the case of natural disasters, the government will be responsible for giving assistance to counter unacceptable consequences as far as possible."

Natural disasters such as floods, runaway veld fires, severe droughts and untimely frosts can totally disrupt communities and can force farmers, over the whole spectrum of farm sizes out of business. Such disasters do not include natural phenomenon, which occurs on a regular basis, such as intermittent droughts in stock-production areas and hailstorms in hail-prone areas. In the case of natural disasters, it is in the interests of the country as a whole that the Government should take steps to counter unacceptable consequences for the rural economy. Such steps could include financial assistance to the Agricultural sector.

2.4 ROLE OF EARLY WARNING SYSTEMS IN SOUTH AFRICA

Monnik (2000) defines an early warning system as a system of data collection that brings about the detection and monitoring of disasters so as to put in place necessary measures to reduce the effect of the disaster. The real importance of an early warning system is to provide adequate information to required agencies in order to be able to put up timely measures to counter or manage the effects of the impending disaster. The following are parameters that should be included in an ideal early warning system: meteorological information, agricultural information, production estimates, price trends of food and feed, availability of water and household vulnerability. A dependable early warning system should incorporate some physical aspects such as spatial extent of drought, duration of drought, time of occurrence of drought in relation to the crop calendar and severity of drought.

The primary users of early warning systems in South Africa include government departments, the agricultural industrial organisations as well as commercial farmers. Over the years there has been a loss of faith in the forecasts. For instance, in 1997, it was forecasted that a large El Nino event would take place which led to a noticeable response from the private sector such as a 20% reduction in tractor sales, but the impact of this ENSO event on South Africa rainfall was minimal (Monnik, 2000). As a result of changing government policies on disaster management, more responsibilities are being placed on the farmers to manage themselves and cope with periods of disasters such as drought. As such, a more reliable system would be required to enable them to be able to anticipate such disasters so that they can effectively respond. A good early warning system brings farmer representatives and government together to decide on the appropriate combination of crops to sow in order to maximise the overall yield. It also helps in the management of water resources, agricultural planning and adequate management of reserves of grains and fuel oil.

Measures taken in anticipation of severe droughts in early years in South Africa included stock transfers, where livestock could be conveyed out and back to better pastures, fodder could be railed to drought-stricken areas at one-quarter the original rate. These were usually done with co-operation between Railway co-operation and National Treasury in South Africa. Fodder banks were also created, with the government contributing 75% of the total storage and administrative costs. A committee was established to draw up a permanent drought aid plan. This plan was premised on the understanding that farmers should be enabled as far as possible to make their own provision against normal droughts, only when a very long period of drought prevailed would the state assistance be required. During these periods, farmers were encouraged to save in good years and such savings were not taxable in the Land Bank. Planning by farmers whose farms were situated in proclaimed soil conservation districts was required; otherwise, such farms would not be able to make use of the state's drought assistance scheme.

2.5 CURRENT DISASTER MANAGEMENT IN SOUTH AFRICA

Although various committees presented recommendations to drought in South Africa, recent drought proved that actual practice on the ground remains one of drought relief and response with few notable cases of drought-risk response being implemented (van Zyl and Vogel 2009). Various consultations with a range of stakeholders to bring about a new drought risk reduction policy that would reflect the international thinking of the time has been carried out. These include risk-reduction frameworks and development of a strategy to reduce the vulnerability of all South Africans at all levels, especially the poor and disadvantaged communities. This led to recommendations of the White Paper on Disaster Management in 1999, and the Disaster Management Act of 2002. From the National Disaster Risk Management Framework (NDRMT) of 2005, the Department of Agriculture accepted the primary responsibility of drought management by sharing responsibilities with other tiers of the government, organized Agriculture and the farming community. As a result, the Agricultural Drought Management Plan (ADMP) was brought into place by the Agricultural Department with the following roles: to integrate institutional capacity/arrangements, for disaster risk assessment, for disaster risk reduction, for response and recovery.

The Department of Agriculture was also expected to facilitate drought risk management; information management and communication, education, training, public awareness as well as funding for other programs prescribed by the NDRMT. The long term aim of the ADMP was to ensure that the Agricultural sector has an effective and integrated drought management system for plant, animal husbandry and income, where negative impacts of drought have been minimized for sustainable use of natural resources. This new policy exhibits a departure from the existing approach to disaster management. It brings about a rational national framework for disaster management aimed at integrating risk reduction measures into all development initiatives in order to avoid human, economic, and environmental and property losses. Although there was a paradigm shift in policy from reactionary to a more proactive measures, the focus on drought management across various governance scales has remained focussed on reactionary measures which includes large financial bailouts and subsidies rather than institutional capacity development and training in ensuring that drought efforts are more risk reduction in focus and where possible ensuring drought efforts are linked to various development initiatives (van Zyl and Vogel, 2009). For instance, as reported in the annual reports of National Department of Agriculture (1993/94), drought assistance to livestock farmers was about R143.7 million, free-of-charge transportation of donated stock feed/licks by rail was also offered by the government. Interests on loans by sugarcane farmers hit by drought were downwardly reviewed by the government subsidising the interest up to 8% per year. Assistance in 1994/95 was mainly loans and subsidies and the expenditure were less than in the previous year (1993/94). In 2001/02, Early Warning System (EWS) was established in collaboration with the South African Weather Service. Training of extension officers in the interpretation of weather climate forecast began, by 2002/03, a pilot project was launched regarding an awareness program on weather/climate interpretation and five of the country's nine provinces were visited. To date, only a few extension officers have been trained compared to the large farming community in South Africa.

In 2003/04 season, maize planting was the lowest in more than sixty years (NDA, 2003). A total of R500 million was approved by the South African Government as emergency drought relief fund in 2003/04 season, another R500 million was also approved for the preceding year. The funds were used for emergency relief to vulnerable rural communities, provision of fodder for livestock to both established and emerging farmers, as well as the provision of water for both human and animal consumption. The trends above show drought mitigation always taking the form of emergency relief; there is a need for the government to take more proactive measures as stipulated by the policies on natural disasters, especially drought.

2.6 COPING WITH DROUGHT: GLOBAL CASE STUDIES

Eriksen et al. (2005) describe coping mechanisms as the actions and activities that take place within existing structures, such as production systems. Kivaria (2007) defines coping mechanisms as responses of an individual, group or society to challenging situations. However, the coping mechanisms rest within the framework of the individuals/groups/societies risk aversion or tolerance level. In other words, coping mechanisms are instituted to minimize risk or tolerance level, or manage loss. According to him, some coping mechanisms may be brought into play by a stress factor; another factor may be to strengthen an already inbuilt strategy. According to Adams et al. (1998), the aim of coping is to maintain the various objectives of the households, including livelihood security, consumption, health and status, thus ensuring individual and/or collective well-being. These objectives include livelihood security and status, which are longer term objectives involving the strengthening of assets, income and social position to maximise future claim on resources. The other objectives are immediate and these are food consumption and health objectives, which involve finding sufficient food and income to meet the health and nutritional needs of the household.

Kinsey et al. (1998) noted that financial assets might have negative real returns as a result of non-market interventions (such as interest ceilings) and may, in addition, involve substantial transaction costs. Food stocks are subject to deterioration and livestock face risks of theft, disease, and loss from other causes. The result may be that household saving is largely for smoothing consumption rather than for accumulation.

Many countries have developed different coping mechanisms and adaptation strategies to survive drought. This section gives a few examples of coping mechanisms and adaptation strategies adopted by different countries during droughts in sub-Saharan Africa and Asia.

2.6.1 Coping and adapting to drought in Bangladesh

Droughts are a recurrent phenomenon in Bangladesh, afflicting the country at least as frequently as major floods and cyclones. Since its independence in 1971, Bangladesh has suffered severe droughts in 1973, 1978, 1981, 1982, 1989, 1992, 1994 and 1995 (Paul, 1998). Areas in Bangladesh are not equally vulnerable to drought. The North-western region of Bangladesh, popularly known as North Bengal, experienced a severe drought in 1994/95, which led to the failure of fifteen different crops. A lot of crops were affected because the drought period coincided with the 1994/95 planting seasons. As a result of the 1994/95 droughts according to Paul (1998) various adjustment, measures were taken by the affected farmers, and these includes household level adjustments as well as supports from both formal and informal sources.

North Bengal being prone to frequent droughts, the local communities have over the years developed a wide range of long adaptation and short-term coping mechanisms. These mechanisms include a crop replacement strategy, cultivation of more water-efficient crops such as kaon, jute, wheat and onion instead of the popularly cultivated rice. Some employed irrigation, gap-filling and inter-culture of some crops.

In developing countries, household and personal assets are not generally disposed of under normal circumstances. In times of drought, when domestic food stock becomes exhausted or very low, there comes the need to sell assets to raise cash to buy food. Non-agricultural adjustments practiced in North Bengal during the 1994/95 drought period included the sale of household belongings to buy food so as to reduce their vulnerability to the drought, including livestock, lands, the mortgaging of lands, poultry, and housing structures.

In the same study by Paul (1998) migration was not part of the adjustment, contrary to the expectations; members of only one respondent household migrated. This was contrary to expectation because usually, it’s a practice for drought affected families to migrate to other areas to seek income-producing employment that can help them to survive the drought period. Out-migration did not occur because people living in this area have frequently experienced a drought for over two decades and are now used to it. They do not consider migration as an option anymore as they believe that drought period would not persist forever. Some people who are affected by drought received help and support and sources from the community nearby. Although these supports were delayed and inadequate, some household received financial and other forms of support from various government and nongovernment services. This assistance included cash loans, foods, seeds and fertilizers.

2.6.2 The Kenya drought experience

Campbell (1999), reports drought coping and adaptation mechanisms adopted during the 1972-1976 and 1994-1995 in Kenya. Prayer and payment to a rainmaker, movement of livestock to areas with water and pasture, liquidation of assets, sale of land, use of environmental resources such as fire wood, use of moral economy, engagement in tourism and wildlife activities, horticultural activities as well as migration in search of jobs were some of the adopted coping mechanisms. During the severe drought in Kajiado district, praying for rain which is one of the universal responses to drought, furthermore, rainmakers were paid by both farmers and herders which were seen as an investment and therefore are related to the severity of the circumstances.

Livestock was moved to areas with secure water and grazing. In times of severe drought, the sales of livestock were significant among herders while working in town and selling crops was practiced by farmers. This was done so as to meet immediate needs for cash which included clothing, animals, and school fees, but the most important of all was food. Environmental resources employed included the gathering of wild fruits, hunting, and collection of wild plants to supplement food supplies.

During the drought of 1994-95, farmers engaged themselves in various activities such as trading in small stores or running a taxi as well as horticultural activities. As a long term strategy, the increased involvement of the areas affected by drought in cash economy and improved transport links with major cities of Kenya has opened up possibilities for migration in search of employment.

2.6.3 Botswana coping and adaptation mechanisms

The National Disaster Management Office (NDMO) under the Office of the President is responsible for coordinating disaster risk management activities in Botswana. Drought, however, is managed under the Ministry of Local Government and Rural Development through the implementation of the 1992 Drought Policy which gives priority to labour intensive public works to provide temporary employment as it aims to link relief and development (Buchanan-Smith and Tlogelang, 1994). During drought periods all ministries and local authorities are mobilized to assist in relief programs including public works projects designed to create employment during difficult times. The primary aim of the drought packages is to provide relief to human suffering and prevent loss of life.

The types and forms of emergency provided by government during times of drought include increasing the employment quota for intensive labour works (Ipelegeng), purchase of additional water bowsers to help augment human water supply shortages (emergency water supply), free supplementary feeding of vulnerable groups in schools and direct feeding for all children under the age of five years who attend child welfare clinics and other vulnerable groups. Provision of drought relief subsidies on selected livestock feeds, vaccines and supplements, cattle purchase schemes and monitoring of food supplies with the view of importing more if the need be being some additional measures undertaken.

In line with major agricultural policy changes in the world economy of the green agenda and the reduction of farm policy programs, the government in 1992 reviewed the Drought Relief Programme. Past relief measures that contributed to land degradation such as clearance and de-stumping schemes were dropped. Support was given to proposals that gave priority to investments in water conservation, appropriate land use, and improved management techniques. The introduction of the National Water Master Plan, National Conservation Strategy and Agricultural Policy contributed an implementation of this approach.

In order to address the drought situation in the short-term water restrictions and rationing were introduced. In the medium term, Government has put funds aside for the implementation of drought mitigation projects. These include projects to upgrade and refurbish boreholes, build treatment plants and upgrade water treatment schemes. To alleviate the impacts of drought related mortalities, farmers are encouraged to sell some of their livestock and to buy animal feed for the remaining. Cattle farmers are also encouraged to link up with arable farmers to use failed crop as fodder for livestock, Also the Livestock Advisory Centres are stocked with feed which is sold to farmers at a subsidised price during drought. The government has put in place measures to provide treated waste water from sewage ponds around the country for irrigation of horticultural crops.

Although Government has put in place strategies to mitigate the impacts of drought, there is a need to create awareness among the citizenry on the cyclic nature of drought as years of good rainfall are usually followed by those of drought conditions as such people should adopt coping strategies. Research institutions should develop drought forecasting models and enhance early warning systems to minimize negative impacts of drought on vulnerable groups. Consequently, there is a need to increase targeted training and development programs towards areas of scarcity and comparative advantage in Botswana.

2.6.4 The Zimbabwe 1992/93 experience

Kinsey et al. (1998) described drought as a major risk facing rural households in Zimbabwe. Rural households whose source of livelihood is dependent on agriculture face enormous risks, incomes are highly uncertain as a result of the effect of weather variability. The effects of the1991-1992 drought on food consumption were that it was below what it used to be, and was maintained partly through government’s drought relief programs. Individual farming household was unable to cope with drought without the help of the national government.

The main form of relief provided by the state was household income support operated by the Department of Social Welfare (DSW); this was in two categories; free food distributions for the elderly and the disabled as well as distributions on the basis of participation in food for work program for destitute families with able-bodied members. The food program also targeted children under the age of five. Income support was also provided to the needy household in the form of assistance with school and examination fees, seeds and fertilizer packs were also distributed before the subsequent season.

Other coping mechanisms adopted by farmers during these periods included gardening and selling vegetables, working as casual labourers, selling livestock and livestock products such as milk. Little use of credit was employed unlike in other countries of the world, except in rare cases. Sale of personal effects (such as jewelry or watches), household effects (such as furniture) or items of agricultural equipment to raise cash during drought emergencies did not occur among farmers in Zimbabwe.

2.6.5 Coping mechanisms in Ethiopia

The National Adaptation Programmes of Action (NAPA) has sorted out traditional and contemporary coping mechanisms to climate variability and extreme in Ethiopia. These mechanisms include changes in cropping and planting practices, reduction of consumption levels, collection of wild foods, use of inter-household transfers and loans, increased petty commodity production, temporary and permanent migration in search of employment, grain storage, sale of assets such as livestock and agricultural tools, mortgaging of land, credit from merchants and money lenders, use of early warning system, food appeal/aid, etc.

2.6.6 The 1992-93 drought in Namibia

Sweet (1998) states that prior to the drought of 1992/93; there was no institutional capacity to deal with serious drought or other environmental disasters in Namibia. Coupled with various efforts made by communal and commercial farmers to cope with the effect of drought as much as they could, the national drought task force was constituted by the government. There were many activities adopted by communal and commercial farmers as well as government efforts in mitigating the effects of drought.

During the period of drought when crop production or household income declined, rural households drew on a number of alternative sources for cash and food, such as livestock sales, assets sales, informal transfer, and borrowing. Three related coping strategies practiced were a reduction in non-food expenditures, rationing of available foods for both human and livestock consumption, and demographic adjustments. When livestock is threatened by drought, the main option is to sell some animals, buy in feed and/or move some animals.

Not many communal families sold domestic assets because they got free food from the government, but there was an outflow of household adults in search of food. Other methods employed by communal households in coping with drought included;

seasonal movements of animals which were evident in the Northern region where there was significant movement into Angola where less concentration of animals exists and there is the use of fodder provided by the government.

Communal households were generally reluctant to sell animals in a drought for a number of reasons: they were not commercially oriented and had different reasons for keeping livestock, the majority of their herd and flock size were small, by the time drought was apparent, the animals had already lost condition and their sale value reduced. Lastly, the sale points tend to be few and far between, at least in Northern region communal areas, and the stock lost further condition by the time they reached the sale point.

The commercial farmers were able to cope and manage the effect of drought better than the communal farmers, measures taken included a compensation scheme from government, availability of larger resources of capital to draw upon, better access to market and supplies for buying in and selling out, the main concern was to avert loss of livestock and wildlife unlike communal farmers who were worried about household daily needs and it was easier to obtain credits to fund mitigating drought activities because they had collateral.

The national government put in place various measures to mitigate drought, these measures included: preparation of an emergency drought budgets in 1992, appeal for donor support, an increase in allocation for water, food distribution to vulnerable groups i.e. children under 5 years old, pregnant/lactating women, elderly and physically challenged people. This was done to prevent drought relief dependency syndrome because almost half the Namibian population was at risk.

In trying to execute the above-listed measures by the Namibian government failure was encountered and this was due to non-availability of guidelines to classify a village or community as drought affected, hence all rural communities were included if they were in a region designated as drought affected. Another reason for the failure was that aid was targeted at individuals and it was distributed to the household for lack of guidelines to screen out wealthier households.

Other measures by the government included food for work, this is a situation whereby food aids were to be received by able-bodied adults in affected areas through a food-for-work scheme devised and run by local communities. This also failed due to lack of adequate coordination during drought as the intervals between submitting projects for approval and the arrival of food were too long, as such discouraging potential participants.

The government also provided fodder and lick subsidies for livestock farmers, grazing lands were purchased from small freeholders to serve as alternative grazing sites for livestock farmers and subsidies on transportation of animals to such areas were also provided. There was also the provision of emergency water supply; the main components of the water assistance offered under the drought relief program were in four categories which are the rehabilitation of disused or faulty boreholes, provision of new boreholes, extension of pipelines and branch lines as well as the provision of water tanker services with priority given to schools, clinics and disadvantaged rural communities.

Sweet (1998) concludes that failure was experienced in the drought relief program practiced during these periods, as a result, he recommended that the need for a better targeting of all drought relief subsidies, structure for food-for-work should be put in place before any drought period and above all, an effective early warning system is invaluable for timely implementation of drought mitigation and relief resources, but must be accompanied by an infrastructure for effective implementation.

2.6.7 Coping and adaptation mechanisms in desert regions

According to Bruchweiler and Gabathuler (2006), arid and semi-arid regions face increasing difficulties which include recurring drought, overgrazing, resource greedy agricultural production and population growth which causes disruptions and severe degradation leading to impoverishment, hunger, and distress. The main activities of desert regions include livestock production and gathering. Various management activities that have been in use for centuries in mitigating drought and desertification effects by an indigenous population increasingly prove inadequate. Until recently nomadism allowed for regeneration and perpetual use of natural resources but this can no longer support livelihoods. As a result of increasing numbers of livestock producers and herds, as well as hazardous climatic conditions, there are conflicts and wars among the locals over access to resources. In traditional practices in these areas, milk is only being produced during the raining season when there is enough fresh grass for the animals. At the end of this season, the grass withers and thus loses its essential nutritional values which are just enough at best for the animals to survive. This does not provide sufficient basis for milk production.

During the dry season or drought periods, pastoralists travel long distances to ensure sufficient grazing opportunity for the herds, which are often very large. Their presence among the sedentary population, which has its own livestock, is often perceived as undesirable leading to conflicts over grazing and water points. When household strategies are adapted to ecological, economic and social conditions, it enhances the quality of life for household members and also fosters the more sustainable use of natural resources. According to the Swiss agency for Development and Cooperation (SDC) in Kirgizstan, household strategies are developed according to existing potentials and promising opportunities. These strategies are oriented towards limiting the risk of total dependency on water and seek to make use of positive synergies between various activities in order to create substantial added values.

For households to ensure access to water, social networks were key. Large families with influential social networks stand a better chance in negotiating and promoting their interests. The main principle of this strategy which is all understood by participating families is that one good turn deserves another, i.e. if a family solicits help, they must be able to return it whenever the need arises. A household that did not respect this principle was excluded from such network; the only disadvantage of this strategy is that poor households continue being marginalised.

In order to source the needed water, households adhere to formal and informal groups that take care of construction and maintenance works on the distribution system. Allocation of water and defense of their interests' vis-a-vis other groups and state organisations that are in charge of water management and irrigation infrastructure upstream is maintained from distribution systems.

This is another strategic aspect on the household level which helps to minimise the potential risks that are linked to hazards of climate or economic and social crises. Based on their resources, households invest simultaneously in rain-fed and irrigated agriculture. Horticulture and tree growing are two further areas of investment. Others include livestock, which comprises of poultry, small ruminants and for the wealthier households, cattle, and horses.

Livestock farmers were shown the importance of the vegetation. Pastoralists were advised to protect vegetation and trees of important and specific values, they were asked to also collect seeds and to multiply the trees in favourable seasons. The processing of farm products, along with crafts, small-scale commerce, tourist accommodation, transport services and seasonal jobs are the main opportunities that enable the households to reduce their dependency on water. Various ways are being employed by farmers to produce or supply needed water to plants, for example, perforated bottles or cans filled with water are buried between two plants to supply the roots with water in an economical and targeted manner. Another example is adding clay to the soil where trees are planted so as to reduce the need for irrigation water.

In 1989, several Burkinabe's livestock producers, who were involved in a pilot program organised by the Swiss Agency for Development and Cooperation (SDC) created a group called Association for the Promotion of Livestock in the Sahel and Savannah (APESS) with the aim of dissemination of ideas and innovations to improve living conditions for Sahelian livestock producers. According to Bruchweiler and Gabathuler (2006), various activities were put in place to bring about the increase in quality of livestock production and farmers' livelihood. Such activities included hay storage, livestock selection and livestock production system, protection of vegetation cover as well as education and training.

In the ancestral method of livestock production in Burkina Faso, there used to be nothing like hay or pasture production. Animals are fed with naturally grown grass as well as traveling long distances sometimes over the border of Burkina Faso into Angola whenever the need arise. With the help of APESS, herdsmen were encouraged and convinced to make hay reserves on managed grazing lands that would be sown with seed and fertilized with animal manure, harvested and stored in sheds; this was a practice that was never part of their ancestral tradition. It also helped to gradually eliminate animals of poor quality and thus reduce the size of their herds. As a result, milk production is possible all year round, improving the food situation and family income, while diminishing the pressure in the natural vegetation.

Practical research is being carried out with instruments and infrastructure that are technically and economically available to pastoralists who enable them to better manage water resources. Reading and writing courses were also offered along with special training for women that aims to strengthen their role in the development of families and societies as a whole. In various activities brought about by the Swiss Agency for Development and Cooperation (SDC) to cope with drought in the Sahel and Savannah areas, psycho-cultural forces played a basic role in the realisation of their objectives. They realised the fact that every Sahelian pastoralist is culturally sensitive to knowledge and beauty, and this was the basis of presentation of coping innovation to livestock producers.

2.7 COPING WITH DROUGHT IN SOUTH AFRICA

Before 1992, drought response by the Government of South Africa focused primarily on mitigating the impact of drought on the industrial and commercial agriculture sectors (Association for Rural Advancement (AFRA), 1993). Little was done to reduce the impacts on the economically impoverished communities of the rural areas, and the response was based primarily on relief rather than mitigation strategies. South Africa has addressed many of these shortcomings by developing new policies and institutions.

2.7.1 Dryland Cropping Systems

Studies have highlighted many socio-economic challenges in the smallholder farming sub-sector (Baloyi, 2010; Mpandeli and Maponya, 2014). Intervention strategies include availing affordable inputs to smallholder farmers, increase on extension services, and investing in smallholder farming. However, there are other interventions that can improve agronomic practices in the rainfed cropping systems that can improve crop water productivity, improve the livelihoods of the rural majority and attract the youth to agriculture (Nhamo et al., 2016). Although programs such as the Comprehensive Agricultural Support Programme (CASP) and the Farmer Support Programmes (FSP) have made some progress to revive smallholder farming at the national level, more can still be done (Sinyolo et al., 2014). This section outlines some of the strategies that can be used to cope and adapt to drought in rainfed cropping systems.

2.7.1.1 Drought tolerant crops

In South Africa, one of the coping strategies most frequently used is for farmers to shift to crops that require less water such as sorghum (Annandale et al., 2002, Wilk et al. 2013, Ncube and Lagardien, 2015). With climate change concerns, unpredictable droughts and high energy prices across the country, nearly everyone is looking for ways to conserve resources. A simple step to conserve water usage in the farms is to select drought-tolerant plants. Drought-tolerant plants have built-in features to minimize water loss and maximize water uptake. Plants may have reduced leaf areas and bear small leaves or needles in the case of evergreens. Another sign of drought tolerance is leaves covered with a heavy accumulation of wax. This wax serves to conserve water within a plant.

2.7.1.2 Zero tillage

Other coping strategies used by farmers in South Africa include direct zero tillage to conserve soil moisture. This system is one that incorporates the use of no or minimal disturbance disc seeders with diverse rotations and continuous soil cover through retaining the entire residue on the soil surface and most times including controlled traffic farming (Ellis, 1993). This method also requires less water and is good for early planting (Hansen, 2005). According to the United Nations Food & Agricultural Organization (UN-FAO), zero-till or conservation agriculture will have all of the above and can integrate other features such as perennial plants, inclusion of allopathic and smother crops such as canola or saia oats, all to increase the biomass in the soil and feed the good macro and micro-organisms in the soil.

2.7.1.3 Multi-cropping systems

Multiple cropping refers to growing more than one crop on the same field during the season. This technique makes effective use of inputs such as soil, water, fertiliser etc. Thus, output per unit area increases with manifold returns to the growers. Multiple cropping is done in annual food crops, fodders, vegetables, fruit plants and perennial crops. Crops are prone to insect pest attacks which may cause a reduction in crop yield and losses. With multiple cropping, the incidence of crop failure owing to biotic agents is minimised. One crop may provide cover to the other against such agents through biological control. The practice of multiple cropping systems enables smallholder farmers to achieve several production and conservation objectives simultaneously. Polycultures exhibit greater yield stability and fewer productivity declines during a drought than in the case of monocultures (Altieri and Koohafkan, 2008).

2.7.1.4 Crop Rotation

Crop rotation is the alternation of subsistence, cash and green manure/cover crops with different characteristics, cultivated on the same field during successive years, and following a previously established sequence. One of the major advantages is the maintenance of a more abundant and lasting soil cover that results in the reduction of runoff and soil erosion (Florentín et al., 2010). Crop rotation also mitigates the build-up of pathogens and pests that often occurs when one species is continuously cropped, and can also improve soil structure and fertility. Understanding the relationship between nitrogen (N) and crop rotation is very important when making N management decisions. There are several benefits to using crop rotation, including improved nutrient cycling, soil tilth, and soil physical properties; and enhanced weed control which are all important characteristics for the survival of crops during drought. Crop rotation also may influence the rate of N mineralization or the conversion of organic N to mineral N by modifying soil moisture, soil temperature, pH, plant residue, and tillage practices.

2.7.1.5 Mulching

Mulch is any type of material that is spread or laid over the surface of the soil as a covering. It is used to retain moisture in the soil, suppress weeds, keep the soil cool and make the garden bed look more attractive. Organic mulches also help improve the soil fertility as they decompose. Mulching with organic materials may not be feasible on a large scale, but can be highly effective for smaller plantings. Larger farms use black plastic mulch, laid out with a tractor, to manage weeds and retain soil moisture. The problem with such strategies is that the majority of farmers in South Africa have very limited access to technology and farm inputs (Vogel, 2000; Ziervogel & Downing, 2004) to enable them to implement mulching. In addition, smallholder, farmers use crop residues as animal feed, and there is never enough to use as mulch.

2.7.2 Coping with drought in irrigation systems

Water is a critical determinant in coping with drought. With continued population growth and socio-economic development, water demands are expected to rise throughout the Limpopo River Basin and SADC region in general. As water resources in the basin are very limited, there is an urgent need for suitable demand and conservation management measures to sustain social and economic development. Soil conservation measures are also important in managing and conserving the water resources, as soil erosion is causing high silt loads and turbidity in the Limpopo River and its tributaries, affecting water treatment and the storage capacity of dams. Access to water for agricultural production is poor due to unavailability of appropriate water sources, but at times the problem is that of unequal access to the resources; for example large commercial farms having good access to water and infrastructure, while smallholder farmers lack even drinking water (Ncube et al. 2010)

2.7.2.1 Water tariffs

Increased water tariffs during times of drought have reduced water usage and in many cases corrected the water use pattern permanently. While such financial measures may be very effective, they can have a far-reaching impact on the overall socio-economic character of communities and water use sectors. Therefore, Department of Water and Sanitation is developing various sector water demand and tariff strategies to help guide implementation of such demand management measures.

2.7.2.2 Irrigation scheduling

Various measures are promoted to reduce water loss in distribution pipes and canals, irrigation application methods and their use during times of the day and night when evaporation is reduced. In some irrigated areas, such measures were considered unimportant as water tariffs were very low and water restrictions were imposed infrequently. As water becomes scarce and is shared by more users, irrigation scheduling is gaining importance and many commercial farmers are now applying these techniques with success. Ncube and Lagardien (2015) report various examples of farmers practicing irrigation scheduling in the Karoo.

Research shows that a lot of water is lost because of poor infrastructures maintenance in the irrigation schemes. The Department of Agriculture, Forestry & Fisheries (DAFF) transferred infrastructure ownership to communities and their local authorities to promote self-sufficiency and responsibility for maintenance. Extension officers trained operators in maintaining and operating the infrastructure for effective water use was introduced in many irrigation schemes. Department of Agriculture, Forestry & Fisheries directorate Water Use and Irrigation Development made community awareness regarding the scarcity of water, the potential pollution of water, water use efficiency, possible reuse of water, water storage, etc.

2.7.2.3 Drip Irrigation

Drip irrigation is a method of delivering water slowly, at low pressure, at or near the root zone of plant material. It is often referred to as targeted or precise watering because drip irrigation allows targeting the precise area that needs water. As a result of drought conditions and water restrictions throughout much of the country, the concept of drip irrigation has caught on with more and more contractors in recent years. Research has shown that drip tape uses 30-50% less water than overhead irrigation. Drip irrigation used about 35% of the water used by the surface irrigation systems thus giving much higher water use efficiencies at Zhulube Irrigation Scheme in Zimbabwe. The study, however, recommended that low-cost technologies should be used in conjunction with good water and nutrient management if higher water and crop productivity were to be realized than surface irrigation systems (Ncube et al, 2010).

2.7.2.4 Root zone irrigation

Bainbridge (2001) describes the buried clay pot irrigation technology which uses a buried, unglazed clay pot filled with water to provide controlled irrigation to plants as the water seeps out through the clay wall at a rate that is influenced by the plant's water use. South African smallholder farmers have come up with modified versions of the technology using locally available materials such as plastic bottles and tin cans (Ncube and Lagardien, 2015). There are several benefits associated with the technology that makes these methods something that is worth considering. Apart from benefiting the environment and the plant itself, this system will also reduce the amount of time that a farmer spends watering plants. The irrigation keeps the soil moist throughout the day; in some areas, the farmers were even using recycled water a further conservation of the resource. No high capital costs are needed to set up the system.

2.7.2.5 Rainwater harvesting and water storage

Rainwater harvesting can be a significant drought mitigation strategy at the local level. Captured rainfall can be stored either in containers (cisterns) as drinking water or in the soil for plant production. This runoff water is often available at the household level, an important factor for enhancement of water security. A farmer living in dry regions cannot usually direct government policy and single-handedly bring about the creation of a large regional water infrastructure projects to supply piped irrigation water to his home. The rain falling on his land is the only water resource available to him in many cases in developing countries.

Normally, a significant part of tropical rains is lost as runoff, potentially causing erosion. The building of bunds parallel to elevation contour lines, in accordance with the topography, can capture much of this runoff rainwater, which now will infiltrate into the soil. Thus, more crops can be grown even in a drought year. There are various systems possible for rainwater harvesting (Baloyi, 2010), both for crop farming and pasture enhancement. Rainwater harvesting, therefore, is an excellent example of enhanced water use efficiency.

Drought can be also mitigated by building more dams and reservoirs. The Department of Agriculture, Forestry & Fisheries under directorate: Infrastructure Development specialises in the planning, design, construction, rehabilitation and safety requirements of dams ranging from small stock watering dams and large agricultural dams to large municipal structures. Commercial farmers in South Africa have also relied on building dams and even abstracting water from rivers as some of the strategies to mitigate drought (Wilk et al. 2013). Storage tanks that collect rainwater from rooftops are reserve water by Department of Water and Sanitation. Rainwater harvesting can be a significant drought mitigation strategy at the local level. Captured rainfall can be stored either in containers as drinking water or in the soil for plant production.

2.7.2.6 Infrastructure maintenance

Infrastructure maintenance is one-way communities have conserved water during drought, although this remains a challenge in many areas especially small irrigation schemes. A review by van Averbeke et al (2011) found that poor performance in smallholder irrigation schemes was associated with a range of factors, including poor maintenance of infrastructure and equipment. However, in recent years DAFF transferred infrastructure ownership to communities and their local authorities to promote self-sufficiency and responsibility for maintenance. Extension officers have trained operators in maintaining and operating the infrastructure for effective water use in many irrigation schemes. The department also invested in community awareness regarding water scarcity, the potential pollution of water, water use efficiency, possible reuse of water, water storage, etc.

2.7.3 Livestock systems and drought

Drought can reduce livestock farming in two ways: directly through mortalities and indirectly and through distress sales. The possibilities for distress sales of game animals tend to be lower than for domestic stock. Households dependent on livestock must cope with large livestock losses. When households anticipate droughts, they shy away from higher return activities in order to pursue safer strategies, keeping themselves poorer on average than they need to be. During and after a drought, cash-strapped households sell off remaining livestock, driving down prices, making it even harder to cope with the disaster, and again reinforcing the poverty impacts of uninsured risk. There are a number of strategies that farmers can implement to reduce drought impacts.

2.7.3.1 Stocking rates

Reduced forage production due to drought necessitates reducing stocking rates or providing supplemental feeds as a means of replacing forage which was lost due to the lack of water for irrigation or soil moisture. In March 2016 the Agricultural Research Council Economic Outlook Report noted that beef and sheep industries were severely affected by the current drought as farmers faced less supply of fodder due to poor pasture conditions and water scarcity. In situations like these farmers are usually left with no choice but reduce livestock numbers. Reducing stocking rates is usually accomplished by culling, selling yearlings, or early weaning. Short- and long-term drought plans should evaluate each of these options. Providing supplemental feed is a means of dealing with the lack of forage. During droughts, South Africa imports fodder from neighbouring countries (Palmer and Ainslie, 2006), but this was not possible in the recent drought because the whole of Southern Africa was affected by the drought.

2.7.3.2 Pasture management

The occurrence drought has a direct negative impact on natural pasture growth, often resulting in a lack of fodder and consequent economic loss for livestock owners that may reach disaster levels. Traditional drought-coping mechanisms of pastoralist societies in Africa, such as splitting the herd into various groups spread over the country under the care of relatives or "stock friends," seem to have become less effective due to socioeconomic and political changes. In this context, drought contingency planning is gradually receiving more attention as an important strategy to lessen drought impact. It invariably involves the formation of reserves, whether of water, grains or money. Vulnerability, reserves, economic strength and access to resources are key elements of drought-coping ability (Downing and Bakker 2000). Ncube and Lagardien 2015 identified a number of strategies adopted by farmers to conserve water in pastures such as construction of spreader banks to conserve moisture in the grazing lands, rotational grazing, and adopting ecological principles to maintain grazing lands, and manage livestock units based on the carrying capacity of grazing lands

2.7.4 Water conservation strategies

During the 1991/92 drought, the Water Supply Task Force provided emergency water supply by means of water tankers to 950 communities, repaired existing water infrastructure, installed some 800 emergency pipelines, drilled more than 5 000 new boreholes, protected springs, and installed packaged water treatment plants. The Nutritional Task Force coordinated transport and distribution of food, while public works programs facilitated job creation to stabilize household income. Various state structures were involved at a local and regional level in drought relief. A number of water conservation strategies were adopted during the recent drought.

2.7.4.1 Boreholes

Boreholes are frequently appropriate for mitigating extreme droughts. However, they are often not the most efficient use of limited resources due to a greater chance of pump breakdown and salt-water intrusion through over use (Moss, 2004). Additionally, groundwater surveys and proper siting of boreholes are necessary for achieving maximum impact. In many droughts, regional groundwater depletion is not the main factor affecting domestic access to water. When individual boreholes fail during drought, the cause is often local drawdown or mechanical failure. During the recent drought in southern Africa, a survey of water points by Oxfam revealed that most non-functional boreholes had failed because of problems with hardware (e.g. pump failure) or demand management. Repairing damaged boreholes is a quick and inexpensive way to prevent this cascade of water point failure (Calow et al., 1997).

Drilling new boreholes forms the basis of conventional approaches to improving groundwater access to farmers (Barker et al. 1992). During the recent drought in South Africa, DAFF drilled many boreholes for livestock in KwaZulu-Natal, Free State, Mpumalanga, and North-West provinces. Non-governmental organization initiatives such as Operation Hydrate were set up with the aim is to get water to the areas that are most affected by the drought. In conjunction with the Department of Water and Sanitation the organization aimed to build 67 boreholes by the end of the year and a further 28 are planned (http://operationhydrate.org/). The DWS also committed funding for R352.6 million to the initial drought intervention projects in Kwazulu-Natal for interventions such as water tankering, borehole drilling and rehabilitation, water conservation and demand management, as well as water source augmentations.

2.8 CONCLUSIONS AND RECOMMENDATIONS

The review revealed that drought transcends the water shortage problem in agriculture, and includes other aspects such as the socio-economic environment of production systems. The review also highlighted that coping mechanisms adopted by farmers during a drought in various countries depended on the availability resources; and also included farmers' financial background and level of diversification. It was also evident that drought affects smallholder farmers more than commercial farmers as a result of resource differences.

A number of strategies that can help farmers cope with drought have also been identified by the review. Early warning systems have become an integral part of agriculture. The development of drought and famine early warning systems that would allow for early drought or famine detection and improve response in a proactive manner is very important. An early warning system is the foundation of a drought or famine plan, allowing for the dissemination of agrometeorological information to farmers in near real-time. The dissemination of information is the cornerstone to successful farming especially in this era of climate change. The information relevant to farmers includes weather updates, soil and nutrient status, pest management reports and recommendations and advice on crop varieties to plant in various field conditions.

Introducing crop varieties that suit the changing climate and improve the agronomic practices is also crucial. New crop varieties and improved agronomic practices are very effective mainly in rainfed systems where water management practices are generally poor.

Investing in agriculture is another effective strategy for economic growth and poverty reduction in rural areas where the majority of people who are highly vulnerable to drought and climate change risk live. Many strategies can be implemented in irrigation, including scheduling, drip irrigation, rainwater harvesting and infrastructure maintenance. Smallholder farmers can implement even simple technologies such as supplying moisture to the root zone using local material.

Strategies in livestock could include creating fodder banks and pasture management. Finally, drilling boreholes is a strategy that has been implemented for decades. In the recent drought, South Africa drilled many boreholes to provide water for both agriculture and domestic use, proving that groundwater plays a very important role in agriculture.

CHAPTER 3: POLICY AND RESEARCH GAPS

3.1 INTRODUCTION

This chapter covers the third aim of the project, which was to identify policy and research gaps and make recommendations of what should be done in SA under current drought conditions and future droughts. The chapter also suggests a national drought response strategy for agricultural water use in SA. The chapter takes an in-depth review of the socio-economic aspects of drought in SA, followed by a technical review of water supply and demand oriented measures to cope and adapt to drought, the issues of water management in agriculture, and the solutions. Finally, the chapter then identifies options that SA can adopt during future droughts.

3.1.1. Drought in the South African Context

It is argued that no definition of drought is all-inclusive (Van Zyl, 2006). A more comprehensive definition of drought is covered in Deliverable 2 of this project. Drought can be defined as a shortage of precipitation over an extended period (Rouault and Richards, 2003). A drought could also result from a decrease in water availability to substantially below the normal condition for a certain place and time, typically associated with a period of below-average rainfall (Mwendera, 2016). The simplest definition is any unusual dry period, which results in a shortage of water (Van Zyl, 2006). Rainfall deficiency is, therefore, the trigger, but it is the shortage of useful water in the soil, in rivers or reservoirs, which creates the hazard.

In SA, a drought is a prolonged, abnormally dry period, when there is insufficient water for users' normal needs. Agriculture suffers first and eventually, everyone feels the impact (Van Zyl, 2006). In SA's climate, drought is a regular and recurrent feature (Rouault and Richards, 2003). This notion is also supported by Mwendera (2016), who submitted that indeed, the drought which recently devastated parts of the country is a recurrent characteristic feature of SA's highly variable climate and weather extremes. Additionally, droughts are a frequent occurrence in SA's arid and semi-arid rangelands (Vetter, 2009), and this is regarded as a normal and natural phenomenon, which cannot be prevented.

Drought is unlike other natural hazards, such as floods, in that there is often no well-defined start and end (Mwendera, 2016), and is different from the rapid-onset environmental hazards (Van Zyl, 2006). Drought is a 'creeping' hazard because it develops slowly and has a prolonged existence, sometimes over several years, and its effects accumulate slowly over a substantial period (Van Zyl, 2006). Although drought can be difficult to recognise, especially in the early stages, it is defined in terms of its effects rather than causes. Since the onset and end of drought is difficult to determine, it is often difficult for scientists and policy makers to agree on the criteria for declaring an end to drought (Wilhite, Sivakumar and Pulwarty, 2014). Furthermore, it is important to view any water shortage in relative terms of need rather than absolute rainfall amounts. Droughts are not confined to areas of low rainfall any more than floods are confined to areas of high rainfall, and drought should always be viewed in the context of a specific climatic regime and the associated demands for water (Van Zyl, 2006).

3.1.2 Drought Response

Molle (2003) proposes that policy response to drought should be considered in a wider political economy framework. This suggests replacing the sequential approach with one that recognises that all strategies tend to be pursued in parallel when drought becomes severe. Objective criteria such as cost-benefit analysis and cost-effectiveness analysis can help these decisions, but they will always be taken in a political economy framework (CA, 2007). To complicate matters, the response options are often interdependent and come in packages.

There is a key difference between responses by the state at the national level and the local response of small groups or communities. These two types of responses are interdependent. Although the emphasis is often placed on state policies, adjustments made by local farmers are crucial in shaping the demand for water from agriculture and its impact on the hydrological cycle (FAO, 2010). Elements like the nature of the state and state-citizen relationships, the impact of shock events, the nature of the political economy and the conditions of agrarian change are crucial in shaping the responses to drought (Molle, 2003).

An effective water resources plan is one that has an optimal combination of both long and short-term measures. The measures that can be included in each of the above two categories for alleviating drought impacts can also be grouped into three main types or sub-categories:

- Water-supply oriented measures;
- Water-demand oriented measures; and
- Drought impact minimisation measures.

The measures related to supply management aim at increasing the available water supplies, whereas those pertaining to demand management aim at improving the efficient use of the available resources (Molden *et al.*, 2001). These two categories of measures aim to reduce the risk of water shortage due to a drought event, while the third category minimies the environmental, economic and social impacts of drought. In practice, the measures are interrelated and, at times, even overlapping; but such interrelationships are necessary in order for the plan to achieve its goals.

3.2 IMPACTS OF DROUGHT IN SOUTH AFRICA

Quantifying the impacts of drought is a socio-economic problem and it is indeed intricate (Garanganga, 2011). Wilhite *et. al*. (2014) added that quantifying the impacts and providing disaster relief is a far more difficult task for drought than for other natural hazards since the impacts can filter through economies and the environment for months, years and even decades. These characteristics of drought have hindered the development of accurate, reliable, and timely estimates of severity and impacts, that is, drought early warning and information systems, and ultimately, the formulation of drought preparedness plans and drought policies. Additionally, the impacts of drought are, at times, enormous and result in economic and environmental impacts as well as a personal hardship (Wilhite, *et. al*., 2014).

In qualitative terms, drought has affected the South African economy, agriculture, environment, social life and hydrology (Wilhite *et. al.* 2014). Although the focus is on agricultural effects, the effects on other aspects of development cannot be understated. The effects are interlinked and difficult to mention in isolation.

3.2.1 Impacts of Drought on Agriculture

Most droughts result in widespread crop failure, livestock deaths, consequently loss of draught power for the ordinary farmers. SA's agricultural sector recorded a decrease of 12.6% in the third quarter of 2015 (Brink, 2016). Significant livestock mortalities were reported in KZN, Limpopo, NW and the FS provinces (Agri-Western Cape, 2016). SA's first maize production forecast estimated the 2015 harvest to be the worst in 8 years, with a drop of 21% relative to the average of the last 5 years and 32% down on 2014's year bumper crop (Drought Report, 2015). The United Nations Office for the Coordination of Humanitarian Affairs (OCHA, 2016) reported that the expected commercial maize crop for 2016 was 29.1 percent less than for 2015, which was also a drought year and that the expected total maize imports for 2016/17 stood at 3.65 million tonnes (OCHA, 2016). The 1991/1992 drought is still ranked as the worst natural disaster in SA, which resulted in approximately 70% of crops failing and maize had to be imported into the country (Mniki 2009).

Crop production has been adversely affected by dry conditions. About 83% of SA's maize, 53% of the country's wheat crop and 73% of sugarcane are produced under dry land (Briefing of the Standing Committee, 2016). It was indicated that with reduced production volumes, SA might become a net importer of food and this will negatively affect the trade balance (Makube, 2016). The author added that sectors such as maize and sugar, which would normally contribute to the sector's positive trade balance, would shift to a negative net trade position in 2016, following estimated more than 5 million tonnes of grains such as maize and wheat that had been imported. This implies a loss of revenue for both the country and the agricultural sector. It was highlighted that sugar production was already well below normal levels in 2015 and was projected to remain at similar levels for the second consecutive year in 2016, representing a 28% reduction from the normal harvest in 2014 (BFAP and IVIS, 2016). There was a notable decrease in yield and size of fruits like pome and stone, and decreased yield in the table and wine grapes, and the quality of citrus fruit was also poor (BFAP and IVIS, 2016). It was noted that in horticulture, it is difficult to assess drought impacts as they vary according to producer, area, and the conditions under which they are produced (Bureau for Food and Agricultural Policy (BFAP) and IVIS, 2016). Unlike the crop sector where production declines in a drought year, beef production tends to increase, as producers cull due to poor or insufficient grazing and high, feed costs (BFAP Drought Policy, 2016). Notably, commercial beef slaughters had already increased by 8% year on year in 2015, rising almost 18% above the 5-year average (BFAP Drought Policy, 2016).

3.2.2 Environmental Impacts

Droughts in most cases result in general environmental degradation, and the problem is more pronounced in areas of inappropriate land use patterns. Soils in drought-hit areas have been left 'exhausted' and will be very costly to restore to their optimal production potential (Garanganga, 2011). There are limited reports of how droughts have affected the environment in most parts of SA.

Some rivers, dams and lakes either dry out or water volumes shrink, thereby paralysing the fish, hydroelectric power generation, and recreation industries (Garanganga 2011). Reports show that there was a growing water crisis in the Republic of SA, with an average dam level as of 2016, of approximately 54 per cent to 22 per cent, less than the same period in 2015 (OCHA, 2016).

3.2.3 Socio-economic Impacts

The general welfare of society is usually affected adversely by the advent of each drought (Garanganga, 2011). Agreeably, Van Zyl (Undated) noted that outcomes associated with a drought event, particularly an extreme event, are also tightly coupled to other societal elements, including economic changes, conservation and land care practices, rural livelihoods, agricultural practice, and most of all on food security. Income transfers from urban to communal areas become more common, while population movements to urban centres increase, resulting in urban overcrowding, increase in crime and poor health and nutrition become common occurrences (Garanganga, 2011). This poses a complication in measuring and dealing with drought effects. Latham (2016) noted that in SA, it is the cost of food, in an economic downturn that has been the immediate effect.

The poverty trap small scale farmers find themselves in is made worse by each drought that strikes. On poor farmers, this has adverse implications on their ability to maintain and/or improve soil fertility, by application of fertiliser (Garanganga, 2011) and servicing of loans (Brink, 2016). Input providers are also affected, and usually record lower sales and are left with unsold stock and heavy financial losses (Brink, 2016). The depreciation of the rand had a strong correlation on the landed price of fertiliser and oil-based products, resulting on year-on-year increase of 11 per cent on fertiliser and 10 per cent on fuel (Latham, 2016). Reduced production volumes and planted areas in the case of grains and oilseed crops result in serious financial losses for input suppliers due to lower demand for seed, fertilizers, pesticides and herbicides. On the same note, at a food manufacturing level, the shortage of grains and higher prices result in higher production costs (Makube, 2016).

In SA, farmers were retrenching their workforce and the new class of black commercial farmers had been rocked by the drought, and small towns were reporting business closures, growing unemployment and social instability (Latham, 2016).

Crop failure results in farm labour lay-offs, increased farm debt and farm closures and affects households that depend on the agricultural sector (Mniki, 2009). It was estimated that during the 1991/2 drought, 50 000 jobs were lost in the agricultural sector, with a further 20 000 in related sectors, affecting about 250 000 people (Mniki 2009). According to the Reserve Bank of SA, the loss of Gross Domestic Product during the 1992 drought was approximately 1.8 per cent, representing US$ 500 million (Pretorius & Small 1992). The figures for the current drought have not been quantified, but indications show high losses. However, it was reported that, in October 2015, the cost of a basic food basket in SA was already 14% more than the average household's monthly income (Bio Watch, 2016). Due to the drought, the National Agricultural Marketing Council predicted that a basic food basket would cost 25% more, with dire consequences for food security (Fact Sheet Food Crises, 2016). SAWS reported that with a recorded annual total rainfall of 403 millimetres, 2015 represented the driest year for SA since 1904 (Briefing of the Standing Committee, 2016).

Famine is the most serious potential outcome of drought although the linkage is not simple. Drought is the most important environmental hazard in semi-arid regions for two reasons. First, a low mean annual rainfall is associated with high variability. It is the lack of rainfall reliability, rather than rainfall amounts in these areas, from season-to-season or year-to-year, which creates uncertainty about the available water supplies and leads to drought hazards. Second, the duration of drought is longer in the drier lands. In wetter areas, a rainfall deficit is likely to persist for a few months only. General household welfare impacts of water scarcity, forced migration, and health implications (Hassan and Backeberg, 2010) are profound.

UNEP (2004) also argues that droughts tend to bring out the worst in the affected communities in terms of land degradation, famine, increases in the prices of essential commodities, impoverishment, retardation of economic development, political and resource use conflicts and breaking down of social ethics (Mniki, 2009).

3.2.4 The 2014-2016 Drought Response Experience

As mentioned earlier in this review, limited information was found that clearly describe the strategies that have been implemented by the South African government, in particular the provincial governments. This is because the mandate to develop DMPs was left with the provincial governments and should do so with the NDMP framework. However, some few reports were identified and analysed. The national government has made tireless efforts in order to mitigate the effects of drought, although information is still not consolidated.

Reports show that the national government allocated R1-billion in the 2016 budget to drought relief measures, including, the distribution of animal feed, moving cattle herds, transporting potable water and drilling boreholes (Bio Watch, 2016). The Department of Water and Sanitation spent R500 million on emergency and short-term interventions to mitigate the effects in drought-stricken provinces of KZN, FS, NW, Mpumalanga, Limpopo, WC, EC and NC. Dam operating rules were applied to thirty-five dams and four systems had restrictions applied with regard to the mandatory restrictions on domestic and agricultural use. . Water Conservation and Water Demand Management; through War on Leaks, surface water resource management; optimized operation of the Vaal River System; groundwater resource management; carting of water through a fleet of motorized tankers; and provision of static storage tanks and storage reservoirs interventions were implemented.

It is argued that while these measures saved lives at that moment, many farmers were still unable to carry the losses, and relief was unlikely to reach most of the two-and-a-half million smallholders whose livelihoods depend on farming (Bio Watch, 2016).

The Department of Agriculture, Forestry and Fisheries provided livestock feed and alternative grazing on available state farms and R226million had been reprioritised and allocated (Department of Agriculture, 2016). It facilitated and supported the revolution of credit facilities challenges due to crop failure with Land Bank and other development financial institutions. Additionally, the national government promised to monitor the food prices through the Food Price Monitoring Committee (Department of Agriculture, November 2016). This would be done under the National Agricultural Council, to inform appropriate measures to maintain food security; strengthen climate change adaptation programmes developed for the sector and coordinate inter-departmental food and nutrition security interventions to mitigate the effects of drought on farmworkers and rural communities.

The Department of Rural Development and Land Reform announced that livestock from worst affected regions in five provinces would be relocated to “state-owned land”, where there was still better pasture (Bio Watch, 2016). In the NW, the department reported that it would allocate 200 000 ha to be made available for communal farmers and was busy doing field assessments and infrastructure needs and water assessments and possibility of establishing feedlots. Money was allocated to municipalities and provincial departments to distribute to the drought stricken farmers accordingly.

The Department of COGTA wrote to all the mayors in the country to take various actions to respond to the drought. These actions included, among others, following the guidance of the DWS regarding the introduction of water restrictions, monitoring adherence to water restrictions and application of penalties where necessary; prioritisation of the repair of water leaks, and the promotion of water-efficient technologies, rainwater harvesting, and use of grey water for irrigation (Bio Watch, 2016). It is unfortunate that government seemed to under-estimate the dire consequences of failure to manage water by its citizens, well before, during and after drought. The cost of developing contingency plans to adapt to water shortages and mitigate drought effects is relatively small, compared with the potential benefits (Mukheibir and Sparks 2003). Of importance to note from the few drought management strategies implemented is the absence of adequate planning towards agricultural drought mitigation.

Hassan and Backeberg (2010) noted that apart from few recent examples in Agricultural Drought (AD) management, such as the subsidy to encourage stock reductions among drought management strategies in SA livestock producers, few changes have been made in economic policy to manage drought in SA. It is argued, that even the incentive to reduce stocks and lower the pressure on grazing resources and pastureland, leaves out livestock farmers who are not located in drought disaster proclaimed areas. In addition, crop farmers are largely excluded from agricultural drought management programs (Hassan and Backeberg, 2010). For example, a huge gap remains in developing instruments and institutions that would enable sufficient numbers of crop farmers to participate in yield and weather insurance markets that currently attract a handful of commercial crop farming enterprises in SA.

Formal agriculture insurance and drought insurance in particular have been inaccessible to poor farmers in the developing world in general and particularly, in SA (Hassan and Backeberg, 2010). This needed urgent attention, as small farmers who were farming in very marginal environments could benefit from self-insurance options and off-farm employment opportunities. Brink (2016), cited that in 1992-93, drought-relief was available and state guarantees were used to write off carryover debt and afford farmers an opportunity to make a new start. The current drought seems to have caught the government unprepared to deal with the impacts. There are no risk and disaster programmes in place to secure and reinforce the production base of the agricultural sector, and it is feared that there is going to be a negative long-term impact because SA does not have a safety net for farmers (Brink, 2016). Farmers tend to use their own reserves to leverage additional credit in order to cope with drought, thereby exhausting these reserves. This enhances the continuation of the credit cyclesince farmers would need finance to cater for their production cost for the coming year (Brink, 2016).

Economic policy instruments for the promotion of sustainable farming, water and land use practices are also not well exploited to induce desirable longer-term adaptations to drought in SA (Hassan and Backeberg, 2010). For instance, no policies and programs provide incentives or subsidy schemes to promote adoption of more efficient water use technologies, such as sprinkler and drip irrigation methods, among other water-saving farming practices. On the contrary, it appears that most recent agricultural development efforts plan for further expansions in relatively more water-intensive crops and land use options (Hassan and Backeberg, 2010).

It is reported that, in 2015, many farmers were unable to obtain adequate input financing for the current production season, because of the liquidation of some input financing companies and the high risks of lending money to struggling farmers, considering the possibility of further interest rate increases (Brink, 2016). Reports note that fodder prices had increased dramatically and the availability of fodder was being hampered by the drought, resulting in even more emergency slaughtering or selling of animals at lower prices for these farmers (Brink, 2016). However, the government encourages farmers to slaughter their animals as early as possible, ideally at the onset of drought to avoid wastage by buying fodder. This could work as a coping strategy for those farmers who would not afford to buy fodder, but at the same time minimising on loses. On the other hand, the latter coping strategy is not without its own challenges. Considering the issue of continuity, if the farmer sells or slaughters his total herd, or even most of it, it means that he loses his genetic base, which would have been developed over years (Brink, 2016).

The Inter-Ministerial Task Team was also concerned about issues such as the poor monitoring, reporting and evaluation of the impact of the response and intervention process, non-expenditure and delayed implementation of grant programmes to address service delivery issues. Seemingly, this is not unique to SA. Responses to drought by governments throughout the world are regarded as generally reactive, poorly coordinated and untimely, and are typically characterized as “crisis management” (Wilhite and Pulwarty, 2005). In addition, the provision of drought relief or assistance to those most affected has been shown to increase vulnerability to future drought episodes by reducing self- reliance and increasing dependence on government and donor organizations. Thus, it is imperative that emergency relief be provided in such a manner that it provides a safety net for those elements of society that are most vulnerable while promoting self-reliance and the principles of a national drought policy based on the concept of risk reduction (Wilhite *et. al.*, 2014).

3.3 GAPS IN DROUGHT MANAGEMENT IN SA

3.3.1 Knowledge of Drought Occurrence in SA’s Agricultural Sector

Reports indicate that the frequency and impacts of natural disasters in the farming community in SA has significantly increased, and the most common type of disaster is drought (Ngaka, 2012). The Minister of Water and Sanitation noted that the water sector was facing considerable challenges, which included climate change, lack of rainfall, ageing and poor maintenance of infrastructure in some areas, water leaks, water pollution, illegal water connections, alien and invasive species, and heat wave (Mokwenyane, 2015). The Minister noted that the current El Nino was perhaps the worst in history. The last worst drought was experienced in 1992/3. The Republic of SA was reported to be experiencing one of the worst droughts ever recorded due to two consecutive below average rainfall seasons since early 2015 (OCHA, 2016). Table 3 shows drought occurrence in each province, as indicated by few relevant reports that were found during this review.

Table 3: Drought occurrence in selected province in SA for the period 2014-2016

PROVINCE	**DROUGHT OCCURRENCE**
North West	The country experienced the signs of a new round of El Nino, with the onset of the current drought in the NW province in 2013, which was subsequently declared as a disaster on 29 July in the same year (Mokwenyane 2015). Due to the deteriorating drought conditions in 2016, the NW was declared as a disaster area again on 24 July 2015 (Mokwenyane, 2015). Dam storage levels decreased by 14% (Anonymous, 2015).
Eastern Cape	If provincial dam storage levels were compared to values for the same point in time in 2014, the values decreased in all provinces except the EC, where it was 1% higher (Anonymous, 2015).
Northern Cape	The province received total rainfall ranging from 0-50mm (Mokwenyane, 2015)
Limpopo	Drought was declared as a disaster in Limpopo on 4 November 2015 (Mokwenyane, 2015).
Western Cape	The province received total rainfall ranging from 0-50mm (Mokwenyane, 2015). The high value of a decrease of 30% for Western Cape is probably associated with rains arriving late during the winter season (Anonymous, 2015).
KwaZulu Natal	KwaZulu-Natal declared drought as a disaster on 12 December 2014 (Mokwenyane, 2015). Northern KZN, where Biowatch works with smallholder farmers, had been experiencing severe drought since 2014. This prompted the KZN Cabinet to declare some districts as emergency disaster areas in January 2016 (Bio Watch, 2016). The water levels of dams in the area had fallen dramatically. By March 2016 the Jozini Dam was only 47% full – compared to 61% full at the same time in 2015 – and the Hluhluwe Dam had dropped to only 18%. Half of the total water available in these catchments is used for irrigation, and an amount equivalent to half of irrigation use is lost in stream flow reductions (Fact Sheet Water Crisis, 2016). The extent of drought in KZN is well depicted by how far the water storage trend for 2016 was falling below the medial storage trend for past thirty years (Drought report, 2005). Water storage situation in the Usuthu-Mhlatuze water management area was at its lowest point (about 61%) for past thirty years, and far below the 30-year Median Storage Trend (Anonymous, 2015).
Free State	In Free State, drought was declared as a disaster on 4 September 2015 (Mokwenyane, 2015)
Mpumalanga	In Mpumalanga was at an advanced stage of preparation for the declaration of drought as a disaster, which would be completed soon (Mokwenyane, 2015).

It was reported that the lower than normal rainfall eastwards in June indicated that the drought could intensify in KZN, Mpumalanga, Limpopo and some other parts of NW (Anonymous, 2015). The drying trend seemed to have started to manifest during the summer season of 2012/13 and had been intensifying ever since in all the summer rainfall regions, which includes dominant parts of all the provinces except for WC (Anonymous, 2015). The seasonal climate forecasts provided by the SAWS heightened high probabilities of below-normal rainfall for the start of the summer season (Anonymous, 2015). This was expected to continue throughout summer with relatively small chances of above normal rainfall for localised areas in early to mid-summer. This suggests a strong possibility of the dry conditions persisting, which may lead to a long-term drought (Anonymous, 2015). A combination of the delayed onset of the season and a poor mid-season rainfall pattern at critical stages of maize development, led to unfavourable expectations for regional maize production (Anonymous, 2015).

At the time of this review, there was limited information on how drought had been occurring in the different provinces of SA, including the current. However, it is difficult to conclude that there is no such information on record, although efforts to obtain it were unsuccessful, largely. In an attempt to secure any drought-related information, provincial offices were written emails requesting for any relevant documentation. On the same note, it could be concluded that, since drought effects are regarded as difficult to assess, information could take longer than anticipated to be documented and made available to the public. The little information that was found report the current and the 1992/3 droughts, implying that where drought has not been reported, it has not been occurring. This is not the case, since drought has been reported as a recurrent and normal phenomenon, and that the country was experiencing the worst drought ever.

On the other hand, it can be implied that information on drought could be available, but limited in terms of how it is exposed for public consumption. Since, drought management is one of the government's responsibility, reasons for limited information on the extent to which it affects the country's poorest, and how far the government has gone in managing it could be complex. Seemingly, it suggests that there is need for researchers to shift their focus to drought occurrence and management in SA.

3.3.2 Drought management in SA

Public policy in the water and agriculture sectors has seen major shifts since 1994 (Hassan and Backeberg, 2010). Various government policy papers advocate for a new approach and strategy in managing drought, emphasizing a shift towards a more proactive approach that adopts risk reduction, rather than the reactive drought relief strategy of the past (Hassan and Backeberg, 2010). Figure 2 is an illustration of the structures involved in disaster management in SA, including drought.

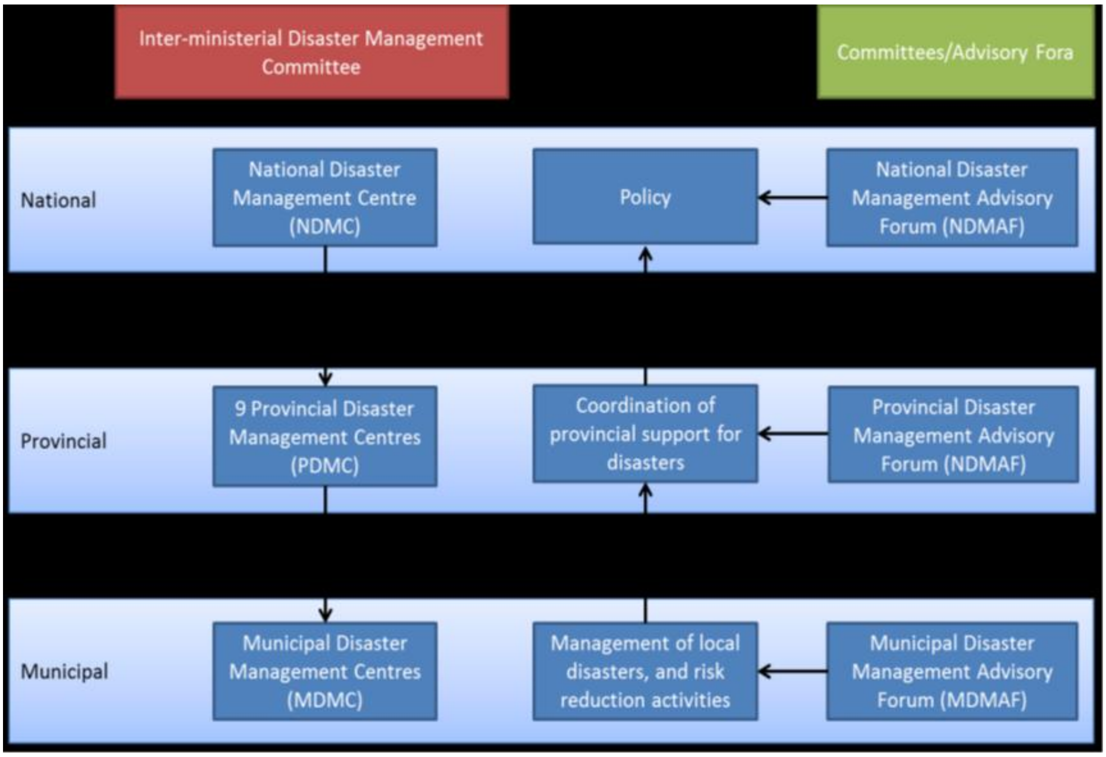

Figure 2: Structures of disaster management in South Africa (Extracted from Environmental Affairs, undated)

It is important to note that drought management cannot be complete without the involving the water sector. Water needs to be properly managed before, during and after drought. SA’s water sector went through a major reformation after the 1994 elections, culminating into a series of documents and principles to guide the water management and development (Mukheibir, 2003). These principles guided the intensive programme of work involving the minister and other political leaders, and other government departments. They organized user groups and South Africans in a process of consultation, research and synthesis (Mukheibir, 2003). One of the results was a new national water act, which was approved in 1998, as well as progress to integrating these concepts with other policies, such as drought, disaster and agriculture. SA’s National Water Act (Act 36 of 1998) states that its purpose is to ensure that the nation’s water resources are protected, used, developed, conserved, managed and controlled in ways that take into account, among other things, management of floods and droughts (Mukheibir, 2003). For achieving this purpose, the act would establish suitable institutions and ensure that they have appropriate community, racial and gender representation.

A new approach to disaster management was adopted in a white paper on disaster management and the ensuing Disaster Management Act (Act 57 of 2002) (RSA, 2002). The act is administered by the Department of Provincial and Local Government. Unlike previous policies that focused mainly on relief and recovery efforts, this act highlights the importance of preventing human, economic and property losses, and avoiding environmental degradation. This new approach aims to:

- create an environment for effective disaster management;
- promote proactive disaster management through risk reduction programmes;
- improve the ability to manage disasters and their consequences;
- promote integrated and coordinated disaster management through partnerships with stakeholders and cooperative relations between government departments;
- ensure adequate financial arrangements; and
- promote disaster management training and community awareness

The National Disaster Management Act tasks all spheres of government, in collaboration with civil society, to undertake to protect people, infrastructure and other national assets from the impact of disasters (RSA, 2002). It is therefore, the duty of government to plan for climate change adaptation and mitigation to reduce the vulnerability of people, infrastructure and other national assets to climate change.

The Agricultural Drought Management Plan (ADMP) was developed as mandated by the Disaster Management Act (Hassan and Backeberg, 2010). The National Drought Management Plan serves as the framework for all nine provinces to develop their suitable DMPs and strategies, designed according to each province's needs. The Disaster Management Act 57 states that each province is charged with the responsibility of preparing a disaster management plan for the province as a whole, coordinating and aligning the implementing of its plans with those of other organizations of state and multinational role-players and regularly reviewing and updating its plan (Republic of SA 2003). Likewise, each metropolitan and each district municipality is responsible for establishing and implementing a framework for disaster management in their municipalities aimed at ensuring an integrated and uniform approach to disaster management in their respective areas (Mukheibir, 2005). These relief measures should, however, be seen as the exception and not be implemented on an on-going basis (Mukheibir, 2005). However, the national government remains with the mandate of overseeing the implementation of the framework and at times intervening when need arises.

3.3.3 Drought Mitigation in South Africa

During the early 1990s, drought policy was changed in order to place greater obligations on farmers to reciprocate for state aid by committing themselves to practices aimed at promoting resource conservation and the long-term sustainability of economic production (Walters 1993). Only farmers who submitted stocking rates quarterly to their local Department of Agriculture office, and who reduced stock when drought warnings were issued, were eligible for state aid. Critics of this policy stated that insufficient consideration was given to the protection of the rural poor from threats posed by insufficient water, food, and employment (Walters 1993). In addition, definitions of disaster drought conditions tended to favour the western portions of the country, where the coefficient of variation of rainfall was greater. In fact, certain magisterial districts had been declared disaster drought for 70% of a 30-year review period, while some eastern portions of the country had never been declared (Walters, 1993).

Australian drought policy places considerable emphasis on encouraging primary producers to adopt self-reliant approaches to coping with drought and farm management. The South African minister for Agriculture noted that a prolonged drought would affect everyone in the country, and that drought aid would encourage bad practice; was inequitable in the past; and creates expectations that government would bail out farmers in all disasters. Recent draft legislation on agriculture recommended that government enhance access by the agricultural sector to meteorological and financial information that could forewarn a farmer of upcoming natural disasters, particularly drought.

Two types of strategies that could be used for mitigation of drought effects were proactive and reactive measures. Proactive approach involves pre-drought preparation of various measures, and is intended to make the water users more resistant to water-shortage and deficit during prolonged duration (Mniki, 2009). Reactive approach involves contingency plans undertaken during the on-going droughts and relate to changes in water supply and water demand that decrease the impacts of drought (Mniki, 2009). According to the same author, contingency plans should also include post drought measures undertaken to minimize the spread of drought impacts beyond unavoidable geographic areas and their economic and social sectors involved. The main strategies for effective short-term and long-term drought mitigation are:

- Better targeting of crops and cultivars to specific agro-ecological environments
- Natural resources management adapted to the limitations of drought-prone areas, in particular crop management to increase water use efficiency, soil and water conservation, including water harvesting; and sustainable use of irrigation water.
- Policy and institutional measures to facilitate implementation of drought mitigation practices, in particular the conservation and harvesting of water, and shifts to more adapted crops, (Mniki, 2009).

One critical component for disaster risk reduction is effective EWS, and effective DEWS have high potential in contribution towards tackling the cycle of droughts, by way of providing timely, relevant and comprehensible information on impending droughts (Masinde, 2014). Climate information, including seasonal climate forecasts, has been heralded as a promising tool for EWS and agricultural risk management in Southern Africa (Vogel and O'Brien, 2006). Nevertheless, there is concern that climate information, for example climate forecasts, is not yielding its expected results in the Southern African region and beyond. Climate scenario assessments and agricultural projections, based on general circulation models, indicated that the outlook for agriculture in the Southern African region was not promising (Vogel and O'Brien 2006).

Since SA is regarded as water-scarce and dry, and is prone to recurrent droughts, accurate seasonal forecasts to assist with the mitigation of drought effects. Together with the changing policy framework and governments' commitment to reduce direct assistance to farmers in times of disaster, the challenge to provide effective drought warning to farmers and rural communities increases (Monnik, 2016). These users cannot depend on vague warnings, and would soon discard systems that proved unreliable (Monnik, 2016). In SA, EWS that can be used across a range of agricultural production systems are needed, and have to change to cope with the greater variety of the crops, and the scale at which the information is available and focus on accurately reflecting the needs of small-scale farmers (Mniki, 2009).

It is reported that during 1991/2 drought, unfortunately, the country did not have DEWS and it was difficult to anticipate and avert the full range of human, environmental, economic, and other consequences of drought (WRC, 2015). For small-scale farmers and rural communities, many other social and economic factors interact, requiring a more comprehensive suite of indicators (Monnik, 2016). Farmers and agricultural organizations are now increasingly being required to manage themselves, hence they require systems to enable them to anticipate drought, to be able to respond effectively (Monnik, 2016). Additionally, National EWS may have been sufficient for the needs of the state in the past, but EWS that are locally based and focused on the systems used by farmers are now required.

The NDMP seeks to reduce the impacts of droughts by providing information management, monitoring and evaluating systems for the early warning of droughts (Ngaka, 2012). SA has a number of, and is in the process of developing more EWS for different sectors and different weather-related hazards (Environmental Affairs Report, undated). SAWS is the legally mandated institution, as per the Weather Service Act (Republic of SA 2001), responsible for weather and climate forecasting and the issuing of severe weather-related alerts (Environmental Affairs Report, undated). It has adopted the Multi-Hazard Early Warning Systems, which makes use of multiple monitoring systems and meteorological, hydrological and climate information to prepare for and respond to multiple weather-related hazards (Environmental Affairs Report, undated).

In SA, information is disseminated to the Disaster Management Centre (DMC) and public prior and during events via internet, email, telephone, television, newspapers, radio, and local disaster managers (Poolman, undated). The SAWS Severe Weather System disseminates early warning information to affected communities about potentially damaging weather events. SAWS has collaborated with a number of research institutions and government departments to develop a number of other EWS (Poolman, undated). Work is underway to improve EWS in SA, in order to improve the communication and dissemination of information at the local municipality and community level (Environmental Affairs Report, undated). The SA EWS aims to be an integrated, end-to-end, right down to community level, incorporating all four elements of an effective EWS and involving all stakeholders (Poolman, undated).

3.3.4 Limitations of current EWSs in SA

There is lack or limited institutional knowledge on how to secure funds, and municipalities do not budget for Disaster Risk Reduction programmes (CSIR, 2014). It is the responsibility of provincial governments to budget and mobilise funds in order to implement drought management strategies.

Reports show that, despite the existence of the National Disaster Management Centre (NDMC), the uptake of early warning information remains slow in SA (CSIR, 2014). While assessments of the need, value, and uptake of forecasts in many parts of the world have been positive, case studies in southern Africa illustrate that several factors frustrate the uptake and effective use of forecasts in this region (Vogel and O'Brien 2006). These factors, resonating with similar findings from other assessments in other regions, include the spatial and temporal scales of long-range forecasts, the timing of forecasts, and the diverse information and interpretation needs of different user groups (Vogel and O'Brien 2006).

It was reported, that provincial offices of Department of Agriculture, Forestry and Fisheries (DAFF) remain incapacitated and constrained because of the lack of structure and defined roles for individuals (Anonymous, 2014). Botha *et al*. (2011) found that 50% of local municipalities in SA lacked the disaster management structures, while 68% of local and 25% of district municipalities did not have disaster management advisory forums (CSIR, 2014).

Effective dissemination of warnings to all levels of society was still a problem and needed significant support and participation with other structures, including disaster management, media and other role players (Poolman, undated). The Minister of Corporative Government, Mr Van Rooyen, admitted in his speech that, “Our people do not have much information”, and highlighted that there should be increased communication of drought-related information to all communities. Jordaan (2012) argued that, in addition to the accuracy of forecasts, the challenge is of communicating the forecasts and early warnings in such a way that they reach all farmers and stakeholders. Few farmers understood the methodology used to illustrate the forecasts in the first place and the communication channels used for seasonal forecasts were not as effective as the communication channels used for daily and weekly forecasts (Jordaan, 2012). The main constraints to future development and access of drought EWS in SA were identified, including

- Lack of a completed drought policy framework
- Lack of coordination between institutions that do provide some type of drought EW
- Lack of vulnerability data bases, and
- Lack of social indicators to form part of a holistic EWS

A clear policy framework would provide the foundation on which further systems development and integration between institutions could occur (Monnik, 2016).

3.3.5 Governance and Social Aspects of Drought Management

The environment in which end users of climate information make use of such information is not neutral and egalitarian (Vogel and O’Brien, 2006). End users, including farmers, usually operate in an environment of considerable uncertainty, reacting to and coping with multiple stressors and risks whose impacts are not always clear or predictable (Vogel and O’Brien, 2006). As put forward by Mniki, (2009), the real culprit responsible for the severe negative impacts of drought may not be the drought itself, but rather the socio-economic structures where the affected are situated. For developing communities, drought is a problem that is often aggravated by poor infrastructure, economies, lack of access to technology and institutional capabilities to deal with it (Mniki, 2009). Climate is only one factor that influences production decisions; other factors, such as market liberalization and changes in production subsidies, are likely to confound any direct responses to climate, while HIV/AIDS is already undermining the ability of the region as a whole to respond to, let alone prepare for climate variability (Vogel and O’Brien, 2006).

It is argued that successful DEWS rely on weather forecasting systems, but implementation of such systems in many African countries is hampered by among other things, inadequate coverage by weather stations (Masinde, 2016). Farmers are further hampered by very poor utilisation of the Seasonal Climate Forecasts (SCFs), mostly because the content, format and dissemination channels used do not address the farmers' needs; hence they continue to rely on their local/indigenous knowledge forecasts, to derive critical cropping decisions (Masinde 2014). Furthermore, climate information is also likely to have uneven effects, potentially exacerbating existing inequalities and potentially undermining local knowledge systems (Vogel and O'Brien, 2006). Climate information, its position in various on-going dialogues in the region and its use in the 'development' arena, therefore, require the inclusion of a 'socially informed perspective' in addition to the 'technocratic' approaches that often dominate (Vogel and O'Brien, 2006).

Therefore, the only realistic long-term effective measure would be to change the socio-economic environment of the vulnerable community (Mniki, 2009). It is further emphasized that the socio-economic framework should be developed to the extent that the communities involved are no longer so vulnerable to the impact of drought (Mniki, 2009). The process and 'vehicles' through and in which climate information is being transferred to end users in the southern African region is also limited (Vogel and O'Brien, 2006). Agricultural extension agencies have been shown in several cases to be poor 'boundary institutions' for information brokering (Vogel and O'Brien, 2006). Many farmers have little contact with such agents and therefore cannot depend on receiving timely information from such sources of information (Vogel and O'Brien, 2006). In support, Jordaan (2012) added that the sources used to communicate agricultural related information are almost beyond reach by the poor, rural, smallholder farmers. In SA, farmers who qualify for credit/loans of any other form of drought relief are that that would have adhered to the requirements of the National Disaster Management Act. This poses a serious challenge for the poor farmers who might have missed most of the information, as it would have been availed.

Managing climate variability in southern Africa has become far more complex than merely dealing with extreme drought and flood events (Vogel and O'Brien, 2006). Such a shift in the linkage between climate and other causal mechanisms in a chronic and yet worsening situation of food insecurity, as persists in the SADC region, forces a re-conceptualisation and re-thinking of how climate information is produced and used (Vogel and O'Brien, 2006). Preoccupation with dissemination, including issues related to the scale of forecast applicability; the understanding of probabilities used in the production of the forecast;

credibility of the forecasts and other problems in communicating the forecast message often diverts the focus from the contextual situations in which these tools are embedded (Vogel and O'Brien, 2006). Efforts must not be shifted towards providing effective climate forecast information only, but also ways in which uptake of such information could be improved. In a recent assessment of forecasts information flow in the Limpopo Province, SA, the over-burdening of the climate information system in government, characterized by too many links in the communication chain, has been found to result in delays in effective climate risk management and effective early warning (Vogel and O'Brien, 2006). Understanding the institutional issues and dynamics surrounding the most appropriate fit of forecasts within institutions, and the scale of their use (local and/or national/regional), is a fundamental prerequisite to realizing the potential value of seasonal climate forecasts (Vogel and O'Brien, 2006).

3.3.6 Possible Strategies to Improve EWSs

Regardless of the challenges and many other limiting factors of effective use of EWS, there is still hope that this tool has great potential of achieving good results. This is possible, only if there is a rethinking on how best they can be used and swift action by all the stakeholders involved. In order to realise the potential, there is need to recognise that a critical component of planning for drought is the provision of timely and reliable climate information, including seasonal forecast that aids decision makers at all levels in making a critical management decision (Mniki, 2009). Early warning information should be effectively communicated in order to reduce drought impact. However, although most drought-prone areas usually have their own EWS, it is also quite common to find a number of NGOs operating EWS covering a particular district/ location, where the NGO is working (Mniki, 2009). The absence of a single EWS bulletin providing a clear and consistent message is a hindrance to timely decision making, by government and other role players alike and that may delay response (Mniki, 2009). An example of an incident that occurred in Ethiopia in 1997 was noted, whereby two early warning messages were issued, but unfortunately, they were contradicting each other. In this scenario, the National Meteorological Services Agency was warning of a higher probability of drought in the main rainy season of 1998, which Famine Early Warning System contradicted, saying that the probability of abnormal rainfall was only slightly changed from normal years and that confusion led to the delay in decision-making and response (Mniki, 2009). This is bound to happen when climate information producers fail to work together to achieve a common goal.

Another hindrance to effective EWS was noted as "*the wait and see attitude*" (Mniki, 2009). To support his argument, an example of the 1997 El Nino event in Ethiopia was cited, whereby the early warning information was provided and publicized early, but it encountered the attitude that "*we'll wait until something actually happens*" (Mniki, 2009). This attitude was noted as dangerous, and encouraging bidding up of crisis severity, potentially backfiring if the situation do not reach the predicted level. This was argued to undermine the credibility of the EWS.

On the other hand, weather forecasts, although they could be largely reliable, they could never be fully trusted. According to Jordaan (2012), one cannot value the accuracy of meteorological forecasts, which is an indication of drought early warning from one year's forecasts and blame the weather service for poor forecasting. However, the vagueness of the forecasts gives some perspective on the scepticism of farmers regarding the meteorological forecasts available (Jordaan, 2012). It is noted that special weather forecasts for agriculture are among the main requirements of farmers, but the problem of their relative lack of reliability, and consequently the lack of trust in forecasts, exists in many countries of the African region (Stigter *et. al.*, 2000). As an example of the use of these forecasts, the authors state that some agricultural agencies in Malaysia are nevertheless, using short- and medium-range forecasts for planning daily, weekly and even monthly operational field activities and that they also use long-range forecasts (Stigter *et. al.*, 2000). However, in SA, it is argued that farmers do not adjust their management practices sufficiently, according to the meteorological forecasts since they have little trust in current forecasts (Jordaan, 2012).

Political will has been identified as one of the most important factors that may contribute positively towards the use of early warning information in decision-making (Mniki, 2009). An example of the situation in Turkana was given whereby there were two episodes of drought. The first episode occurred from 1990-1991 and the EWS generated reliable early warning information and recommended a response (Mniki, 2009). The District commissioner was supportive and donor/government relations were good at district level. In this instance, the political will to respond early was present, resources were made available and measures were taken to protect livelihoods before lives were threatened. The second episode occurred in 1992, but the situation was different, although EWS was still in place. It was different in the sense that at national level, the government was more concerned with preparations for the forthcoming multi-party elections. The District Commissioner in Turkana was not supportive of a rapid response and as a result the decision-making body, District Drought Management Committee, was paralysed. The relief operations started very late and there was acute food insecurity and human suffering.

Wilhite (2000) also identifies media as one of the most powerful vehicles that can be used in disseminating early warning information (Mniki, 2009). Additionally, it is argued that agro-meteorological information must be disseminated in an optimum way, based on the type of advice required and the needs of the end user (Weiss, Van Crowder and Bernardi, 2000). Valuable agro-meteorological information can be transmitted to farmers through the extension services or through the media (Weiss *et. al*., 2000). In developing countries, radio broadcasts of agro-meteorological information to rural farmers play an important role to provide timely advice at the local level (Weiss *et al*, 2000). This was confirmed during the 1984 famine in Ethiopia whereby the famous BBC television played a significant role in disseminating EW information by exposing to the world the horrific famine that was unfolding and the international community's failure to respond in time (Mniki, 2009). Because of that, more energetic and increased response from many western donors was triggered

Agro-meteorological bulletins may also be used to transmit information. Most of the times, agricultural information contained in these bulletins is generated by interviews with farmers, particularly when the agro-meteorologist is far away from the area to be monitored (Weiss *et. al.*, 2000). This kind of field information can be very useful, for example, to assess the predictions produced by crop simulation models and to report to central bodies about crop conditions. However, when the farmer makes use of additional inputs, for example, fertilizer, pesticides and high potential varieties, his own experience may not be sufficient to take advantage of these inputs. In this situation, the farmer would require additional advice beyond that normally received. This information can be supplied through the local extension services or specialised advisory services, and if current trends continue, eventually for a fee (Weiss *et. al.*, 2000). The same opinion was shared by Stigter *et. al.* (2000), who cited that warnings, as required by different types of clients, followed by advice on the use of the information, for example, for food security programs, are required

3.3.7 Role of Indigenous Knowledge in Drought Management

The term indigenous knowledge is used to refer to the 'place-based knowledge' that is rooted in local cultures and generally associated with long-settled communities, which have strong ties to their natural environments (Masinde, 2014). The local community would have built this knowledge over the years from their understanding of the forecasting and the probability of future rain, based on variance in wind, humidity and temperature (Masinde, 2014). Secondly, based on the kind of social-economic activities the community indulges in, interpretations of animals, insects, birds, and plants behaviour is performed. Reports show that there has been a sharp increase in publications in the area of indigenous knowledge in Africa, especially in

SA, where tens of research projects are funded through the National Research Foundation (Loubser 2005). Despite this encouraging trend, publications in the category of weather/droughts/climate-variation prediction are still rare, and specifically, studies on agriculture and environment are minimally represented, as compared to other categories like culture (Masinde and Bagula, 2012).

Generally, publications on IK on drought/weather management in Africa reveal that communities in Africa use more or less common approaches to predicting drought and weather (Masinde and Bagula, 2012). They observe the changing seasons, lunar cycles, natural environment, like behaviour of animals/birds and the appearance of certain plants (Alcock 2010; Masinde and Bagula, 2012 and Ncube and Lagardien, 2015). Like modern weather forecasters, IK also involves studying meteorological parameters such as air temperature, cloud colour and direction, and wind direction (Masinde and Bagula, 2012). It has been noted that researchers today concur that IK and modern science complement each other. According to the study carried out by Ncube and Lagardien (2015), farmers in the Karoo region of Western Cape, SA, were using local known strategies to cope and adapt to droughts and have been doing this for many years. By heeding to indigenous drought indicators, for example, cloud colour and wind direction, and sounds or behaviour of birds, farmers were able to make informed decisions on how to mitigate effects of drought.

Indigenous strategies that have been used to manage water shortages include planting and irrigating small areas, thereby, using little water as possible. On adaptation, farmers harvest water from the mountains, drill boreholes, and construct stock dams to conserve water (Ncube and Lagardien, 2015). In Zimbabwe, farmers were harvesting water from rooftops and diverting water from natural springs into tanks (Shumba, 2001). This ensures that farmers have a substantial amount of water stored up, and in case of a drought, the stored water would be able to sustain them for about five months depending on the volume of the tank.

Farmers in the Karoo purchased lucerne from others to supplement their feed for animals. As an adaptation strategy, long-term storage of lucerne was also considered. Farmers also planted saltbush, Prosopis and Agave, to provide animals with alternative feed species. Farmers also slaughtered or sold their animals, leaving the breeding herd for continuity. However, slaughtering animals was the last option, they would have spent much time developing the breed. Some marketed their livestock early before their quality was affected by drought (Ncube and Lagardien, 2015). Drought-resistant herds and low-input systems were also adopted as a way of adapting to drought in the long-term. For fruit producers grew short-season cash crops to improve cash flow and changed systems to alternative high value crops and enterprises. To mitigate the effects land degradation, farmers grazed their animals alongside the roads or migrated animals to areas with more grass and imported fodder from other regions. Medium term strategies included rotational grazing, pen feeding, treating animals with natural plants, traditional animal disease management, building of weirs and slots to provide long-term erosion control and construction of contours across slopes to conserve soil (Ncube and Lagardien, 2015).

3.3.8 EWSs and IKSs

Researchers today concur that IK and modern science complement each other (Masinde, 2014). Bridging local farmers' and scientists' knowledge through participatory research led to adoption of more appropriate technologies (Masinde, 2014). The differences and synergies between local knowledge used to manage climate risks and seasonal climate forecasts are also rarely profiled and given the critical attention that they require (Vogel and O'Brien, 2006). Masinde and Bagula (2012) give a comparison between indigenous knowledge-based seasonal forecasts and seasonal climate forecasts (Table 4).

Table 4: Comparison between indigenous and scientific drought forecasts (Masinde and Bagula, 2012)

Indigenous	**Scientific**
Use biophysical indicators of the environment as well as spiritual methods	Use of weather and climate models of measurable meteorological data
Forecast methods are seldom documented	Forecast methods are more developed and documented
Up-scaling and down-scaling are usually complex	Up-scaling and down-scaling are relatively simple
Application of forecast output is less developed	Application of forecast output is more developed
Communication is usually oral	Communication is usually written
Explanation is based on spiritual and social values	Explanation is theoretical
Taught by observation and experience	Taught through lectures and readings
Adapted to local conditions and needs	Formulated at a larger scale and lacks relevance at local level
Refers to rainfall duration and distribution and it is aligned to crop weather indicators	Refers to rainfall quantity at a regional level
It is language based and qualitative	It is number-based
It is holistic – it covers large number of variables qualitatively	Covers small number of variables quantitatively
It is a way of live – looks at both the process of knowing and the knowledge itself.	Has no social context
It has rules of the 'knowing process'	It is based on rules of science, that is evidence, repeatability and quantification

It is reported, that used alone, seasonal climate forecasts and other adaptive strategies for climate change may offer little benefit to many farmers, including commercial and smaller scale producers, their dependants and others in southern Africa, whose livelihoods strategies are centred on living with complex vulnerabilities, including changing state support, HIV/AIDS, and conflict. Rather than simply focusing all efforts on better forecasts, one should also be finding ways of linking forecasts to other development priorities (Vogel and O'Brien, 2006).

Masinde (2014), argues that, using IK alone makes it is difficult to forecast beyond a season and, that some terminologies used in IK may sometimes have more than one meaning, for example, 'abundant rainfall' may mean rainfall for the day or a season. Climate forecasts are thus seen as a promising but underutilized tool for enhancing food security. Case studies confirm earlier concerns by showing that information dissemination and communication is not a neutral process, and that forecasts alone are not necessarily empowering, since they often overlook a number of complex interactions and processes occurring at local levels, including the use of traditional knowledge (Vogel and O'Brien, 2006). In spite of potential benefits, IK interventions can and do simplify complex situations and strengthen existing assumptions and myths about the ‘powerlessness’ of impacted people’ (Pulwarty *et al*. 2004).

As revealed, the channels used to disseminate early warning information, its content and format do not address the farmers’ needs and are unreliable and irrelevant. It is reported that farmers have in turn continued to rely on their local/indigenous knowledge forecasts (IKFs), to derive critical cropping decisions (Masinde, 2014). Despite the challenging contexts they operate in, meteorological institutions in Sub Saharan Africa continue to provide regular climate forecasts especially in form of SCFs (Masinde, 2014). However, the utilisation of this information by the small-scale farmers whose crops/livestock depend solely on rainfall is still below par (Masinde, 2014). Studies reveal that over 80% of farmers in some parts of Ethiopia, Kenya, Zambia and Zimbabwe relied on IKFs (Masinde, 2014).

It is argued that the scientific approaches to weather prediction are hardly utilised by the mostly illiterate farmers most of whom live in the remote villages where modern technologies such as televisions and internet are still a foreign concept, and the implementation of modern drought prediction technologies is still a costly affair for most African countries (Masinde, 2014). IK and modern science-based weather forecasts are not mutually exclusive but significant discordance between the two is still apparent (Masinde, 2014). Clear understanding and careful integration of IK present opportunities especially in the dissemination process of weather forecasts to farmers in Sub Saharan Africa, because this would support ways that are culturally appropriate and locally relevant (Masinde, 2014). On the question whether IK needs modern science, there is evidence that IK has been eroded and is slowly disappearing (Masinde, 2014).

3.4 GAPS IN POLICY AND RESEARCH

3.4.1 Policy Development

The NDMP of SA is almost silent on the role of other stakeholders including the smallholder farmers, NGOs, IKSs and civil society. Farmers, specifically smallholder, are seemingly playing a passive role in drought policy development, implementation and management, implying a ‘top-down’ approach of drought management. This approach has always had its own challenges ranging from lack of ownership, confusion, ignorance and independence by affected stakeholders, delaying the process. The NDMP does not show to what extent the farmers were involved in its development; neither does it show their place. It remains a mystery, how the government intends to assist smallholder farmers in their assumed contribution towards food security in SA. The extent to which IKSs, NGOs and civil society play their role in drought management is not clear as well. Although, limited reports have shown what civil society has done, it remains unclear on their working and the relationship that exists among them, the government, IKSs, and NGOs.

The South African drought management policy is not clear about provision of water for agricultural use by farmers during drought. Emphasis on water provision for, example, domestic and sanitary use has been evident throughout the review. Agricultural water provision and utilization is completely out of the picture, which remains difficult to assess effectiveness of management programmes for water.

3.4.2 Absence of DMPs in provinces

Only two provincial DMPs were identified during this review, the one for NC and WC. Reasons for the absence of these in other provinces of SA are not known. However, as reiterated earlier, it cannot be concluded that these are non-existent. There is need for further investigation, because clear understanding of how provincial government plan or are managing drought is necessary. It is anticipated that an investigation into the matter could reveal serious concerns that may need urgent attention by the national government.

3.4.3 Research

Limited research has been conducted to determine what local governments in SA have or are doing to pursue the goals of DMP. In 2008, the South African NDMC commissioned research into the measures taken by local municipalities in anticipation of and response to climate change (Tempelhoff, e*t. al.*, 2012). It is argued that if the development goals of the country are to be achieved despite the impacts of climate change, then the appropriate lessons need to be incorporated into national and local water management policy (Mukheibir and Sparks, 2003). Sadly, within the growing literature on climate forecasts, there is a tendency to identify and publicize the success stories, while the failures are seldom reflected upon, and often dismissed as ‘growing pains’ (Vogel and O’Brien, 2006). However, the failures of forecasts to affect livelihood strategies can offer valuable insights into the possibilities and limitations of climate forecasts (Vogel and O’Brien, 2006).

The key to drought preparedness and readiness is about knowing the what, how and when of the drought (WRC, 2015). To achieve this goal the scientific expertise to monitor and predict, the capability of the observation networks, information systems for drought early warning have to be improved (WRC, 2015). A similar need was identified from a number of water resources assessment studies and discussed extensively for five years in various scientific forums concerned with water resource planning and development (WRC, 2015). To address this need, the WRC made a call for proposals to investigate the feasibility of establishing a Hydrology Institute to act as a clearinghouse for all hydrological datasets to support the water sector in the implementation of the NWA (WRC, 2015). The proposed institute/facility could play a critical role for the water sector in drought monitoring and research (WRC, 2015).

It is argued that there is need for researchers to reflect on these failures and widen the current debates surrounding the potential use of climate information (Vogel and O'Brien, 2006). They suggest that some of the questions that need to be addressed in future discussions of climate information and food security include the following

- What are the users' needs, concerns and priorities? How can these be better matched to climate information including seasonal forecasts?
- What 'user spaces' would be required and could be created for such sustained dialogues and interactions to occur?
- In what ways can current institutions inject climate information into regional, national and local discussions on the design of food security interventions?
- How can such insights be used to better frame current government policy relating to climate, disaster risk and development?

In the past, most of this research has been conducted in agricultural sector, and, more recently, has been focused on the impacts of drought and floods on people and their livelihoods (Mukheibir and Sparks, 2003). The lessons from this research, and resilience strategies of vulnerable communities, need to be taken into consideration when developing strategies to deal with the impacts of future long-term climate change (Mukheibir and Sparks, 2003). To have an impact on food security in southern Africa, climate information and seasonal climate forecasts need to be placed within a much wider context that includes not only the improvements of the product, for example, forecasts, but also efforts to understand better, the needs and demands of society, and manage climate risks (Vogel and O'Brien, 2006). If the emphasis continues to be only on the production of climate information, divorced from the development needs of a region or country, and does not pay serious attention to the holistic implementation required to avert crisis and chronic problems, then adverse situations will persist despite well-meaning efforts (Vogel and O'Brien, 2006).

3.5 DROUGHT MITIGATION MEASURES IN AGRICULTURE

3.5.1 Water Supply and Demand Oriented Measures

This section discusses response options on both the supply and the demand sides. Not all response measures fit easily into these two categories. For instance, improvements to the distribution of water could be regarded as either supply-side or demand-management measures, depending on where they fall in the continuum from source to user. The re-purchase and restriction of historical water rights, which is happening in Australia, and which occurred in South Africa through the 1998 National Water Act, could be regarded as a supply side measure, or as a measure for promoting the economic efficiency of water use, or as re-allocation (FAO, 2003).

Supply enhancement includes increased access to conventional water resources through the construction of hydraulic structures aiming at regulating water supply and conveying water to the end user (dams and reservoirs; conveyance systems), as well as enhancing supply with treated wastewater, and desalination. Demand management, in contrast, aims to raise the overall economic efficiency of water use, or to re-allocate water within and between sectors. In agriculture this might involve producing more highly valued crops from irrigation, or raising crop productivity, or reducing the consumptive use of water by minimizing evapotranspiration, or restraining the cropped area under irrigation.

Demand management options are usually more difficult and less popular to implement than supply enhancement options. This is the reason why they are often considered in a second stage, after the easier supply-side options have been implemented (Molden *et al.*, 2001). Improvements in the technical efficiency of distribution of water can be regarded either as a supply-side or a demand management measure, depending on the nature and scale of the action, and where responsibility lies. Major improvements to canals and pipelines, for instance, can be regarded both as supply-side measures and as demand-side measures, whereas local and on-farm improvements, particularly those under the control of farmers themselves, are more akin to demand management, since they affect the economic efficiency with which the water is used. In agriculture this can be done through better crop and water management and the modernization of irrigation infrastructure (Perry, 2007). Over time, measures to enhance supply through the more systematic re-use of wastewater also become important. Eventually, other, costlier, forms of supply enhancement, e.g. desalination, may become feasible (FAO, 2011). The pressure will mount on agriculture to increase its water productivity not only through more technically efficient use of water but also through a shift towards higher value crops in order to optimize the economic return from irrigation water.

In the early stages of water development, when water supply can easily satisfy demand, priority is usually given to supply management through the construction of storage and conveyance infrastructure in support of irrigation development. Later, when the supply of water no longer satisfies unrestricted demand and the low-cost gains in efficiency have already been made, efforts focus on demand management: increasing the productivity of water in agriculture and reducing losses are obtained through management and technical measures that can help to offset supply limitations (Loeve *et al.*, 2004).

As drought persists, the combination of forces that drive demand for water often lead to a fall in both the share and absolute allocation of water to agriculture (FAO, 2003). This outcome reflects the priority given to water supply for domestic uses in fast growing urban areas. In many situations, preference is also given to industrial users over agriculture, both through regular allocation processes or, in emergencies, by direct appropriation. The increasing recognition of the need to reserve water for the functioning of ecosystems is a further challenge for agriculture in water-scarce areas (CA, 2007).

In negotiating its legitimate share of water, agriculture can invoke the multiple functions it performs, which go beyond commodity production and deliver important social and environmental benefits. Nevertheless, agriculture must be able to show more productive use of its water, and for this to happen, sizeable investment will be needed, which farmers will only do if it is profitable.

Tunisia illustrates a progression that began with supply enhancement measures: large dams, small earth dams, mixing fresh water with wastewater, water transfers from inland to coastal areas, and desalination of brackish water for domestic use (FAO, 2012). Over the last 15 years this has been complemented by programmes on the demand side which include modernization of irrigation systems, backed by subsidies, re-allocation of land and water to strategic crops, a halt to the production of sugar beet, and the promotion of inter-cropping trees with crops by small-scale farmers (FAO, 2010). In Spain, current measures are a mix of supply-side programmes for wastewater re-uses desalination and on-farm and district storage, with demand management actions on the modernization of irrigation to improve service levels and the re-allocation of water to high-value crops (Rockström *et al.*, 2009).

3.5.2 Water Management

The general aim of demand management is to ensure that a given supply of water is distributed to according its optimal use pattern. In economic terms, this will be achieved when the marginal unit of water for each user has the same value (Winpenny, 1994). The aim of equalizing marginal values of water in all uses is a theoretical ideal, but where water becomes scarce, and its cost of supply is increasing, it is important for policy makers to encourage society as a whole to make the most productive use of the water available, however this is conceived (FAO, 2006). This can be pursued by giving incentives to individual users to make more efficient use of water and by encouraging a shift of water from less to more beneficial purposes.

Increasing the availability of water for agriculture can be done at different scales. At the river basin scale, dams for the storage of irrigation water, either for single or multipurpose use, represent major, capital-intensive solutions (Rockström *et al.*, 2009). At a much smaller scale, individual farmers are able to dam rivers and store and harvest water for the benefit of their own operations. At farm level, in rainfed conditions, farmers can practice on-farm water conservation to reduce runoff, and encouraging the infiltration and storage of water in the soil (CA, 2007). At this local level, increasing the availability of water is highly decentralized and involves huge numbers of farmers involved in pumping groundwater and developing small-scale water harvesting (FAO, 2010).

The term water use efficiency is sometimes used in a narrow sense as the ratio between beneficial use and water withdrawals. This applies to the notion of water supply efficiency or irrigation efficiency, where the difference is analysed between water withdrawn and the physical losses resulting from leakage from pipes and canals and wastage through excessive or inappropriate application for the crop or productive process. Among the 23 countries of the Mediterranean, an estimated 25% of water is lost in urban networks and 20% from irrigation canals, while global estimates of irrigation efficiency are around 40% (FAO, 2012). Appreciating the real scope for water savings by reducing these losses is an important issue in water demand management, but it can only be identified through water accounting procedures (Molden *et al.*, 2001). However, part of the water lost between the source and final user finds its way back into the hydrological system, either through percolation into the aquifers or by return flow into the river systems (Perry, 2007). In this situation, water losses may from become unintended uses. This being said, targeting the reduction of losses in distribution systems is still justifiable in many cases. Excessive levels of losses and leakages reflect failures of infrastructure or its management, and cause financial costs for producing, pumping and transporting water, as well as degradation of the distribution system, increased environmental and health risks, and lost opportunities for beneficial use of water (Faurès and Santini, 2008). In irrigation, losses in distribution may reduce the water available to the end user irrigators.

3.5.3 Water recycling and re-use in irrigation

The scale of re-use and re-cycling of drainage water and wastewater is an important part of water accounting. In large-scale contiguous irrigation projects, excess water returns to the system through drainage or infiltration and is re-used within the same system or further downstream. In the Nile Valley, for instance, about 20% of the water is recycled in this way between the Aswan dam and the sea (Molden *et al*., 1998).

The large-scale paddy systems of South-Eastern Asia follow very similar patterns of re-use. A good estimation of the rate of re-use is essential in gauging the effectiveness of water saving measures: efforts to increase water use efficiency by reducing distribution and on-farm losses may turn out to have marginal net impact when assessed at basin scale (Molden *et al*., 1998).

Although it is of minor global significance, the re-use of urban wastewater in agriculture is of potential importance in a growing number of localities. There are no reliable figures on the extent of municipal wastewater use in agriculture, but direct use of treated and untreated wastewater is significant in certain water-scarce areas such as the Middle East and in the Tula Valley near Mexico City (FAO, 2010). Efforts are needed to better assess and map current informal wastewater re-use and its potential, particularly in water-scarce areas (FAO, 2010).

3.5.4 Reducing water losses

The scope exists for the adoption of technologies or management methods that result in reduced losses of water in the distribution and application process, and it would be wrong to automatically discard water conservation measures on the ground that most of the return flow can be used further downstream (Perry, 2007). The share of the non-recoverable fraction and non-beneficial consumption in comparison with return flow and beneficial consumption is very much site specific and varies from one place to another. In addition, water conservation options are usually associated with increased water productivity and other, non-water-related co-benefits, such as reduction in energy use, reduction in labour costs or increased precision and reliability of water delivery (Gleick *et al.*, 2011).

The most widely promoted conservation measures include canal lining and conversion from gravity to pressurised irrigation, in particular, localized irrigation (micro irrigation). Canal lining in large surface irrigation schemes are among the most widely promoted approaches to reduce losses in irrigation, in particular in South Asia (Perry, 2007). When designed for areas with large, continuous unconfined aquifers, such as the Ganges basin, such interventions may be designed to improve water control and may reduce local leakage, but will not necessarily induce significant water saving across the whole command area (Gleick *et al.*, 2011). In current drought conditions, with the increasing importance of the conjunctive use of surface water and groundwater through the digging of shallow groundwater wells in individual farm plots, gravity irrigation systems with poor conveyance efficiency play an increasingly important role in terms of aquifer recharge (Shah *et al.*, 2000). Rehabilitation or modernization planning in such irrigation schemes, therefore, need to take a much more comprehensive approach to water saving and focus more on the overall productivity of water in a system rather than strict technical efficiency (Perry, 2007). Canal lining may still be justified in the framework of irrigation modernization plans when it is required to improve water control, or in areas where conveyance losses are high and, downstream water recovery is unlikely (Perry, 2007). A similar approach needs to be adopted in the case of transformation from gravity to pressurised irrigation systems. Pressurised irrigation does not always deliver real water savings at the farm, system and basin scales. The adoption of pressurised irrigation often represents also a step forward towards better control, flexibility and accountability of irrigation water delivery, and therefore allows for transformation from low-return to high-return agriculture. Such transformations can, therefore, be justified not only in terms of water saving but in terms of increasing the productivity of irrigation.

3.5.5 Improving crop water productivity

The Comprehensive Assessment of water management in agriculture (CA, 2007) provides an extensive review of increasing agricultural water productivity. Agricultural productivity can be raised either by increasing production from a given volume of water or by reducing the volume of water while maintaining acceptable levels of production. The latter is the case of deficit irrigation, a strategy by which farmers apply less irrigation water than that needed to meet full crop water requirements. By accepting some yield losses in the major annual crops, deficit irrigation aims at achieving an economic optimum in the relation between water use and crop yields under water scarcity (FAO, 2006). Its application requires knowledge of the crop response to water deficits in the different stages of growth in order to formulate an irrigation schedule that maximises water savings while it minimises yield loss. For many tree crops, deficit irrigation offers the possibility of reducing irrigation water use while maintaining farmer income in water-scarce conditions (FAO, 2012).

Plant breeding and biotechnology can help by reducing biomass losses through increased resistance to pests and diseases; vigorous early growth for fast ground cover and/or root development; and reduced susceptibility to drought (FAO, 2010). Although substantial progress has been made in several water-scarce countries in reducing the gap between the actual and potential yield of crops, much progress can still be made (Faurès and Santini, 2008). Yield increases are made possible through a combination of water control, improved land management, seed material, and prudent use of fertilisers and plant protection chemicals.

3.5.6 Allocating water for higher value crops

The scope for increasing value per unit of water use in agriculture varies considerably, but in some cases, it may be a more promising avenue than increases in physical water productivity (Bruinsma, 2009). There is no correlation between crop water requirements and economic return. In drought-stricken areas it makes sense to use water for crops providing a high economic return, rather than for staple crops with lower economic returns. Where market conditions exist and staple production can be substituted from other sources, farmers can be encouraged to shift from lower value to higher value crops and increase the productivity of water in agriculture (Loeve *et al.*, 2004). However, higher value crops usually require more flexible and reliable water supply systems than what many large-scale public irrigation schemes can offer (Faurès and Santini, 2008). This may call for changes in both the management and technology of irrigation. High-value crops are usually very capital-intensive and sensitive to market conditions, and riskier for farmers for these reasons. Shifting to higher value crops requires access to inputs including seeds, fertilisers and credit, as well as technology and knowhow (FAO, 2010). The extent to which national policies in drought stricken areas will focus on such conversion to productive agriculture will also be linked to national food security strategies. It is possible for highly efficient and highly productive irrigated agriculture to simply exploit all sources of water.

3.5.7 Increased Water Storage

Currently, agriculture in South Africa is predominantly rainfed. According to FAO estimates of 2012, only about 13% of total cropland is equipped for irrigation, of which an estimated 95% is actually irrigated, and agricultural water withdrawals amount to just 15% of total renewable water resources. The country’s rainfall and river flows are variable, erratic and seasonal; droughts occur frequently and agricultural yields are often constrained by insufficient water (Bruinsma, 2009). Under these circumstances, even relatively small volumes of water storage can, by safeguarding domestic supplies and supporting crops and/or livestock during dry periods, significantly increase agricultural and economic productivity and enhance people’s well-being.

Water storage is often associated with large dams mainly because of their considerable financial requirements, as well as the political opportunities that they represent. There is ample evidence of the broad links between high storage capacity constituted by many large dams and increased agricultural productivity and economic growth. Generally, water storage provides a mechanism for dealing with drought which, if planned and managed correctly, increases water security, agricultural productivity and climate variability adaptive capacity (Bruinsma, 2009). Building dams with large storage capacity are one of the strategies governments use to match water demand with stored supply, and for security against the risk of drought.

One of the indicators of water resources deployment is the water storage capacity, which is the amount of water stored in reservoirs per capita. Improved water resource management and water storage capacity make the economy more resilient to external shocks, such as rainfall variability and drought, and thus provide a stable and sustainable base for increased food and industrial productivity and production to maintain economic growth and development. Water storage infrastructure is an indispensable tool for mitigation of, and adaptation to, drought. The review shows that South Africa needs to improve on storage capacity as the country is water scarce. Apart from large storage reservoirs, there is a need for smaller scale storage, which offers the benefit of more local control and less externality in terms of submerged area.

3.5.8 Groundwater Development

Intensive groundwater exploitation has grown exponentially in scale and intensity over recent decades with the bulk of this growth being concentrated in agriculture. Irrigated agriculture is the principal user of the major sedimentary aquifers of the Middle East, North Africa, North America and the Asian alluvial plains (Shah *et al.*, 2000). Groundwater has been driven by the drought disaster for irrigated production and facilitated by government subsidies and the ready availability of affordable pumps and drilling technologies. In India, crop yields from farms irrigated by groundwater were found to be 1.2 to 3 times greater than farms irrigated with surface water (Shah *et al.*, 2000).

While the growing use of groundwater has reduced the impact of current drought in the rural areas, it has also caused depletion of aquifers and pollution of groundwater. The problem with groundwater is that, as an open access resource, there are strong incentives to deplete it. Existing groundwater withdrawals in South Africa cannot be sustained without much more effective management of groundwater. However, since groundwater development is mostly undertaken by individuals, it is difficult to regulate and monitor, and the legal basis for this is often absent (FAO, 2003). The National Water Act (36 of 1998) exists, but it faces serious enforcement challenges when it comes to groundwater withdrawal. This is confirmed by the findings of Petersen *et al.* (2012) who found that: The groundwater monitoring is weak and assessment of groundwater resources is poor, both in terms of quantity and quality;

- There are fair provisions for water-well drilling and groundwater use rights, but provisions to control groundwater abstraction and pollution are weak;
- Provisions for establishment of an aquifer-management organisation are non-existent;
- Cross-sector policy coordination is weak or non-existent; and
- From an operational point of view, a groundwater management action plan which includes both water-quantity and water-quality aspects exists but has not been implemented to date.

This hinders measures for the conservation and efficient use of groundwater. The highest management priority will be to protect the main recharge zones, and in this context, the encouragement of aquifer recharge in large irrigation schemes has been discussed as an alternative to improved water service to users (Shah, 2009). In any case, groundwater recharge must be designed within a clear water budgeting framework to ensure the effectiveness of options selected. A monitoring plan and the establishment of a groundwater monitoring network and monitoring schedule are proposed in order to observe the aquifer's response to groundwater abstraction as well as to monitor the water supply (GCS, 2006). The monitoring would include groundwater quantity and quality, surface water and effluent, reticulation systems, and treated water.

3.5.9 Desalination

Desalination of seawater and brackish water is increasingly affordable due to progress in membrane technology. This process is used mostly for drinking water and industrial supplies in countries such as Malta, Cyprus, Israel and the Gulf States, where water withdrawal has reached the limits of the total renewable water resources (Joseph, 2003). Desalination is not widely used for agricultural water. High-energy costs and brine disposal are considerations, but its use for high-value crops is practised where there are physical water scarcity and market demand and agro-climatic comparative advantage in certain export crops coincide, particularly in the Mediterranean. In Morocco, plans exist to build a desalination plant for the irrigation of cash crops. Indirectly, desalination for urban water supply can free water for other uses, including agriculture (FAO, 2006).

According to Joseph (2003), desalinized (removal of salts), sea-water is an important and rapidly growing source of drinking water in the world. The mineral composition of the water is significantly changed and then partially rebuilt to achieve a stable product that can be distributed in pipes. Water differs from natural water, which varies over a very wide range of composition that is a matter of geology and chance. Recycled water is in the sense that its composition is controllable. Matthew and Schwarz (2001) described major desalination technologies as follows:

- SS (Solar Stills) uses solar energy to elevate the temperature of salt water and enhance evaporation. It captures condensate as pure water. It uses solar energy. Simplicity and independence make it appropriate for small-scale.
- MSF (Multiple Stage Flash) feeds heated water into low-pressure vessel causing it to “flash” into vapour, which is condensed and collected as pure water. Captures heat from condensing vapour to supply heat for feed water. Uses heat. Appropriate for medium to large-scale projects.
- MED (Multiple Effect Destil) heats water to boiling and collects vapour as pure water. It captures heat from condensing vapour to supply heat for next stages (effects). Uses heat. Appropriate for medium to large-scale projects.
- VC (Vapour Compression) compresses water vapour to cause condensation as pure water. Uses heat from condensation to heat feed water and generate vapour. Appropriate for small to medium scale. Simplicity & reliability make it attractive for small installations. It uses electricity.
- ED (Electro Dialysis) uses electric current to force salt through the membrane, separating it from the feed water. It is normally used only for brackish water. It uses electricity.
- RO (Reverse Osmosis) uses electric current to force pure water through the membrane, separating it from the feed water. It can be appropriate for any scale. It uses electricity.

Therefore, desalination can serve as a good way to desalinize sea water and increase availability as well as solving water chaos faced in South Africa. More research needs to be done to explore this option to cope with future droughts.

3.5.10 Investing in Rainfed Agriculture

Rainfed agriculture represents 80% of land under cultivation and contributes 58% of global crop production (Bruinsma, 2009). It is, therefore, the primary source of agricultural production at the global level. This has prompted a broadening of the scope of agricultural water issues to include both irrigated and rainfed agriculture (Rockström *et al.*, 2009). The concept of water flowing into rivers, lakes and aquifers and rainwater stored in the soil and used directly by plants through evapotranspiration has been promoted to show the relative importance of rainfed agriculture in relation with irrigation in terms of water use. Freshwater consumed in irrigation represents only 20% of all the water consumed by crops through evapotranspiration (CA, 2007).

There are several reasons to invest in rainfed agriculture as part of a drought coping strategy, but the opportunities vary greatly from one place to another. Where the climate is suitable for rainfed agriculture, there is great potential to improve productivity where yields are still low, as is the case in many regions of sub-Saharan Africa (CA, 2007). Here, a combination of good agricultural practices (through management of soil, water, fertility and pest control), upward (inputs, credit) and downward (markets) linkages, combined with weather insurance schemes can go a long way in improving agricultural productivity with little impact on water resources (CA, 2007).

It is in the semi-arid tropics that the issue of balance between irrigated and rainfed agriculture gets the most attention. In these areas, relying on rainfed agriculture involves considerable climate-related risk. A range of water-harvesting techniques have been advocated for bridging short dry spells, and thus decreasing risk in rainfed agriculture (Faurès and Santini, 2008). However, such techniques generally do not protect crops from longer dry spells that may lead to crop failure. Benefits, costs and risks associated with such practices must be carefully appraised in order to judge their appropriateness. Semi-arid tropics have been identified as particularly vulnerable to climate change and associated climate variability (FAO, 2011).

3.6 CONCLUSION AND RECOMMENDATIONS

3.6.1 Conclusions

The purpose of the review was to get a general picture of what is known about drought, its occurrence and management in SA. The review also aimed identified gaps in the drought policies and other related issues such as EWSs and IKSs, and possibly, to give recommendations on the way forward in addressing future droughts.

Review findings reveal that there is little known about drought occurrence in SA. In some provinces, only the information on when drought was declared as disaster could be found (Table 1). There is no information on the severity or impacts of drought. On the same note, no reports could show what strategies were implemented in these provinces in order to mitigate drought effects. Challenges seemingly faced in implementing the NDMP, including lack of finances, capacity and expertise were identified. Arguably, it can be concluded that effective drought management implementation in SA is far from being realised.

Regardless of the resources that have been used to develop and transform the policy post-apartheid, huge sums of money continue to be injected in fruitless drought relief aid. As argued earlier, unless the useful and relevant drought information is piled up somewhere in the government departments, there is limited reports that show proper drought management strategies that have and are being implemented to tackle drought in the provinces of SA. Reports have shown that in fact, the government has assisted farmers with fodder and other ways of mitigating drought. Nothing is there to show that the planning that was done years ago in terms of managing drought has yielded results.

There are no reports of the evidence of monitoring and evaluation of the provincial drought management plans by the responsible persons at the national level. It was noted that some provinces had no DMPs and no follow-up were made to ensure that this was rectified. This poses a serious challenge. Although the lack of capacity, funds, and structures at provincial/local government have been cited as obstacles to implementing the NDMP, there are no reports that indicate what was done in order to implement the NDMP. It is also understood that the lack of clarity on the roles and responsibilities of stakeholders imply that no one ensures that the policy is being implemented accordingly. EWS were reviewed in general, and in particular, the SA, Southern Africa and Sub-Saharan Africa. EWSs have been found to be a promising tool for drought mitigating. However, in the African continent, the implementation and effective use of EWS has been hampered by many other factors characterising the poor, emerging smallholder and subsistence farmers. Nevertheless, governments have continued to issue early warning information to the people through the responsible institutions, in the case of SA, the South African Weather Services (SAWS). It was also revealed that dealing with drought by the use of EWS is compromised by the social environment in which many of the African smallholders, emerging, and farmers are operating. Providing early warning information in isolation is argued to be ineffective, considering that the farmers in question face many challenges. Poverty is complex, hence the manifestation of many forms of it due to the stresses that accompany climate change. Climate forecast information could be argued to disadvantage the poor farmers who depend on farming for their survival, due to lack of access, interpretation, and use of such information for decision-making. When they turn to local knowledge without support with scientific information, the farmers are limited and eventually become desperate and frustrated.

IK has been found to be another useful tool for drought coping, adaptation and mitigation. However, research has shown that there is a lack of interest by governments to acknowledge, adopt, and formalise IK. It can be argued that IK coping strategies are the only option for those poor farmers that lack access to scientific knowledge, although the extent to which IK can be used successfully without complementing it with scientific knowledge, for example, EWS is very small. Ultimately, this kills the enthusiasm for the farmers to adopt scientific knowledge, resulting in lack or limited success by the producers of climate information to communicate it to the farmers.

Effective drought management is a result of proper planning, culminating to adequate preparedness. Drought relief can only be applied when all efforts have been exhausted to avoid or mitigate effects of droughts. Although drought is inevitable in SA, given the comprehensive drought management policy in place, implementing the mitigating and adaptation strategies could go a long way in addressing drought before it affects people, the rural poor in particular. Drought relief, if not managed or coordinated properly, has potential to create dependence on the government by the rural poor. Farmers need to be empowered in order for them engage in drought management efforts, making decisions on themselves and managing their own activities.

It is evident that many aspects of drought still require further research in order to understand the drought phenomenon. However, the research itself is not useful, unless its findings are translated into action. Of importance to emphasise is an investigation on the livelihoods of smallholder farmers in SA. These farmers are surrounded by a myriad of challenges that need the government and other stakeholders to understand if ever they are to manage drought effectively. Unless and until this is done, it will remain a dream for smallholder farmers to achieve their goals of contributing to food security and having food on the table for their families. However, it would be improper and unfair to blame the government only, about the failures of all other stakeholders in managing drought. The government has the responsibility, with the support of all other stakeholders, to protect its people from the risk and effects of drought. It must oversee the activities of other stakeholders, of course, being flexible to give a reasonable degree of freedom and independence, so that it would not become an obstacle for development. The role of the NGOs, in this instance, in drought management, is yet to be clear. An investigation is needed in order to determine the level and extent to which NGOs in SA have contributed to drought management, the challenges that they face, successes and the lessons learnt overtime. NGOs are potentially effective, if interested in drought management, to effect change. This is because they operate amongst the people and find it easier to reach out and influence change. This could work well also, in collaboration with the IKSs so that they could get the support they need to improve the use of IK and at the same time adopting new technologies.

The review shows that SA is a dry country that is prone droughts. A closer look at the provinces shows that they experience drought differently, according to climate. The country is currently experiencing a severe drought. However, the amount of information available at the time of this review did not reflect the severity of drought experiences by the South African agricultural sector; neither did it reflect the work done by the government to mitigate drought effects. The absence of DMPs by the provinces implied lack of preparedness by the government and confirmed the view that drought management remains reactive. Regardless of the fact that the government of SA understands and acknowledges its mandate to manage drought, little is there to show for it that action is being taken to implement the drought management policy. Nevertheless, it is important to acknowledge that SA has been able to develop a sound drought management policy. The national government has also taken strides in providing drought relief to its people. However, the extent to which relief has been received and has addressed the rural poor, smallholder farmers is yet to be revealed. It can also be concluded that there is limited research on drought in general, and on its occurrence and management in SA. No monitoring and evaluation are being done on the implementation and effectiveness of programmes for drought management. Therefore, it is difficult to determine to what extent has the implementation of NDMP gone and is achieving its purpose.

Both IKSs and EWSs are critical in addressing drought in SA, and should not be used in isolation. On the same note, the context and environment in which these are provided should be conducive. This means that a holistic approach should be taken into consideration when using these tools of drought mitigation, including the social context in which different farmers operate, particularly the resource poor farmers.

3.6.2 Recommendations

There is a need for investing in research, by the government of SA. This includes research on drought occurrence and management by the provinces. An investigation would be necessary in order to understand the perceptions on drought, of those involved in drought management and the challenges they are facing in implementing the NDMP. It is needful that all stakeholders understand the concept for them to be able to respond effectively. Swift action is also required to utilise the results of research. It is typical of governments, especially in developing the world to dump the reports on the shelves for them to gather dust whilst they continue to commission more research and implementation never materialising. The sound drought policies need to be implemented urgently if ever the SA government wants to manage drought effectively. Planning for drought, including preparation of farmers for it, is very expensive and requires huge sums of money and other resources. In SA, reprioritizing the measures taken in drought management is required, that is, refocusing on drought planning. This includes training and building capacity of personnel involved in the implementation of programmes. No matter how good a policy is, there is a need for it to be monitored well at different stages of implementation. This is because implementation could yield un/intended results, and this needs to be understood so that programmes can always be brought back on track if need be, and that good or bad lessons could be learnt. It would be wasting of resources to invest in projects that never achieve their purpose, but rather exacerbate the problems.

Research, monitoring and evaluation findings are known, largely, to receive a negative attitude by the commissioners or those who must implement the findings. It is the time the mind-set of people changed if ever these concepts would be valued accordingly. Monitoring and evaluation are never to expose people or programmes' weaknesses, but rather to bring accountability and if given the due value, to cause programmes to achieve their purpose.

The role of stakeholders in the drought policy, especially the smallholder, emerging and subsistence farmers are passive. There is need to clarify the extent to which they are expected to participate in drought management. This can only be addressed by strengthening the relationship that exists between the farmers and the policy makers and implementers. This can also make these farmers own the policy and would act as an incentive for them to adopt whatever programmes meant to solve their problems. The role of

IK can never be underestimated. However, as noted earlier, this needs to be complemented with scientific knowledge so that their complementary potential can be realised. The local strategies need to be encouraged for sustainability and independence.

As revealed already, there is a need for government departments to be well integrated and coordinated in working together, to accomplish effective drought management for the people. No government department or any other stakeholder involved in drought management can achieve much in isolation. This remains a very big challenge because it requires leadership, capacity and cooperation from other stakeholders. On integration, all stakeholders must come to the party, including IKSs, NGOs and Civil Society. The vision must be one, to reduce the impact of drought on agriculture.

It is recommended that EWSs be used with the IK in order to maximise on their strengths. As has been noted, poor farmers need to be provided with an environment in which they can engage the producers of forecast information and share the challenges they are facing. The focus should be shifted from effective production of forecast information and be placed on balancing between production and utilisation. Workshops and farmers' meetings could be conducted as a way of providing a platform for the farmers to share their knowledge and concerns.

The South African strategy to address drought in agriculture includes the promotion of water user associations, licensing reforms, encouragement of the efficient use of water, the control of invasive alien vegetation and water pricing. The coping and adaptation in dryland, irrigation and livestock systems for current and future drought is to manage natural resources and store seasonal and irregular water flows. Managing water resources can be done by increasing access to conventional water resources, dam storage, groundwater withdrawals or rainwater harvesting. It can also be done through re-using wastewater and drainage water or through developing 'non-conventional' sources of water, including desalination of brackish or salt water and the use of fossil groundwater.

A combination of infrastructure and managerial upgrades in a way that improves water delivery services of irrigation schemes is likely to be central to national strategies aiming to increase the performance of crop production. Combined with soil fertility management and plant protection, modernization has the potential to substantially reduce yield gaps in irrigated production.

With the current government responses for drilling more boreholes, it is strongly recommended that strengthening and implementing groundwater governance measures should preferably follow a ‘parallel track and adaptive approach’ within the existing legal and institutional framework. Such an approach would strengthen the said frameworks without disruption, taking cognizance of the capacity and willingness to implement. A groundwater protection strategy needs to be developed and implemented in South Africa. It should include the establishment of a groundwater model, a monitoring plan and public awareness campaigns. It should also include the establishment of protection zones around wells and pollution pathways such as sinkholes or swallow holes. A groundwater model should be constructed to evaluate the dynamics of the groundwater system with the aim of determining optimum and sustainable groundwater abstraction.

4 OVERALL PROJECT RECOMMENDATIONS

It is recommended that the identified National Drought Management Plan be implemented urgently. There is need to re-prioritise drought management and focus more on pro-active approach to prepare farmers for drought. This includes training and building capacity of personnel involved in the implementation of programmes. Farmers should be empowered for them to be dependant and own decisions that they make concerning drought. This would incentivise them to adopt strategies of drought management in future, lessening pressure on the government budget. Government departments need to be well integrated and coordinated so that they work towards a common goal. This requires leadership, capacity and cooperation from all stakeholders.

The role of stakeholders in the drought policy needs to be re-visited, especially the smallholder farmers, who seem to be playing a passive role in drought management. Relationships need to be strengthened. Responsibilities of those implementing the plan must be clarified to ensure accountability.

It is recommended that managing water resources be done by increasing access to conventional water resources, dam storage, groundwater withdrawals or rainwater harvesting. Additionally, re-using wastewater and drainage water or developing 'non-conventional' sources of water, including desalination of brackish or salt water and the use of fossil groundwater could be encouraged. With the current government responses for drilling more boreholes, it is strongly recommended that strengthening and implementing groundwater governance measures should preferably follow a 'parallel track and adaptive approach' within the existing legal and institutional framework. Such an approach would strengthen the said frameworks without disruption, taking cognizance of the capacity and willingness to implement. A groundwater protection strategy needs to be developed and implemented in South Africa. It should include the establishment of a groundwater model, a monitoring plan and public awareness campaigns. It should also include the establishment of protection zones around wells and pollution pathways such as sinkholes or swallow holes. A groundwater model should be constructed to evaluate the dynamics of the groundwater system with the aim of determining optimum and sustainable groundwater abstraction.

Early warning systems have become an integral part of agriculture. The development of drought and famine early warning systems that would allow for early drought or famine detection and improve response in a proactive manner is very important. An early warning system is the foundation of a drought or famine plan, allowing for the dissemination of agrometeorological information to farmers in near real-time. The dissemination of information is the cornerstone to successful farming especially in this era of climate change. The information relevant to farmers includes weather updates, soil and nutrient status, pest management reports and recommendations and advice on crop varieties to plant in various field conditions.

It is recommended that EWSs be used with indigenous strategies. As has been noted, poor farmers need to be provided with an environment in which they can engage the producers of forecast information and share the challenges they are facing. The focus should be shifted from effective production of forecast information and be placed on balancing between production and utilisation. Workshops and farmers' meetings could be conducted as a way of providing a platform for the farmers to share their knowledge and concerns.

A combination of infrastructure and managerial upgrades in a way that improves water delivery services of irrigation schemes is likely to be central to national strategies aiming to increase the performance of crop production. Combined with soil fertility management and plant protection, modernization has the potential to substantially reduce yield gaps in irrigated production.

Introducing crop varieties that suit the changing climate and improve the agronomic practices is also crucial. New crop varieties and improved agronomic practices are very effective mainly in rainfed systems where water management practices are generally poor.

Investing in agriculture is another effective strategy for economic growth and poverty reduction in rural areas where the majority of people who are highly vulnerable to drought and climate change risk live. Many strategies can be implemented in irrigation, including scheduling, drip irrigation, rainwater harvesting and infrastructure maintenance. Smallholder farmers can implement even simple technologies such as supplying moisture to the root zone using local material.

Strategies in livestock could include creating fodder banks and pasture management. Finally, drilling boreholes is a strategy that has been implemented for decades. In the recent drought, South Africa drilled many boreholes to provide water for both agriculture and domestic use, proving that groundwater plays a very important role in agriculture.

The government needs to invest in research, including research on drought occurrence and management by the provinces. This could help improve understanding of drought, perceptions of those involved in its management and the challenges they are facing in implementing the NDMP. Swift action is also required to utilise the results of research. There is need for change of mind-set on the usefulness of research findings by those commissioning it.

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