COPING AND ADAPTATION STRATEGIES FOR AGRICULTURAL WATER USE DURING DROUGHT PERIODS

Review of drought coping and adaptation strategies in dryland cropping systems, irrigation, livestock and mixed systems

Project Leader: Dr Bongani Ncube

Deliverable 2

By

Bongani Ncube and Sydney Shikwambana
Cape Peninsula University of Technology, Bellville, Cape Town

Project No. K5/2602

November 2016

Executive Summary

This report is Deliverable 2 of the Water Research Commission Project 2602 entitled “Coping and adaptation strategies for agricultural water use during drought periods”.

The report starts by defining vulnerability to drought. This is followed by a brief history of drought in South Africa, then an outline of the role of early warning systems. The report then gives examples of coping and adaptation strategies adopted by selected countries.

A number of strategies in water use in agriculture that have been implemented by South Africa are then described in the report. Drought resistant and new crop varieties and improved agronomic practices were identified in rainfed systems. Many strategies were implemented in irrigation, including scheduling, drip irrigation, rainwater harvesting and infrastructure maintenance. Strategies in livestock included creating fodder banks and pasture management.

South Africa drilled many boreholes to provide water for both agriculture and domestic use during the recent drought, showing the importance of the groundwater resource in agriculture.

1. INTRODUCTION

South Africa is currently experiencing persistent drought due to the El Nino phenomenon which has caused below-normal rainfall coupled with high temperatures during the late part of the 2014/15 summer season. The continued low rainfall resulted in dry conditions with drought being reported in all nine (9) provinces. All sectors were adversely affected, mainly by extreme water shortages, especially in Agriculture where total crop losses were experienced. The Weekly State of the Reservoirs report from the published by the Department of Water and Sanitation showed a decline in dam levels, and underground water tables across the country were also reportedly declining.

Agricultural production was severely affected by the drought, with veld condition deteriorating at alarming rates. By mid-2016 a total of 246 425 farmers was reported to be affected by the drought. A total of 252 884 livestock loss was recorded while 9 340 508 livestock are reported to be still vulnerable to drought. Crop farmers both small scale, emerging and commercial could not plant household and market crops during the planting season due to inadequate rainfall. Commercial farmers both on rain-fed and irrigation planted late while others had to defer their planting altogether. The high temperatures, especially in December 2015 and January 2016, affected pollination in a number of areas that resulted in lower yields. According to the analysis of the South African Vulnerability Assessment Committee (SAVAC) which Department of Agriculture, Forestry & Fisheries (DAFF) is the chair and secretariat, it is reported that the number of people affected by the drought is 6 291 900 across South Africa. Out of this number 2 516 800 are the poor and very poor and they were the worst affected by the drought and their livelihoods remain vulnerable. South Africa therefore, urgently needs to deal with the drought problem to cushion the farmers before the situation gets out of hand. Unfortunately, South Africa does not have a harmonized drought response for agriculture, especially in the provision of water for agriculture. Coping and adaptation strategies for agricultural water use during drought periods are scattered in different departments and sectors, and the response to drought is mostly reactive instead of being proactive.

The national drought management plan was developed in 2005 but its implementation has been lacking in many respects. Every province is also supposed

to have its own drought response strategy, and in some provinces, the drought plans are almost obsolete, for example, the Western Cape Province Drought Plan was last revised in 1998, and the new revision has been recently released. Drought effects are also felt by farmers differently and the response strategies largely fail to recognize this. Subsistence and smallholder farmers are usually the hardest hit because they lack funding and insurance to save their crops and animals, or to build water infrastructure or even drill boreholes, but they do not necessarily receive priority in response programs.

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 report is Deliverable 2 of the Water Research Commission Project entitled “Coping and adaptation strategies for agricultural water use during drought periods”. The main aims of the project are to:

1. Review of the current knowledge of drought and drought occurrence in South Africa, including the review of current drought policies and strategies, national and provincial response strategies
2. **Review of drought coping and adaptation strategies in dryland cropping systems, irrigation, livestock and mixed systems. Identify potential strategies that can be adopted by South Africa, including strategies from Sub-Saharan Africa and other regions**
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

This report 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 report 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. 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

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.

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.

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.

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.

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.

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.

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 was 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.

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.

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.

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.

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 are 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.

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.

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.

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.

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.

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.

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.

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.

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.

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).

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.

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.

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)

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.

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.

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).

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.

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.

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.

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.

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.

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

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.

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.

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.

9. REFERENCES

Adams, A. M., Cekan, J. and Sauerborn, R. 1998. Towards a conceptual framework of household coping: Reflections from rural West Africa. Africa. 68: 263-283.

Adger, W. N., 2000. Social and Ecological Resilience: Are they Related? Progress in Human Geography.24:347-364.

Altieri, M.A. and Koohafkan, P., 2008. Enduring farms: climate change, smallholders and traditional farming communities (Vol. 6). Third World Network (TWN).

Annandale, J. G., Jovanovic, N. Z., Mpandeli, N. S., Lobit, P., & du Sautoy, N. (2002). Two Dimensional Energy Interception and Water Balance Model for Hedgerow Tree Crops. *Paper presented at Southern African Society of Horticultural Sciences congress at Cedara, Kwazulu Natal, 15-17 January 2002*.

Bainbridge, D.A., 2001. Buried clay pot irrigation: a little known but very efficient traditional method of irrigation. Agricultural Water Management, 48(2), pp.79-88.

Baloyi, J. K. (2010). An analysis of constraints facing smallholder farmers in the Agribusiness value chain: A case study of farmers in the Limpopo Province, University of Pretoria, Pretoria, South Africa.

Barker, R.D., White, C.C., and Houston, J.F.T. (1992) Borehole siting in an African accelerated drought relief project. In “Hydrogeology of Crystalline Basement Aquifers in Africa. Ed. Wright, E.P. and Burgess, W.G. Pp.183-201.

Biazin, B., Stroosnijder, L., Temesgen, M., AbdulKedir, A. and Sterk, G., 2011. The effect of long-term Maresha ploughing on soil physical properties in the Central Rift Valley of Ethiopia. Soil and tillage research, 111(2), pp.115-122.

Binayak, S. 1996. Risks, vulnerability and poverty in Bangladesh: Issues and Evidence (Variation on a Theme).

Booysen, J. and Rowswell, D.I., 1983. The drought problem in the Karoo areas. Proceedings of the Annual Congresses of the Grassland Society of Southern Africa, 18(1), pp.40-45.

Bruchweiler, S. And Gabathuler, E., 2006. Coping with Drought. Swiss Agency for Development, Centre for Development and Environment, 3008 Bern, Switzerland.

Buchanan-Smith M and Tlogelang L, 1994. Linking relief and development: a case study of Botswana. IDS Bulletin Vol.25 No3 1994, pp 1-6.

Calow, R.C., Robins, N.S., Macdonald, A.M., Macdonald, D.M.J., Gibbs, B.R., Orpen, W.R.G., Mtembezeka, P., Andrews, A.J., and Appiah, S.O. (1997) Groundwater management in drought prone areas of Africa. Water Resources Development Vol. 13:241-261.

Campbell, D. J., 1999, Response to drought among farmers and herders in Southern Kajiado District, Kenya: A comparison of 1972-1976 and 1994-1995. *Human Ecology*. 27: 377-1416.

Dow, K. 1993, Exploring differences in our common future(s). The meaning of vulnerability to global change, *Geoforum.* 23: 417-436.

Downing, T.E. 1991. Assessing socioeconomic vulnerability to famine: Frameworks, concepts and adaptations. *Research Report*. The Alan Shawn Feinstein World Hunger Programme, Brown University, Providence, Rhodes Island.

Downing, T.E. and Bakker, K. 2000. Drought discourse and vulnerability. Chapter 45, in D.A. Wilhite (Ed), *Drought: A Global Assessment, Natural Hazards and Disasters Series*, Routledge Publishers, U.K.

Ellis, F. (1993). *Peasant Economics: Farm Households and Agrarian Development* (p. 309). Cambridge, UK: Cambridge University Press.

Eriksen, S., Brown, K. And Kelly, P. M., 2005. The Dynamics of Vulnerability: Locating coping strategies in Kenya and Tanzania. *Geographical Journal*. 171:287-305.

Florentín, M.A., Peñalva, M., Calegari, A., Derpsch, R. and McDonald, M.J., 2010. Green manure/cover crops and crop rotation in conservation agriculture on small farms. Integrated Crop Management, 12.

Hansen, J. W., Marx, S., & Weber, E. (2004). The role of climate perceptions, expectations and forecasts in farmer decision making: the Argentine Pampas and South Florida, *International Research Institute for Climate Predictions Technical Report, 04-01*. Palisades, New York.

http://operationhydrate.org (accessed 03/12/2016).

Kinsey, B., Burger, K. and Gunning, J.W. 1998. Coping with drought in Zimbabwe: Survey evidence on responses of rural household to risk. *World Development.* 26: 89-110.

Kivaria, K. 2007. Pastoral Coping Mechanism to Drought and Floods.

Leichenko, R.M., and O'Brien, K.L., 2002. Double Exposure: Assessing the impacts of climate change within the context of economic globalization. *Global Environment*, 10: 221-232.

Monnik, K. 2000. Role of Drought Early Warning Systems in South Africa`s Evolving Drought Policy.

Moss, S., 2004. 'Complex drought'in southern Africa–a water and sanitation perspective. Waterlines, 22(4), pp.19-21.

Mpandeli, S., and Maponya, P. (2014). Constraints and challenges facing the small scale farmers in Limpopo Province, South Africa. *Journal of Agricultural Science* 6, 135.

National Department of Agriculture 1993/94 Annual Report. Government Printer. Pretoria, South Africa.

National Department of Agriculture 2001/02 Annual Report. Government Printer. Pretoria, South Africa.

National Department of Agriculture 2003/04 Annual Report. Government Printer. Pretoria, South Africa.

National Department of Agriculture 2004/05 Annual Report. Government Printer. Pretoria, South Africa.

Ncube, B. and Lagardien, A., 2015. Insights into Indigenous Coping Strategies to Drought for Adaptation in Agriculture: A Karoo Scenario.

Ncube, B., Manzungu, E., Love, D., Magombeyi, M., Gumbo, B. and K. Lupankwa. 2010. The Challenge of Integrated Water Resource Management for Improved Rural Livelihoods: Managing Risk, Mitigating Drought and Improving Water Productivity in the Water Scarce Limpopo Basin. CPWF Project Number 17: CGIAR Challenge Program on Water and Food Project Report series. www.waterandfood.org.

Nhamo, L., Matchaya, G., Nhemachena, C., and van Koppen, B. (2016). The impact of investment in smallholder irrigation schemes on irrigation expansion and crop productivity in Malawi. *African Journal of Agricultural and Resource Economics Volume* 11, 141-153.

O' Meagher, B., du Pisani, L.G. and White, D.H., 1998. Evolution of Drought Policy and Related Science in Australia and South Africa. *Agricultural Science*. 52: 231-258.

Palmer, T. and Ainslie, A., 2006. Country pasture/forage resource profiles. Food and Agriculture Organization, South Africa.

Patrick, E., 2003. Drought: Vulnerability and Crisis in Dry lands. Dry land development Centre, UN Development Program.

Paul, B.K. 1998. Coping Mechanisms Practiced by Drought Victims (1994/95) in North Bengal, Bangladesh. *Applied Geography.* 18: 355-373.

Selvarajan, S., Roy, B.C., and Mruthyunjaya, 2002. Use of Vulnerability Indices for Agriculture. National Centre for Agricultural Economics and Policy Research (ICAR), Library Avenue, Pusa, New Delhi.

Sinyolo, S., Mudhara, M., and Wale, E. (2014). The impact of smallholder irrigation on household welfare: The case of Tugela Ferry irrigation scheme in KwaZulu-Natal, South Africa. *Water SA* 40, 145-156.

Sweet, J., 1998. Livestock-Coping with Drought: Namibia-A Case Study. Northern Regions Livestock Development Project, Tsumeb, Namibia.

Van Averbeke, W., Denison, J. and Mnkeni, P.N.S., 2011. Smallholder irrigation schemes in South Africa: A review of knowledge generated by the Water Research Commission. Water SA, 37(5), pp.797-808.

van Zyl, K., and Vogel, C., 2009. A 'Persistent' Truth: Living with Centuries of Drought in South Africa. REVAMP Research Group, University of Witwatersrand, Johannesburg.

Vogel, C. (2000). Usable science: an assessment of long-term seasonal forecasts among farmers in rural areas of South Africa. *South African Geographical Journal,* 82, 107-116.

Walters, M.C, 1993. Present State Drought Policy in Republic of South Africa and Possible Areas of Adaptation. Presented at Planning for Drought as a Natural Phenomenon, Mmabatho, South Africa. January 28, 1993.

Wilhelmi, O.V. and Wilhite, D.A., 2002. Assessing vulnerability to agricultural drought: a Nebraska case study. Natural Hazards, 25(1), pp.37-58.

Ziervogel, G. and Downing, T.E., 2004. Stakeholder networks: improving seasonal climate forecasts. Climatic Change, 65(1-2), pp.73-101.