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Adapting to the Impacts of Drought by Smallholder Farmers in Sekhukhune District in Limpopo Province, South Africa

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Abstract

Smallholder farmers have been affected by drought impacts for several years. Sekhukhune district is characterized by poor and unreliable rainfall, frequent droughts and periodic flooding most of the time. Due to low and unreliable rainfall the smallholder farmers in the Sekhukhune district are finding it difficult to obtain high crop yields. As result of unreliable rainfall the majority of the households in the district are food insecure. The drought impacts in the Sekhukhune district has affected smallholder farmers in different ways including economically, socially and the production. Sekhukhune district has been receiving lower rainfall due to the effects of high extreme climatic events, climate variability and change. The impact of lower rainfall has negative effects on the agricultural sector, resulting in decrease in agricultural activities, loss of livestock, shortage of drinking water, low yields and shortage of seeds for subsequent cultivation in the district. The lowest average annual rainfall recorded was 438 mm in 1992. Limpopo Province including the Sekhukhune district has been characterised by low rainfall and recurrent drought problems especially in 1981/1984, 1988/1989, 1991/92 and in the 2004 and these hinder agricultural production in the province. The majority of farmers in the Sekhukhune district in 1992 lost high volumes of crops and livestock due to shortages of water and because of drought problems during that year. It was highlighted by several experts that the drought impacts in the Sekhukhune district are not only affecting the crop and the livestock smallholders, it is also affecting the vegetation status in the district. The quality and status of vegetation can be severely impacted by drought periods. The combination of these factors, for example low rainfall, poor vegetation condition and a range of other constraints, heightened during droughts, unfortunately produces a range of additional stressors for farmers in the Sekhukhune district. Poor vegetation usually means poor grazing and therefore poor cattle condition. This can further translate into loss of livelihoods as poor cattle often receive poor market prices.

Keywords: drought impacts, extreme climatic events, climate variability, climate change, low rainfall, Sekhukhune district

1. Introduction

In the Southern African Development Community region (SADC), for example in Zimbabwe, many farmers suffer frequently from drought. Farmers have however developed varies strategies to cope with drought (Babi et al., 2005). Coping strategies refer to action or activities used by farmers or households usually over short time spans to survive when confronted with unanticipated livelihood failure (Babi et al., 2005). Corbett (1988) observed that coping strategies seek to balance present adversity and sometimes comprise of a variety of livelihoods as a drought progresses. The majority of people in South Africa are also affected by poverty, a high unemployment rate, recurrent drought and inequitable land distribution (World Bank, 1997; FAO, 1998; UNAIDS, 2000; NEPAD, 2001; UNAIDS, 2004; UNDP, 2004). These factors are major problems further constraining the livelihoods of ordinary South Africans, for example, the farming community. Extremes of climate, such as periods of drought and floods, exert additional pressures on livelihoods (UNDP, 2004). Most

parts of South Africa were affected by flooding in the year 2000. Drought, for example, has also been a recurrent phenomenon occurring in the 1960s, 1980s, 1990s, 2002 and 2003 (Tyson & Dyer, 1978; Vogel et al., 2000; Adger, 2001; Kihupi et al., 2003). Drought frequently adversely affects agricultural production in various provinces including Limpopo, Free State, parts of Western Cape and Northern Cape (e.g. Sowetan, 2003). Limpopo Province has been experiencing high frequency of severe drought occurring in different districts including Sekhukhune. Recently it has been noted that the agricultural drought in Limpopo Province is creating problems not only for the smallholder farmers but also for the commercial farmers. During drought periods, farmers may also embark on a number of agricultural and technical activities such as adjust fertilizer input, adopt varieties that are tolerant to drought environments and plant crops that require less water. Other coping strategies used by farmers in South Africa include direct seeding. Farmers also use the zero tillage system in order to conserve soil moisture (Ellis, 1993; Hansen, 2005; Patt & Gwata, 2002). This method also requires less water and is good for early planting. Some smallholder farmers in Zimbabwe, for example, have been known to sell their livestock to compensate for a lack of income because of insufficient harvest (Phillips et al., 1999; Adger et al., 2002; Patt & Gwata, 2002). This, however, only usually occurs under severe periods of stress.

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). The problem with such a strategy is that the majority of farmers in South Africa have very limited access to technology, market access and farm inputs (Vogel, 2000; Ziervogel & Downing, 2004).

While coping strategies usually refer to short-term activities, they can be expanded for use in the longer term. Adaptation strategies refer to all those responses to climatic conditions that may be used to reduce vulnerability (IPCC, 2001; Adger et al., 2002). Adger et al. (2002), argue that adaptation will allow a system to reduce risks associated with hazards by reducing its social vulnerability. Adaptation can be reactive, concurrent or anticipatory, spontaneous or planned (Smit et al., 1996; Smithers & Smit, 1997; Smit et al., 2000). The objectives of this paper are: (a) Evaluate and analyse how smallholder farmers in Sekhukhune district have been coping and adapting to impacts of drought. (b) Identify better adaptation strategies used by smallholder farmers in Sekhukhune district. (c) To improve the understanding of current drought risk–reduction and coping mechanisms in Sekhukhune district of Limpopo Province. (d) To recommend effective drought adaptation strategies in Sekhukhune district.

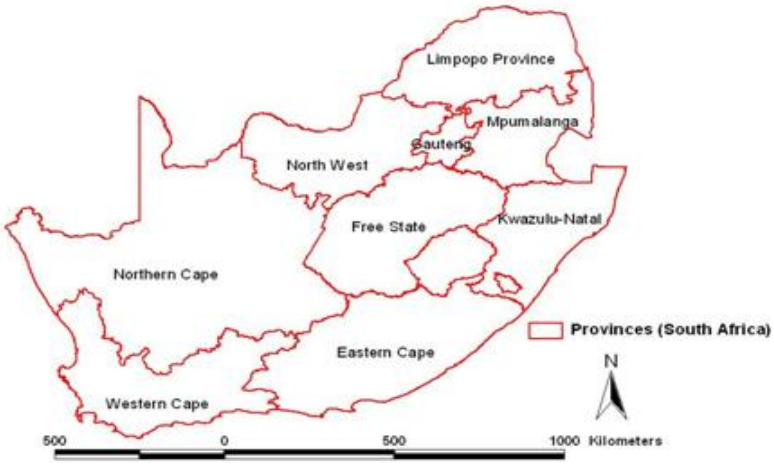

Figure 1a. Map of South Africa showing all 9 provinces

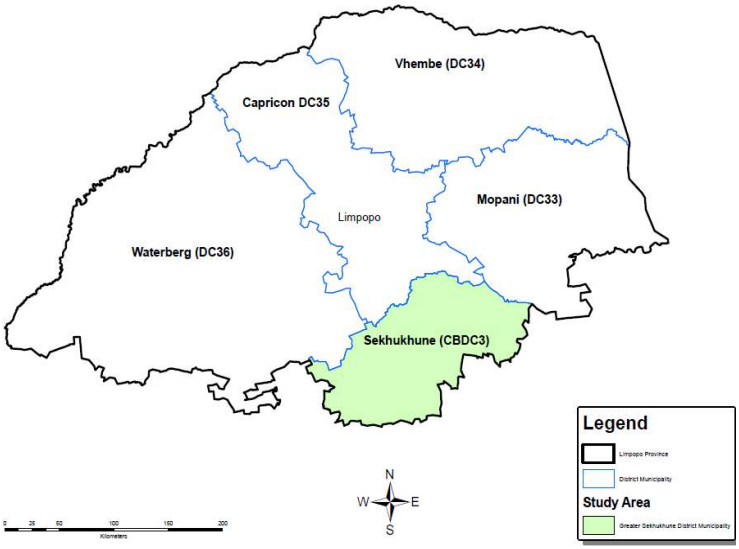

Figure 1b. Shows map of the Sekhukhune district in Limpopo Province

Source: ARC-ISCW (2014).

2. Study Site

According to Siambi et al. (2007), Greater Sekhukhune district is largely rural as 90% of the district population reside in the rural areas. Agriculture is considered the main contributor to employment and livelihoods. The Greater Sekhukhune district is rich with mineral deposits such as large reserves of platinum. The southern parts of the district have more agricultural potential than the rest of the district. The district average annual rainfall is approximately 560 mm. Subsistence or smallholder agriculture accounts for 70% of the farming activities in the district whilst the other 30% is commercial agriculture (Siambi et al., 2007). The Sekhukhune district is situated in semi – arid and it always experience water shortages most of the time. However, the majority of the commercial farmers depend on irrigation system for farming. Water shortages and poor rainfall distribution have been cited as one of the constraints hindering the growth and the development of the agricultural production in the district.

3. Materials and Methods

Two methods were used to analyze the results from this paper and this includes:

3.1 Mean Annual Rainfall Map

The rainfall data downloaded from the AgroMet databank at the Agricultural Research Council – Institute for Soil, Climate and Water (ARC-ISCW), South African Weather Service (SAWS) and ISCW weather stations from 1921–2013 with a recording period of 10 years and more. Regression analysis and spatial modelling were utilized during the development of the surface.

3.2 SPI Time Series

Rainfall GIS surfaces, covering South Africa, have been produced from data within the ARC-ISCW Climate Databank. The databank holds historical data from the South African Weather Service and the ARC-ISCW. Monthly rainfall GIS surfaces are produced from the historical rainfall data over the period from 1921–2013. The rainfall surfaces are produced as follows:

(i) Rainfall data from between 1200 and 3000 mechanical and automatic stations are extracted;

(ii) The long-term average rainfall for a specific month is used as a trend surface for interpolation;

(iii) Rainfall at a specific point is expressed as a percentage of the underlying rainfall trend surface;

(iv) The rainfall percentage values for a specific ten-day period are interpolated using the inverse distance weighting method.

The method results in a monthly rainfall surface that is true to the points where rainfall is recorded, but follows the climatology resulting from the influence of factors such as topography or distance from the ocean. The

rainfall surfaces from 2003 onward are created through a combination of the abovementioned method and satellite rainfall estimates to supplement rainfall data over the South African plateau.

The resulting monthly rainfall surfaces are summarized to quaternary catchment (These are represented by +/- 1700 polygons in a GIS, covering the surface area of South Africa). For each catchment, the rainfall at monthly to 48-monthly time scale is transformed to Surface Precipitation Index (SPI) value for the catchment. The result is an SPI dataset for several time scales for each month since 1920. The SPI values can be used to study the time series of drought intensity classes by considering the traditional classification of the SPI ranges.

4. Results and Discussion

According to Mpandeli (2014), the average annual rainfall in the Sekhukhune district is less than 600 mm. The rainy season starts in late October in most areas of the Limpopo Province especially in the Sekhukhune district. The rainfall pattern peaks in January-February months, and thus when floods are also expected (Figure 2). As was reported by Mpandeli (2014), droughts across the Limpopo Province have impacted on crop & livestock production on top of their impact water supplies for irrigation activities, mining, and domestic use. It was also noted that the meteorological drought is the result of the negative deviation of rainfall from the mean and is normally the most common indicator for drought (Wilhite et al., 2000; Wilhelmi & Wilhite, 2002). Limpopo Province has high climatic variability & change and therefore farmers need to have seasonal climate forecast information or projections in advance in order for them to be able to plan their farming calendar accordingly. The Greater Sekhukhune district is well known to be dry – land area therefore smallholder farmers are expected to been use different coping and adaptation strategies including: (a) Plant crop that require less water such as groundnuts, lab lab, sorghum etc. (b) Some smallholder farmers in the area have adopted rain water harvesting and conservation agricultural principles in order to increase yields and income, for example, minimum tillage, zero tillage etc. (c) Livestock smallholder farmers in some of the areas in the district are also using the destocking especially during uncertainty periods. Other smallholder farmers in the district plant early mature crop varieties in order to counter act any natural vagaries.

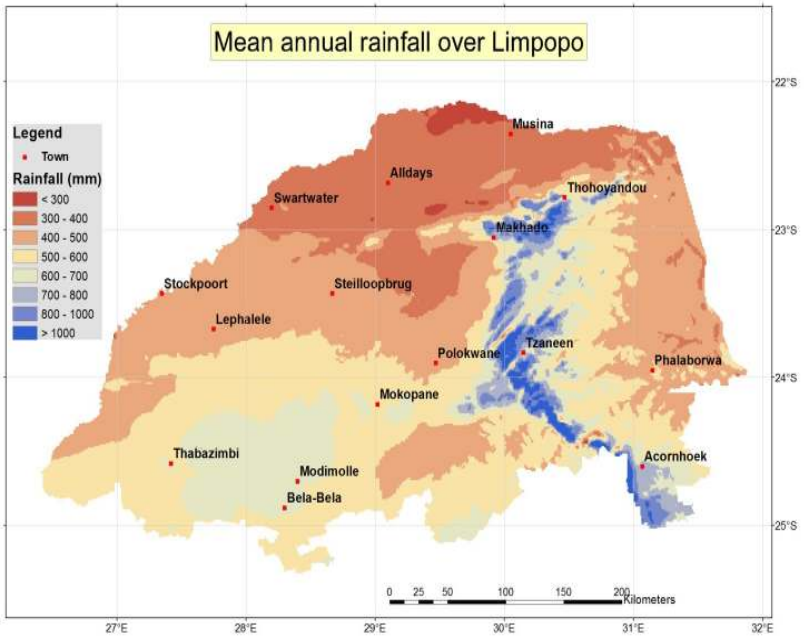

Figure 2. Mean annual rainfall map for Limpopo Province

Source: ARC-ISCW (2014).

Greater Sekhukhune district is different from the Vhembe district according to Mpandeli (2014) because Vhembe district is located in micro- climatic areas. In the Vhembe district, for example, the highest average monthly amount of rainfall received is normally from November to March every year (Mpandeli, 2006). Small holder farmers in the Greater Sekhukhune district are facing multi stress besides extreme climatic events, high climatic variability and change. These small holder farmers in the district also have to deal with the wild fire

outbreaks which affect livestock grazing and also threaten human lives. The fact that the Greater Sekhukhune district is situated semi – arid area, any disturbances on the ecosystems especially changes in land use, diversion of water from local streams will have major consequences to the majority of the small holder farmers in the district. According to Greater Sekhukhune District Municipality report (2007) and Maponya (2013), the average annual rainfall in the Greater Sekhukhune district is 600 mm compared to other district such as Vhembe. According to Maponya (2013), Limpopo Province is a drought prone province which faces challenges of drought from time to time and Sekhukhune district is also not immune to drought impacts. Maponya (2013) further highlighted that due to this severe drought impacts across districts grazing and water for livestock and also irrigation activities were negatively affected and this also has an impact on the agricultural sector in general. According to Naidu (2003) and Maponya (2013), Limpopo Province was worst affected by drought in the past 8 years where dams were only 50% full compared to with 84% in the late 80s. This has severely affected the agricultural sector, smallholder farmers were most affected due to the fact that they are vulnerable and also low adaptive capacity. For the 15 years drought in the Sekhukhune district did not only affected the farming community, households, mining operations but have also have economic consequences (Greater Sekhukhune District Municipality report, 2011).

According to Mpandeli (2006), commercial farmers most of time have more wide choices during drought than subsistence and small-scale farmers. Due to the fact that the majority of the commercial farmers have strong financial backups, they also have good infrastructure especially irrigation systems such as Centre Pivot and drip irrigation system. Commercial farmers could easily switch their enterprise to a safer environment or to an area where they will be able to cope and adapt easily and most of the commercial farmers had enough reserves for their activities even if they are farming in new area. However, for subsistence and smallholder farmers, they have limited options due to the fact that these farmers do not have enough financial resources, they do not have collateral or security in case if they need loans from banks compared to the commercial farmers in the area. Besides the fact that the majority of the commercial farmers around Greater Sekhukhune district have good irrigation infrastructure, the majority of these farmers are literate, they have good technology and knowledge on how to apply the proper climate change adaptation strategy in order to deal with all type of agricultural risk including drought.

The high rainfall variability in Limpopo Province and some other parts of the country have led some farmers to use seasonal forecasts information for farm planning and decision making. Daily weather forecasts allow farmers to plan their daily activities. The daily weather forecast is provided by the SAWS through both the print and the electronic media and is published on line 24 hours.

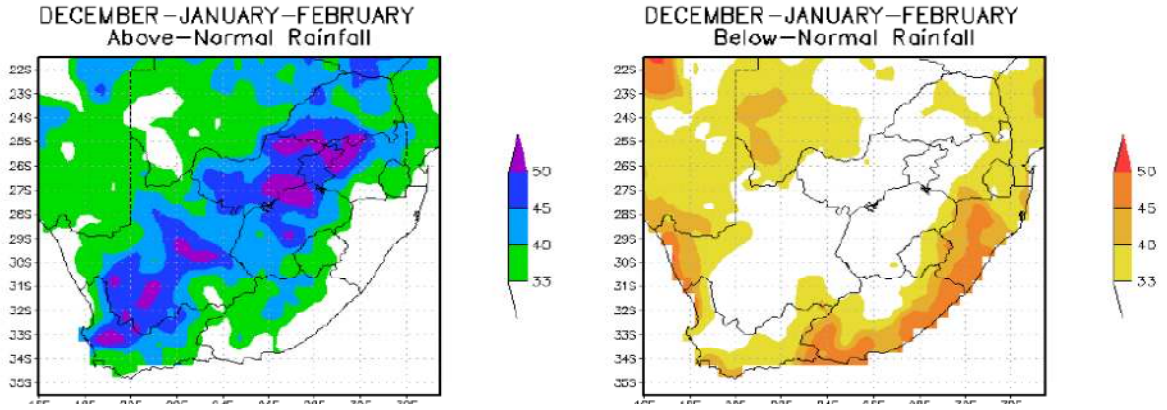

Figure 3. Seasonal climate forecast map for November, December and January 2012/2013

Source: SAWS (2014).

Forecast information that is useful to farmers is part of a process that includes an examination of the current needs, problems and context in which users operate. Forecasts, moreover, need to be expressed in the language of the users. Figure 3 shows that the above – normal rainfall in most parts of the Limpopo Province during December–January–February compared to other provinces such as North West and Northern Cape.

Seasonal climate forecasts are issued as probabilistic outlooks for the future usually for a coverage period of three months and with a rather broad spatial coverage (Figure 3). Conveying notions of 'probabilistic'

information to a variety of users is not easy. It is important for users to understand that all seasonal forecast information or data are given as probabilities and not as deterministic. A probability forecast outlines how likely an event is likely to occur, as a percentage, and can assist farmers to be aware of the risks associated with weather and climate events. Figure 3 shows that the rainfall distribution in the Greater Sekhukhune district was below normal. These confirmed other studies done by Maponya (2013) which shows the rainfall distribution in Limpopo Province varies from area to area and district to district including Greater Sekhukhune. Figure 3 on the left hand side shows the probabilities for above – normal rainfall in most parts of Limpopo Province including Greater Sekhukhune district during December–January–February during 2012/13 (Figure 3). However, figure 6 on the right hand side shows that the probabilities for the below – normal rainfall in most parts of the Limpopo Province including Greater Sekhukhune district during December–January–February 2012/13.

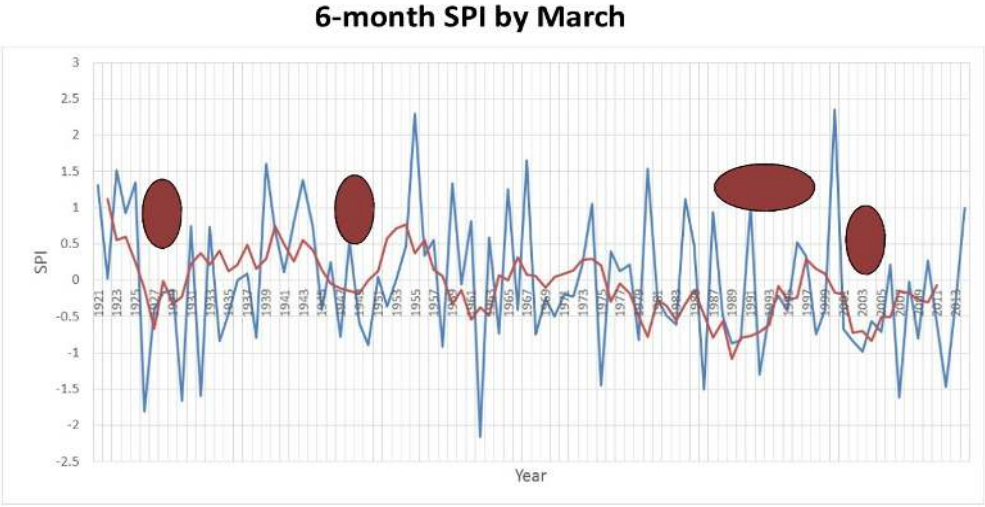

Figure 4. Shows the 6 month Surface Precipitation Index (SPI) for the Greater Sekhukhune district in Limpopo Province

As highlighted in earlier in this paper Greater Sekhukhune district has been affected by drought for number of years. Figure 3 shows that the Greater Sekhukhune district has been affected by the worst drought in 1926/1930/1932/1962/1975/1986/1992/2006/2012 (Figure 4). The worst drought record was in 1962, the majority of the smallholder farmers lost both the livestock and crops. According to Pachauri (2004) a decline in agriculture production would have serious implications on the rural populations and this would lead to food insecurity, reduced income and livelihoods of the poor of the poorest would also be affected. Some of the smallholder farmers decided to abandon their farming land and looked for employment opportunities in the non agricultural sector. The impact of lower rainfall in 1926/1930/1932/1962/1975/1986/1992 had negative impacts on the agricultural sector. According to Mpandeli and Maponya (2014), low rainfall resulting in decreases in agricultural activities including shortage of drinking water, loss of both livestock and crops and also lack of grazing capacity. However, figure 4 also shows that Greater Sekhukhune district also recorded the highest rainfall between 1921 and 2014. The highest rainfall recorded it was in 1923/1940/1955/1967/1980/2000 (Figure 4). During these periods the majority of people in the district lost their properties, roads were also damaged, and some of the people also lost their lives during these periods, smallholder farmers lost high production due to high rainfall distribution, lack of climate advisory information, poor access to Early Warning Information (EWS).

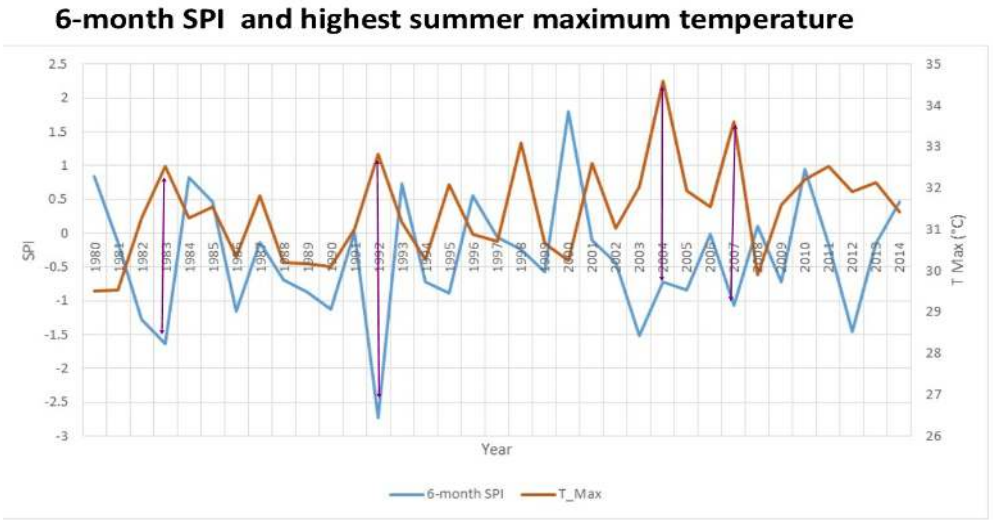

Figure 5. Shows the highest maximum temperature in Sekhukhune district, Limpopo Province

Figure 5 shows the relationship between the SPI and the maximum temperature from 1980 to 2014. The lowest temperature recorded was in 1980/1980/1983 and 1992 during that periods the majority of the smallholder farmers in the Greater Sekhukhune district experienced frost, hail etc. Figure 5, shows that in 1992 Limpopo Province experienced one of the worst droughts, smallholder farmers lost large number of livestock and crops. This had serious implications on the income of the smallholder farmers across the province including Greater Sekhukhune district. Similar trends of temperature effects were also depicted by Mpandeli (2014) in the Vhembe district. Due to high extreme climatic events and climatic variability and change smallholder farmers in the Greater Sekhukhune district should be able to access climate advisory information all the time due to poor rainfall distribution in the district. Small holder farmers in the Greater Sekhukhune district should be use different types of climate change adaptation strategies in order for them to be able to increase crop yields including: (a) Changing farming practices, (b) Use early matured crop varieties, (c) Use of drought resistance seeds etc. Figure 4 shows that the highest temperature recorded was in 2004 which was 34.5 degrees followed by 2007 which was 33.2 degrees. Greater Sekhukhune district recorded the highest rainfall in year 2000 and the year 2010 (Figure 5). More than 1100 mm of rainfall was recorded during those periods. According to Mpandeli and Maponya (2014) the majority of smallholder farmers lost large number of livestock and crops, the majority of the smallholder farmers in the district did not have good agricultural production. During that periods, the year 2000 and year 2010, the majority of the smallholder farmers were relying on their extended families for support and also on the non agriculture sector like mining, local municipality for survival etc.

In the Limpopo Province, the condition of the vegetation is a major concern for livestock farmers. Limpopo Province is characterised by different kinds of veld types, especially in the morphology, palatability and the nutritive value. Sweet veld grass is found around the Thohoyandou area in the Vhembe district and the sweet veld grows in frost-free and low-lying areas (Acocks, 1998). Sourveld grows mostly in the Tshakhuma area; these types of grass usually grow in a high rainfall area.

The quality and status of vegetation can be severely impacted by drought periods. One way to monitor the condition of the vegetation is to use the Normalised Difference Vegetation Index (NDVI). A relationship between rainfall and vegetation status exists, usually expressed as an index the NDVI. This index generally shows the presence and absence of green vegetation (Figure 6). Since green vegetation reflects more infrared radiation than visible radiation, the higher the value of NDVI, the higher the vegetation activity. An example of the relationship between periods of drought and vegetation can be observed in Figure 6.

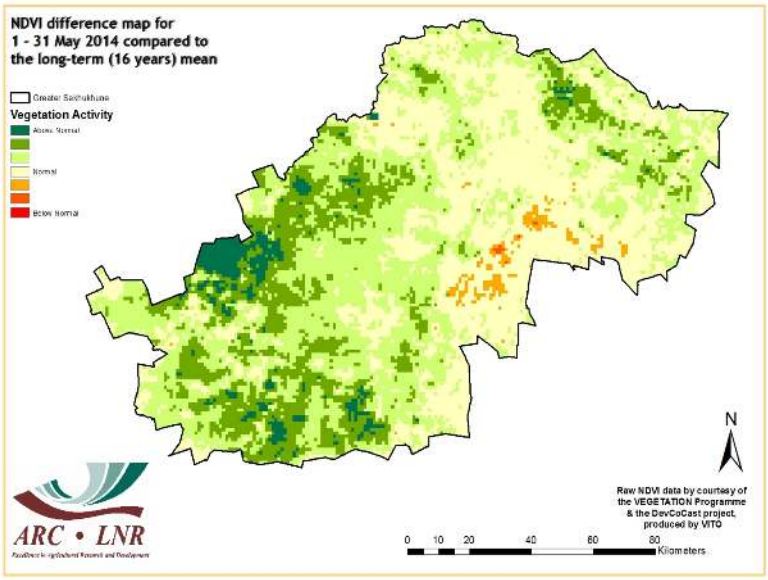

Figure 6. Normalised Difference Vegetation Index map for May 1, 2014 to May 30, 2014, compared to the long-term mean for 16 years

Source: ARC-ISCW (2014).

NDVI can thus be displayed and interpreted spatially over time. For example, from Figure 6, one can infer that the rainfall distribution was very low and sparse in Sekhukhune district compared to other parts of the Limpopo Province for the period 01 May 2014 to 31 May 2014. The green colour in most parts of Limpopo Province shows that the vegetation activity was higher than normal over this period. The green colour shows that there was higher vegetation than normal. In areas where the green colour dominates, there was good rainfall distribution (Figure 6).

The combination of these factors, for example high rainfall, good vegetation condition and a range of other available opportunities, heightened by figure 6, shows those smallholder farmers in the Sekhukhune district had good forage production and also managed to obtain good yields. According to Mpandeli (2014) poor vegetation usually means poor grazing and therefore poor cattle condition. This can further translate into loss of livelihoods as poor cattle often receive poor market prices. In the district such as Vhembe, older farmers indicated that drought has been a recurring process since the 1950s and this it was confirmed by results from figure 6. Some farmers stated that in 1992 they had severe drought problems resulting in a shortage of grazing and crop failures in many parts of the district (Bakali, pers. comm., 2004; Mpandeli, 2006, 2014). Livestock was slaughtered and farmers had to sell their livestock at prices as low as R5 per unit. The drought impacts in 1992 increased farming debt and affected food exports in the province (Koch, pers. comm., 2005; Mpandeli, 2006). According to Mpandeli (2006, 2014) farmers in the Vhembe district farmers describe drought based on the following factors such as food and feed shortages, low rainfall, decrease in water availability, dying vegetation and animals etc. These factors were also highlighted by O' Farrell et al. (2009). According to O' Farrell et al. (2009) farmers described drought in terms of the way it affected the agricultural systems.

5. Conclusions and Recommendations

Assessing the importance of climate variability is important in a drought-prone area such as Sekhukhune district in Limpopo Province. To improve drought management, risk reduction and responses of farmers in the Sekhukhune district were probed. A better understanding of the role drought plays in communities in Sekhukhune district, as well as strategies that may be used to best mitigate drought, were examined. Limpopo Province offers a range of opportunities as well as challenges for farmers. The results from this paper show that the changes in temperature and precipitation in the Greater Sekhukhune district in Limpopo Province could probably affect the accessibility, availability and the distribution of water resources in the area. The impact of drought in the Greater Sekhukhune district is not affecting the smallholder farmers or the agriculture sector only but other sectors such as water, mining and tourism are also affected. The Greater Sekhukhune district has been experiencing several types of droughts such as hydrological, agricultural and meteorological droughts for several decades. However, smallholder farmers in the Greater Sekhukhune district have been using several climate

change adaptation strategies including, plant crops that requires less water, plat drought resistant crops, adjust agronomic practices and plant matured crop varieties..

References

Acocks, J. P. H. (1998). *Veld Types of South Africa: Memoir of the Botanical survey of South Africa* (No. 57, 3rd ed., p. 146). Department of Agriculture and Water Supply, Pretoria.

Adger, W. N. (2001). Scales of governance and environmental justice for adaptation and mitigation of climate change. *Journal of International Development, 13*, 921-931. http://dx.doi.org/10.1002/jid.833

Adger, W. N., Kelly, P. M., Winkels, A., Huy, L. Q., & Locke, C. (2002). Migration, remittances, livelihood and trajectories and social resilience in Vietnam. *Ambio, 31*, 358-366. http://dx.doi.org/10.1579/0044-7447-31.4.358

ARC-ISCW. (2014). Agricultural Research Council – Institute for Soil, Climate and Water.

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*.

Babi, D. D. (2005). Assessing the vulnerability of FADAMA (flood plain) agriculture to climate variability and change. *A case study of semi-arid Northern Nigeria*.

Bakali. (2004). Agricultural scientist, personal communication.

Corbett, J. (1988). Famine and households coping strategies. *World Development, 16*, 1099-1112. http://dx.doi.org/10.1016/0305-750X(88)90112-X

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

FAO (Food and Agriculture Organization). (1998). Agricultural Policies for Sustainable Use and Management of Natural Resources in Africa. *Report presented at 20th Regional Conference for Africa, February 16-20, 1998*. Addis Ababa, Ethiopia.

Greater Sekhukhune District Municipality (GSDM). (2007). *2006/2007 IDP Review*. Retrieved December 15, 2009, from http://www.sekhukhune.gov.za

Greater Sekhukhune District Municipality (GSDM). (2011). *2010/2011 IDP Review*. Retrieved January 15, 2012, from http://www.sekhukhune.gov.za

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.

Intergovernmental Panel on Climate Change Report (IPCC). (2001). Impacts, Adaptation and Vulnerability. *Contribution of the Working Group II to the Third Assessment Report on the Intergovernmental Panel on Climate Change*. UK: Cambridge University Press.

Kihupi, N., Kingamkono, R., Dihenga, H., Kingamkono, M., & Rwamugira, W. (2003). Integrating indigenous knowledge and climate forecasts in Tanzania. In C. Vogel & K. O'Brien (Eds.), *Coping with climate variability: The use of seasonal climate forecasts in Southern Africa* (pp. 155-169). Burlington, Vermont, USA: Ashgate.

Koch. (2005). Agricultural project manager, personal communication.

Maponya, P. I. (2013). Climate change and agricultural production in Limpopo: Impacts and Adaptation Options (Ph.D thesis, p. 108). Environmental Management, University of South Africa, Pretoria, South Africa.

Mpandeli, N. S. (2006). *Coping with climate variability in Limpopo Province* (Unpublished PhD thesis). University of Witwatersrand.

Mpandeli, N. S., & Maponya, P. I. (2014). Constraints and challenges facing the small scale farmers in Limpopo Province. *Journal of Agricultural Science, 6*(4), 135-143. http://dx.doi.org/10.5539/jas.v6n4p135

Mpandeli, N. S. (2014). Climate Risks Using Seasonal Climate Forecast Information in Vhembe District in Limpopo Province, South Africa. *Journal of Sustainable Development, 7*(5), 68-81. http://dx.doi.org/10.5539/jsd.v7n5p68

Naidu, E. (2003). *Large parts of South Africa face water restrictions*. Sunday Independent, South Africa.

NEPAD. (2001). The New Partnership for Africa's Development. *NEPAD* (Unpublished memorandum, October 2001).

Siambi, M., Simalenga, T., Mpandeli, N. S., Liphadzi, K., Mailula, N., Mkhari, J., & Ramugondo, R. (2007). Increased food security and income in the Limpopo Basin through integrated crop, water and soil fertility options and public-private partnerships. *Proceedings of the CGIAR Challenge Program on Water and Food*. Addis Ababa, Ethiopia.

Smithers, J., & Smit, B. (1997). Human adaptation to climate variability and change. *Global Environmental Change, 7*, 129-146. http://dx.doi.org/10.1016/S0959-3780(97)00003-4

Smit, B., McNabb, D., & Smithers, J. (1996). Agricultural adaptation to climate variation. *Climate Change, 33*(1), 7-29. http://dx.doi.org/10.1007/BF00140511

Smit, B., Burton, I., Klein, R. J. T., & Wandel, J. (2000). An anatomy of adaptation to climate change and variability. *Climatic Change, 45*, 223-251. http://dx.doi.org/10.1023/A:1005661622966

SAWS. (2014). South African Weather Service.

Sowetan. (2003). *Drought takes its toll in Limpopo Province* (p. 23, May 5, 2003). Gauteng: Sowetan.

Patt, A., & Gwata, C. (2002). Effective seasonal climate forecast applications: Examining constraints for subsistence farmers in Zimbabwe. *Global Environmental Change, 12*, 185-195. http://dx.doi.org/10.1016/S0959-3780(02)00013-4

Pachauri, R. K. (2004). Climate change and its impacts on development: The role of the IPCC assessments. *Climate and Development, IDS Bulletin, 35*(3). Sussex: Institute of Development Studies.

Phillips, J., Makaudze, E., Unganai, L., Makardho, J., & Cane, M. (1999). Current and potential use of climate forecasts for farm management in Zimbabwe. *Paper presented at the Society for Applied Anthropology Meetings*. Tuscon, AZ.

Tyson, P. D., & Dyer, T. G. J. (1978). The predicted above-normal rainfall of the seventies and the likelihood of droughts in the eighties in South Africa. *South African Journal of Science, 74*, 372-377.

UNAIDS. (2000). *Report global estimates of HIV/AIDS* (p. 32).

UNAIDS. (2004). *Report on the global AIDS epidemic* (p. 63).

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

Vogel, C., Laing, M., & Munnik, C. (2000). Drought in South Africa. In D. Wilhite (Ed.), *Drought Volume 1, A Global Assessment, Routledge Hazards and Disasters Series* (pp. 348-366). London: Routledge. http://dx.doi.org/10.1080/03736245.2000.9713700

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.

World Bank. (1997). Towards Environmentally Sustainable Development in Sub-Saharan Africa. *Findings: Africa Region* (p. 78). World Bank, Washington D. C., USA.

Ziervogel, G., & Downing, T. E. (2004). Stakeholder networks: improving seasonal climate forecasts. *Climatic Change, 65*, 73-101. http://dx.doi.org/10.1023/B:CLIM.0000037492.18679.9e

Wilhite, D. (2000). Drought as a natural hazard: Concepts and definitions. In D. Wilhite (Ed.), *DroughtVolume 1: A Global Assessment, Routledge Hazards and Disasters Series* (Vol. 1, pp. 3-18). London: Routledge.

Wilhelmi, O. V., & Wilhite, D. A. (2002). Assessing Vulnerability to Agricultural Drought: A Nebraska Case Study. *Natural Hazards, 25*, 37-58. http://dx.doi.org/10.1023/A:1013388814894

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