

# CLIMATE RISK AND VULNERABILITY

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A HANDBOOK FOR SOUTHERN AFRICA

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For correspondence about this handbook, please email Claire Davis-Reddy: [cdavis@csir.co.za](mailto:cdavis@csir.co.za)

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## CHAPTER 5: AGRICULTURE AND LIVESTOCK

AUTHOR: DALEEN LÖTTER

*Agriculture is impacted directly by changes in precipitation, temperature and evaporation. Increasing temperatures and more variable precipitation are likely to have a significant impact on a wide variety of crops, particularly on the yields of rain-fed crops such as maize, wheat and sorghum.*

### 5.1. Introduction

The agricultural sector in southern Africa needs to produce enough food to feed its current population of 277 million and future predicted population of over 300 million by 2025 (United Nations ESA, 2015). All of this must happen within the many restrictions imposed on the sector by an unpredictable climate, finite natural resources and sometimes limited access to modern production technology (Kotze & Rose, 2015). Southern Africa is currently not producing enough food to adequately provide for the needs of its present population. According to the Stellenbosch Institute for Advanced Studies (STIAS, 2015), the region needs to increase overall production by at least 1 to 2 percent per annum to keep up with population increases. Figure 5.1 shows the severity of hunger in southern Africa, as it was assessed in 2013, ranging between moderate and very high. Global projections suggest that the number

of people at risk of hunger will increase by 10 to 20 percent by 2050 as a result of climate change, with 65 percent of this population in sub-Saharan Africa.

Agriculture is a major social and economic sector in the SADC region, contributing between 4 and 27 percent of the region's gross domestic product (GDP). The majority of the population in the region depends on agriculture for their primary source of subsistence, employment and income (Department of Environmental Affairs, 2014a) (LTAS). This happens within various farming systems ranging from large-scale irrigation schemes to root crop farming, maize mixed farming, pastoral farming and coastal fishing (Figure 5.2). Overall, farming systems are characterised by a great level of diversity and even at the level of the individual farm unit, farmers typically cultivate 10 or more crops in diverse environments (IAC, 2004).

Maize, wheat and sorghum are the most produced cereals in the region, and the major staple foods for most of the population. Root and tuber crops, especially cassava, contribute significantly to food supply in the region and play a central role in the nutrition and economy of rural families. Overall, subsistence farming or smallholder agriculture is the most widely used method of agricultural farming in sub-Saharan Africa, and the majority of the rural poor depend on it for survival. The exception is South Africa, which has a more productive and competitive agricultural sector compared with the other countries in the region. The commercial farming sector in South Africa is highly complex and sophisticated, and plays a critical role in ensuring food security in the greater African region (DAFF, 2010). South Africa is the largest producer of milk, sugar and fresh fruit in southern Africa and also produces 17% of total maize in Africa. According

to Van Rooyen and Sigwele (1998), the reasons for insufficient production in the other SADC countries include 'unfavourable climatic conditions, a complex natural resource base, inappropriate sectoral and macro-economic policies and support systems and internal strife/war'.

The SADC region is considered to be a semi-arid environment which is often plagued by droughts. The frequency of weather- and climate-related disasters has increased since the 1970s, and southern Africa has become drier during the 20<sup>th</sup> century. Significant food shortages are associated with these droughts. After the most recent drought of the 2015/2016 season, it was estimated that 32 million people would become food insecure between June 2016 and March 2017. In some African countries, agricultural yields could be reduced by as much as 50% by 2020.

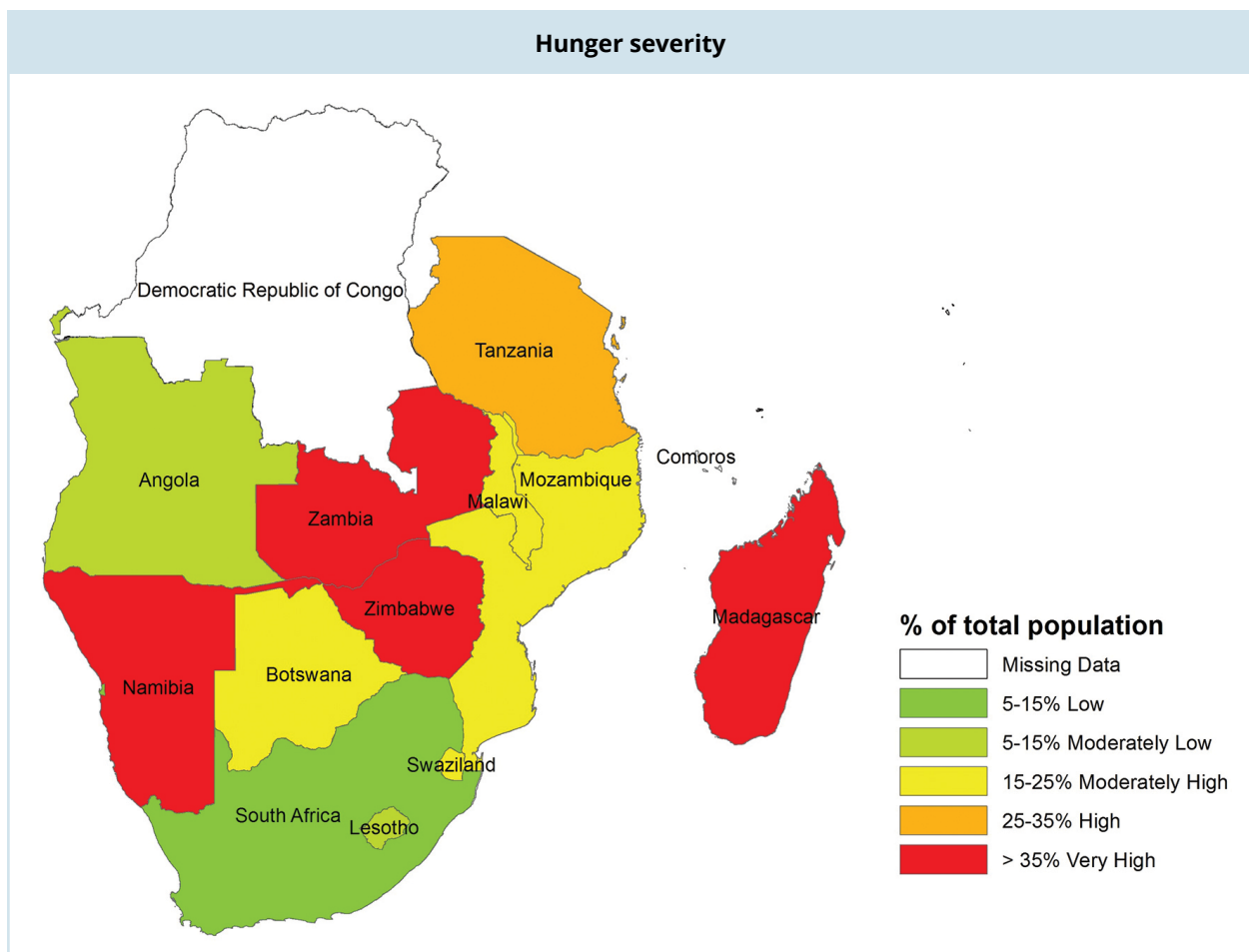


Figure 5.1: Proportion of the population in a condition of undernourishment (FAO, IFAD and WFP, 2015). The FAO defines hunger as being synonymous with chronic undernourishment. Undernourishment means that a person is not able to acquire enough food to meet the daily minimum dietary energy requirements, over a period of one year.



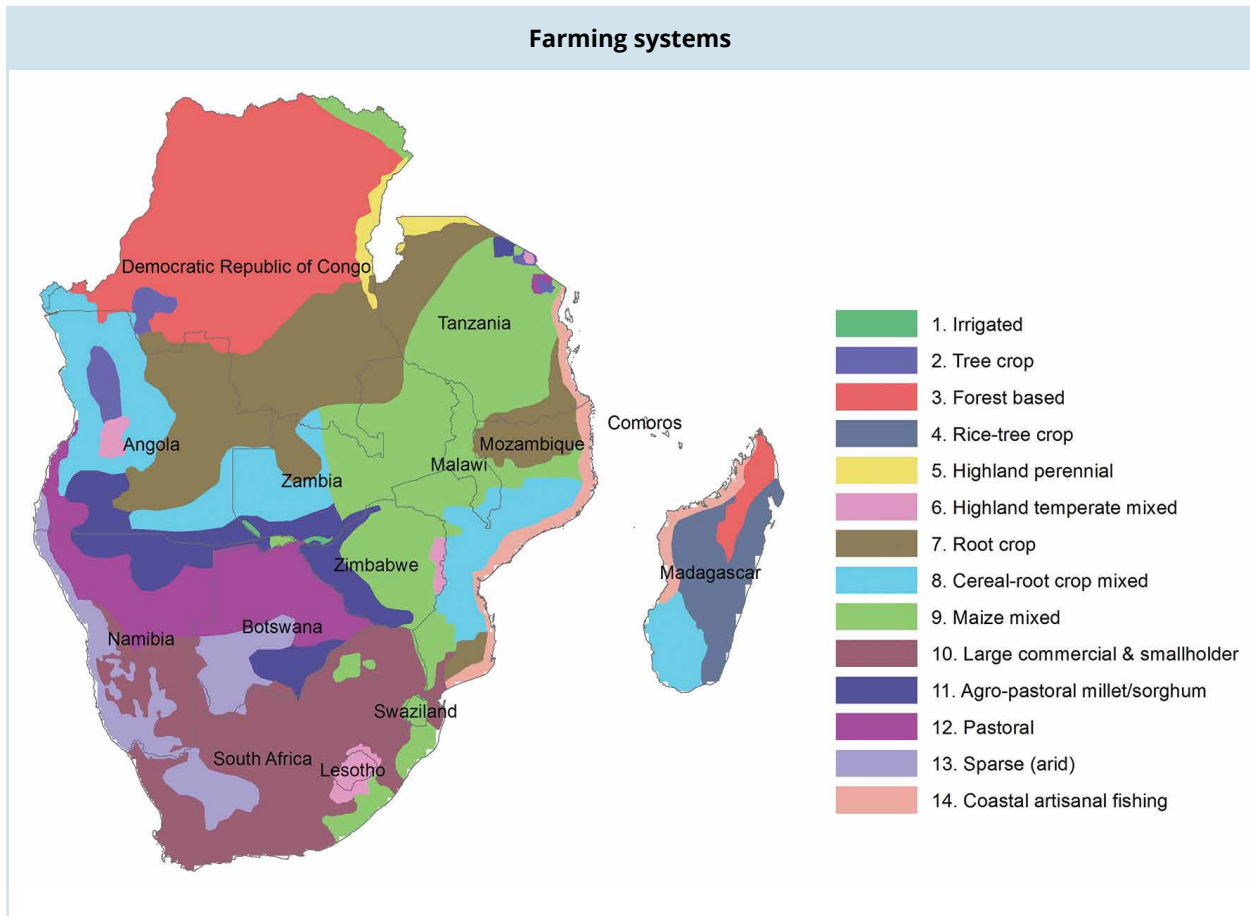


Figure 5.2: Farming systems in southern Africa (FAO, 2001).

## 5.2. Key drivers and processes of change within the sector

The agricultural sector in southern Africa is dictated by several important drivers and processes of change affecting its ability to guarantee food security for the region. These can roughly be divided into factors affecting the demand for food (e.g. population growth, changes in consumption patterns, urbanisation), environmental factors (e.g. climate change, environmental degradation) and external or governance factors (agricultural support and trade policies, conflicts).

### 5.2.1. Demand for food

Agricultural demand in southern Africa is expected to increase as population and income levels increase. New data from the United Nations laying out population growth projections to the year 2100 show that Africa

is set to experience the highest population growth in the world and is the only region where the population is projected to keep increasing throughout the 21<sup>st</sup> century. Currently there are 1.2 billion people in Africa and by 2050 the population is expected to double to 2.4 billion. In southern Africa alone, the population of Angola, Democratic Republic of Congo, Malawi, United Republic of Tanzania and Zambia is projected to increase at least five-fold by 2100 (UN, 2015). Such population growth imposes profound challenges in meeting future food requirements. Along with population growth, population distribution is having a big impact on the supply of agricultural produce. According to Ziervogel and Frayne (2011), Africa will have the second largest urban population on the planet by 2030. The pace of urbanisation in sub-Saharan Africa is twice the global average, and is expected to persist for decades to come. Of the total southern African population of

277 million, at least 100 million already live in urban and peri-urban areas. By 2020, this figure is expected to rise to 150 million and to exceed 200 million by 2030. Such a change in the spatial distribution of the population will bring major changes in demand for agricultural products both from increases in urban populations and from changes in their diets, which might lead to issues of food insecurity and deepening malnutrition in southern Africa.

Not only is population growth driving food production, but major shifts in people's dietary patterns are driving the type of food being produced. There is a clear shift towards diets that are richer in meat and animal products. Sub-Saharan Africa is projected to have the greatest annual growth in the consumption of meat of any other region and the second highest growth in milk consumption. This is causing an increased demand for water and agricultural land for growing feed for livestock production, while at the same time it is further contributing to greenhouse gas emissions. Even more challenging, the necessary increases in food production will coincide with increasing changes in climate and climate variability.

## 5.2.2. Environmental factors

### Climate change

Climate variability and change is arguably the most important driver of agricultural production. Increases in temperature and reductions in water availability will have a direct effect on agriculture through changes in soil characteristics, water availability and crop productivity as well as indirect effects through changes in farm management systems, pest and disease life cycles and competition for land and water resources. Agriculture is not only impacted by climate change, but also contributes to greenhouse gas emissions (both carbon- and nitrogen-based) primarily through land conversion, particularly deforestation, tillage and burning practices, volatility of organic and inorganic fertilisers, and methane emissions from ruminant livestock.

### Availability and degradation of key natural resources

Agriculture is the largest water consumer in the region, using between 70 and 80 percent of available freshwater resources (Malzbender & Earle, 2007). Many countries in the region already face a gap in water supply versus demand (Allan, 2002). This discrepancy will impede



their ability to meet the current and future needs of the agricultural sector to produce food (Figure 5.3). According to the Food and Agriculture Organization (FAO) of the United Nations, the SADC region could face a decline in agricultural productivity of up to 50 percent over the next 10 years as a result of water scarcity and insufficient irrigation. This could severely affect many countries' prospects of greater social and economic development.

Water in the region is not only scarce, but also of exceptionally poor quality, owing to increased pollution caused by industry, urbanisation, afforestation, mining, agriculture and power generation (Ashton et al., 2008). More specifically, the pollution is a result of the progressive increase in harmful micro-organisms, nutrients, salts, metal ions, toxic chemicals, radionuclides (can emit radiation) and suspended sediments entering water courses and water supply reservoirs. The deterioration in the quality of water available for irrigation poses an increasing risk to agricultural crops and ultimately to human health. Kotze and Rose (2015) emphasise that climate change

will first be felt through impacts on water resources, with far-reaching effects on water availability and quality. A rise in air temperature of 2 °C will raise water temperatures, which will alter water-gas equilibria and increase the rates of microbial processes. Higher water temperatures will lead to increased rates of evaporation, thereby reducing the volumes of water needed for dryland and irrigated agriculture (CSIR, 2010).

In sub-Saharan Africa, the most food-insecure communities live in highly degraded environments where climate change could increase degradation rates. Severe and prolonged droughts, flooding and loss of arable land as a result of desertification and soil erosion are reducing agricultural yields and causing crop failure and loss of livestock, which endanger rural and pastoralist populations. Drylands are particularly susceptible to land degradation. Unsustainable land management practices, including over-grazing, over cultivation, illegal and excessive fuelwood collection and poor irrigation technologies, among other things, have become prevalent, often due to institutional barriers.

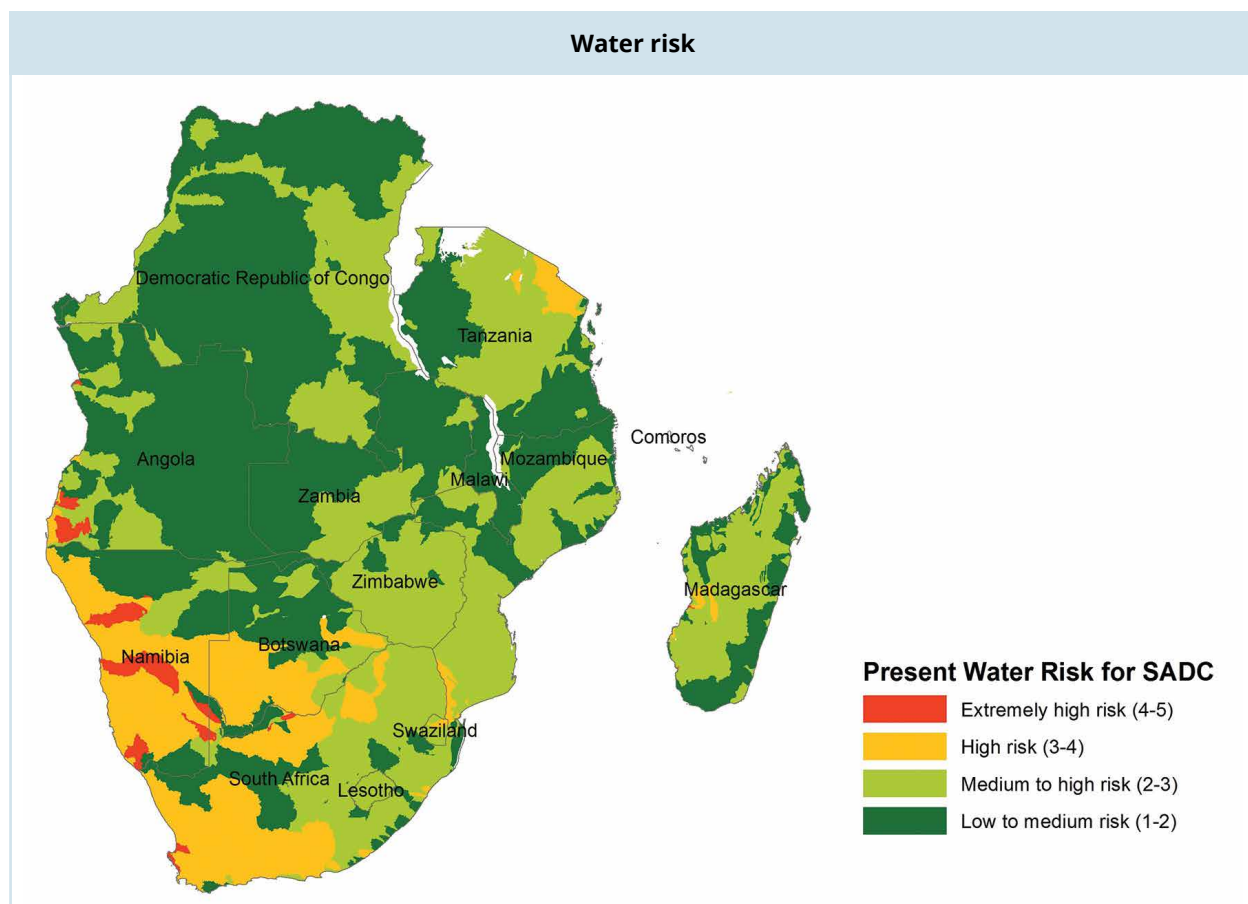


Figure 5.3: Current situation of water scarcity in southern Africa (Source: International Water Management Institute (IWMI), Web: www.iwmi.org).



### 5.2.3. External factors

#### Land reform

Land redistribution is one of the mechanisms to enable agrarian reform aimed at including marginalised farmers and communities in a country's food production system. It is widely acknowledged that land reform is absolutely necessary, but it must be implemented without compromising agricultural productivity, development, and food security. Many conflicting reports and interpretations of the manner in which the process would be applied have created concern and uncertainty for many stakeholders. In Zimbabwe, land redistribution is a bitterly contested political issue which is ultimately having a detrimental impact on the country's ability to produce food. Zimbabwe was once considered the "bread basket" of southern Africa, but is now struggling to feed its own population. Nearly 28 percent of children under age five in Zimbabwe are stunted owing to chronic malnutrition. By contrast, land reform in Namibia based on the concept of 'right of first refusal' has been very successful and roughly 28 percent of its commercial farmland has been transferred to emerging farmers. In South Africa, commercial farmers are concerned about signs that government wants to fast-track the land reform process, while local communities are concerned by the lack of

progress (Pereira, 2014; Kotze & Rose, 2015). A review of land reform in 2009 indicated that 90 percent of land reform projects had failed. Close to R30 billion had been spent by that time to transfer seven million hectares of commercial farmland, which was now operating sub-optimally or was no longer in productive use.

#### Lack of enabling environments and political unrest

In the SADC region, many countries lack appropriate government policies to support an enabling environment for the development of their agricultural sector. This includes low funding of the national agricultural research and extension institutions, leading to ineffective technology development. Infrastructure deficiencies of roads, ports, telecommunications, irrigation, storage, cold chains, energy generation, and distribution remain a constraining feature of the agri-sector.

In recent decades, the Southern African region has also been subjected to several types of political unrest, civil war and armed conflict. Conflict and wars can disrupt agriculture in a variety of ways, depending on the characteristics of the country's agriculture. In a broad sense, conflict prevents farmers from producing food, they displace populations, destroy infrastructure and litter the countryside with land-mines.



### 5.3. Vulnerability of sector to climate change

Agricultural activities in southern Africa are subject to many hazards and uncertainties such as climate variability, economic and price-related issues, environmental degradation, water scarcity, and pests and diseases. The region's low adaptive capacities arising from endemic poverty, limited access to capital, infrastructure and technology; and exposure to disasters and conflicts (Parry, 2007) greatly enhance its vulnerability. When climate change issues are superimposed upon the existing vulnerabilities, the effects are exacerbated. These changes are having a dramatic impact on food and nutrition security in sub-Saharan Africa (NOAA, 2007).

#### 5.3.1. Specific vulnerable sectors

##### Dryland production

75% of the SADC region is classified as arid to semi-arid. The region's climate varies from desert, through temperate, savanna and equatorial climates. Most of the region's population rely on agriculture as their main source of livelihood, either directly or indirectly. For the most part, this is derived from rain-fed production systems susceptible to droughts and floods. The projected increase in rainfall variability and extreme events for the region will exacerbate the vulnerability of these rain-fed systems. It is estimated that rain-fed farming covers around 97% of total cropland in sub-Saharan Africa.

Regardless of the approach used, most studies show a negative impact of climate change on rain-fed crop production over southern Africa. In a meta-analysis and systematic review of the projected impacts of climate change on the yield of eight major crops in Africa, Knox et al. (2012) have shown mean yield changes of -17% (wheat), -5% (maize), -15% (sorghum) and -10% (millet) across Africa by the 2050s. In terms of climatic suitability, Dinesh et al. (2015) indicate that the area suitable for maize could decline by 20 to 40% relative to the period 1970 to 2000.

Parts of southeastern Africa might experience some gains in maize yield as a result of the fertilisation effect associated with higher atmospheric concentrations of CO<sub>2</sub> as well as anticipated increases in rainfall in the near future (Lotsch, 2007). These benefits will, however, be negated by some losses as aridity increases towards the end of the century. Cassava appears to be more resistant to high temperatures and variable precipitation than cereal crops, with some opportunities to expand cropping areas in certain countries and regions (Dinesh et al., 2015, Niang et al., 2014). Another crop which contributes substantially to the food security and nutrition of many people in the region is the common bean (*Phaseolus vulgaris L.*). This crop is projected to experience significant yield losses in most of sub-Saharan Africa (Lobell et al., 2008; Thornton et al., 2009, 2011).





Apart from rainfall anomalies, crop sensitivity to temperature thresholds is another important factor to consider in assessing future crop yield changes. Engelbrecht et al. (2015) project increases of 4 to 6 °C over southern Africa by the end of the century relative to present-day climate under the A2 (a low mitigation) scenario. In addition, extreme events such as heat-wave days are consistently projected to increase drastically in their frequency of occurrence. This will lead to general decreases in soil-moisture availability, even for regions where increases in rainfall are plausible, due to enhanced levels of evaporation. Maize has been found to have a particularly high sensitivity to temperatures above 30 °C, with a yield reduction of 1% for each growing day spent at a temperature above 30 °C (Lobell et al., 2011). Wheat has an even lower optimal temperature range than maize and in many areas it is already close to threshold values for maximum temperature (Adhikari et al., 2015).

#### Livestock-based systems

Livestock are an integral part of the livelihood strategy of many people, especially the poor in the region. It is an important source of food (such as meat, milk and other dairy products) and provides cash to supplement income (IAC, 2004; Seo and Mendelsohn, 2007). Climate change is expected to affect livestock productivity indirectly through forage availability and quality as well as directly through heat stress. Heat stress relates to the animal's inability to dissipate environmental heat and is affected by temperature, humidity and wind speed. An increase in air temperature, as associated with climate change,

will have a direct effect on animal performance through alterations in the heat balance. According to a report by the CGIAR (Dinesh et al., 2015), most domesticated species perform best at temperatures between 10 and 30 °C and will eat around 3 to 5% less for each 1 °C increase above those levels. These temperatures are already exceeded in a number of regions.

Indirectly, climate change can affect the availability of feed resources for livestock through changes in the primary productivity of crops, forages and rangelands. Changes in species composition in rangelands and some managed grasslands will also have a significant impact on the types of animal species that can graze them (Thornton et al., 2007).

#### Other

Given the strong linkages between agriculture and other sectors of the economy, climate change will have many secondary implications for other industries. According to Haywood (2015), the biophysical impacts of climate change can have a ripple effect along the whole agricultural value chain which spans input companies, farmers, distributors, agro-processing companies, and retailers. In the Status Quo Review of Climate Change and the Agriculture Sector of the Western Cape (Western Cape Department of Agriculture, 2014), a case study is provided of climate change impacts on the wine value chain in terms of role players along the value chain and their exposure to climate change impacts. Specific risks relate to the increased risk of spoilage during cold chain distribution caused by increased temperatures.



### 5.4. Response measures

Potential climate change responses in the agriculture sector cover a broad range of options on different levels – from national level strategies such as investment in research and innovation, development of infrastructure and consideration of water resource allocation, to local level responses, which may be specific to agriculture production methods and local conditions. Providing food for the region in future will require an interlinked approach of producing food in the most economical yet most environmentally responsible manner, continued research on new crop varieties and technology, minimising of food waste, climate and environmental education and increasing the production of small-scale farmers.

There is an urgent requirement to intensify agriculture and enhance food production systems in order to achieve food security. Reducing the environmental impact of agricultural production is an important overall adaptation strategy. According to the Department of Agriculture (2008), land degradation, water scarcity and pest control are the most significant environmental issues facing agriculture in southern Africa. By following an environmentally sustainable approach to soil, water and natural veld management, the agriculture sector will be able to sustain the natural resource base while ensuring greater productivity and food security. Specific measures include more efficient use of irrigation water, minimum disturbance of the soil, crop rotation, crop diversification, crop residue management and incorporation of organic matter, best grazing systems, and erosion prevention practices. All these measures are inherent to the principles of initiatives such as conservation agriculture, climate-smart agriculture and agroecology. These environment-centred approaches have the advantage that they can achieve the same, or greater, productivity compared with conventional agriculture, but with greatly reduced production inputs. This will have the effect of making producers more competitive by lowering input costs, while reversing the trend of agriculture's negative contribution to the trade balance.

Looking at specific examples of response measures such as those required during the most recent drought season, the sector needs interventions from government and related institutions to ensure the financial survival of farmers during the disaster, but also to facilitate drought

recovery in the aftermath of the drought. This might entail subsidising feed and fodder for six months after the drought and helping farmers retain farm workers by means of a wages cash grant. National crop and/or disaster insurance would also become a priority as more extreme conditions are expected. Emerging producers are especially vulnerable.

In terms of infrastructure, less than 5% of cultivated land in the SADC region is equipped for irrigation. Development of irrigation infrastructure may allow the region to grow crops all year round and not only depend on climatic conditions.

Communicating agro-climatic information in an appropriate format to government, agri-business (e.g. seed companies), extension services and farmers is essential to enhance decision support. This could relate to the onset of rains, number of rain days, persistence of rain days, enhanced rainfall variability, droughts and long- and short-cycle crops. Communication and trust should be increased between authorities and all farming sectors (commercial, small-holder and subsistence) to disseminate relevant knowledge on climate change and promote adaptation (Department of Environmental Affairs, 2013). Such communication should be augmented with processes that support vulnerable communities to interpret and respond to such messages.

Early warning systems serve an important function as mechanisms to give timely warnings of potentially damaging weather events (e.g. heavy rain, heat waves and cold weather). Such information plays a critical role in helping farmers to prepare and act sufficiently ahead of time to reduce the possibility of harm or loss. Despite the warning being issued, early warning information does not always reach the people who need it. The packaging of early warning information also needs to be improved, including translation into local languages.

Another critical response measure is continuous investment in climate change education and awareness programmes in rural areas. In collaboration with agricultural extension services, these outreach activities could enable both subsistence and commercial producers to better understand, respond and adapt to the challenges of climate change.



### Case study: Modelling rooibos crop suitability and distribution under scenarios of climate change

Arguably, the economically most significant indigenous crop within the Fynbos Biome is the leguminous shrub *Aspalathus linearis* (better known as rooibos tea). Rooibos tea is an invaluable wild resource as well as a commercially cultivated plant which has significant nutritional and health benefits. Being a rain-fed crop with wild populations having a narrow geographic range within the Fynbos Biome, climate change is expected to have important consequences for future species distribution and crop suitability. Rooibos has recently been granted geographical indication (GI) protection due to the unique environment within which the plant is cultivated, its limited geographical range and strong link with local farmers' heritage.

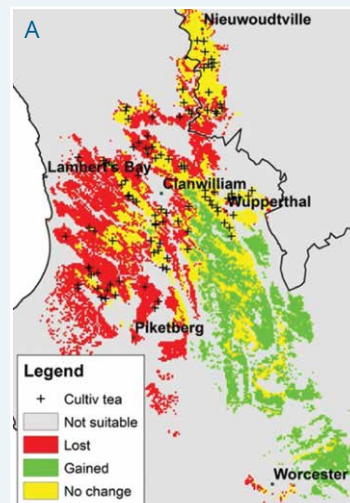
#### Model scenarios of rooibos crop and wild type distribution

Using a species distribution model and an ensemble of climate change scenarios, rooibos range contractions, expansions or shifts were quantitatively assessed for the time period 2041-2070 relative to 1960-1990. Using the CCAM climate change projections and Maxent species distribution modelling software, it was predicted that wild rooibos tea may lose up to 69% and cultivated tea 57% of their climatically suitable habitat range by 2070 (refer to figure below). Range contraction is most pronounced in the lowlands, while rooibos crop and wild types are likely to persist in mountain areas or expand their ranges to higher elevations.

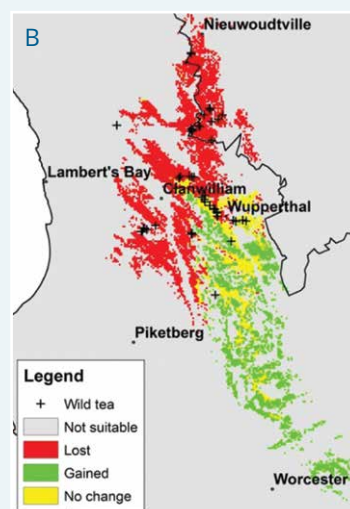
#### Implications for livelihoods, conservation, and adaption planning

Unlike indigenous tea, the distribution of cultivated tea is assisted by several management interventions which make it possible to expand its indigenous range. This leads to cultivation in suboptimal locations and production in these marginal areas is likely to decrease rapidly under the influence of accelerated global climate change. Hence, lowlands along the west coast and the northern periphery of the production area are predicted to be the most vulnerable. Novel areas for future crop suitability are expected to move south-eastwards and upslope of mountain ranges. However, most of the areas where future crop suitability is indicated are located in existing conservation areas or include conservation-worthy vegetation, which may bring farmers into conflict with the biodiversity conservation sector. Current land-use legislation prevents farmers from cultivating in such areas although illegal ploughing of land does occur.

Emerging, small-scale and resource-poor farmers are often particularly vulnerable in that they do not have sufficient resources and access to timely information to deal with adverse effects of climate change. The bulk of wild tea is harvested by small-scale farmers located in near-pristine natural environments around Nieuwoudtville and Wupperthal. If species' ranges shrink or shift in the future as is predicted by the models, it is doubtful whether farmers will relocate to areas where species have colonised new sites. More pressure might be placed on harvesting the remaining populations, which may contribute to the species' decline. These findings will be critical in directing conservation efforts as well as developing strategies for farmers to cope with and adapt to climate change.



Suitability of areas for cultivated (A) and wild (B) *A. linearis* under future climate change for the period 2041-2070.



Maps show areas where range contraction, no change and range expansion occur relative to the current climate (1960-1990).