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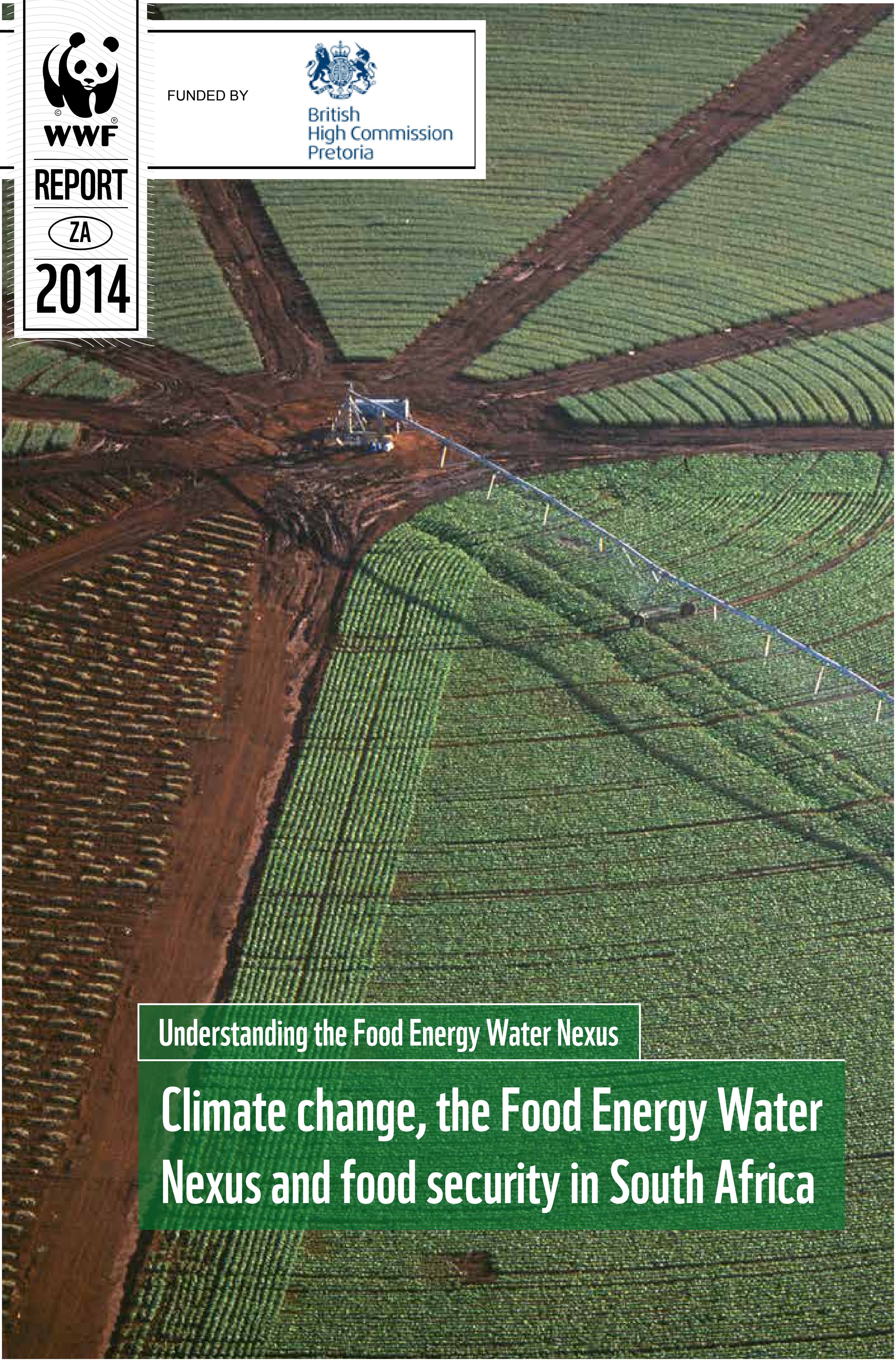

Understanding the Food Energy Water Nexus

Climate change, the Food Energy Water Nexus and food security in South Africa

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ABOUT THIS STUDY

Food, water and energy security form the basis of a self-sufficient economy, but as a water-scarce country with little arable land and a dependence on oil imports, South Africa's economy is testing the limits of its resource constraints. WWF believes that a possible crisis in any of the three systems will directly affect the other two and that such a crisis may be imminent as the era of inexpensive food draws to a close.

WWF received funding from the British High Commission to establish a research programme exploring the complex relationship between food, water and energy systems from the perspective of a sustainable and secure future for the country. This paper is one of nine papers in the Food Energy Water Nexus study.

PAPERS IN THIS STUDY

1. *Climate change, the Food Energy Water Nexus and food security in South Africa:* Suzanne Carter and Manisha Gulati
2. *Developing an understanding of the energy implications of wasted food and waste disposal:* Philippa Notten, Tjasa Bole-Rentel and Natasha Rambaran
3. *Energy as an input in the food value chain:* Kyle Mason-Jones, Philippa Notten and Natasha Rambaran
4. *Food inflation and financial flows:* David Hampton and Kate Weinberg
5. *The importance of water quality to the food industry in South Africa:* Paul Oberholster and Anna-Maria Botha
6. *The agricultural sector as a biofuels producer in South Africa:* Alan Brent
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9. *Water, energy and food: A review of integrated planning in South Africa*: Sumayya Goga and Guy Pegram

ABOUT WWF

The World Wide Fund for Nature is one of the world's largest and most respected independent conservation organisations, with almost five million supporters and a global network active in over 100 countries. WWF's mission is to stop the degradation of the Earth's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

DISCLAIMER

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ABSTRACT

It is becoming increasingly clear that climate change is an inevitable process. Increasing climatic variability would have serious implications for the supply of food, energy and water (FEW).

Of particular concern is the impact of climate change on food security. This impact could be amplified by the interconnections and interdependence between the Food Energy Water (FEW) resources or what is popularly known as the FEW Nexus. Research specific to South Africa shows how food production in the country is susceptible to climate risk and is therefore vulnerable to climate change. Practices on farms suggest that farmers have already started to implement adaptation strategies at various levels in response to climate variability and change.

Climate variability and change could also benefit food production, but the gains and losses will vary across farming systems and provinces. It is therefore imperative to identify where these gains and losses are, and to direct the policies and adaptation strategies in a manner that the expected overall negative effects may be reduced. In such cases, it is possible that food production in the country may reap the benefits from climate change. This would require policy responses supported by adequate research and climate information, and a better understanding of farmers' decision-making processes and farming systems.

KEY WORDS

Climate change, nexus, food security

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1. INTRODUCTION

It is becoming increasingly clear that climate change is an inevitable process. With likely long-term changes in rainfall patterns, rising temperatures and shifting climate zones (IPCC 2013), climate change is expected to increase the frequency of climate-related shocks, which in turn will put pressure on food, energy and water supply. The impact will be amplified through the interconnections and interdependence among these three resources, popularly known as the Food Energy Water (FEW) Nexus.

South Africa's energy system is the major source of greenhouse gas (GHG) emissions, accounting for about 83% of the total emissions in the country (DEA 2011). These GHG emissions are the main drivers of climate change. A staggering 86% of the country's electricity-generation capacity is derived from coal, which is the biggest source of GHG emissions as far as electricity generation is concerned. Altogether 95% of the country's crude-oil requirement is imported and the consumption of oil is steadily rising (Business Monitor International 2011).

Climate change will exacerbate the challenges of meeting FEW needs. It will affect food availability and accessibility and the stability of the food system directly through changes in productivity, quality of yield, crop failures, loss of livestock, farming costs and the effects of changing weather conditions on agricultural practices; and indirectly through the potential effects on water resources and the distribution of pests/disease.

Water supply is impacted by rising temperatures through higher rates of evapotranspiration and decreasing run-off. Changes to the frequency and intensity of rainfall lead to the increased incidence of droughts and floods. Evidence indicates that more frequent and more intense extreme weather events, rising sea levels and increasing irregularities in seasonal rainfall patterns are already having an immediate impact not only on food production but also on food distribution infrastructure (FAO 2008).

Adverse changes in the quality, quantity and accessibility of water resources would require increased energy inputs to purify water of lower quality or pump water from greater depths or distances, and would intensify the competition between the energy and food sectors for the existing water resources. Other possible impacts on the energy system relate to possible changes in renewable energy feedstocks (wind speeds, solar radiation levels and hydro-energy).

At the same time, climate policies themselves may have implications for FEW security. For instance, the mitigation of climate change through carbon sequestration, the expansion of biofuels or hydropower can create significant new water demands. Adapting to climate change can be very energy-intensive: irrigation requires more energy than rain-fed agriculture and desalination more energy than conventional water supplies. Increased groundwater use and water storage may require additional pumping (Hoff 2011).

Countries differ in terms of exposure, vulnerability and their capacity to adapt to climate change. At the same time, the impact would be experienced differently within countries, with positive effects seen in some regions and negative effects in others. South Africa's ability to protect its food security from climate change will depend on the understanding of risks and the vulnerability of its food security to climate change; specifically from the FEW Nexus perspective. The Citrus Growers' Association in South Africa lists a volatile climate and the increased frequency and intensity of extreme weather events among the top five factors shaping the citrus industry in the next 5 to 10 years (Chadwick 2012). The industry cites volatility in supply patterns, volatile prices and the impact on quality as the most important challenges it will have to face due to climate change.

More importantly, there is a need to understand how projected changes will play out at the local level, and how potential impacts may be altered by adopting risk management measures and adaptation strategies that strengthen preparedness and resilience. Simultaneously, climate policies will need to take an integrated perspective across the FEW Nexus to avoid maladaptation and negative externalities.

The Bottom Line: It is imperative that there is an understanding of how climate change links with or affects food security through the FEW Nexus.

2. IMPACTS OF CLIMATE CHANGE ON WATER SECURITY

Rainfall projections for the country predict a change in rainfall intensities characterised by the decreased frequency of low-intensity rains and longer dry periods between rainfall events (Christensen et al. 2007). These changes increase the likelihood of floods and droughts. Downscaled climate models suggest higher precipitation in the east of the country, a shorter winter season in the southwest and less rain in the far west (Hewitson et al. 2005). Projections by the UK Met office (2011) suggest as much as a 20% decrease in the far west and overall projects a general decrease in rainfall.

This is of specific concern, given that South Africa is approaching physical water scarcity (International Water Management Institute 2007) and has developed most of its water resources. Moreover, the availability of natural water resources across the country is very unevenly distributed, with more than 60% of the surface flows arising from only 20% of the land area (Basson et al. 1997).

In simple terms, most rainfall is taken up as green water (the rainfall absorbed by plants and the soil), thus impacting dryland agriculture, whereas blue water (the rainfall in water bodies and groundwater) impacts the energy system, water infrastructure, irrigation and food processing. Although stress on the blue water system is better understood, most rainfall is stored as green water and the impact of less green water may put further pressure on blue water reserves as irrigation becomes more prevalent.

Evapotranspiration rates increase with rising temperatures, changes in radiation, humidity and wind speed, which can reduce the water available in reservoirs and reduce the green water available to agriculture (Milly et al. 2008).

3. IMPACTS OF CLIMATE CHANGE ON FOOD SECURITY

The most direct impact climate change is expected to have on food security is through changes in crop and livestock productivity. Higher temperatures and humidity are known to reduce yields of agricultural crops and tend to encourage weed and pest proliferation. Higher CO_2 concentrations favour weeds more than agricultural crops. For climate variables such as rainfall, soil moisture, temperature and radiation, crops have thresholds beyond which growth and yield are compromised (Porter & Semenov 2005). For example, cereals and fruit tree yields can be damaged by a few days of temperatures above or below a certain threshold (Wheeler et al. 2000). A vast body of studies and assessments (Chijioke et al. 2011, FAO 2008 & HLPE 2012) has illustrated how climate change is likely to affect food security (Table 1). Agricultural production, prices and infrastructure will change, limiting the amount and quality of food produced (Wlokas 2008).

Rising temperatures and changes in rainfall patterns have a direct effect on crop yields, as well as an indirect effect through changes in the availability of irrigation water. In the context of South Africa, a study by the UK Met Office (2011) showed that there has been widespread warming over South Africa since 1960 in both summer and winter, and that between 1960 and 2003 the number of warm days and nights became more frequent while cool days and nights became less frequent. This confirms that there is already a discernable warming trend.

Research on climate change also shows that a sharp increase in temperature is already being experienced in the Western Cape Province. Future climate projections show that this upward trend is expected to continue and that rainfall is expected to decline or to be distributed differently throughout the seasons (Provincial Government of the Western Cape 2011). There are also indications that climate change could cause increased variability of rainfall over the eastern parts of the country (mainly subtropical wet zone), and a further decrease in rainfall from the west (desert and arid zones) and over the Western Cape region (winter rainfall zone) (DWAF 2002). Warmer climate conditions may necessitate allocating a higher proportion of water resources to agriculture. The country already has a relatively low allocation of 60% of total water available for agriculture, compared with a global average of 70%. The South African government is currently assessing water allocation and wants to increase allocations to domestic use, mining and industry (in discussion with stakeholders). Finally, variations in rainfall patterns increase the likelihood of short-run crop failures and long-run production declines.

Table 1: Impact of climate change on food security through the FEW Nexus

Impact of climate change	Direct consequences	Indirect consequences
Average temperature increase	• Reduced quantity and reliability of agricultural yields • Increased susceptibility to crop burning • Increased heat stress in livestock • Increased evapotranspiration rate • Destruction of crops and impact on livestock due to increased prevalence and incidence of pests • Decline in certain fish stocks due to increased sea temperatures • Increased disease transmission in fish species and influence on marine pathogens • Shift in the range of fish species	• Intensified competition for water between food and energy sectors due to increased evaporation and decreased water balance, and increased demand for energy for cooling • Lowering crop productivity or damage to crops due to reduced soil moisture • Increased energy usage due to greater need for cooling/refrigeration to maintain food quality and safety • Increased evapotranspiration resulting in reduced soil moisture • Disruption to fish reproductive patterns
Change in rainfall amount and patterns (frequency and intensity)	• Reduced quantity and quality of agricultural yields and forest products • Reduced water availability for crops and livestock due to decrease in water resources, decrease in run-off/stream flow • Heavy reliance on irrigation • Increase of energy consumption for irrigation and crop-spraying systems • Fisheries will be impacted by changing water levels	• Lowering crop productivity due to soil erosion • Increased probability of fire • Poor quality of crops due to deteriorating water quality
Increased severity of drought	• Decreased crop yields • Trade-offs for food production as water reservoirs come under pressure to meet residential and commercial needs	• Lowering crop productivity due to damage to soil and increased probability of fire
Increased intensity of extreme events	• Increased land degradation and desertification • Damage to crops and food stores • Soil erosion • Inability to cultivate land because it has become water-logged • Fisheries will be impacted by flooding events • Damage to infrastructure from extreme events	• Lowering crop productivity from increased soil erosion

Source: Compiled by authors

Constraints on water resources will have implications for both food production – through restricted availability of irrigation and the impact on crop productivity – and livestock. Evidence indicates how droughts increase livestock mortality (Table 2).

Table 2: Impact of droughts on livestock numbers in selected African countries, 1981 to 1999

Year(s)	Location	Livestock losses
1981–1984	Botswana	20% of national cattle herd
1982–1984	Niger	62% of national cattle herd
1983–1984	Ethiopia (Borana Plateau)	45–90% of calves, 45% of cows, 22% of mature males
1991	Northern Kenya	28% of cattle; 18% of sheep and goats
1991–1993	Ethiopia (Borana)	42% of cattle
1993	Namibia	22% of cattle; 41% of sheep and goats
1995–1997	Greater Horn of Africa (average of 9 pastoral areas)	20% of cattle; 20% of sheep and goats
1995–1997	Southern Ethiopia	46% of cattle; 41% of sheep and goats
1998–1999	Ethiopia (Borana)	62% of national cattle herd

Source: IPCC (2007) cited in FAO (2008)

Decreased rainfall for prolonged periods will result in drought, with more frequent high-intensity rain events additionally contributing to soil degradation and desertification. Soil erosion can create problems regarding the viability of land for agriculture, as nutrient depletion limits the ability of many crops to prosper. Moreover, increasingly greater quantities and types of inputs are required to make the soil productive. Such impacts could be of particular concern for South Africa, where the availability of agricultural land is limited; only 13% of the land is arable and only 3% of this is considered to be high-potential land (Laker 2005).

Climate change will also cause new patterns of pests and diseases, affecting crops and livestock. In addition, the increased incidence of water-borne diseases in flood-prone areas, changes in vectors for climate-responsive pests and diseases, and the emergence of new diseases could affect both the food chain and the human physiological capacity to obtain the necessary nutrients from the foods they consume (Tadesse 2010). Finally, with an increase in the frequency and intensity of severe weather, there is a growing risk of storm damage to transport and distribution infrastructure with the consequent disruption of food supply chains (FAO 2008).

4. IMPACTS OF CLIMATE CHANGE ON ENERGY

While there are few direct impacts, rising temperatures will result in increased evapotranspiration rates which could increase the amount of water lost in cooling (mainly applicable to coal and nuclear power plants). Renewable energy has lower water usage requirements, which will be an important consideration for future energy planning in water-scarce areas of the country. Changes in wind patterns, cloud cover and rainfall can impact on renewable energy production, with hydropower particularly vulnerable to a drier future climate. Indirectly, climate change can increase the amount of energy required by the country as a result of adaption policies. Increased irrigation, for example, is a likely response to reduced water supplies in areas where rainfall is expected to decrease. Similarly, hotter temperatures will increase the demand for air-conditioning. Some adaptive strategies will have trade-offs. For example, biofuels require additional water to grow the plant feedstock and take arable land away from food production.

5. IN-DEPTH: FOOD SECURITY IN SOUTH AFRICA

A fair amount of research and commentary exists regarding the impact of climate change on food security in South Africa (see Table 3). This research takes into account the indirect consequences through the Food Energy Water Nexus, particularly the impact on water resources. But the majority of this research focuses on maize and wheat and shows that both crops are susceptible to decreased yields, maize especially, under a range of studies at various scales (see Box 1). The focus on wheat and maize is appropriate, given that these are the country's two major crops. More recently, the concerns of industry associations and farmers regarding climate change have emphasised the impacts of climate change on other crops, such as potatoes (see Box 2).

BOX 1

Impact of climate change on maize and wheat

A range of studies has shown the current and future impacts of climate change on maize and wheat in the country. One study (Akpalu et al. 2009) shows that a 10% reduction in mean precipitation reduces the mean maize yield by approximately 4%. Correspondingly, an increase in mean precipitation increases mean maize yields; however, as rainfall continues to increase, the additional gain in maize yield begins to diminish. It also finds that the average maize yield increases by 0.4% with an increase in the mean temperature from 21.4 to 21.6° C. However, like increased precipitation, the gain in maize yields prompted by increased temperature begins to diminish as temperature increases further. The study concludes that increasing mean temperature, decreasing mean rainfall and rainfall variability would have a significant negative impact on maize yields, and consequently pose a serious threat to food security in South Africa and other countries in the southern African region that depend on maize imports from South Africa.

Another study (Turpie et al. 2002) observes, with a reasonable degree of certainty, that significant damage can be expected in the maize sector due to the impact of climate change. This study estimates that the total value of maize production lost due to the impact of climate change varies between R46 million with the CO_2 fertilisation effect, and R681 million without the CO_2 fertilisation effect. These findings, however, contradict the findings of another study (Dube et al. 2013), which predicts gains between 5 and 25% for rain-fed maize. This is regarded as an encouraging outcome as maize forms a staple food for the majority of South Africans.

A historical study (Benhin 2006) notes a decrease in area under maize and wheat during the period 1966 to 2004. The study observes that this decrease may be indicative of the fact that higher temperatures over this period may have made some areas, especially in the arid agro-ecological zone, too hot and less suitable for these crops. In the case of wheat, the study also suggests the role of variability in precipitation levels for the decline in the area under cultivation. What is reassuring is that despite the decrease in total area of certain crops planted in response to higher temperatures, the yields for each of these crops have not changed significantly over the years and total production has not seen a significant fall (NDA 2005).

The increased production of maize is expected to continue in future. One study (Johnston et al. 2012) finds that, although the harvested area for maize will decrease between 2010 and 2050 by about 25%, yields will rise by about 60% on average. There is very little difference in yields between scenarios, but there is about a 15% difference from the climate model with the lowest yield to the climate model with the highest yield. At first, total maize production will rise with yield increases. After 2035, these gains will be offset by the loss in area, resulting in 2050 production at a level only slightly higher than that in 2010.

There are, however, reasons to worry. If the expected yield increases do not materialise, total production will decline dramatically (Johnston et al. 2012). Moreover, exports are projected to increase through 2020, declining thereafter to a point where the country will become a net importer of maize (Johnston et al. 2012). Thus, climate change is expected to impact the security of maize, the main staple, especially during years of extreme weather.

BOX 2

Impact of climate change on potato production in South Africa

Research (Franke et al. 2013) conducted into the impact of climate change on potato production in three agro-systems in the country, viz. the Sandveld, Eastern Free State and Limpopo, shows a moderate increase to indicate that climate change not only poses risks but also brings opportunities for potato production. Potatoes grow best at temperatures of 28° C and cooler. Climate change-induced increases in the number of warm days (over 30° C) and hot days (35° C) in spring and summer mean that there is and will continue to be a reduction in the suitable heat-free period for growth. Heat stress has negative repercussions for tuber quality. Moreover, the increase in temperature has a negative effect on photosynthesis, thereby leading to yield reduction for a crop planted in December. In areas with declining water levels, such as Limpopo, the heat stress will also increase the water needs.

However, there are positive impacts too. The increased CO_2 will benefit the potato crop due to the CO_2 fertilisation effect, which means that plants may become more productive at enhanced levels of CO_2, and increase yields. Then, in a region like Limpopo where potato crops are occasionally severely damaged by frost in winter and crop growth is sometimes halted, the increase in the number of warm and hot days will lead to a reduction and even a disappearance of frost events, and therefore represent a major reduction in potato production risk.

From a water-availability perspective, water shortages due to the current scarcity of resources, an increasing demand for water from other sectors and climate change are likely to restrict irrigation and increase the costs of irrigating potatoes across the country in future (Franke et al. 2013). This is of particular concern, given that 80% of the potato farmers in the country are dependent on irrigation. In fact, research suggests that for some farmers in Limpopo, the cost of irrigation could increase to such an extent that irrigation crop production would become economically unsustainable (Franke et al. 2013).

Climate change is also likely to alter disease and pest intensity for potato crops in the country. The effects would however vary for different pest-related diseases. Most pathogens are likely to increase in intensity if planting times remain unchanged. Studies (Van der Waals et al. 2013) suggest that the incidence of diseases related to pests such as early blight and brown spot is likely to increase in areas with major precipitation increase. Therefore in these areas, farmers may need to apply extra fungicide sprays per season. There are however pests, such as late blight, for which temperature increases would decrease the number of disease cycles. Then there are organisms, such as the blackleg and soft rot-causing Pcb, that would pose a bigger problem for the potato crop as temperatures increase. This will have repercussions for stricter import requirements to ensure pest-free seeds.

Finally, extreme weather events could have repercussions for crop production. High-intensity rainfall could damage the crop and waterlogged soil conditions could lead to rotting of tubers (Van der Waals et al. 2013).

Table 3: Impact of climate change on food security in South Africa through the FEW Nexus

Impact of climate change	Direct consequences
Impacts on crop productivity	• The increase in temperature and changes in the timing, amount and frequency of rainfall may have severe effects on all agricultural systems in South Africa (DEA 2013). • In the dry western areas crop production will become more marginal, while in the high-potential eastern areas there may be a slight increase in production (Du Toit et al. 2002). • The AVOID programme (UK Met Office 2011) agreed over the possibility of decreased yields for nearly all cropland in South Africa, but cautioned that there is a high degree of uncertainty. • While the possibility exists that nearly all croplands could experience early and sustained declines in suitability, even under the mitigation scenario, there is a high degree of uncertainty among projections regarding the amount of area undergoing decline.
Impacts on food production	• Yields could potentially increase for rice and groundnuts, although confidence is limited by the small number of studies. In the case of groundnuts, rain-fed groundnut production is likely to increase. This is interesting from a protein food security perspective because groundnuts are currently a relatively minor crop in the country (Dube et al. 2013). Moreover, while nutritionally rich, groundnuts do not form a major dietary component for the country. • Sugarcane appears to be the most resilient to climate change. Both yield and harvested area are projected to increase. Yield is projected to increase by about 55% and area is projected to increase by about 16%, increasing total production by about 80%. The difference in yields between the least favourable and the most favourable climate models is only about 5%, as is the difference in yields between the pessimistic and optimistic scenarios (Johnston et al. 2012). • For barley, yield reductions of 20 to 50% are predicted for warmer regions, but this effect might be somewhat compensated for by rising atmospheric CO_2, suggesting a reduction in the order of 10 to 40% (Midgley 2001). Warming will also lead to a reduction in malting quality. • In the case of hops, responses are presently unknown, but are likely similar to those of barley in terms of production and quality. However, given the fact that hops is an irrigated crop, rainfall deficit and variability would subject farmers to greater irrigation costs (Midgley 2001). • Sorghum is likely to benefit from increasing temperatures and higher atmospheric CO_2 levels, but no estimates are available yet (Midgley 2001). • Soil type is a significant determinant of the impact of climate change on food production. Certain soil types, such as vertisols and xerosols, are less productive and therefore affect crops negatively in the face of climate change; other types, such as acrisols and arenosols, have a positive effect on crops and may help control adverse climatic effects (CEEPA 2006; Benhin 2006). • A look at the distribution of crop framing in the country suggests that large portions of field crop farming are located in the arid zone of the Free State (32%), the North West (17%) and Mpumalanga (14%) provinces. The implication is that if the arid zone becomes even warmer, then the majority of field crop production in the country will be displaced (Benhin 2006).

Impacts on food production (cont.)	• The agricultural sector consumes 60% of the total water resource in the country. Only about 10% of farms are under irrigation (Benhin 2006). This means that if climate change obliges farmers to irrigate more, especially in the western parts of the country that are arid and desert zones, further pressures will be put on the country's already scarce water resources. This could have trade-offs for (i) agricultural activities elsewhere in the country or, (ii) for water resources for different uses, such as energy production, that could compete directly with food production.
Impacts on food quality	• Rising minimum temperatures are a problem for the fruit industry, especially for apple farming, in terms of fruit quality. • An accelerating increase of minimum temperatures during autumn (1 to 2° C since the 1960s) has led to reduced fruit quality due to sunburn and heat stress (Turpie et al. 2002). This appears to have decreased the country's critical export-grade apple production (Turpie et al. 2002). • In the case of apples, a certain number of chilling units during autumn and winter is needed to ensure coordinated budburst and subsequent harvest. In their absence, hormone sprays are used to ensure this coordination. But EU countries demand that these be phased out within the next few years, due to possible health concerns. Developing and replanting appropriate cultivars that are less sensitive to this effect may take several years (Turpie et al. 2002). • Heat waves cause sunburn of apples and induce water stress in trees, which leads to smaller fruit size (Fujisawa et al. 2013).
Impacts on livestock	• Livestock farming will be affected in terms of greater water requirements for livestock and livestock heat stress (Archer & Tadross 2008) • The Northern Cape, which is a desert zone, accounts for the largest proportion of livestock (44%) in the country. It is followed by the Eastern Cape (14%) and the Free State (12%), both of which fall in the arid zone. The Western Cape, which falls in the winter rainfall zone, is the next largest (Benhin 2006). This suggests that if climate change exacerbates water shortages in the desert or arid zones, livestock farming will be affected.

Source: Compiled by the authors from various studies and interviews conducted with stakeholders in the food sector in the country

6. CURRENT STATE OF KNOWLEDGE RELATED TO THE IMPACT OF CLIMATE CHANGE AND THE FEW NEXUS ON FOOD SECURITY

Discussions with industry associations and experts suggest that there is a high level of awareness of the impacts of climate variability and climate change on food production at farm level. This is evident from the extent and types of adjustments farmers are making in their farming practices in response to these changes. Industry associations have also begun to develop their understanding and knowledge through their interaction with farmers on studies devoted to the subject. They point out that there is little understanding of these issues among those at the "front end of the food chain", viz. retailers, food marketers and food chains, although some of the large retailers and food marketers have a strong grasp of the subject and are making active interventions at their end to manage the risks from climate change.

7. PROTECTING FOOD SECURITY BY ADAPTING TO CLIMATE CHANGE

Discussions with industry associations in the food production sector in the country and available research on the link between climate change and specific crops suggest that adaptation measures would be key to managing the impact of climate change; more specifically, in maintaining the levels of production and quality, in spite of the increased temperatures and the high variability in the rainfall.

Researcher and stakeholder discussions also suggest that farmers have actually started deploying various adaptation methods in response to climate variability and change. These methods can be seen at multiple levels and mostly comprise adjustments in farming operations through changes in planting times, increased chemical application to slow down evapotranspiration, increased irrigation and shifts from flood irrigation to sprinkler irrigation, provision of shelter and shade for crops, increased use of modern machinery to take advantage of the shorter planting period, and soil conservation practices (Benhin 2006 and discussions with stakeholders). It is interesting to note that irrigation appears to be the most favoured adaptive strategy (Benhin 2006), which is in keeping with water being the most important factor limiting agriculture in South Africa (Benhin 2006).

Going forward, adaptation will include changes in the variety of crops, substitution or diversification; moving out of crop farming, livestock rearing or aquaculture altogether; or stronger changes in production practices relating to planting time, crop duration, viz. planting crops or varieties with a shorter growing period, and water development (Franke et al. 2013; Benhin 2006 and discussions with stakeholders).

Some of these adaptation practices will actually benefit farmers and crop production in more ways than one. For example, potato growers in the Sandveld and the Free State currently have a conflict of interest, as the planting period giving the highest potential yield does not coincide with the period giving the highest water-use efficiency. With an advancement of planting time to optimise crop yield in response to higher temperatures, this will reduce the conflict as the planting time will become closer to the time giving the highest water-use efficiency for the crop. Changing the lengths of the growing season could also improve the yield and water-use efficiency if suitable varieties with appropriate growing periods can be found. Moreover, shifting planting times to avoid excess heat or to take advantage of less risk of frost, or for higher water-use efficiency, could largely or entirely compensate for the increased intensity of pests and related diseases.

In the case of livestock, farmers have adopted practices aimed at the more efficient use of water and to produce their own fodder, such as lucerne or maize, and stock it for use during the long dry seasons when fodder is scarce. Farmers are also switching to more heat-tolerant breeds over the traditional ones, and changing the timing, duration and location of grazing (Benhin 2006).

8. THE WAY FORWARD

In general, food production in the country is susceptible to climate risk and is therefore vulnerable to climate change. However, there will be expected gains and losses specific to each farming system and each province. It is imperative to identify where these gains and losses are, and to direct the policies and adaptation strategies in such a manner that the expected overall negative effects may be reduced. In such cases, it is possible that food production in the country may reap benefits from climate change. But this would require policy responses supported by adequate research.

8.1 AREAS FOR FURTHER RESEARCH

Farmers have already started taking measures to adapt to the changing climatic conditions, given their current resource endowments. But there is little surety or understanding of how these measures will stand up to progressive climate change (Vermeulen et al. 2010). The continued ability of farmers to adapt and maintain yields would depend on :

- the development and availability of appropriate crop varieties that are less sensitive to climate change;

- an understanding of the effects of climate change on both crops and pathogens – to mitigate adverse effects and to take adaptation measures that benefit the crop (Van der Waals et al. 2013) and soil type;

- the actual magnitude and direction of each of the climate-induced changes (Akpalu et al. 2009).

It is important to note here that there are 10 major soil types in the country. Certain soil types, such as vertisols and xerosols, are less productive and therefore aggravate the harmful effects of climate change; other types, such as acrisols and arenosols, may help reduce them. Research and modelling, where undertaken for crops, do not cover all soil types but focus on the main ones.

The modelling of climate change impacts and general statistical information is best for maize, which is also the largest field crop. A reasonable estimate is possible for some crops while for others, increasing numbers of assumptions need to be made in order to model impacts, thus making the estimates less certain (Turpie et al. 2002). The concerns of industry associations and their farmers are leading to a growing emphasis on the research and modelling of impacts on other crops, but this is still limited.

The potential benefits of rising atmospheric CO_2 on crop and rangeland production are still poorly understood in the country (Archer & Tadross 2009). In general, CO_2 fertilisation tends to increase crop yields and increase water-use efficiency, as increased CO_2 reduces water release by crops and can increase carbon assimilation rates (Turpie et al. 2002). However, these effects have not yet been quantified for many crops grown under South African field conditions, such as maize, and it is possible that the CO_2 fertilisation effect saturates at certain temperatures (Turpie et al. 2002). Finally, less attention has been paid to the impacts on livestock and fish production from a food consumption perspective.

In light of the above and the discussions with industry associations in the country, future research in the context of climate change and food security should focus on:

- Vulnerability of different food systems – the main factors causing vulnerability to climate change and climate variability among different food crops and products.
- Responses of individual crops to changes in climatic conditions throughout the country – for as many crops as possible countrywide, to examine the potential impacts of climate change on the production of these crops.
- The impact of climate change on pests and disease vectors – adaptations of pathogens and pests to climate change, efficacy of pesticides under changing climatic conditions, and crop protection tools that could be available to industry, such as cultivars with durable and innate resistance to pests.
- New crop varieties – appropriate cultivars that are heat tolerant, have high water-use efficiency or mature early, as the case may be for different crops.
- The impact of climate change on crop production by soil type in the country.
- The impact of the CO_2 fertilisation effect on yield increase, balanced by the decrease in yield attributable to ozone depletion (UK Met Office 2011).
- New animal breeds – focused new animal breeds that are heat tolerant and less affected by water stress.
- The impact on fish production, focusing on whether rising temperatures would increase or decrease the production of consumptive fish.

Research should also consider the cost implications of the adaptation strategies. For example, while extra fungicide sprays could help tackle an increased incidence of pests, this would have cost implications in terms of higher production costs and consequently a direct impact on the affordability of food. In the case of apple farming, research suggests that farmers have introduced new cultivars with lower chill requirements as coping strategies. But some of these cultivars are prone to sunburn. The solution to protecting apples from sunburn is to use shade nets. However, some farmers think that the cost exceeds the profit, and instead plan to plant other cultivars. Similarly, technological changes may be able to compensate for yield losses, but the sheer costs of technology may be a deterrent for many farmers and even force farmers to switch crops or move out of farming completely.

Finally, research should attempt to better understand farmers' decision-making processes and farming systems. This will help align climate information to the farmers' needs, and attempt to close the gap between the information provided and that required (Fujisawa et al.).

8.2 RECOMMENDATIONS

Policy makers in the country should recognise the climatic impacts on food production. The overall impact, in the short term, may not be as adverse as envisaged if adaptation interventions are considered. But long-term planning and adaptation would require deeper insights into the impacts to determine tailored policy responses. These responses would need to be based not only on the overall effects of climate change, but also the effects in different seasons, on different farming systems, and at different agro-ecological and provincial levels. Some farmers or areas would experience positive impacts, while others would experience negative ones. Policies should therefore be directed at taking advantage of the positive effects of climate change while reducing the negative ones.

Long-term planning must also recognise that there would be several indirect impacts or trade-offs for the food sector in the context of climate change. For example, warmer climate conditions will increase the energy consumption on account of cooling needs, and there could be increased competition for water resources by the energy sector for energy production. Therefore, while advancing planting times to avoid heat stress may be a good adaptive response, the availability of water due to increasing energy demand to meet warm weather conditions may be a restrictive factor. Similarly, while irrigation emerges as the best adaptation option in controlling the adverse effects of climate – both temperature increases and decreasing precipitation – an increase in water demand for a projected scenario of physical water stress would mean that existing water resources would be put under more pressure. This means that the country's water resources must be efficiently managed. The 19 defined Water Management Areas (WMAs) would therefore play an important role in the efficient distribution of water.

Policy responses could include support for agricultural intensification and diversification, avoiding marginal agriculture, facilitating increased participation in markets within the small-scale sector and encouraging sustainable practices to manage environmental resources (soil, water and natural vegetation) (Johnston et al. 2012). Other measures could ensure the availability of imports of vital commodities should climate change result in local deficits, while allowing easy and efficient exports in the event of a surplus (Dube et al. 2013). Policy responses should also consider that there could be serious repercussions for food security in the country should adaptation strategies for farmers include moving out of crop farming or livestock rearing altogether and looking for alternative livelihoods, as experts have suggested might happen. While these adaptation strategies would safeguard the livelihoods of farmers, they would jeopardise food security as domestic agriculture is the main source of food for the country's population.

Most importantly, policy making needs to reflect that the adverse effects of climate change could have severe implications – not only for the country but also for the southern African region. South Africa is the region's major source of food. For example, 50% of the maize, the main staple in the Southern African Development Community (SADC) region, is produced in South Africa. Adverse effects in South Africa could therefore have security implications for the whole region.

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