



FUNDED BY



British
High Commission
Pretoria

REPORT

ZA

2014

Understanding the Food Energy Water Nexus

Water as an input in the food value chain



AUTHORS

Hannah Baleta and Guy Pegram

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
7. *Virtual water*: James Dabrowski
8. *Water as an input into the food value chain*: Hannah Baleta and Guy Pegram
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 organizations, 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

The views expressed in this paper do not necessarily reflect those of WWF. You are welcome to quote the information in this paper provided that you acknowledge WWF, the authors and the source. If you would like to share copies of this paper, please do so in this printed or PDF format.

In conducting the analysis in this paper, the authors have endeavoured to use the best information available at the time of publication. The authors accept no responsibility for any loss occasioned by any person acting or refraining from acting as a result of reliance on this paper.

CITATION

Should you wish to reference this paper, please do so as follows:

Baleta, H. and Pegram, G. 2014. Water as an input in the food value chain. *Understanding the Food Energy Water Nexus*. WWF-SA, South Africa.

For further information please contact:

Manisha Gulati at mgulati@wwf.org.za or
Tatjana von Bormann at tvbormann@wwf.org.za

ABSTRACT

Food security in South Africa has a number of dimensions and layers of complexity. First, food security at a national level must distinguish between food security through the internal production and processing of crops vs food security through purchasing and importing food staples. Secondly, food security at a national level does not necessarily translate into food security at a household level. This is especially true in the North West and Northern Cape provinces of South Africa where up to 20% of the population are food insecure, although South Africa is deemed to be food secure.

Agriculture in South Africa is a major sector within the economy. This is not so much because of the GDP contribution, but rather because of the support to social benefits such as employment and rural upliftment. However, the contribution and conditions for agriculture vary: within South Africa there are regions that have a comparative advantage for particular crops over others. Across the country there is a range of livestock, horticulture or field crop production intensity. Each agricultural type has different water requirements; not only in terms of quantity, but also in terms of quality and timing. These distinctions further contribute to the complexity of understanding the role of agriculture and food security in South Africa.

Some crops in South Africa are irrigated. The irrigation for these crops represents 60% of all water abstracted in South Africa. Therefore, should water supply become increasingly stressed, this poses a significant risk, not only to rain-fed crops but also to those dependent on irrigation. Crops such as wheat and maize are critical for food security, while others such as apples and grapes are exported to earn foreign exchange in order to purchase crops such as rice. Therefore, no single form of agriculture is preferable. Decisions whether or not to support the production of food-secure crops such as maize as opposed to export crops such as apples needs to take into account not only water requirements but also the social impact from employment as well as the economic impact, for example foreign exchange.

There are a number of risks associated with food security from water security. These range from the assurance of supply for irrigation to increasing the price of water as a result of the stress on this resource. The threat of climate change causes additional uncertainty and requires planning in order to adapt. Lastly, policy and planning regarding how both water and agricultural policies may shift and change pose a risk to future production for food security.

Response to these risks range from increasing efficiency to trading and institutional arrangements. These are useful tools for the food and water sectors to improve resilience in the face of an increasingly uncertain future. In response to these suggested opportunities to build food security resilience against future water stress, significant additional research is necessary. The scope for future research includes better understanding of the resilience of coping mechanisms that farmers have in place during times of water stress. This includes the potential for increasing efficiency (and the affordability of water), trading water rights (and the applicable legislative environment), and improving water resources management and governance (with the required data or information to inform this).

Depending on the scale of the focus on food security and water scarcity, there are a number of institutions or groups particularly suited to better inform the challenges faced and the potential response. At the heart of both water and agricultural policy and planning is agriculture: a purely market mechanism would not support the critical social elements of both access to water and adequate food. For this reason government is central.

Markets are important in driving efficiency. In terms of water-use efficiency, markets are a useful tool to drive optimal water use. Similarly, civil society is important in driving societal change. Promoting informed consumer decisions that take into account the water intensity of growing particular crops may help to reduce the pressure on farmers to produce under inadequate conditions.

The concept of national food security stemming from internal production alone needs to be expanded. Social groups have a role to play as communicators of the complex nature of food security. The political nature of agricultural policy, water pricing and reliance on trade for national food security all need to be considered to fully understand its complex nature. Therefore, the concept of food security is heavily embedded within, and impacted by, the policies and politics of South Africa's development objectives. Although water is an important input into the food value chain, a number of other factors also impact on South Africa's food security.

KEY WORDS

National food security, agriculture, trade, household food security, climate change, water markets, water pricing, water and food policy

CONTENTS

ABSTRACT

1.	Introduction	5
1.1	South Africa's developmental goals and food security	5
1.2	What is food security?	5
1.3	The food value chain and virtual water	5
1.4	National food security	6
1.5	Household access to food	9
2.	Water and food in South Africa	11
2.1	The nature of agriculture in South Africa	11
2.1.1	Field crops	11
2.1.2	Horticulture	13
2.1.3	Livestock	14
2.2	Agricultural water requirements in South Africa	15
2.3	Water availability in South Africa	18
2.4	Export and import of food and water	21
3.	Future – and current – challenges	22
3.1	Increasing water and food demands	22
3.2	Climate	24
3.3	Policy and planning between water and food	25
3.4	Water pricing	25
4.	Observations and key messages	27
	REFERENCES	30

1. INTRODUCTION

1.1 SOUTH AFRICA'S DEVELOPMENTAL GOALS AND FOOD SECURITY

This paper investigates water as an input into the food value chain, particularly regarding the relationship of water and food with respect to food security in South Africa. The relationship between water and food security is rooted in an understanding of the economic and social developmental goals for South Africa.

The National Development Plan (NDP): Vision for 2030 that was compiled in 2011 identifies key priority areas for the development of an improved South Africa in 2030. Many of the suggested strategies will impact water availability, food production or food security in some or other form. One of the major objectives highlighted in the NDP is to support an economy capable of creating more jobs. Labour-absorbing industries (such as agriculture and agroprocessing) and increasing exports are suggested to boost employment (implying a growth in the sector). A positive trade balance for primary and processed agricultural products is an additional target for 2030. At household level microeconomic reforms in the areas of food, transport and telecommunications are suggested to reduce the cost of living for households. Regional and global trade targets make mention of developing regional markets for food, energy and water with neighbouring states.

The development priorities (among others) indicate the importance of agriculture in the 2030 vision. Due to the water-intensive nature of agriculture and the potential impact of climate change in South Africa, the projections and planning regarding food security and production in South Africa need to consider the availability of water resources. Water is also central to energy in South Africa, both in terms of hydropower and coal-fired generation, and agriculture, making it an important link when considering the development goals of energy and food production.

1.2 WHAT IS FOOD SECURITY?

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life. Food security is most often assessed at an individual or household level.

Food security may be established either through the self-sufficient production of foodstuffs or through the acquisition of food. Therefore, nationally, food security may be gained through agriculture and agro-processing or trade, through buying the food a country requires. Both trade and self-sufficiency through production ensure that a country has the food available to be “food secure”. However, security of food supply at a national level does not imply household food security: whether the food reaches the most vulnerable or poor at a household level is not certain.

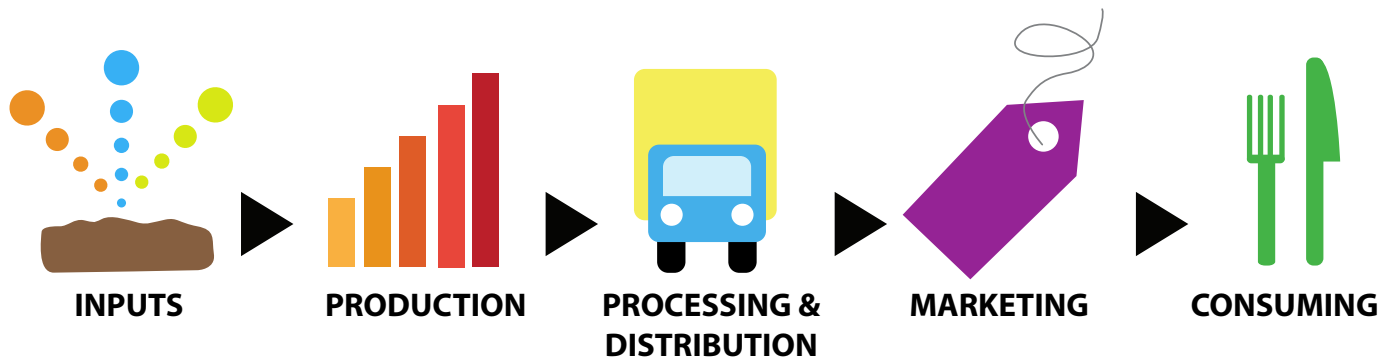
The Bottom Line: National food production or trade vs household food security is an important distinction as national food security does not translate into household food security.

1.3 THE FOOD VALUE CHAIN AND VIRTUAL WATER

According to the FAO (2010), “a ‘value chain’ or ‘supply chain’ in agriculture identifies the set of actors and activities that bring a basic agricultural product from production in the field to final consumption, where at each stage value is added to the product. This can involve processing, packaging, storage, transport and distribution”.

There are a number of stages in the food value chain, as indicated in Figure 1. Water is used at every stage of the chain. Embedded water or virtual water represents the water embodied in the inputs required to produce the final product. Agricultural products generally have a significantly larger water footprint attributed to the crop production stage than the processing stage.

Figure 1: Value-chain approach to water footprinting



Source: Dreaming New Mexico (<http://www.dreamingnewmexico.org/food/ff-local-foodshed>)

The development of a final product, such as a loaf of bread, in terms of embedded water is as shown in Figure 2. The largest proportion of water stems from growing crops: in terms of the food value chain, the majority of embedded water is in agriculture as opposed to processing. The largest proportion of crop water use is green water (rainfall) in the case of wheat. This may be different for crops grown in drier regions that require larger amounts of irrigation.

Figure 2: Embedded water in a loaf of bread



Source: Water Footprint Network (<http://www.waterfootprint.org/>)

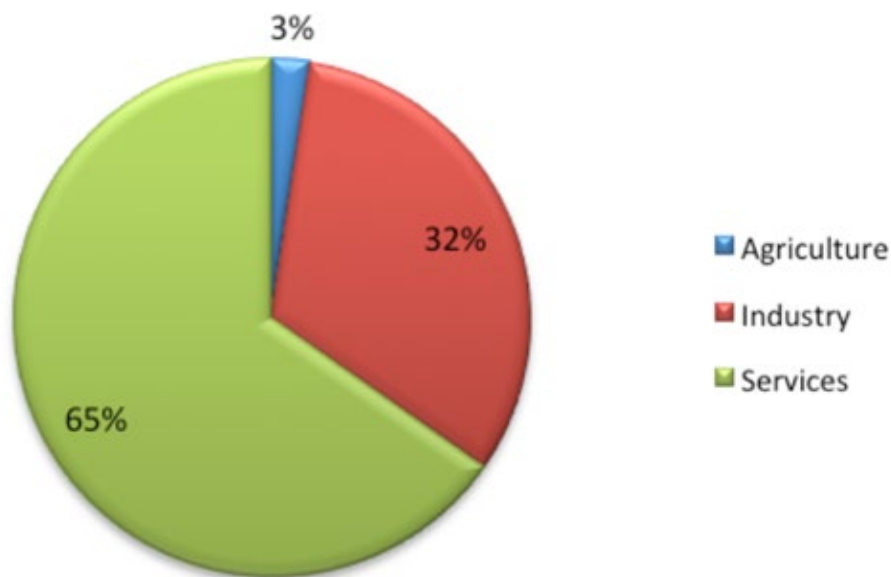
The distinction between green and blue water is a useful concept to communicate the distinct water requirements of different crops in different regions. The planning, resource management and infrastructure needs of green water (rainfall) are very different to those of blue water (irrigation).

1.4 NATIONAL FOOD SECURITY

“South Africa is largely deemed a food ‘secure’ nation, producing enough staple foods or having the capacity to import food if needed in order to meet the basic nutritional requirements of its population” (Du Toit et al. 2011). South Africa is self-sufficient in most major agricultural products and is a net food exporter in an average year. As indicated previously, however, the national production of food does not clearly reflect the nature of household food security (especially for the poor) within South Africa.

Primary agriculture contributes about 3% to South Africa’s gross domestic product (GDP) and about 7% to formal employment. However, agriculture has strong linkages with the manufacturing economy, so that the agro-industrial sector comprises about 12% of GDP and 20% of manufacturing employment.

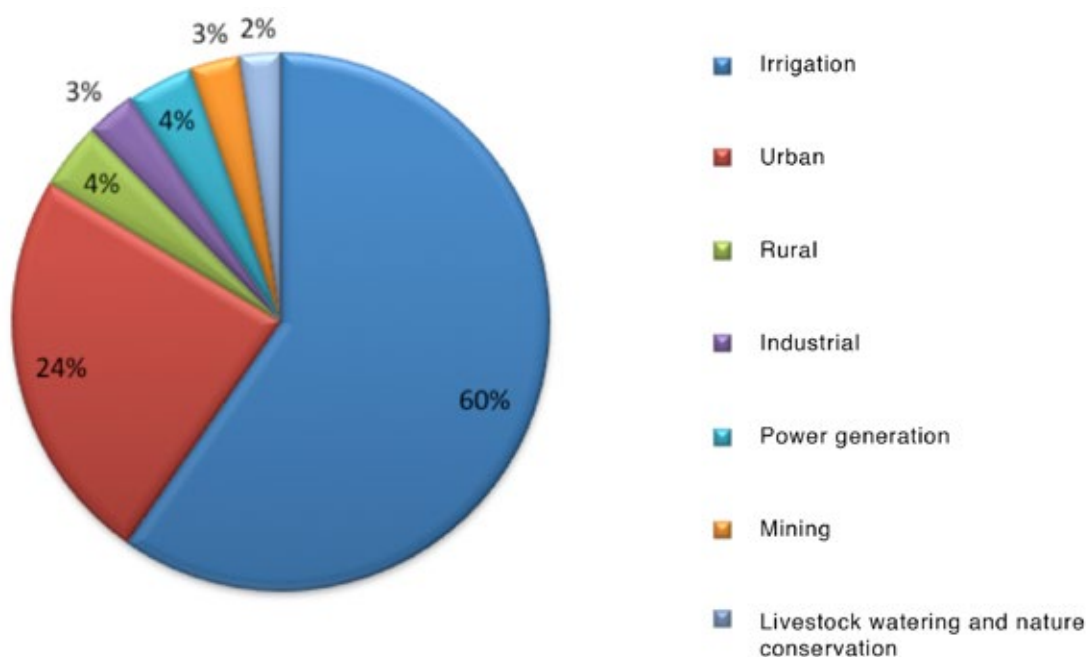
Figure 3: South Africa's GDP contribution per sector



Source: Adapted from World Bank (2012)

The South African economy is delinked from water in the industrial sector (in many cases) and the tertiary sector. This is not the case in agriculture, however, as agriculture represents the largest proportional sector of water use, as indicated in Figure 4.

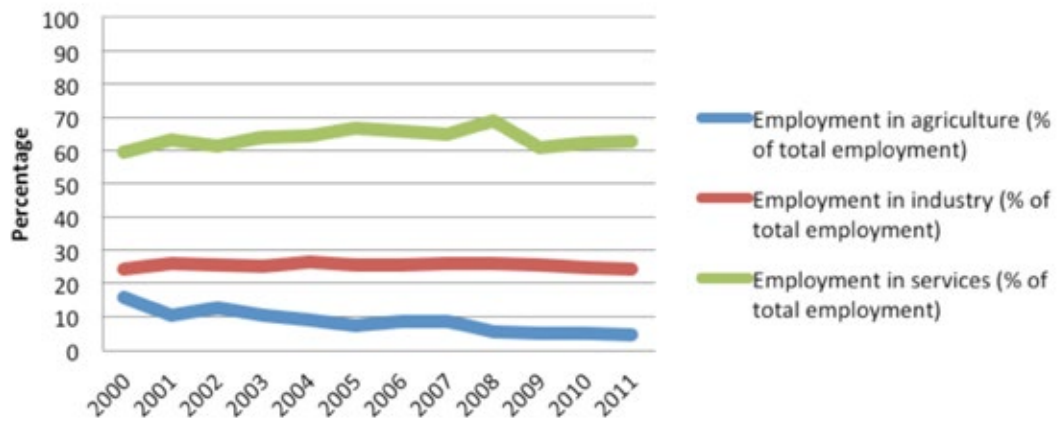
Figure 4: Proportional water abstraction per main economic sector



Source: DWA (2013b)

Although the GDP contribution of agriculture and agroprocessing may be low, the sector is a critical source of employment, especially in the rural areas of South Africa. This has decreased in recent years, as indicated in Figure 3. The rural population represents 49% of the total South African population and is heavily dependent on agriculture as a source of employment. In addition to employment, the majority of small rural-town economies depend on the sector. Therefore, the value of agriculture to the South African economy cannot be considered through GDP alone, but also through factors such as employment, support to the rural economy, food security and foreign exchange from exports.

Figure 5: South Africa's employment per sector



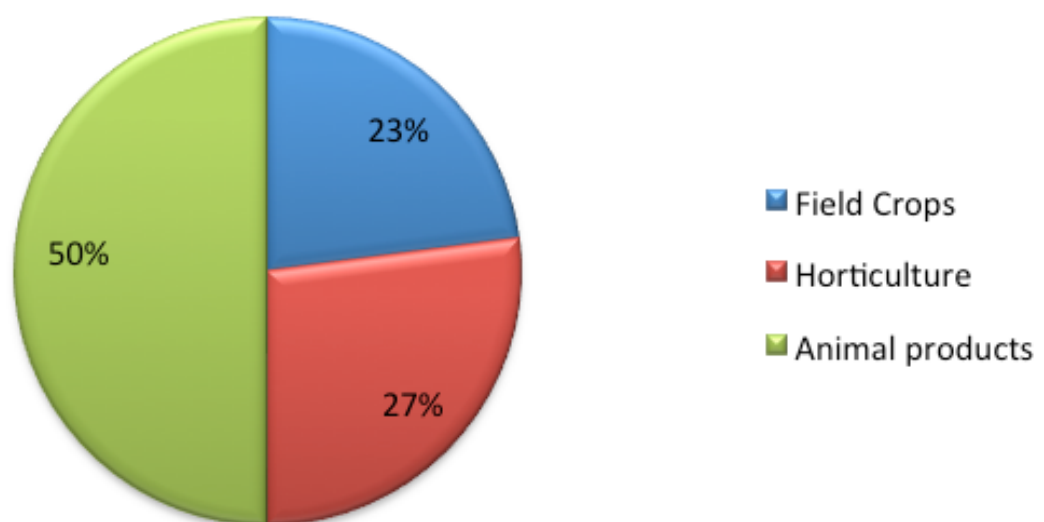
Source: Adapted from World Bank (2013)

The gross value contribution of each production type is shown in Figure 6. Field crops, traditionally seen to be critical in ensuring food security, do not contribute as much value to the economy as animal products. South Africa has become one of the world's top exporters of products such as wine, citrus, maize, grapes, apples, pears and sugar. Almost half of the fruit including citrus production is exported, earning important foreign exchange.

Agricultural export revenues accounted for about 5% of total export revenue in 2010, while imports were only 2% of total imports. However, importation of agricultural products is also growing (SAGI 2013). The export of high-value horticultural crops like citrus and wine allows the country to afford more staple foodstuffs such as additional maize, if required, to ensure food security.

The Bottom Line: Although horticultural crops themselves are not considered in terms of food security, they are important.

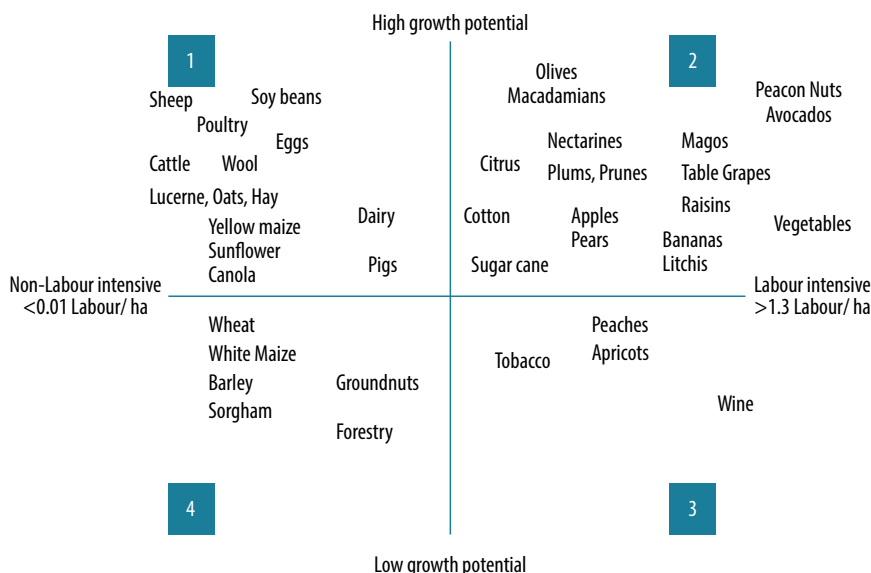
Figure 6: Gross value of agricultural production, 2010 (R'000 000)



Source: SAGI (2013)

As indicated by the comparison of GDP and employment, the economic indicators for agriculture are not linked to the social benefits. Horticulture, for example, has a lower gross value contribution to agriculture, yet it has the highest potential in terms of growing agriculture. Field crops, important for food security in South Africa, do not have a good employment potential in the sector (Figure 7).

Figure 7: Agricultural growth and employment potential



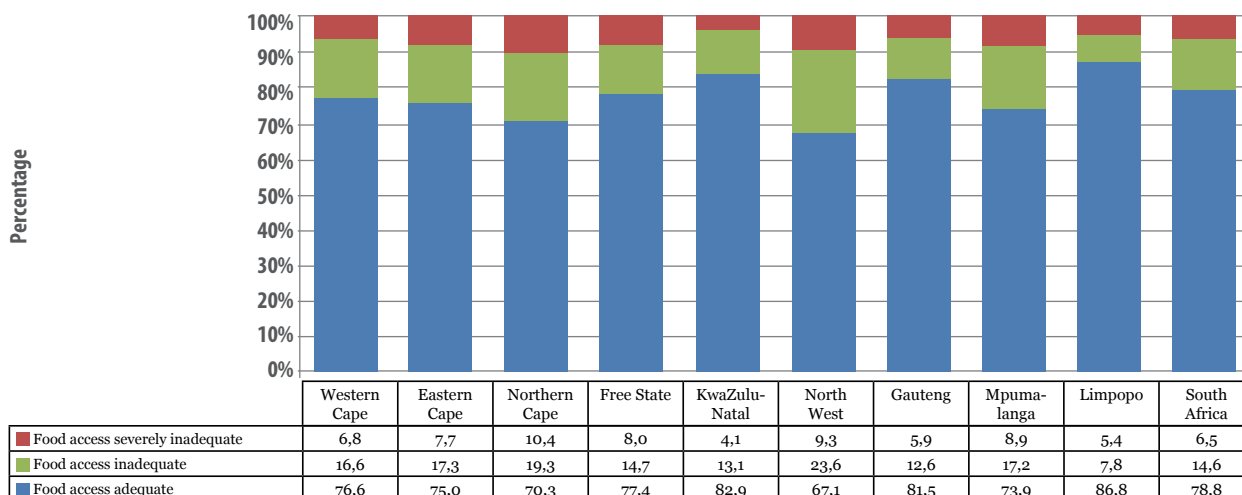
Source: NPC (2013) 223

The Bottom Line: The development goals of South Africa heavily impact on the planning decisions made about agriculture. Whether driving social development through expanding agricultural employment or driving economic growth by moving towards a service-based urban economy, there are particular water implications that need to be considered.

1.5 HOUSEHOLD ACCESS TO FOOD

Although as a country South Africa is food secure in terms of production and estimated consumption, about 20% of the population is deemed food insecure, expressing difficulty to access adequate food for a balanced diet (General Household Survey 2011). Inadequate access to food is particularly high in the North West province (32.9%) and the Northern Cape (29.7%).

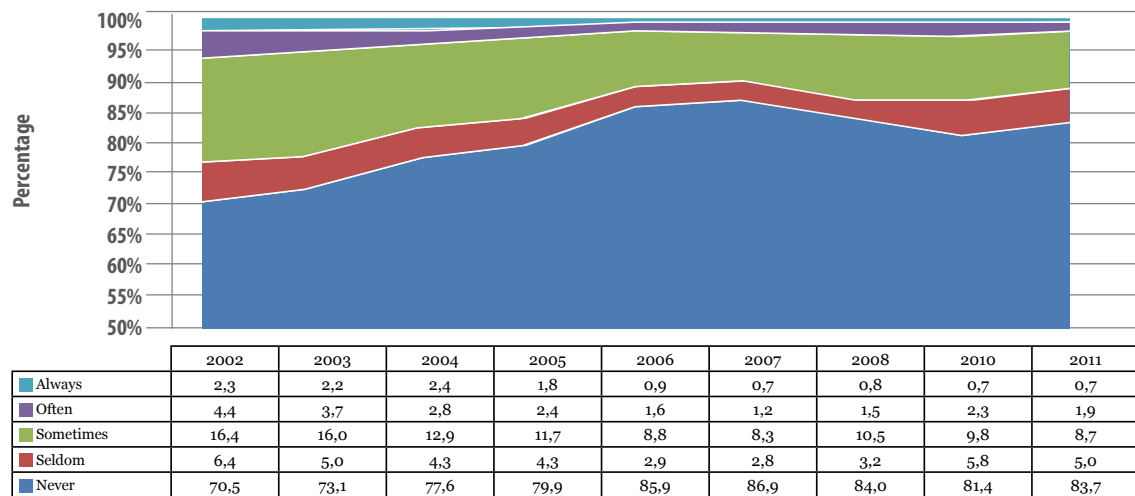
Figure 8: Food adequacy status of households by province, 2011



Source: StatsSA (2012)

The Bottom Line: Although the national average of food supply indicates that South Africa is food secure, this does not translate at a household level for many homes in South Africa. The adequacy of a food metric is supported by additional data indicating the number of households that have experienced hunger, as indicated in Figure 9.

Figure 9: Household experiences of hunger, 2002-2011



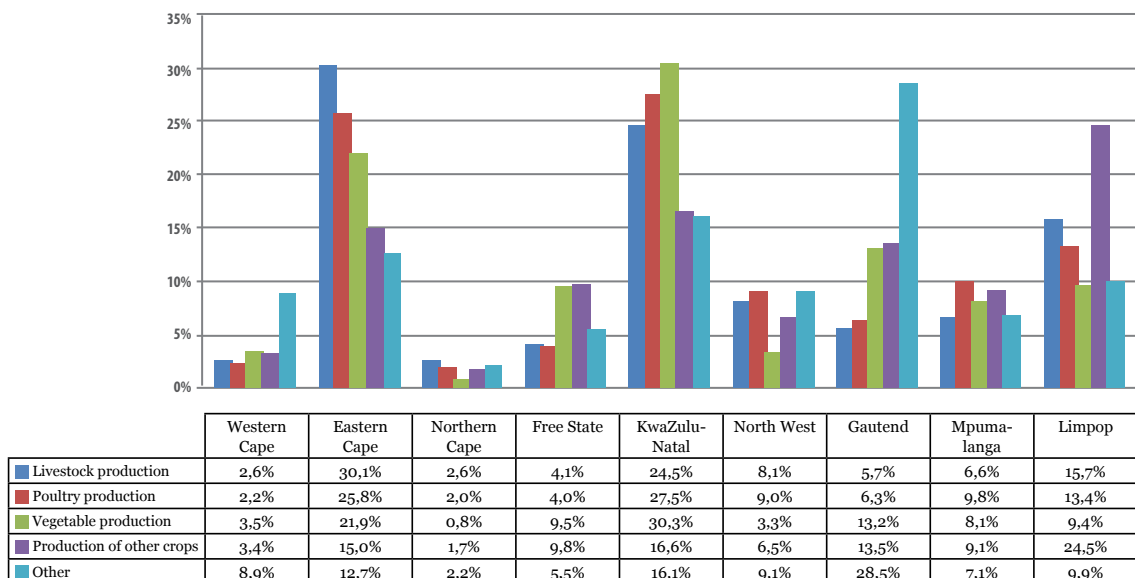
Source: StatsSA (2011)

A decline in agrarian activities, including subsistence agriculture, and growing urbanisation have meant that the South African economy has shifted from a net producer of food to a wage economy with net consumers of purchased food. This means that household cash income deficits are a major cause of inadequate access to food, as opposed to a lack of small-scale agriculture. Less than a quarter of households in South Africa are involved in agricultural activities, as a hobby or otherwise. Of that quarter, 84% of households engaged in agriculture do so to produce extra food for themselves (General Household Survey 2011).

Provinces that have historically had large homeland areas, like the Eastern Cape, KwaZulu-Natal and Limpopo, have a higher proportion of households practising agriculture. This is due to the larger proportion of rural populations and a favourable climate for small-scale agriculture to supplement dietary requirements.

Figure 10 indicates the different types of agriculture practised by households in each province of South Africa. Different agricultural practices are as a result of climatic and soil differences between regions. Depending on the type of crop or livestock agriculture, the nature of water usage may change.

Figure 10: Distribution of agricultural households involved in specific activity by province



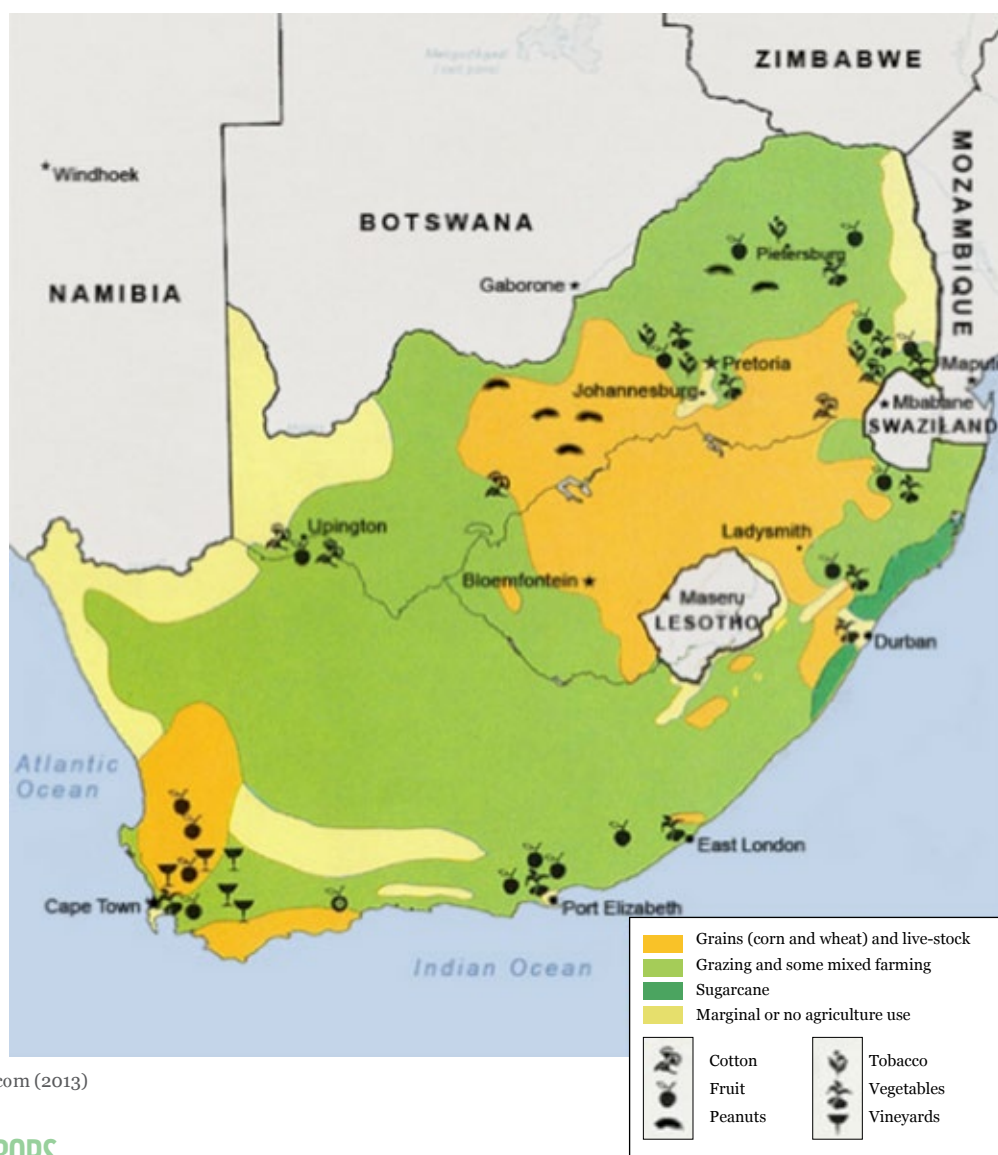
Source: StatsSA (2011a)

2. WATER AND FOOD IN SOUTH AFRICA

2.1 THE NATURE OF AGRICULTURE IN SOUTH AFRICA

About 12% of the country is suitable for growing rain-fed crops while only about 3% of the land is considered truly fertile. About 1.3 million ha of land is under irrigation while 1.3 million small-scale farmers cultivate approximately 14 million ha. Due to the inadequate arable land and water resources, most of the land in South Africa is used for grazing and livestock farming (see Figure 11). A short overview of the three core agricultural types – horticulture, field crops and livestock – will give an indication of the different nature of water use for each sector and its importance for food security or trade in South Africa.

Figure 11: Agriculture in South Africa

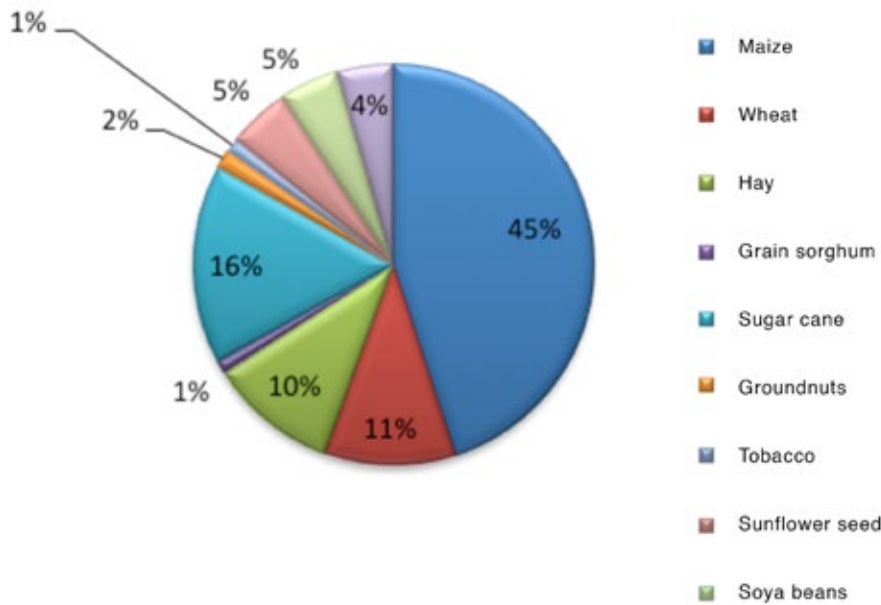


Source: NationMaster.com (2013)

2.1.1 FIELD CROPS

In South Africa, the largest area of farmland under field crops is planted with maize, making South Africa the largest producer of maize in the Southern African Development Community (SADC). Field crops are a major crop type with regard to self-sufficient food security, as maize is the most important form of carbohydrate in SADC for both human and animal consumption.

Figure 12: Field crops – gross value of agricultural production, 2010



Source: SAGI (2013)

It is estimated that more than 8 000 commercial maize producers are responsible for the major part of the South African crop, while thousands of small-scale producers produce the rest. Maize is produced mainly in the North West, Free State and Mpumalanga. A total of 13.4 Mt of maize was produced on 3.3 million ha in 2009–10, non-commercial agriculture included. As maize prices increase, the amount of irrigation of maize by means of centre pivots also increases. It is only at high maize prices that the investment cost of irrigation infrastructure and purchasing water are profitable. In 2010 irrigated maize represented 20% of the total production output (on 250 000 ha) (USDA 2013).

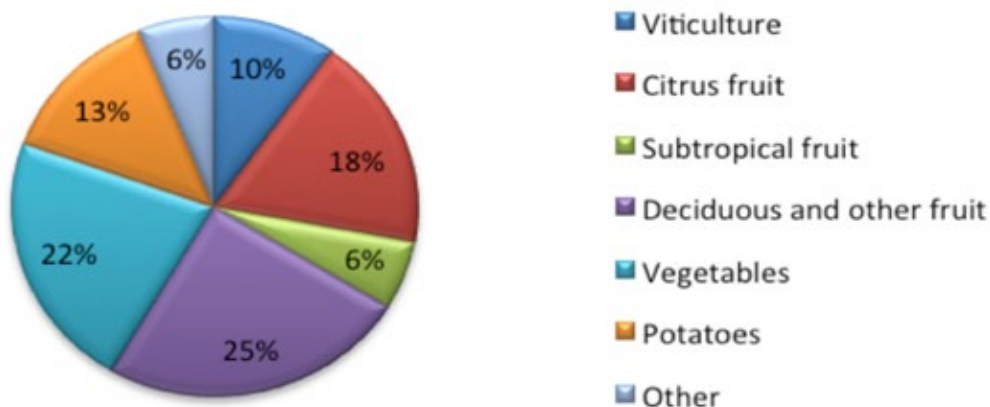
Wheat is produced mainly in the winter-rainfall areas of the Western Cape and the eastern parts of the Free State. The Western Cape wheat is rain-fed and has a different water-use profile than wheat irrigated in the Free State and on the Mpumalanga Highveld. In 2010, 1.52 Mt of wheat was produced on 558 000 ha (SAGI 2013).

The same is true of sugarcane in KwaZulu-Natal (rain-fed) and Mpumalanga (irrigated). The cane-growing sector comprises approximately 35 300 registered sugarcane growers farming predominantly in KwaZulu-Natal, with a substantial investment in Mpumalanga and some farming operations in the Eastern Cape (SAGI 2013). There is a clear distinction with regard to water infrastructure investments between crops that are rain-fed and those that are irrigated.

2.1.2 HORTICULTURE

Horticultural crops (deciduous fruit, subtropical fruit, citrus, etc.) are an important source of revenue through exports in South Africa: a large proportion of the horticultural crop is exported. The gross production of crops is shown in Figure 8.

Figure 13: Horticulture-gross value of agricultural production, 2011



Source: SAGI (2013)

Deciduous fruit is grown mainly in the Western Cape. Smaller production areas are found along the Orange River and in the Free State, Mpumalanga and Gauteng. In 2010, South Africa produced 656 884 tonnes of subtropical fruit. Citrus production is limited largely to irrigation areas in Limpopo (16 255 ha), Mpumalanga (11 681 ha), the Eastern Cape (12 923 ha), KwaZulu-Natal (4 004 ha), the Western Cape (9 524 ha) and the Northern Cape (639 ha). Pineapples are grown in the Eastern Cape and in northern KwaZulu-Natal. Other subtropical crops such as avocados, mangoes, bananas, litchis, guavas, papayas, granadillas and macadamia and pecan nuts are produced mainly in Mpumalanga, Limpopo and the subtropical coastal areas of KwaZulu-Natal and the Eastern Cape.

In 2011 the overall wine-grape crop size was estimated at 1 279 017 tonnes according to the South African Wine Industry Information & Systems (SAWIS). This translated into an amount of 992.5 million litres, calculated at an average recovery of 776 litres per tonne of grapes (SAGI 2013).

A summary of the total field crop and horticultural production in South Africa (2002) is indicated in Table 1. Note the increase in efficiency from dryland to irrigated field crops and horticultural produce.

Table 1: Summary of agricultural production for South Africa

	Dryland area	Dryland production	Irrigated area	Irrigated production	Dryland production	Irrigated production	Total production
Crops	(ha)	(tons)	(ha)	(tons)	(R)	(R)	(R)
Field crops	3 159 670	14 995 096	471 262	6 050 873	8 803 400 205	3 136 438 795	11 939 839 000
Horticultural crops	109 576	1 401 291	291 417	6 024 464	1 570 311 153	9 608 364 447	11 178 675 600
Total	3 269 246	16 396 387	762 679	12 075 336	10 373 711 358	12 744 803 242	23 118 514 600

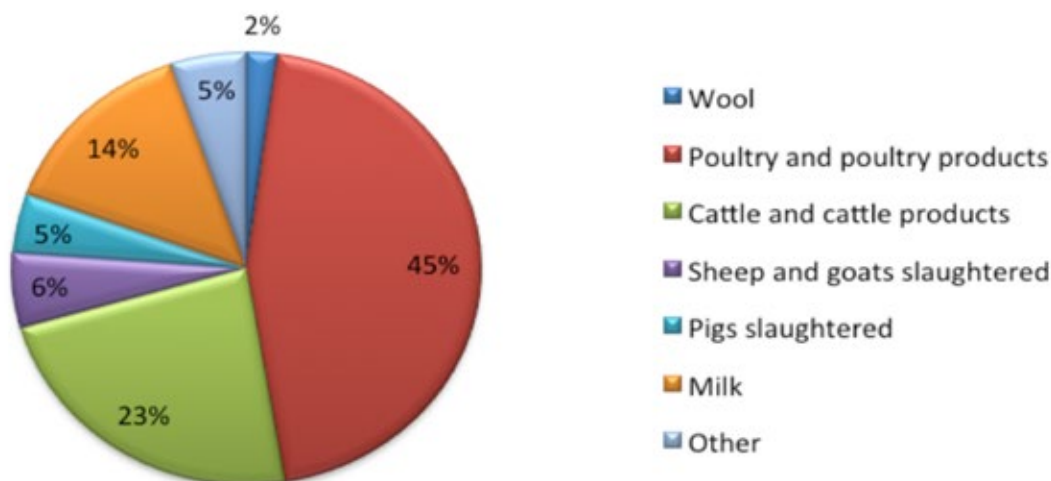
Source: Stats SA, Census of Commercial Agriculture (2002)

Source: StatsSA (2004)

2.1.3 LIVESTOCK

Nearly 80% of agricultural land in South Africa is mainly suitable for extensive livestock farming. Other areas are often made up of a combination of crop and livestock farming. The gross value of animal production is shown in the figure below.

Figure 14: Animal products – gross value of agricultural production, 2010 (R'000 000)



Source: SAGI (2013)

As the largest national agricultural sector, making up 40% of agricultural output, livestock supports 85% of South Africa's meat requirements. The remainder (15%) is imported from Namibia, Botswana, Swaziland, Australia, New Zealand and Europe.

Within the livestock sector the South African dairy industry is especially important to the job market with approximately 4 000 milk producers employing 60 000 farm workers and providing 40 000 people with indirect jobs within the value chain through activities such as milk processing (SAGI 2013). Therefore, although less important in terms of a traditional metric of "food security" through grain production, the agroprocessing of dairy, for example, is critical for providing employment. This is especially true as South Africa is seen as a food-purchasing economy instead of a food-producing economy.

Fish is an additional source of protein which is important for household food security, especially along the coastlines of South Africa. Over 140 000 livelihoods are either directly or indirectly supported through fisheries. Fisheries are especially vulnerable because functioning estuaries are needed as breeding regions. Estuaries in South Africa are threatened due to the overabstraction of water beyond that of the environmental requirements; this is often due to agricultural overabstraction. In addition, the status of fisheries in South Africa is not secure given the current exploitation of fishing resources. The status of many of the line-fish species in South Africa is especially worrying, with less than 10% of the pre-fishing populations left. Legislation regarding small-scale fishers is complicated as it is not dealt with in the Marine Living Resources Act (MLRA) or the General Fishery Policy on the Allocation and Management of Long-term Commercial Fishing Rights. The potential of small-scale fisheries to contribute to poverty eradication and food security is not addressed in the MLRA, while the process of obtaining commercial fishing rights is too complex for small-scale fishers. Yet coastal fisheries play an important role in food security in South Africa. Freshwater aquaculture has been lauded as a potential solution for protein food security in inland regions of South Africa.

Aquaculture has been carried out on a small scale across other countries in southern and East Africa, including Tanzania, Zambia and Malawi. There are direct links between water availability and the potential of aquaculture as a sustainable food source. Certain regions in the Eastern Cape and KwaZulu-Natal have a particularly high potential for aquaculture due to relatively large amounts of water and warmer winters. Tunnels or climate-controlled buildings, or seasonal aquaculture when temperatures are adequate, could be considered where the climate is not naturally suitable.

This sector has the potential to grow in South Africa if managed appropriately in terms of water requirements and environmental impact. The future implications of climate change should be borne in mind. Legislation and social acceptance of the concept are the overriding limiting factors. The greatest concern with aquaculture is not the abstraction of water but the negative impact on water quality. Aquaculture does not consume large amounts of water as most of the water use is “flow-through”. However, high amounts of nitrates causing eutrophication as well as hormones added to boost fish development pose a risk to water quality downstream. The risk of commercial fish species for indigenous fish populations is a further cause for concern. Therefore, although fish is an important food source, the impact of aquaculture on water quality and biodiversity needs to be considered.

2.2 AGRICULTURAL WATER REQUIREMENTS IN SOUTH AFRICA

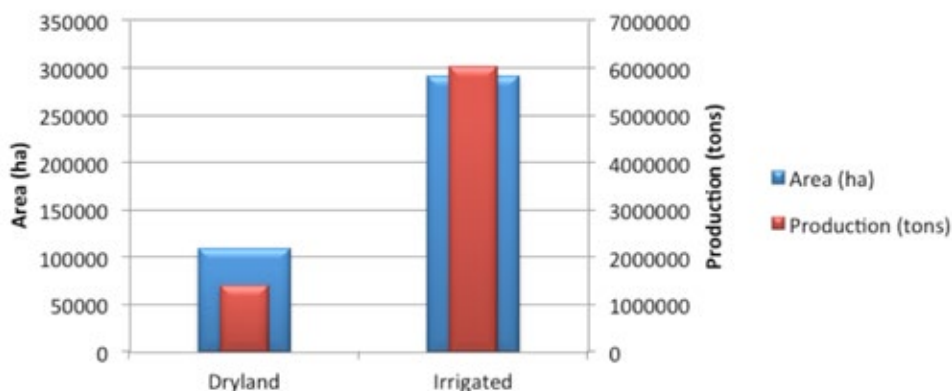
Water is necessary to produce the agricultural products mentioned. A large proportion of South African agriculture consists of the cultivation of rain-fed crops or livestock farming. However, water requirements for irrigation in South Africa are significant, representing 60% of the total water use per sector. The extent of irrigation is impacted by a number of factors including crop type, climate and the level of infrastructure development in the region. Irrigation is necessary for the efficient production of crops. In South Africa, 1.5% of the land is under irrigation, but this area produces 30% of the country’s crops. About 1.3 million ha of land are under irrigation with the average size of a commercial farm being about 2 500 ha.

At the other end of the scale, 1.3 million small-scale farmers use around 14 million ha with an average farm size of just over 11 ha. The different nature of commercial and small-scale farming in terms of irrigation, crop type and use for the produce (trade on the market and household food supply respectively) has implications for food security. This is based on the fact that for each type of farming there is a different relationships between water and food production. For example, stress and scarcity will have a lesser impact on the average household food security of commercial farmers than would be the case for small-scale farmers who use the farm to supplement their food supply.

The Bottom Line: The impact of water insecurity is not stable throughout the agricultural sector.

In terms of irrigated or dryland crop area and production, Figure 15 shows the improved productivity that results from the irrigation of crops. This reiterates the importance of water for irrigation in the optimal production of agricultural products.

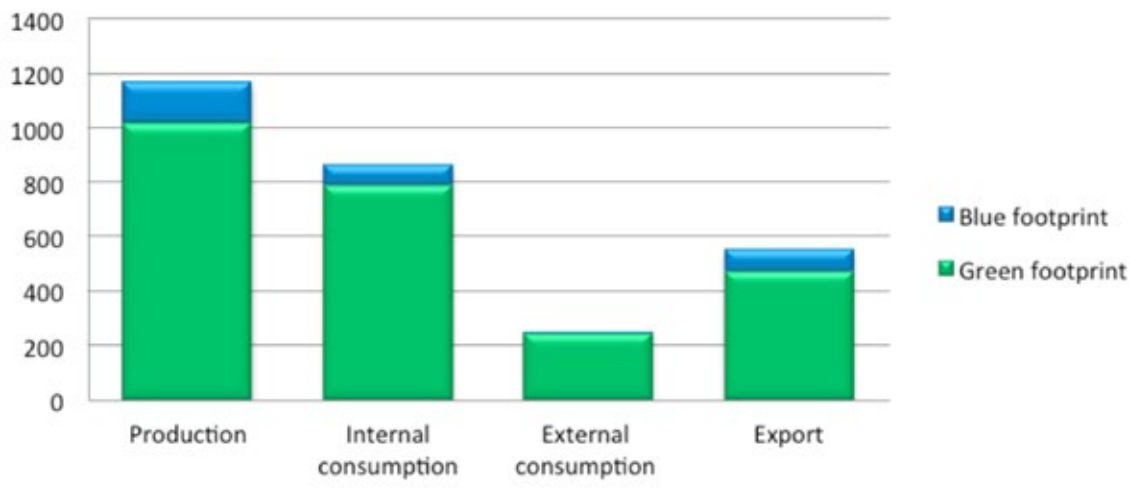
Figure 15: South Africa’s dryland and irrigated crop area and production



Source: Adapted from StatsSA (2009)

The concept of water footprints is used to distinguish between crops that use a large amount of irrigated water (blue water) or are rain-fed (green water). Figure 16 indicates the green and blue water footprints of the different sectors in South Africa. Crop production has a distinctly larger footprint, followed by livestock.

Figure 16: South Africa’s production water footprint (Mm³/yr)

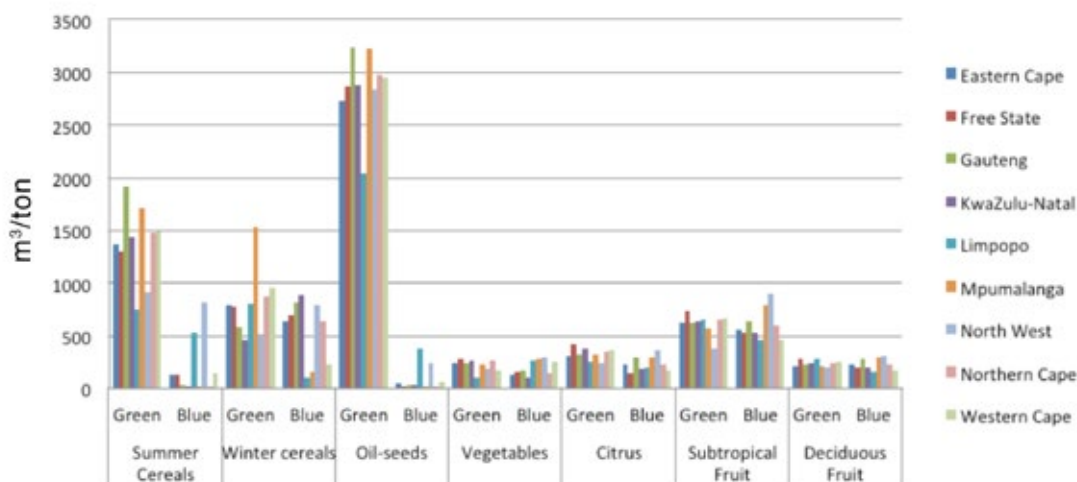


Source: Mekonnen & Hoekstra (2011)

As indicated, there is a great variability in rainfall, climate, soil type, crop production and water availability per region of South Africa. Therefore, the embedded water per crop is variable. Production amounts differ, as do the green and blue water requirements. Data regarding the amounts of crops grown in each region is taken from StatSA, while information regarding the water footprint of each crop within South Africa is taken from Mekonnen and Hoekstra (2011).

Figure 17 gives an indication of the respective blue-and green-water footprints per tonne of production of field and horticultural crops across each province in South Africa. The water input per tonne of product varies depending on the different climate. This is calculated using the transpiration water requirements of the crop. In cases where this water requirement is not met through rainfall, irrigation is required. Where the irrigation applied is either too little (or none) or too much, the yield per hectare of crop changes, affecting the total water footprint per region.

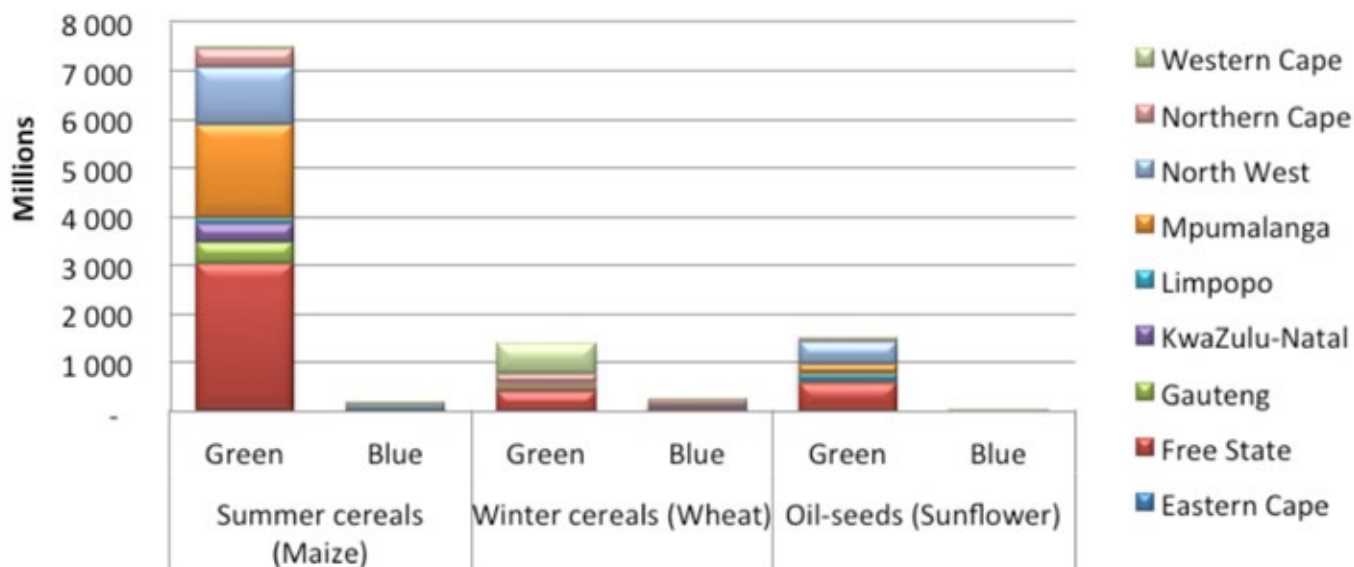
Figure 17: South Africa’s field and horticultural crops - water footprints (m³/tonne)



Source: Adapted from StatsSA (2009) and Mekonnen & Hoekstra (2011)

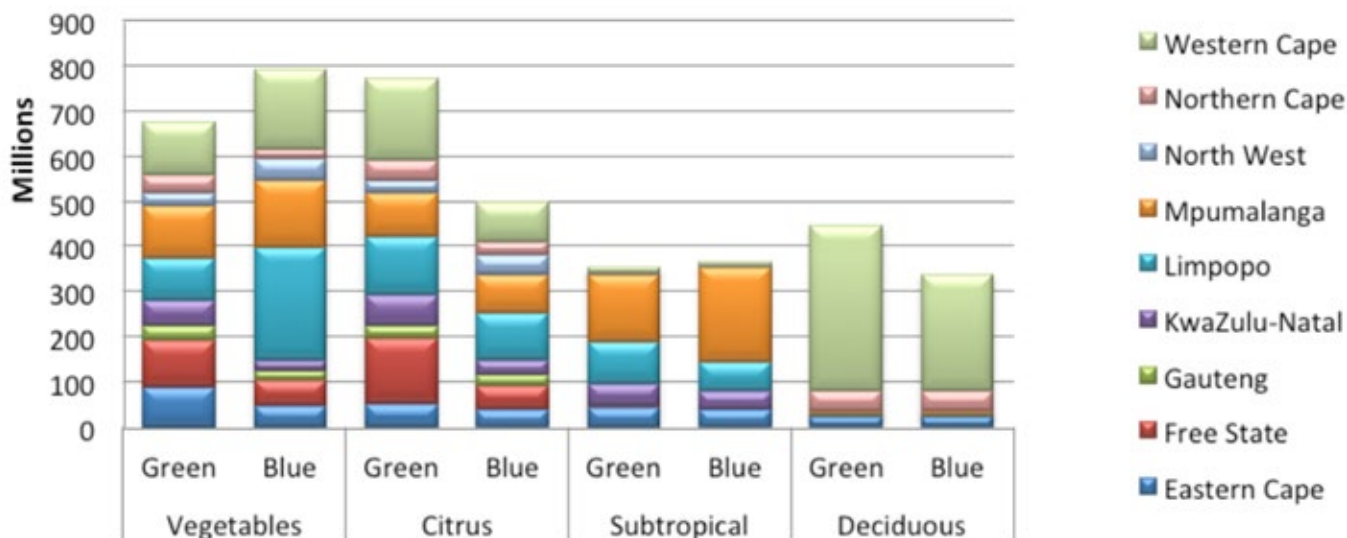
The following figures give an indication of the total field crop, horticultural and livestock water footprints per province. Yield numbers from StatsSA have been used to give an indication of the real production of crop type per region. These water footprints, in particular the blue-water footprint, need to be linked with the actual water availability per region in South Africa. Crops that are large blue-water users in regions where water for irrigation is stressed need to ensure full efficiency.

Figure 18: South Africa's field crops - water footprint (m³/annum)



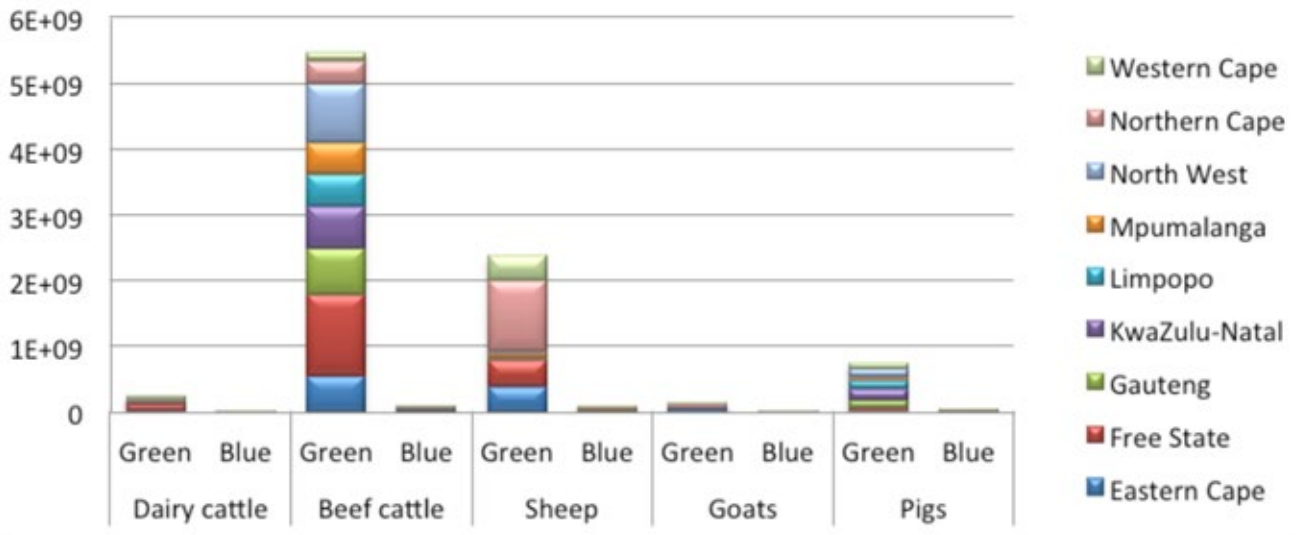
Source: Adapted from StatsSA (2009) and Mekonnen & Hoekstra (2011)

Figure 19: South Africa's horticulture - water footprint (m³/annum)



Source: Adapted from StatsSA (2009) and Mekonnen & Hoekstra (2011)

Figure 20: South Africa's livestock - water footprint (m³/annum)



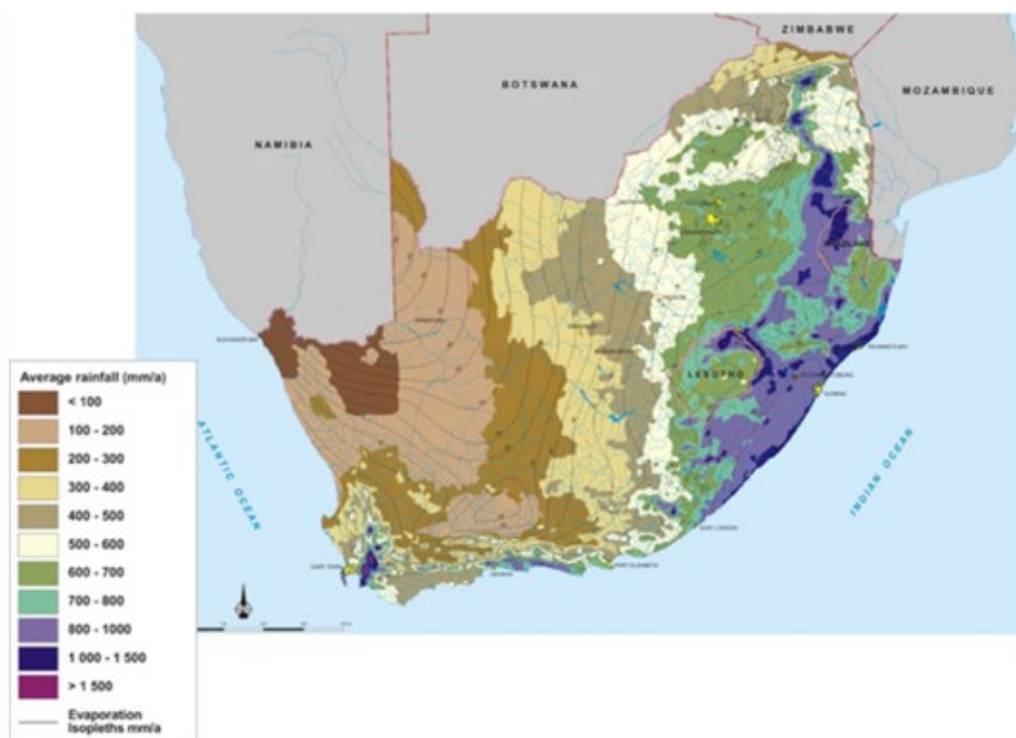
Source: Adapted from StatsSA (2009) and Mekonnen & Hoekstra (2011)

2.3 WATER AVAILABILITY IN SOUTH AFRICA

Water resource availability in South Africa varies. In terms of rainfall, the eastern side of the country receives considerably more rain than the dry western portion of the country. Rainfall varies from less than 50 mm in the extreme northwest to more than 3 000 mm in the mountains of the southwestern Cape (Figure 21).

The high variability in water resource availability is stabilised through well-developed water infrastructure. South Africa has the highest level of artificial water storage per capita in Africa, at around 700 m³ per capita per annum. This enables South Africa to manage long periods of drought. South Africa has limited exploitable aquifers and groundwater only makes up 13% of its supply.

Figure 21: Mean annual rainfall across South Africa

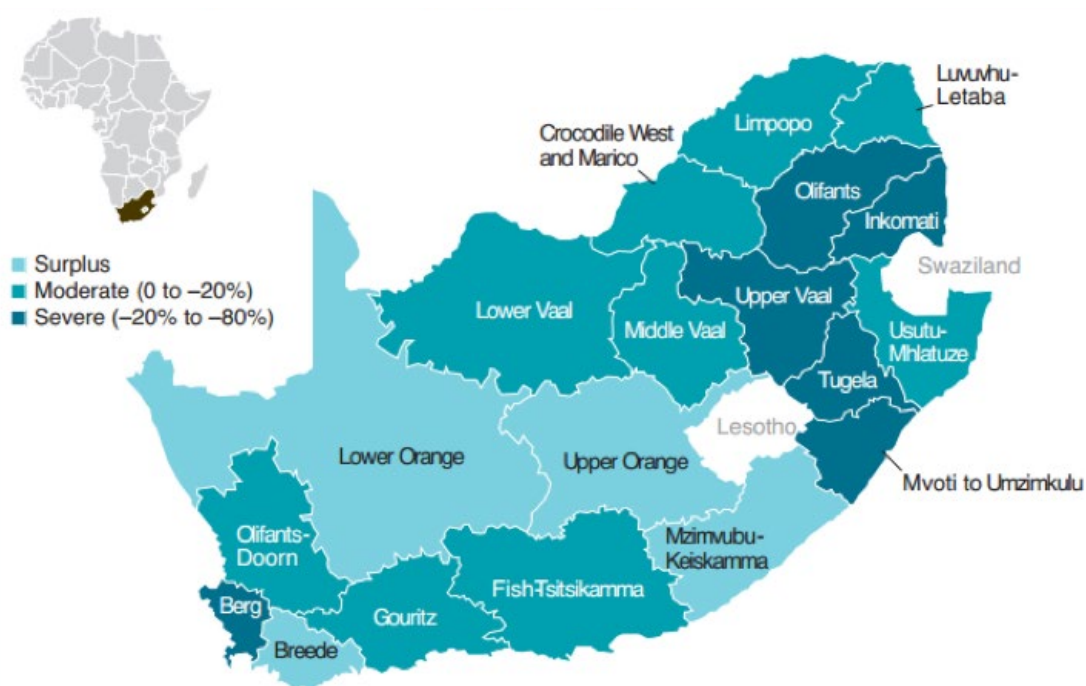


Source: DWA (2013b)

Overall, South Africa is considered to be a water-stressed country with around 1 000 m³ of water available per capita per annum. In 2000 the total reliable volume of surface water available in South Africa (yield) was estimated at 13 227 million m³/yr, while total water requirements were estimated at 12 871 million m³/yr within South Africa and 170 million m³/yr for transfer to Botswana, Mozambique, Swaziland and Namibia.

In many of the water management areas in South Africa there is currently a water deficit in that the demand outstrips supply. This is projected to become increasingly worse as the population continues to expand and water demand grows, as indicated in Figure 22. According to a study by the 2030 Water Resources Group, South Africa is facing a 17% demand-supply gap by 2030. Water is essential for the economic development of the country: the agricultural, manufacturing, energy, mining and residential sectors are responsible not only for the majority of water use but also most of the GDP (WRG 2030 South Africa 2012).

Figure 22: Gap between existing supply and projected demand in 2030



Source McKinsey & Company, *Confronting South Africa's water challenge*, 2010

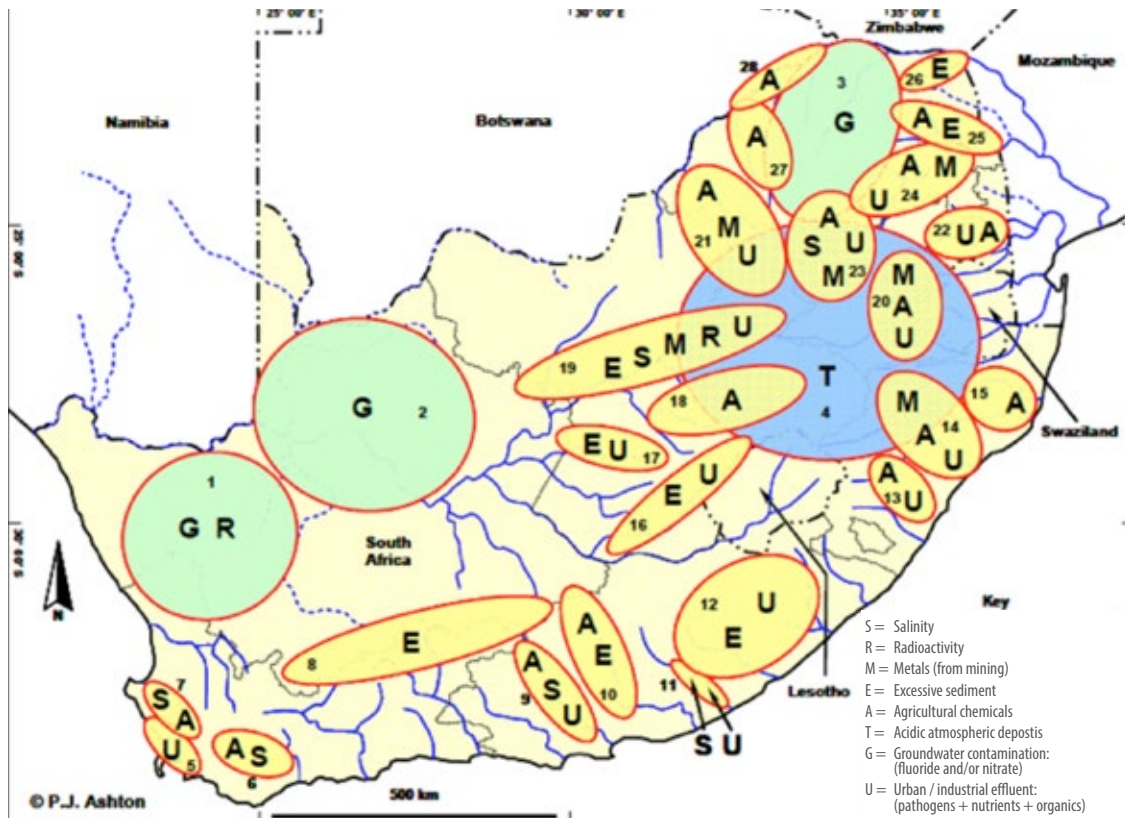
¹ Frozen irrigation levels and limited ability to increase rainfed land will drive an increase in virtual water trade between water-management areas and internationally with trading partners

Source: Boccaletti et al (2010)

The increasing demand for water resources in each of the Water Management Areas (WMAs) has implications for agriculture in particular. This is because water for human consumption and for industrial production is a higher value use of water that requires increased levels of supply assurance. Because agriculture does not demand the same high assurance of supply, during drought years it is the first industry to face abstraction reductions. This has implications for the higher production rates brought about by the use of irrigation. As South Africa is at the cusp of internally produced self-sufficiency, this may change through lower production as a result of lower irrigation allocations. A reduction in production may also result in a reduction in exports, which in turn reduces the foreign exchange available to afford imported staple foodstuffs.

Apart from the quantity of water available for use in South Africa, the quality of water is also important. Poor quality water that is not fit for purpose effectively reduces the amount of water available. Water quality is not uniform across South Africa, with some regions experiencing poor water quality through natural causes.

Figure 23: Water quality in South Africa



Source: Ashton (2009)

Poor water quality may stem from inadequate (or a lack of) domestic waste-water treatment, industrial effluent pollution (including mining effluent) and eutrophication as a result of high levels of fertiliser application. The use of poor quality water in the food sector has a number of adverse health effects. Depending on the form of contamination, these may range from toxically high metal concentrations (mining and industrial effluent) to endocrine disruptors which impact development in humans and animals (industrial) and microbial contamination such as *Salmonella* or *E. coli* (domestic effluent). The Water Research Commission (WRC) has suggested that the ongoing deterioration of water quality in the Vaal catchment area – due to acid mine drainage – will result in the catchment area running out of water because neutralisation through dilution will become unsustainable.

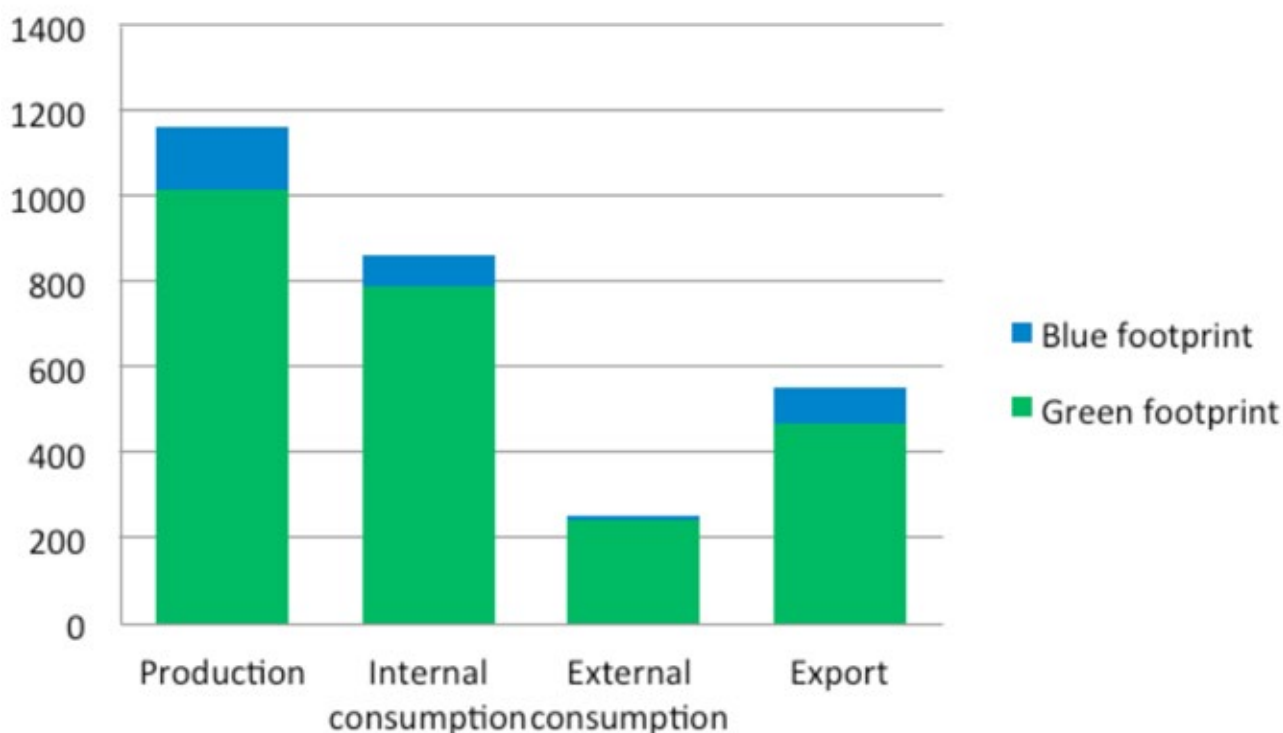
Different sectors require distinct water qualities, therefore there is no single water quality standard. Agriculture, for example, does not require the tertiary treatment demanded for domestic water supply, though poor quality water does pose a particular risk in the export market. Poor irrigation water quality may impact the ability of farmers to export their produce because they do not meet stringent export regulations. This will have a damaging effect on the sector and may impact on the trade balance of agriculture. Due to the multiplier effect in agriculture a large number of jobs may also be at risk. Therefore, poor water quality has a detrimental effect on the health of the crop and on the ability to meet regulatory requirements for export.

2.4 EXPORT AND IMPORT OF FOOD AND WATER

Physical scarcity of resources in South Africa means that there are significant trade-offs between food and water. Water is a significant resource constraint because South Africa is a water-scarce country experiencing huge variations in the temporal and spatial distribution of rainfall. This has implications for crop type selection. In general, crops such as maize for food security are large consumers of water while horticultural crops such as apples consume less water (per tonne), but are good earners of foreign exchange.

Figure 24 gives an indication of the consumption of embedded water by agricultural products in South Africa. A large proportion of South Africa's agricultural production is consumed. However, produce that is imported has a relatively high green-water footprint compared to produce that is exported (which mostly has a blue-water footprint).

Figure 24: South Africa's agricultural production and consumption water footprint ($m^3/capita/annum$)



Source: Mekonnen & Hoekstra (2011)

This figure reaffirms the nature of agricultural production in South Africa. Nationally the country produces sufficient to remain food secure. However, due to the nature of agriculture and the variable rainfall in the country, there has been a large-scale investment in irrigation. A large proportion of irrigated production is exported, while the country imports predominantly agricultural produce with a green-water footprint.

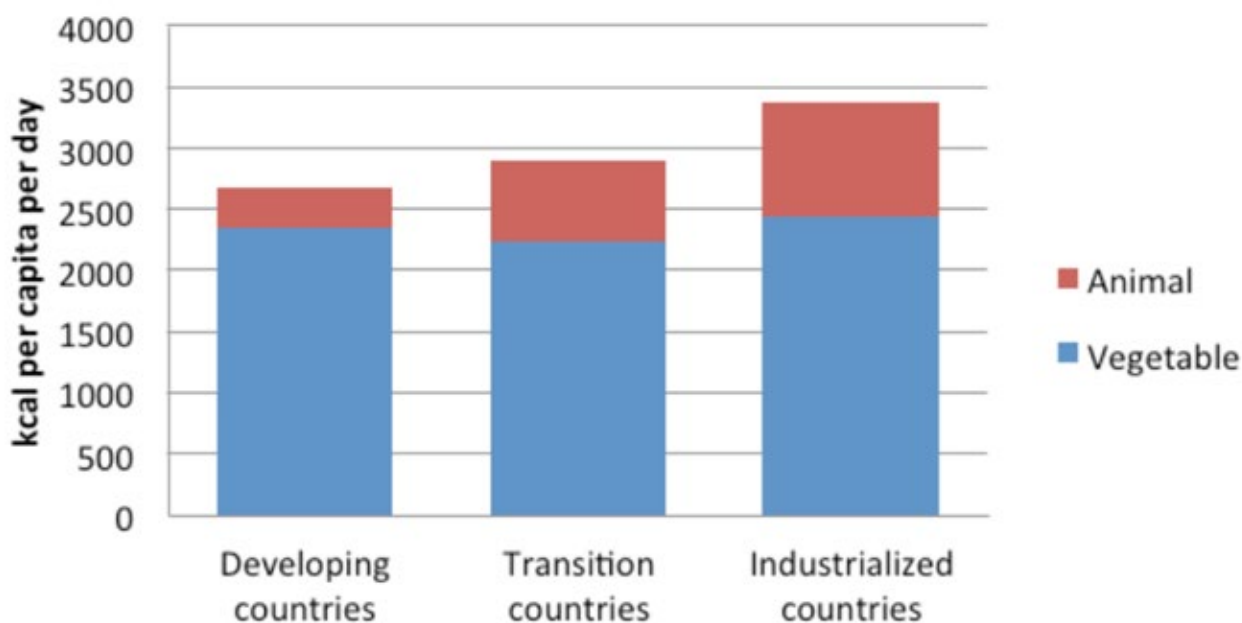
3. FUTURE - AND CURRENT - CHALLENGES

In this section a number of challenges and considerations for water resource availability and supply as well as food production and security are explored. Potential responses to these challenges are identified. In addition, the relative risk associated with food security from water scarcity is highlighted. These are considered as high, medium or low risk for a short or long timeframe.

3.1 INCREASING WATER AND FOOD DEMANDS

With an increasing population (albeit at a reduced rate as a result of HIV and AIDS) and increasing affluence within the population, consumption trends are likely to increase. Studies done by the FAO (2003) regarding the shifts as a country's population becomes more affluent, indicate that not only the amount but also the source of energy for the diets changes, often with an adverse effect on health.

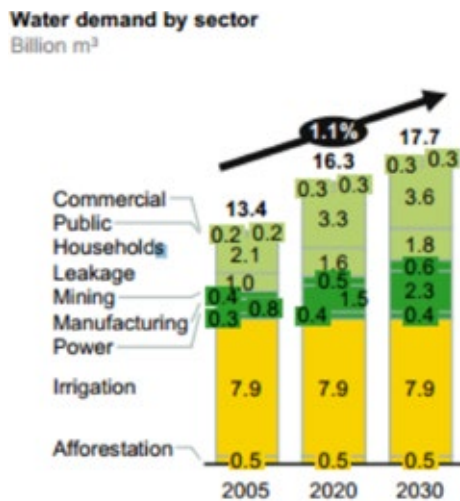
Figure 25: Changing vegetable and animal sources of energy in the diet



Source: Adapted from FAO (2003a) (1999 Data)

Increasing food demand as a result of a growing population and greater affluence will increase the demand for water. More people will demand more food, which will bring about an increase in agriculture.

Figure 26: Water demand by sector



Source: WRG 2030 (2009)

The irrigation volume is unlikely to increase in South Africa as the Department of Water Affairs has capped agricultural allocations to current levels. However, with increasing wealth and calorific intake the demand for food and feed is likely to increase.

Significant shifts to increased water efficiency and productivity of rain-fed production, or a shift to trade will be necessary (WRG 2030 2009). Increased efficiency is also needed to meet the New Development Plan goal of expanding the irrigation area in South Africa by 50%.

With an increasing demand there are a number of trade-offs that need to take place. A number of reconciliation studies have been done in major economic centres of South Africa to ascertain where the additional water supply will be sourced. The cost of additional water (from demand management to desalination) and the resultant energy requirement per cubic metre have been considered.

According to the Water Resources Group (WRG) 2030 (2009), the cost-effective solutions for South Africa to close the 2030 demand-and-supply gap include agricultural efficiency and productivity improvements that will equate to 30% of the required increase in supply. “Seven river sub-basins are almost entirely dependent on agricultural improvements, while the economic centres of Johannesburg and Cape Town are dominated by industrial and domestic solutions” (WRG 2030 2009:13).

The table below indicates the estimated volumes of water wasted through different irrigation types in South Africa. Increasing irrigation efficiency while improving farming practices such as no till or soil moisture analyses will help to relieve the pressure on water resource availability for agriculture. This will have positive effects on the level of production and on food security in South Africa.

Table 2: Irrigation efficiency and irrigation water wastage

Irrigation method	Proportion of total use (%)	Efficiency (%)	Total area in use (ha)	Estimated water wastage (mm³ / annum)
Flood	28.5	65	456 000	465
Sprinkler	25.5	75	848 000	235
Centre pivot	27.5	80		171
Micro	13.1	85	296 000	58
Drip	5.4	90		
Total	100		1 600 000	929

Source: ICID (2008)

Other options for the agricultural sector in the face of increasing water insecurity would be to import water-intensive foodstuffs instead of growing the crop in an inefficient manner in South Africa. This may include investigating regional options where more suitable regions in neighbouring countries supply the food staples. However, additional risks associated with sovereignty-of-country production and the markets associated with food may make this a politically untenable option.

In essence, increasing water and food demand due to an increase in population, development and affluence is a medium risk to food and water security in South Africa (in the long term). Because an increase in demand is highly likely, this risk can be anticipated and planned for, making the risk less severe.

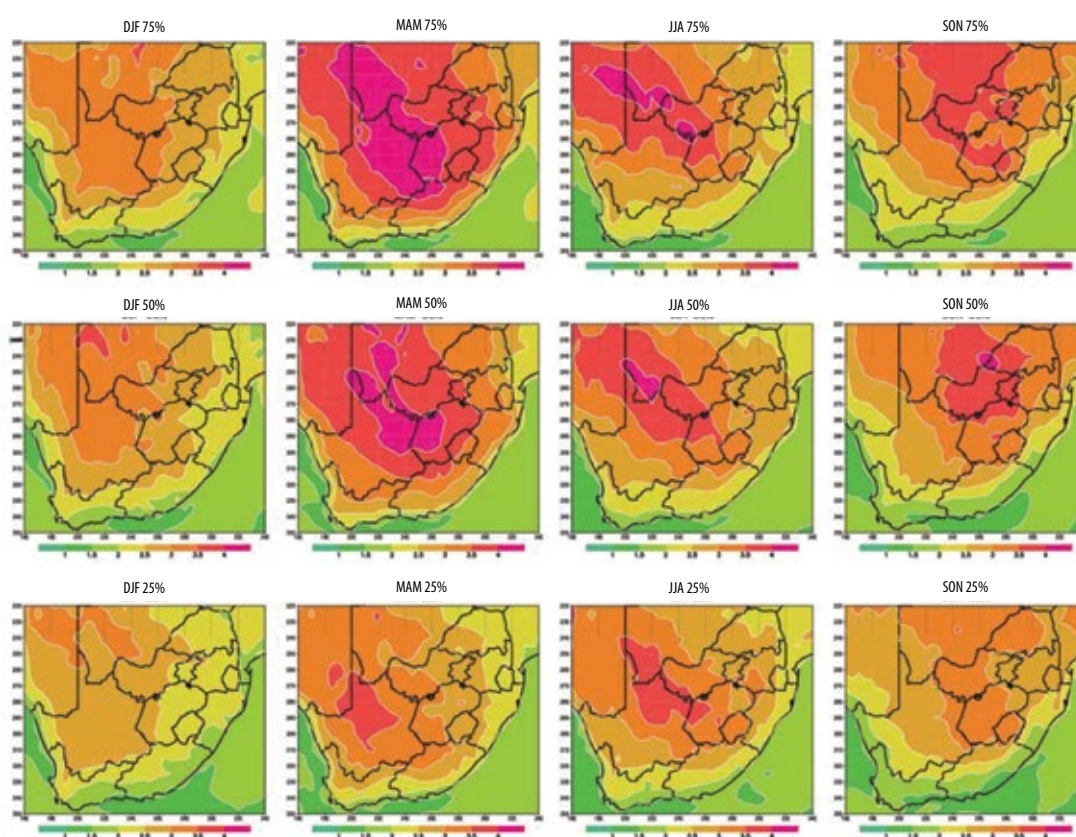
3.2 CLIMATE

In addition to rising demand for water resulting from an increase in population and a greater demand for food production, water security is vulnerable to the uncertainty of South Africa's future climate.

Climate projections for South Africa identify an expected rise in temperature of 1 to 2 °C for coastal regions, and 3 to 4 °C expected for interior regions by 2050. Rainfall patterns are also shifting, although this is a little more variable and unpredictable. It is anticipated that especially the western regions of the country will experience significant reduction in the flow of streams in the region. This has major implications for the agricultural practices in these regions.

One of the coping mechanisms is to invest in more suitable crops for the potential future climate. However, this is likely to happen slowly over time as farmers shift their cropping types accordingly.

Figure 27: South Africa's climate future



Map 3.1: Projected seasonal temperature change (°C) by a dynamic regional climate model for the period 2070-2100 vs 1975-2005 under the A2 SRES scenario. The upper row shows the change in the 75th percentile (calculated separately for each model grid point) of the simulated seasonal temperatures over the period 2070-2100 relative to 1975-2005 time series. The middle and bottom rows are similar, but represent the change in the median and 25th percentile of the seasonal temperatures respectively. Data source: WRC, UP.

Source: DST (n.d)

Small-scale and homestead farmers in dry areas are especially vulnerable to climate change. Irrigation farmers are less vulnerable in terms of crop failure, provided that water resources are available. Predictions for various sectors in agriculture include a decrease in maize production in summer-rainfall areas and a decrease in cereal production in winter-rainfall areas. An increase in fires is projected (a risk to the forestry sector), while rangelands are projected to experience bush encroachment (a risk to grazing lands). There will be an increase in the frequency and severity of extreme weather events, which will have a negative effect on agricultural production.

Due to the variability of water resources across South Africa, significant investments have been made into infrastructure. The engineering of water transfers between catchments has helped to buffer regions faced with insufficient water resources. Through infrastructure, developments have occurred that would otherwise not have been possible. This is true for both urban areas in arid regions and the irrigation of crops. As a result, development has pushed the boundaries not only in terms of what a region can naturally provide but also what is provided through infrastructure. This is a particular risk in the face of an uncertain climate future: we don't know if the current infrastructure will be able to support the changes. This puts the system at higher risk.

Climate change poses a high-level long-term risk to future water and food security in South Africa. This risk is deemed high due to the uncertainty of whether or not – and how – regions will be impacted by climate change. Additionally, because of the extent of rain-fed agriculture in South Africa, shifts in rainfall patterns will have a significant effect on food production. As rain-fed crops are generally food security crops (wheat, maize), the effects for food security are particularly dire.

3.3 POLICY AND PLANNING BETWEEN WATER AND FOOD

Outcome 7 of the National Development Plan is “vibrant, equitable and sustainable rural communities with food security for all”. The National Water Resources Strategy (NWRS) adopts the principle of “source to tap and back to source” and the maximisation of local water resources to improve access to adequate water for domestic and productive use, particularly in rural communities. These policies indicate the importance of water in meeting food security goals in South Africa (NWRS 2013:7).

However, the NDP has a target of a 50% increase in the area under irrigation, despite the fact that there is not enough water available for this expansion. Assuming that this can be achieved by increasing efficiency alone is a risk as some crop types become uneconomical with more efficient (and expensive) irrigation types.

Another policy which is relevant to both food security and water is the South African biofuels targets. In 2007 the South African government released the country's National Biofuels Industrial Strategy which aimed for a 2% penetration of biofuels into the liquid road transport fuel market by 2013. One of the provisos for the strategy was that “no water should be used to produce bio-fuels under irrigation” (NWRS 2013:20). In addition, the strategy protects against potential inflation of food prices by initially excluding maize from the production of bioethanol. According to the Department of Minerals and Energy (DME 2003) biofuels production can only commence “[o]nce certainty on the ability of the currently under-utilised land to produce has been ascertained and the necessary measures are in place to guard against extreme food inflation”. The biofuels policy also states that “under-utilised” lands must be used to meet the biofuels targets, the majority being in former homelands (DME 2003).

The lack of integration between policy and planning for water and food is a medium risk. Although this may have detrimental effects on implementation and the production of food in the short term, over the long term it is assumed that policies will shift accordingly. Integration of policy to optimise water use and food production will take place when the resource becomes stressed enough. Therefore, the risk is moderate.

3.4 WATER PRICING

As mentioned previously, water availability is not constant across South Africa. The shortage of water resources in addition to the management cost and the level of infrastructure investment plays a role in the price farmers pay for water. One of the sure ways of increasing water efficiency is to make it more expensive, forcing investment into improved irrigation types. However, a single increase in water price across the country would be unfeasible. First, as things currently stand, charges are not the same (Figure 28). Secondly, certain crops have different margins. Assuming a single price for water as an input may force particular crops from the South African market. In a purely market-driven society this would be the most economically efficient decision to make. However, in South Africa, food security, employment and support for the rural and agricultural economy are critical. Therefore, there is a risk of forcing marginal farmers out of business.

Figure 28: Average water price per WMA

WATER MANAGEMENT AREA		SECTORAL UNIT COST IN C/M ³		
No	Water Management Area	Domestic/Industrial	Agriculture: Irrigation and watering livestock	Forestry
1	LIMPOPO	0.92	0.58	0.54
2	LUVUVHU AND LETABA	1.33	0.78	0.70
3	CROCODILE (WEST) AND MARICO	0.82	0.63	0.61
4	OLIFANTS	0.89	0.75	0.70
5	INKOMATI	0.85	0.63	0.57
6	USUTU TO MHLATHUZE	0.30	0.30	0.28
7	THUKELA	0.33	0.33	0.31
8	UPPER VAAL	0.96	0.78	0.78
9	MIDDLE VAAL	1.07	1.07	N/A
10	LOWER VAAL	0.59	0.50	N/A
11	MVOTI TO UMZIMKULU	0.81	0.78	0.74
12	MZIMVUBU TO KEISKAMMA	0.85	0.67	0.56
13	UPPER ORANGE	0.38	0.38	N/A
14	LOWER ORANGE	0.49	0.40	N/A
15	FISH TO TSITSIKAMMA	0.89	0.50	0.27
16	GOURITZ	2.36	0.67	0.47
17	OLIFANTS / DOORN	1.77	0.65	0.51
18	BREEDE	2.23	0.58	0.39
19	BERG	3.16	0.70	0.54
	Average	1.11	0.61	0.42

The gross margins of crops as well as their water requirements differ significantly, as indicated by the summary in Table 3. The decision as to where water pricing should sit needs to consider the effect of the water charge on these farmers. For example, the impact of increasing water prices for irrigation on maize farmers on the Highveld will have a significantly different effect compared to an increase in price to sugarcane farmers. This implies that one of the responses to increasing water scarcity is to initiate efficient irrigation practices through an increase in price for the specific crops that can afford such increases.

Source: DWAF (n.d.)

Table 3: Summary of statistics for selected agricultural crops in South Africa

Crop	Gross farm income (R/ha)	Input costs (R/ha)	Profit (R/ha)	Irrigation type	Water abstraction (m ³)	Total water charges (R)	Water charges (% of input cost)
Maize	7 066.594	2 500	1 431.2	Sprinkler	7 800	936	16
Potatoes	58 208	42 395	15 813	Sprinkler	5 122	614	0.8
Apples	192 720	175 112	17 608	Drip	21 567	2 588	1.36
Lucerne	3 179.5	1 589.83	1 859.67	Sprinkler	19 383	2 325	18.4
Sugar	19 228	15 000	4 228.431	Centre Pivot	17 434	2 092	15.4
Citrus	71 040.43	12 960	58 080	Drip	16 621	1 944	13.94

Source: National Treasury (unpublished)

These examples provide an indication of the variability in water costs, input costs and profitability across a representative range of crops. The water-use and cost columns are based on typical water requirements and charges for that crop in that part of the country; it should be noted that there is considerable variation for both water use and charges around this typical value.

Importantly, the figures indicate that apart from maize (and by implication other cereals), water costs are a relatively small portion of production input costs, while an increase in water-use charges of up to 5c/kℓ would not seriously jeopardise the profitability of the enterprise. It must however be noted that this conclusion may not apply to less efficient or less productive farms.

For irrigated maize and irrigated lucerne, water is a significant portion (16% and 18% respectively) of total input charges. Therefore, a small increase in the water charge will have a significant impact on the total input costs. Because the profit margins are relatively smaller than horticultural produce (R1 000 vs R10 000), an increase in price would effectively close down the irrigated maize or lucerne industry. However, maize is an important crop for food security. Therefore, decisions regarding the price of water need to take into account the effect on different agricultural crops. The value of the crop must also be considered, not only in terms of employment and GDP contribution but also in terms of food security.

The Bottom Line: These decisions are influenced by the development goals for South Africa, and will not necessarily be the most economical or water-efficient ones. Should the irrigated maize on the Highveld require protection in order to secure food crop production, subsidies need to be implemented for the maize sector in particular and not across the entire agricultural sector.

Pricing is a low risk factor in terms of food and water security, although an increase in water price will have a large effect on maize production (for example). This will not be allowed to negatively affect food security. Either more efficient crop production will bring in additional foreign exchange to purchase food crops, or subsidies will be put in place to protect the foodstuff-producing farmers. In general, however, the price of food is completely variable. It is affected by markets, policies, politics and economics, which outweigh the potential impact of a water price increase (see Figure 29).

Figure 29: Changes in food prices



Source: FAO (n.d.)

4. OBSERVATIONS AND KEY MESSAGES

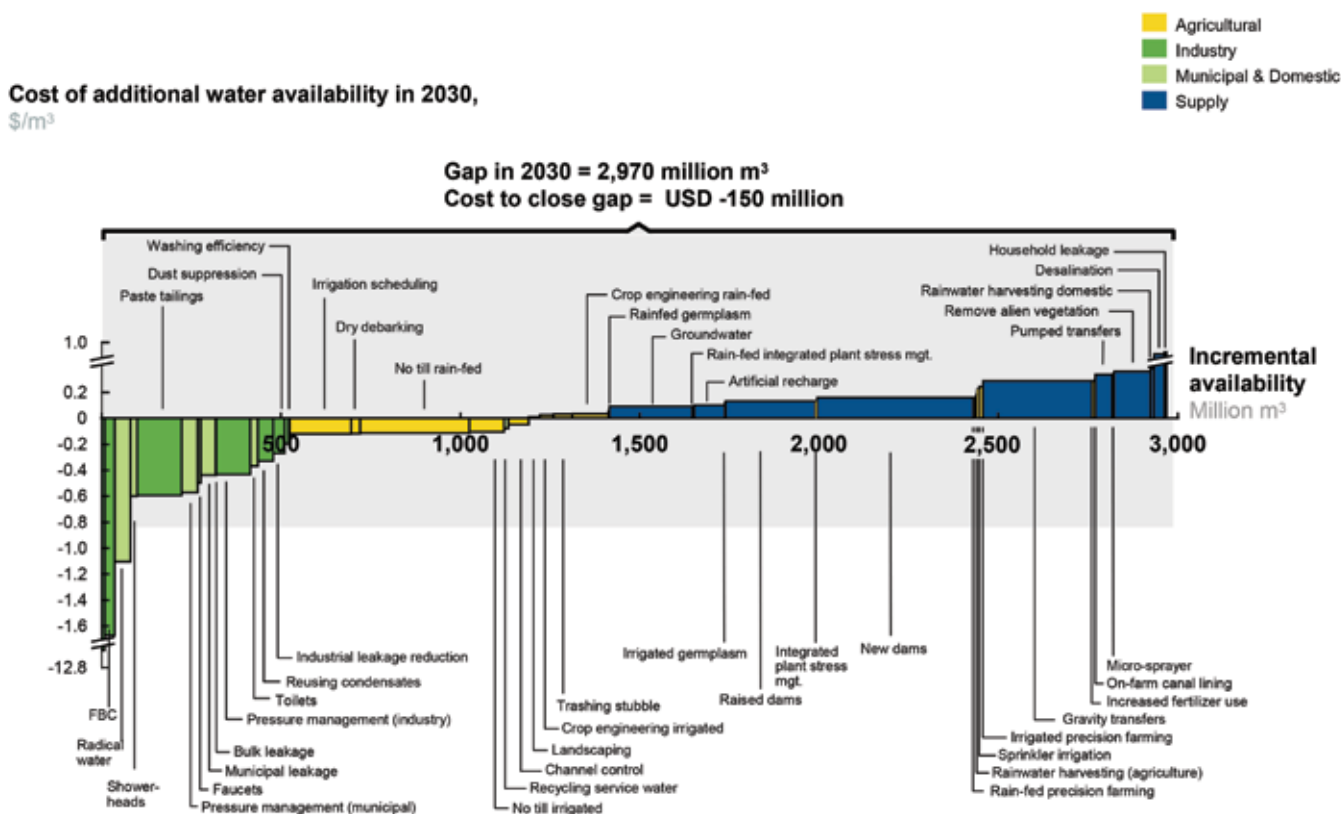
Water is an integral part of agriculture; hence the value of water is integral to the value of the agricultural sector. However, any analysis investigating the economic efficiency of water use in agriculture in terms of direct GDP contribution will lead to a false analysis. Although the agricultural sector accounts for approximately 60% of water use in South Africa, it supports a significant portion of the South African economy and contributes massively to rural development. It contributes to national food production and security for the country as well as job creation and employment throughout the food production value chain (NWRS 2013:55). Although the contribution of agriculture to the GDP is low (3%), when considered in addition to the agroprocessing chain, it becomes substantial (15%).

As water as a resource becomes increasingly stressed, additional pressure is placed on the agricultural sector, which is the largest single user of water. How prepared and able the food sector is to respond to water variability depends on the water-planning process. Irrigation water allocations have already included hydrological variability in the assurance of supply for agriculture. There is already a clear understanding that agriculture has less reliability and assurance of supply, which may affect the yield of agricultural crops. This is not a great concern for perennial crops, which do not require a substantial investment in infrastructure. For crops such as fruits, vines and nuts that require a large investment in water infrastructure, the assurance of supply needs to be greater. In view of the sizeable investment made, it is imperative that these are irrigated. As a result of restrictions during drought, informal spot markets have developed. Those who can afford not to irrigate sell their water allocations to others who cannot. The current policy revision position to prevent trading reduces agricultural resilience in the face of variability. Trading helps producers to manage variability of water supply.

In addition to the provision for water stress made in hydrological forecasting, there are a number of additional ways through which the food sector can begin to cope with water scarcity. The broad areas that help build resilience in this regard include efficiency, trading and institutional management. Efficiency in this sense does not relate to using more water, but to freeing up and making water available. In addition, efficiency stems from growing the correct crop for particular climatic conditions. Trading is not supported in the current policy review. The trading of water rights helps to promote efficiency in the system and therefore should be supported. Regarding institutional management, the institutional structure within South Africa is fairly responsive and timeous concerning decisions about restrictions.

The WRG 2030 cost curves suggest that approximately 30% of the 2030 water demand gap can be filled through efficiency gains to ensure agricultural optimisation. Agricultural water solutions in the WRG 2030 cost curves address both the water challenge and the food challenge because rapid population and income growth increase demand (Figure 30). This figure indicates that water availability in South Africa, although stressed, is not a crisis. There are alternative options available which include irrigation scheduling, no-till rain-fed production and dry debarking, for example. Meeting these requirements will pose a challenge to water users in South Africa.

Figure 30: South Africa’s water availability cost curve



SOURCE: 2030 Water Resources Group

Source: WRG 2030 (2009)

Should water availability shift dramatically, certain sectors in agriculture will be more heavily affected than others. This will depend on the nature of the crop, the margins at which it is produced and the water requirements. A drought and reduction of rainfall in the Overberg region of the Western Cape, for example, will have a detrimental effect on the rain-fed wheat production. The effect will be less on those farmers who irrigate (such as horticulture) and have sufficient storage to meet requirements through the dry period. In terms of food security from internally produced food, a reduction in yield from wheat farmers may have a drastic effect. However, due to the global markets for food, the shortfall in local wheat production may be met through imports. Therefore, responsiveness to emergencies such as droughts is variable depending on the crop, the nature of production and dependency on rainfall.

The responsiveness of the food sector to water prices depends on the margins for producing the food. Where water is a large proportional input into the input costs, then a change in water price will have far-reaching effects. Because in general the price of water is largely insignificant when compared to labour, fertiliser and other inputs, the impact of water pricing on agricultural products will be small. Some crops, where the margins are small, will be affected by increasing water prices, such as irrigated maize on the Highveld and lucerne.

In the face of increasing demand and the potentially negative effects of climate change, there are also options for regional sourcing of food supplies and selecting crops more suited to the African climate. Regional food supply consideration is supported by the following excerpt from the National Water Resources Strategy: “There is a debate about virtual water and importing food from neighbouring countries with high food production. The potential for this option must be broadened” (NWRS 2013:20). However, concerns over the sovereignty of produce and the mistrust in meeting contractual agreements is likely to be a political stumbling block for this form of regional integration.

Under the policy review proposals, the restrictions on trading and the proposed discontinuation of Water Users Associations (WUAs) (DWA 2013d) may be damaging to agricultural resilience and variability. This poses subsequent risks to food production and security. Currently, however, South Africa is fairly mature and flexible from a policy and legislative perspective, allowing flexibility to long-term variability and change. However, there are social and political perspectives that need to be considered in order to implement legislation as they make the implementation of legislation more complex.

Currently in South Africa, the WUAs and Catchment Management Agencies (CMAs) make timeous decisions regarding restrictions to water use. As the appropriate platforms through which communication and planning regarding water use take place, they are resilient and flexible in their ability to improve resource use in the country. This is especially true with regards to established institutions. Those within the former homelands, however, still face a number of challenges.

Tools such as the Alliance for Water Stewardship (AWS), a vehicle through which producers can gain accreditation for good practice, are useful. This is primarily focused on clients and financial institutions for the producer. The AWS will not replace the value of WUAs and CMAs, but will help create a system for improved self-or peer regulation to support effective regulation within the current institutional framework. In an environment with limited resources and capacity for formal regulation, the AWS is a useful tool to help rather than replace regulation and to support cooperation within the WUA and CMA systems.

REFERENCES

- Ashton, P.J. 2009. An overview of the current status of water quality in South Africa and possible future trends and change. *CSIR, DMIS Report 192725*. Council for Scientific and Industrial Research, Pretoria.
- Boccaletti, G., Stuchtey, M. and M. van Olst. 2010. *Confronting South Africa's Water Challenge*. Mc Kinsey & Company. [Online] Available at: http://www.mckinsey.com/insights/sustainability/confronting_south_africas_water_challenge.
- DME. 2003. *White Paper on Renewable Energy*. Department of Minerals and Energy (DME), Pretoria. [Online] Available at: www.gov.za/documents/download.php?f=68765.
- Dreaming New Mexico (DNM), New Mexico. [Online] Available at: <http://www.dreamingnewmexico.org/food/ff-local-foodshed>.
- DST. (n.d) *South African Risk and Vulnerability Atlas*. Department of Science and Technology (DST), Pretoria. [Online] Available at: http://www.sarva.org.za/download/sarva_atlas.pdf.
- Du Toit, D., Ramonyai, M., Lubbe, P. and V. Ntushelo. 2011. *Food Security*. Department of Agriculture Forestry and Fisheries (DAFF), Pretoria. [Online] Available at: <http://www.nda.agric.za/docs/GenReports/FoodSecurity.pdf> [Accessed: 21/10/2013].
- DWA. 2013a. *Draft NWRs2 2013: Draft National Water Resources Strategy 2*. Department of Water Affairs, Pretoria.
- DWA. 2013b. *National Water Resources Strategy 2 (NWRs2)*. Department of Water Affairs (DWA), Pretoria. [Online] Available at: <http://www.dwaf.gov.za/nwrs/LinkClick.aspx?fileticket=C1wWyptzLRk%3d&tabid=91&mid=496> [Accessed: 14/10/2013].
- DWA. 2013c. *Strategic Overview of the Water Sector in South Africa*. Department of Water Affairs (DWA), Pretoria.
- DWA. 2013d. General Notice 888 of 2013: National Water Policy Review: Updated policy positions to overcome the water challenges of our development state to provide for improved access to water, equity and sustainability. *Staatskoerant* No. 34789. Department of Water Affairs (DWA), Pretoria.
- DWAF. (n.d.) *Average Water Price per WMA*. Department of Water Affairs and Forestry (DWAF), Pretoria. [Online] Available at: <http://www.dwaf.gov.za/Projects/WARMS/docs/pdf/A5eng.pdf>.
- FAO. (n.d.) *Food Price Index*. Food and Agricultural Organization of the United Nations. [Online] Available at: <http://www.fao.org/worldfoodsituation/foodpricesindex/en/>
- FAO. 2003a. *Global and Regional Food Consumption Patterns and Trends*. Food and Agricultural Organization of the United Nations (FAO), Rome. [Online] Available at: <http://www.fao.org/docrep/005/ac911e/ac911e05.htm>.
- FAO. 2003b. *Food Security: Concepts and Measurement*. Food and Agricultural Organization of the United Nations (FOA), Rome. [Online] Available at: <http://www.fao.org/docrep/005/y4671e/y4671e06.htm> [Accessed: 23/10/2013].
- FAO. 2010. *Agriculture Value Chain Development: Threat or Opportunity for Women's Employment?* Food and Agriculture Organization of the United Nations (FAO), Rome. [Online] Available at: <http://www.fao.org/docrep/013/i2008e/i2008e04.pdf> [Accessed: 21/10/2013].
- ICID. 2008. *Data Sheet for South Africa*. International Commissions on Irrigation and Drainage (ICID), New Delhi.
- Koch, J. 2011. *IPC-UNDP 2011: The Food Security Policy Context in South Africa: Country Study Number 21*. International Policy Centre for Inclusive Growth, Brazil.
- Mekonnen, M.M. and Hoekstra, A.Y. 2011. National water footprint accounts: The green, blue and grey water footprint of production and consumption. *Value of Water Research Report Series 50*. UNESCO-IHE, Delft, the Netherlands. [Online] Available at: <http://www.waterfootprint.org/Reports/Report50-NationalWaterFootprints-Vol1.pdf>
- National Treasury. (Unpublished) *Economic Study on Water Pricing in South Africa with a Focus on Agricultural Sector: Options and Recommendations*. National Treasury, Pretoria.
- NationMaster.com. [Online] Available at: http://images.nationmaster.com/images/motw/africa/south_africa_ag_1979.jpg.
- NPC. 2013. *National Development Plan–2030*. National Planning Commission (NPC). [Online] Available at: <http://www.npconline.co.za/MediaLib/Downloads/Home/Tabs/NDP%202030-CH6-An%20integrated%20and%20inclusive%20rural%20economy.pdf>.
- SAGI. 2013. *Agriculture*. South African Government Information (SAGI). [Online] Available at: <http://www.info.gov.za/aboutsa/agriculture.htm> [Accessed: 14/10/2013].

- StatsSA. 2004. *Census of Commercial Agriculture, 2002*. Statistics South Africa (StatsSA), Pretoria. [Online] Available at: <http://www.statssa.gov.za/agriculture/publications2007.asp>.
- StatsSA. 2009. *Census of Commercial Agriculture, 2007*. Statistics South Africa (StatsSA), Pretoria. [Online] Available at: http://beta2.statssa.gov.za/?page_id=1854&PPN=P1102&SCH=4534.
- StatsSA. 2011a. *Agricultural Census, 2011*. Statistics South Africa (StatsSA), Pretoria. [Online] Available at: <http://www.statssa.gov.za/publications/Report-03-11-01/Report-03-11-012011.pdf>.
- StatsSA. 2011b. *General Household Survey, 2011*. Statistics South Africa (StatsSA), Pretoria. [Online] Available at: <http://www.statssa.gov.za/Publications/Report-03-18-03/Report-03-18-032011.pdf>.
- StatsSA. 2012. Food security and agriculture, 2002–2011. *GHS Series Vol IV*. Statistics South Africa (StatsSA), Pretoria.
- USDA. 2013. *Below-Average 2012/13 Corn Yields in South Africa Caused by Drought in North West and Free State Provinces*. US Department of Agriculture (USDA), Washington DC. [Online] Available at: <http://www.pecad.fas.usda.gov/highlights/2013/04/SouthAfrica/>.
- Water Footprint Network (WFN), the Netherlands. [Online] Available at: <http://www.waterfootprint.org/>.
- World Bank. 2012 and 2013. *World Data Bank*. [Online] Available at: <http://databank.worldbank.org/data/views/reports/tableview.aspx?isshared=true&ispopular=country&pid=17>.
- WRG. 2009. *Charting our Water Future: Economic Frameworks to Inform Decision Making*. 2030 Water Resources Group (WRG), Washington DC. [Online] Available at: http://www.2030waterresourcesgroup.com/water_full/Charting_Our_Water_Future_Final.pdf.
- WRG. 2012. *South Africa, Water for Growth, People and Environment*. 2030 Water Resources Group (WRG), Washington DC. [Online] Available at: <http://www.2030wrg.org/project/south-africa/>.

100%
RECYCLED



Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

panda.org.za