The Food Energy Water Nexus

Understanding South Africa’s most urgent sustainability challenge
# CONTENTS

**FOREWORD**

|   |
|---|---|
|   | 3 |

**INTRODUCTION**

|   |
|---|---|
|   | 4 |

**UNDERSTANDING THE CHALLENGES WITHIN THE FEW NEXUS**

|   |
|---|---|
|   | 8 |
| Complications in the food system | 8 |
| The risks | 11 |
| Complications in the energy system | 12 |
| Implications for food security | 12 |
| Implications for water security | 18 |
| The risks | 18 |
| Complications in the water system | 21 |
| Implications for food security | 21 |
| Implications for energy security | 24 |
| The risks | 24 |

**CALL TO CONVERGENT ACTION**

|   |
|---|---|
|   | 26 |
| What information is required | 27 |
| Actions to increase resilience to price inflation and volatility | 28 |
| Government’s role: policy, regulation and planning | 29 |
| Further research and stakeholder engagement | 31 |

**FUTURE VISION**

|   |
|---|---|
|   | 33 |

**GLOSSARY**

|   |
|---|---|
|   | 34 |
We live in an interconnected, interdependent world. This idea, of intersected systems that underpin our natural world and couple resources, has gained currency in recent years but is by no means new. In the 19th century, naturalist John Muir wrote, “When we try to pick out anything by itself, we find it hitched to everything else in the universe.”

WWF encountered exactly this nexus phenomenon when we prioritised the need to understand and build awareness of the confluence of food, energy and water resources and the implications for development and planning in South Africa. Each resource in the Food Energy Water (FEW) Nexus has multidimensional value in society, as its provision is fundamental to human well-being and economic stability.

The nexus concept provides a useful framework for action to resolve complex challenges. The developmental challenges posed by the FEW Nexus are already evident. How do we address energy security without impacting further on our food or water resources? And, conversely, how do we improve water security without swelling the massive energy burden in water management? How do we meet rural job creation ambitions in a stagnant agricultural economy without overextending our scarce water and energy resources?

The message is clear: if we want to ensure the resilience of the environmental and social systems that we need for sustainable development, we must inspire new forms of dialogue underpinned by rigorous science and accurate data, and a new consensus on equitable access. Collated in this report is information commissioned from diverse and reliable sources to construct a vivid picture of the state of the resources in the FEW Nexus. It is intended to stimulate immediate action, and catalyse proactive collaboration within government, the private sector and civil society to identify integrated solutions for the provision of food, energy and water security for all within a framework of equitable and sustainable growth.

“Collated in this report is information commissioned from diverse and reliable sources to construct a vivid picture of the state of the resources in the FEW Nexus.”

FOREWORD FROM MORNÉ DU PLESSIS WWF-SA CEO

“The nexus concept provides a useful framework for action to resolve complex challenges.”

Foreword
Food, water and energy security forms the basis of a resilient economy, but as a water-scarce country with little arable land and a dependence on coal-fired power and 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 South Africa.

This report is the final report on the Food Energy Water Nexus Study. It draws on the papers commissioned in this study, the interviews conducted as part of the research process and the insights received at the workshops organised for this study.

"South Africa’s economy is testing the limits of its resource constraints."

**FIGURE 1: FOOD, ENERGY, WATER: HIGHLY COUPLED AND INTERDEPENDENT**

**WATER DEPENDENCY ON ENERGY:**
- Pumping of water across watersheds for irrigation and distribution to municipal areas
- Treatment of water and waste water
- Heating of water for domestic and industrial purposes

**FOOD DEPENDENCY ON WATER:**
- Water for irrigation
- Rain-fed crops dependent on rainfall
- Water for aquaculture and stock watering
- Water for processing food

**ENERGY DEPENDENCY ON AGRICULTURE:**
- Production of biofuels

**WATER IMPACTS OF FOOD PRODUCTION:**
- Pollution from farming (fertilisers, pesticides, antibiotics, etc.)

**FOOD IMPACTS FROM ENERGY GENERATION:**
- Pollution from mining and fracking

**ENERGY DEPENDENCE ON WATER:**
- Water for electricity generation, including coal-fired power stations and hydropower
- Water for fuel preparation, including coal washing and fracking

**WATER IMPACTS FROM ENERGY GENERATION:**
- Land and water degradation due to mining


Water is a prerequisite for food production and the quantum required is immense. Water is also a prerequisite for energy production and an important input in producing fertilisers and agricultural chemicals, growing crops, raising livestock and accessing marine food resources. Both water and energy are required throughout the food value chain to process, package, transport, store and dispose of food. Furthermore, water-supply systems consume energy at every stage of the water production and supply chain: water abstraction, treatment, distribution to end-users, waste-water reticulation and treatment. Finally, both energy and food production can significantly affect the quality of water bodies.
50% of South Africa’s population doesn’t have enough food.

& OUR POPULATION IS GROWING

1996 49.6 million
2001 44.8 million
2007 48.5 million
2011 51.8 million
2030 60 million

SOUTH AFRICA FACES AN ENERGY CRISIS DEMAND EXCEEDS SUPPLY

COAL ACCOUNTS FOR 86% OF OUR ELECTRICITY GENERATION

BY 2030

The Department of Energy estimates coal will still account for 65% of our electricity generation.

© BRANDFOUNDRY

THE NATIONAL DEVELOPMENT PLAN VISION FOR 2030

proposes a targeted increase of more than 50% of land to be irrigated.

The bulk of our electricity is produced by the mining and burning of FOSSIL FUELS...

this pollutes our water and air and contributes towards CLIMATE CHANGE...

which has a negative impact on South Africa’s CROP PRODUCTION...

we need to find sustainable sources of CLEAN ENERGY.

98% of South Africa’s total water supply is already allocated.

The Department of Water estimates a 1.7% shortfall in the water supply as early as 2025.
This interconnection of resources is referred to as the Food Energy Water (FEW) Nexus. Security of supply in these three resources forms the basis of a resilient economy. However, 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.

The uneven distribution of natural resources and the location of economic development nodes in South Africa amplify the management constraints and inequality of access to these resources. A clear example is the fact that South Africa’s coal deposits coincide with the country’s best agricultural land and sources of some of the major inland rivers (see Box 1). The spatial complexity adds to the task of effective management of food, energy and water resources, making it the foremost challenge for sustainable development in South Africa.

**Spatial development**

The South African economy has historically been built on mining, benefiting greatly from its rich deposits of platinum, gold, diamonds and coal. The mining industry also provided a platform for the growth of the manufacturing, trade and financial sectors. Due to its wealth of mineral resources, Gauteng has come to be the centre of the economic development and output.

Gauteng accounts for as much as 33% of the country’s GDP and 49.6% of all employee remuneration in the country. It is also home to just over a fifth of the country’s population. However, a review of the country’s resources shows that the availability of basic resources in the province itself is rather poor. Gauteng has little of its own bulk water resources and imports 88% of its water from a series of complex transfer schemes, accessing water from the Thukela, Usutu, Komati and Orange rivers. This intricate web of bulk water infrastructure comes at a price. Water prices in the province have increased exponentially over the last few years. Raw water costs alone account for 53% of the water utility’s input costs. Moreover, the province is located on a watershed, which means that outflows of waste water pollute the water resources on which it depends.

On the food side, the province contributes up to 3% of the total agricultural supplies but accounts for 20% of the agricultural demand. The Gauteng-Durban freight corridor carries the highest tonnage of agricultural supplies in the country. Rising energy prices mean that food prices in Gauteng stand to be affected on account of higher transportation costs. The population concentration in the province means that rising energy costs could affect the affordability of food for a substantial portion of the population. Finally, Gauteng is a significant consumer of electricity; it is responsible for about a third of the country’s energy consumption. Its electricity needs are fulfilled predominantly by Eskom’s coal-fired power stations in Mpumalanga.

Clearly, economic and spatial planning in the context of unevenly distributed and variable resources can be an essential element for managing the impacts of the nexus.

**Sources:**
The National Development Plan (NDP) of South Africa seeks to eliminate poverty, deliver environmental protection and promote economic development by 2030. The magnitude of this task should not be underestimated. In a country fraught with unemployment and notorious for having one of the world’s highest wealth gaps between rich and poor, there is an urgent need to grow the economy in such a way that jobs are created for a largely unskilled workforce and that there is a structured redistribution and equity in access to and ownership of resources.

The NDP’s vision for the future, which includes access to affordable food and safe, affordable and reliable water and energy services, is based on the current economic model’s assumption of the infinite availability of these and other resources. The reality is that there is limited water and fertile land resources, and there has been steady degradation of the environment and associated ecosystem resilience. Population growth, shifting diets and urbanisation are putting increasing pressure on food, water and energy supply. At the same time, many natural resources are becoming harder to access, pushing exploration into less accessible resource zones associated with greater technical, social and environmental challenges and increasing cost. Add in the likely impacts of climate change, such as rainfall variability and extreme weather events and the need for integrated planning informed by systems thinking – i.e. to think in terms of the FEW Nexus – becomes urgent. Until now, there has been limited recognition of the interdependence of these three resources – water, energy and food – from a policy and sectoral perspective. Rather, all three are dealt with in silos. It is now evident that failure to accurately understand the synergies and trade-offs between these three resources will result in growing numbers – many millions – of South Africans at risk of hunger, waterborne diseases, energy shortages and ever greater poverty.

Achieving the objectives of the NDP requires the country’s economic development paradigm to recognise the increasing pressure on natural resources and shift towards a more balanced approach that is based on the interlinked management of resources. This is not only a risk, it is also an opportunity: improving the domestic management of the links between water, energy and food will increase the resilience of the economy as a whole to withstand the risks of climate variability and economic volatility.

Ultimately, the challenges posed by resource constraints point towards a coming crisis in the provision of clean water, electricity and nutritious food, which are at the heart of national security and welfare. It is important that we respond correctly to ward off this crisis. This response must be at a scale that allows for national and regional integration. It must focus on the effective management of resources, enabled by wider technology use and greater governance underpinned by an integrated approach to policy, planning, management, development and the appropriate institutional capacity.

To catalyse urgent and judicious action, this report examines the scale of the problem to determine not only the immediate risks but also those that we may have more time to address. It furthermore proposes some of the steps towards a resilience-based, integrated framework for natural resource allocation and management, and concludes with a call to action, identifying necessary steps and the key stakeholders in the process. The aim is to support the increased understanding, particularly among policy makers and business leaders, of the interactions between the three systems in the FEW Nexus in order to promote efficient, equitable and sustainable development in South Africa.
“If the challenges for food, energy and water are addressed in isolation, there is a real risk of adding water and food insecurity to the country’s growing list of challenges.”

In the past five years, South Africa has been grappling with its quest for energy security. If the challenges for food, energy and water are addressed in isolation, there is a real risk of adding water and food insecurity to the country’s growing list of challenges and contributing to growing social insecurity. The balance can still be maintained at the national level, but it is already difficult to ignore the Nexus at local level. Right now a number of municipalities have to manage the tension and conflict resulting from the finite nature of these natural resources and a soaring demand.

The food situation in the country is being redefined by complex forces that are both global and domestic in nature and can be mutually reinforcing. At a macrolevel, food security is inextricably linked to the global market dynamics of production, demand and supply; financial and international forces within the global system that make changes hard to anticipate. At the local level, food security is impacted by drivers such as:

- population growth
- increasing affluence and urbanisation
- availability of arable lands
- soil degradation
- water resources
- climate variability.

A further complicating factor in food availability and supply is that agricultural activities – which produce the food, some of the fuel, fibres and many other raw materials on which we depend – are a critical driver of landscape-level change, eroding the diversity of species living there and placing tremendous pressure on the natural systems that give us the soil, freshwater, air and waste-absorption services provided by nature.

The combined effects of these complex drivers of change are straining existing food supply systems and social security.

Analysts have linked the social unrest in South Africa’s informal settlements, the mining sector and among farm workers during recent years to the rise in global food prices. In 2009, more than half the food intake per capita in the country was from grains, of which 57% was maize and 32% was wheat. The mining riots in August 2012 coincided with record prices for maize and other basic food items. The xenophobic riots of 2008, which coincided with food riots around the world, were attributed to anger about foreigners competing for limited resources – arguably exacerbated by high food prices.
Some of the main drivers underpinning the complexities of the food system and the challenge of ensuring food security for the country are summarised in the following points:

1. South Africa’s population has grown by 25% between 2000 and 2013. Increasing affluence and urbanisation are changing the pattern of food consumption towards greater consumption of processed and high-protein foods, especially meat and dairy products, and putting pressure on existing food resources as fewer people have direct access to land for food gardens. Incidentally, estimates of road-freight emissions associated with different commodities in the country suggest that processed foods have the highest freight carbon footprint across road corridors in the country (see Figure 3).

2. Only 13% of land in the country is arable – i.e. suitable for crop production – and most of this has only low production potential. Only 3% is considered to be high-potential land.

3. Between 1973 and 2006 food prices went down. Producers responded by putting massive emphasis on technology to reduce the costs of production. In doing so they increased production and in the process technology moved from the public sector to the private sector. There is now increasing market concentration and trade in a handful of global companies that dominate in fertilisers and the 10 that control two-thirds of the seed market.

**FIGURE 2: CONSUMER PRICE INDEX FOR BREAD AND CEREALS IN SOUTH AFRICA SINCE 2002**

4. The rise of international food prices and the volatility of prices of agricultural commodities have affected food prices in South Africa. Between 2006 and 2008 average world prices for rice rose by 217%, wheat by 136%, maize (corn) by 125% and soya beans by 107%. The past decade has seen the longest sustained cyclical rise in real prices in 50 years. Although the price increases in the country were much lower than those in many other countries, prices still rose by between 25 and 39% of the rise in world food prices.

5. Despite having a relatively sophisticated agricultural sector that produces grains, vegetables, fruit and livestock, and exports agricultural produce for food, the country is an importer of much processed food. In recent years, South Africa has also imported agricultural products such as rice, sugar and poultry, which are part of the national food basket. A review of the country’s unprocessed and processed agricultural imports indicates that rice, sugar and poultry are among the top seven products imported in terms of quantity.

6. Expenditure on agriculture has declined in real terms. Funding for agricultural research and development (R&D) has failed to grow since 1992, investment has fluctuated since 1997, the intensity of investment has stagnated, and the country has lost a number of experienced scientists. In 2008, for every $100 of agricultural output, the country invested just over $2 in agricultural R&D, which is one of the lowest ratios reported since the 1980s. In general, agricultural expenditure levels have not kept up with the government’s 3% target.

7. A mere 3% of farms yield 99% of the country’s food, which is then distributed largely by the four retail chains (Pick n Pay, Shoprite, Spar and Woolworths), which together control 55% of the food retail industry. Any adverse impacts on these farms (and these distributors) could effectively jeopardise the country’s food security.

8. Climate variability is exacerbating the challenges for water, energy and food production. It is changing rainfall and temperature patterns, increasing atmospheric carbon dioxide levels, shrinking arable land and shifting available water supply. This may affect food systems in several ways: direct effects on crop production (through changes in yield; proliferation of weeds, plant diseases, and pests; and a shift in growing seasons); restrictions on the availability of irrigation water, and impacts on the supply chain infrastructure. The Citrus Growers’ Association of South Africa lists a volatile climate and the increased frequency and intensity of extreme weather events among the top five factors that will shape the citrus industry in the next five to 10 years. Potatoes SA echoes this concern and has initiated research into the impact of climate change on potato production in the country. The impact on agricultural production, animal husbandry and fisheries will be positive in some agricultural systems and regions, and negative in others, and these effects will vary over time.

9. While estimates of food security for the country vary, over 20% of the population – or more than 14 million South Africans – are estimated to be vulnerable to food insecurity. At the household level 20 – 50% of local households are considered food insecure depending on the methodology and indicators used. South Africa’s poorest citizens spend up to 80% of their income on food.

---

1 Research conducted by the University of the Western Cape’s Institute for Poverty Land and Agrarian Studies.
At a global, regional and local level, various factors can act in unison as potential “threat multipliers” that can create greater social, economic and environmental volatility:

- There is mounting competition for the country’s water resources, which are increasingly over-extracted and heavily polluted and associated with accelerating environmental degradation.
- Agricultural land is becoming scarcer due either to areas falling out of production as a result of failing land redistribution efforts or areas being lost to competing interests such as urban development and mining.
- Global factors are pushing up the cost of inputs such as fuel and fertilisers and, locally, of water and electricity.
- The depreciating rand and increasing imports of food are making the country vulnerable to international food-price inflation, high fuel prices and volatile commodity prices.
- The income distribution structure and disparity in food access between communities and households, coupled with a growing population, are increasing affluence and greater urbanisation.
- South Africa is a net importer of wheat and meat, which are staple food items in the country. This is worsening food security for the poor.
- Climate change is threatening to undermine agricultural production, human health, and human settlement and migration trends.
- Smallholder farmers and fishers are struggling and are under-capacitated.
- Food is wasted and lost throughout the supply chain.

FIGURE 3: PROCESSED FOODS SHARE IN ROAD FREIGHT EMISSIONS

Processed foods have the highest freight carbon footprint across road corridors in the country.

The links between energy and food systems in the FEW Nexus mean that energy supply and prices exert pressure on the ability of the agriculture sector to supply affordable food. The reasons can be found in agriculture's dependence on oil – the price of which has been highly volatile in recent years – electricity and fertilisers. Further impacts are due to the growth in bioenergy, which is being promoted as a way to increase energy security and support climate mitigation goals but is competing for key resources, notably land and water. Crude oil is also linked to agricultural commodities in the financial markets, so that the oil price drives movement of traded agricultural commodities. The availability and cost of energy is also critical for the country's water security. The often unconsidered cost of the economy's dependence on interbasin transfers, which require substantial amounts of energy, means that the country is already consuming large energy volumes to overcome its water scarcity challenge.

**Implications for food security**

... through pricing

A close look at the contribution of energy to food production costs shows that rising energy prices are affecting agriculture in several ways (see Figures 4 and 5). The primary agricultural sector consumes only 3% of the total electricity generated in the country and this consumption has risen by 3% per annum between 1999/2000 and 2010/11. But the annual electricity bill for the agriculture sector has increased by over 20% since 2009/10. At the same time, energy price hikes are increasing the cost of materials used in the food-manufacturing process.

There is limited transmission of rising energy prices at farm level into the retail prices of food. There is a great discrepancy between the price farmers get for their products and the eventual retail price because stakeholders along the agrifoods value chain add ever-increasing input costs. Farmers cannot easily pass on higher energy-related costs to consumers and have to absorb these costs themselves. Consequently, rising energy prices, coupled with the higher wages farmers are obliged to pay by law, are impacting the returns on investment (ROI) at farm level, putting considerable financial pressure on farmers.

The links between energy and food systems in the FEW Nexus mean that energy supply and prices exert pressure on the ability of the agriculture sector to supply affordable food. The reasons can be found in agriculture's dependence on oil – the price of which has been highly volatile in recent years – electricity and fertilisers. Further impacts are due to the growth in bioenergy, which is being promoted as a way to increase energy security and support climate mitigation goals but is competing for key resources, notably land and water. Crude oil is also linked to agricultural commodities in the financial markets, so that the oil price drives movement of traded agricultural commodities. The availability and cost of energy is also critical for the country's water security. The often unconsidered cost of the economy's dependence on interbasin transfers, which require substantial amounts of energy, means that the country is already consuming large energy volumes to overcome its water scarcity challenge.
FIGURE 4.1: ELECTRICITY PRICE INCREASE (%)

FIGURE 4.2: IMPACT OF ELECTRICITY PRICE HIKES ON THE AGRICULTURE SECTOR


FIGURE 5: ELECTRICITY AS % OF VARIABLE COST

The rising costs of energy also affect the cost of cooking and preparing food. Back-of-the-envelope computations indicate that if cooking a kilogram of maize meal requires 1.2 MJ of electrical energy, or 0.33 kWh, then cooking this meal daily using paraffin, and at the maximum permitted retail price of paraffin, adds an additional cost of about 20% to the price of maize meal. This suggests that the energy price could have a significant impact on the direct energy costs of food preparation.

Disposing of food waste also carries a cost. Energy resources used in food production, processing and transportation are wasted if the food ends up as waste (see Figure 6). An estimated 10 million tonnes of food is lost to waste in some form or another across the food supply chain every year, from an estimated 31 million tonnes of food available (produced within South Africa and imported). The ballpark cost of energy that is wasted through this food can be pegged at R1 billion. In addition, energy is required for the disposal of wasted food. In fact, the disposal of food waste in landfills represents a further waste of resources, because food waste could be used as a source of energy, as animal feed or to make compost.

**FIGURE 6: HOW MUCH DOES SOUTH AFRICA WASTE?**
... through competition for land and water

South Africa’s energy requirements are growing and could have serious potential impacts on water requirements in future. With 65% of electricity needs that will still be met by coal-powered power stations in 2030, the water requirements for electricity production in particular could be high. If the country faces a generation-capacity gap and consequently no existing plants (which are all coal-based) are
decommissioned, and flue gas desulphurisation (FGD) technology is implemented to reduce sulphur emissions of coal-powered plants, water requirements for electricity generation in 2030 could increase to 173.7 Mm³/annum. This will have serious implications for water-allocation trade-offs between energy and agriculture in the event of future water scarcity.

As it is, coal deposits in the country coincide with the best agricultural land and important water catchment areas. The continued dependence on coal for meeting electricity requirements will therefore directly conflict with food production and impact the quality of water resources.

New energy sources such as non-conventional oil and gas production through hydraulic fracturing, popularly known as fracking, and technologies such as carbon capture and storage (CCS), which can lower the carbon emissions of coal-fired power plants by 80–85%, are water intensive and will only add to the pressure on water resources. CCS could increase water consumption of power plants by between 46 and 90% depending on the technology of the plant. Similarly, fracking could use up to 5 million gallons of water (1 gallon = 3.78 litres) per well. The southern portion of the Karoo Basin, which is potentially favourable for shale gas, has fragile water supply systems and most farmers in the region – which provides much of South Africa lamb and mutton – are dependent on well points for their water supplies. Fracking could have the same devastating impacts on water resources as coal mining does, rendering already marginal farmland useless.

Concerns over competition for land and water also abound in view of the country’s biofuels strategy of a 2% penetration level of biofuels in the national liquid fuels pool. The strategy mandates the use of non-food crops: sugarcane and sugar beet for bioethanol, and sunflower, canola and soya beans for biodiesel. With the restriction on the use of food crops for biofuels, this policy, coupled with the conservative approach of the government in formulating associated policies to protect food systems and most farmers in the region – which provides much of South Africa lamb and mutton – are dependent on well points for their water supplies. Fracking could have the same devastating impacts on water resources as coal mining does, rendering already marginal farmland useless.

Concerns over competition for land and water also abound in view of the country’s biofuels strategy of a 2% penetration level of biofuels in the national liquid fuels pool. The strategy mandates the use of non-food crops: sugarcane and sugar beet for bioethanol, and sunflower, canola and soya beans for biodiesel. With the restriction on the use of food crops for biofuels, this policy, coupled with the conservative approach of the government in formulating associated policies to protect food systems, seeks to minimise the impact of biofuels on food prices and food availability. But the risks persist (see Box 3).

However, biofuels can play a complementary role to food and environmental systems. If bioenergy and food are handled as integrated systems that depend and complement each other, multiple benefits such as sustainable rural development, sustainable land use, and energy and food security for the poor through access to modern energy sources and increased food productivity are possible. An appreciation of the relationships and causal impact between biofuels and food systems is therefore necessary and these aspects need to be studied at national and local level.

**BOX 3:**

**Biofuels – threat or opportunity?**

The business-as-usual approach to the production of biofuels, popularly known as first-generation biofuels, is one of the most water-intensive ways to produce energy, and raises concerns about the increase in water stress in South Africa. While the government’s position of no water usage for producing biofuels under irrigation is positive, diverting 1.4% of the arable land to the production of energy crops, as suggested by the country’s biofuels strategy, is concerning in the context of food security. The use of “currently underutilised” land from the former homelands as suggested by the strategy is also problematic because this land is vital for the food security of local communities. Finally, there is nothing to prohibit farmers from substituting food crops with energy crops if the price for energy crops identified in the biofuels strategy increases.
The country’s impending water scarcity, the deepening water crisis in certain areas and the deteriorating water quality could mean that recycling waste water, desalination, interbasin water transfers, treatment of brackish water and decentralised water supply solutions such as rainwater tanks may become the norm to contribute to the available water supply. However, some of these processes or technologies could be energy intensive. For example, some estimates suggest that desalination could be 10 times more energy intensive than abstracting local water resources. Meeting higher water-quality requirements also often requires advanced treatment technologies to purify and treat waste water, but these processes are associated with high energy requirements.

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 across greater distances, and would intensify the competition between the energy and food sectors for the existing water resources.

Rising energy prices pose risks to food and water security in more ways than one. While the immediate challenge comes from the risks to food security and supply, more serious risks arise from the indirect impact on the agriculture sector:

- **Affordability of food and fuel to cook the food:** The rising cost of food, particularly for staple items like maize, poses the greatest threat to the poor, for whom food already contributes 30% of household spending.

- **Lower business viability and poor competitiveness of farming:** The agriculture sector will be hit on account of the many channels of energy inputs into food production. The resulting impact on the business viability and competitiveness of farming will not only affect investment in the agricultural sector and reduce productivity but will also hinder the agricultural sector’s ability to produce sufficient food in general and certain commodities in particular. The production of biofuels will add to these risks by way of price hikes and/or potential shortages in the supply of some food crops.
Understanding the challenges within the FEW Nexus

- **Adverse impact on livelihoods**: The agriculture sector remains important for local food security as well as the livelihoods of 8.5 million South Africans. Since electricity and fuel inputs have no substitutes, it is more likely that farmers, particularly large commercial farmers, will increase mechanisation, thereby substituting technology for labour. Mechanisation enables them to maintain productivity and efficiency, and manage higher wage costs. However, smallholder farmers, who are an important source of food security and livelihoods in rural areas, are unlikely to be able to invest in mechanisation or manage the pressure of lowered profitability.

- **Adverse impact on rural development and poverty alleviation**: Coupled with inadequate investment in the agricultural sector, this will have broader implications for rural development and poverty alleviation. Rural unemployment is already over 50%, and rising. Agriculture is labour intensive and can be four to six times more effective in reducing poverty than non-agricultural sectors. The risk of companies disinvesting from factory facilities in some areas due to a lack of water and/or energy uncertainties could exacerbate the impact of agricultural decline.

- **Difficulty of accessing new water resources**: With regard to water resources, rising electricity costs could either prohibit the feasibility of accessing new water resources that require pumping, desalination or filtration or involve serious trade-offs between water and energy security. This is because meeting increased energy demands in the current scenario of reliance on water-intensive coal-based electricity would pressurise already stressed water resources. The dependence of the water supply system on energy would also pose a risk to public health and safety if the energy infrastructure fails.

**FIGURE 7: TOTAL NUMBER OF SOUTH AFRICAN FARM WORKERS**

As the linking element across the scale of local, national and regional geography, as well as in energy and food provision, water sits at the centre of the FEW Nexus. In South Africa, fresh water is predicted to become the determining constraint on development. However, the challenge is not only an issue of water availability; it is, perhaps first and foremost, an issue of declining water quality. The quality of freshwater resources has been on a steady decline owing to increased pollution and 40% of the freshwater systems are now in a critical condition, while 80% are threatened. This means that the existing water resources are not able to effectively dilute pollutants, which leads to further deterioration in water quality. Inadequate investment in water-related infrastructure that would maintain water quality at sufficient levels has added to the poor water quality.

In most cases the South African economy is delinked from water, in that most industrial and tertiary sectors do not depend on large quantities of fresh water to manufacture goods or provide services. This is not the case in agriculture, however, which consumes 60% of all water abstracted in South Africa and contributes only about 3% to GDP. The energy sector, by contrast, uses only 2% of abstracted water but contributes about 15% to GDP. However, agriculture’s contribution to the economy must also be measured by the important role it plays in national (food) and social (jobs) security, and it has strong linkages with the manufacturing economy, so that the agro-industrial sector comprises about 12% of GDP (and accounts for 20% of manufacturing employment).

Energy is an engine of growth for any economy. The economic losses due to energy shortages in the recent past, estimated at R50 billion, are proof that the economy cannot do without reliable energy supply. A water scarcity will mean that increasingly water-allocation trade-offs will have to be made between agricultural production, energy generation, industrial development and urban residential consumption. What makes the trade-offs complex is that both energy and agriculture are among the sectors responsible for water pollution. In case of the agriculture sector, inappropriate water management and irrigation technology, and excessive use of fertilisers and pesticides that commonly run off from fields to adjacent rivers and lakes are responsible for contaminating groundwater sources. Water demand will intensify with population and economic growth in urban areas.

Implications for food security

... as a result of water availability

South Africa is a water-scarce country with 98% of available water already allocated. Given the level of water scarcity in the country, water-intensive energy production and an increase in agricultural production in response to growing demand and to support job creation, will challenge the existing balance. Water could be the critical limiting local resource for the sustained supply of both energy and food. The spectres of climate variability and changes in rainfall patterns add to the uncertainty, particularly for vulnerable farmers who lack the resilience to survive even short-term crises. These risks are exacerbated by changing consumption patterns and demographic pressures.

South Africa’s commercial agriculture production is heavily dependent on irrigation with only 12% of the land considered suitable for growing rain-fed crops and less than 3% considered truly fertile. Irrigation accounts for 90% of vegetable, fruit and wine production and 12% of the total area under wheat is irrigated. So, although only 1.5% of the land is under irrigation this currently accounts for 30% of the country’s crops. As there is limited arable land, the only feasible way to grow the agricultural
sector is through irrigation. The National Development Plan Vision 2030 proposes an increase of more than 50% of irrigated land. The Department of Water, on the other hand, estimates a 1.7% water shortfall in the country as early as 2025, which suggests that available water could be the single biggest impediment to this development goal. The misalignment between the targets set in the NDP’s Vision 2030 and the on-the-ground reality may stem from the fact that the NDP used outdated water figures in determining its job creation targets. The 1998 data used in the NDP suggests that water resources are already fully allocated. Nationwide this has yet to be verified – which illustrates the urgent need for targeted research – but water will place a constraint on agricultural growth unless we make significant strides in doing more with less.

... from water-demand management

In the food value chain, the largest proportion of water is embedded at the agricultural product stage as opposed to in the processing stage. Every product has embedded or virtual water, which represents the water embodied in the inputs required to produce the final product. The largest proportion of crop water and animal products is green water (rainfall), which is a full order of magnitude larger than blue water (irrigation) use. However, abstracted or blue water is associated with higher environmental and financial costs, such as water depletion, salinisation and soil degradation.

The production or farming stage requires significant quantities of water. For example, a litre of milk requires in the region of 1 000 litres of water before the product leaves the farm. Producing a single nectarine can require anything between 33 and 140 litres of water. A finished product like a loaf of wheat bread represents in the region of 1 600 litres of water in the supply chain.
The price for blue water in the agriculture sector is significantly lower than the full cost of supplying reliable, safe water. Of far greater concern is the amount of illegally abstracted water, water that has not been correctly permitted. In many cases poor water resource management is not due to the lack of adequate policies but rather to poor implementation and enforcement. Inadequate enforcement of the National Water Act means that South Africa’s already stressed resource is further compromised. It is expected that there will be a fuller cost recovery of the actual cost of water throughout the value chain in future. On the one hand this may have a marginally negative impact by driving up food prices, but on the other, and more importantly, it is an opportunity to drive better behaviour and improve the measurement and management of water resources. It may also have a positive knock-on effect towards better planning, as better measurements will make allocations more accurate. However, the combination of higher water and energy costs will negatively affect farmers and compound the challenges to the business viability of farming enterprises.

**Box 5:**

**Water pricing**

Free basic water is an important provision for the poor, ensuring their right to water. Many municipalities in South Africa use a stepped-tariff system for consumers with prices increasing as volumes increase, and this is an important component of demand management. However, bulk water prices paid by water authorities and user associations vary by orders of magnitude across the country. These prices do not reflect full cost recovery of the engineered infrastructure, treatment (including of waste water), maintenance and catchment care. A more integrated and internalised costing scheme is long overdue for South Africa, which includes incentives for demand management, adequate provision for catchment management and subsidies for the poor.

...from water quality

Declining water quality is a serious concern in South Africa. This could compromise not only the production of food that is safe for consumption domestically but also agricultural export markets. A pertinent example can already be found in the Western Cape, which accounts for 25% of the agricultural sector’s total gross income and more than 50% of the exported produce of the country. It has approximately 23 000 ha under irrigation, which produce a gross farm-gate value of approximately
The looming water scarcity in the country poses several risks for food and energy security. It remains unknown exactly what the future demand for water will be or what the full consequences of water shortages will be. The country has enjoyed 16 years of plenty and made few preparations for the inevitable droughts that are sub-Saharan Africa’s dominant climate risk. What is certain is that the overconsumption of water, water pollution, poor management and inadequate pricing of the resource results in massive loss of ecosystem benefits that sustain life and well-being.

- **Poor water management and lack of capacity at the individual and institutional level**: As the allocation and distribution pressure increases so the complexity of the management task escalates, requiring skilled individuals within functioning local government institutions. Some of the most significant and potentially catastrophic water-pollution sources, such as run-off from poorly serviced informal settlements and waste-water treatment plants, are directly within the sphere of local government service delivery responsibilities. However, in many areas South Africa lacks the functional institutions and local managerial capacity to address these problems. As a result, the management of water services and bulk infrastructure is left to a diminishing number of qualified civil engineers in local government. The result is that just continuing with business as usual is challenging enough without even venturing into the technical, financial and project management skills required to commission and implement the massive water infrastructure projects required.

“The annual embedded water lost in food that is never consumed equates to about 600 000 Olympic-sized swimming pools in South Africa alone.”

R1.3 billion. Altogether 75% of export crops from this region are destined for UK and European markets. During the 2004/2005 export season, the Western Cape agricultural sector came under threat due to salinity, nutrient enrichment and microbial pollution of the Berg River. With the water quality of the river not being within the European Union’s microbial standards for food production, overseas retailers threatened to cancel fruit imports. The potential loss of the export market by this region is estimated at anything between R190 million and R570 million. This has triggered action from municipalities and the provincial government to improve water quality in this catchment.

... from food waste and loss

A lot of water is wasted, not just from poor supply management, but also through embedded water in wasted food. About 1.6 million m$^3$ of water is extracted from ground- and surface-water bodies to produce the food that is subsequently wasted in South Africa (in 2012). That is approximately 600 000 Olympic-sized swimming pools, with embodied water valued from R260 million to well over R1 billion per annum. This indicates that around a fifth of South Africa’s total water withdrawals are used to produce food that is never consumed.

**Implications for energy security**

The country’s impending water scarcity poses a challenge for future power generation plans and electricity supply. The electricity supply is dependent on water-intensive coal-fired power stations, which account for 86% of generation capacity. Efforts are being made to transition to dry-cooled coal-powered power stations, which require 5 to 10% of the water relative to wet-cooled stations. Nevertheless, these power stations are still 100% dependent on water and there is a high codependency between water and electricity production. The effort to increase energy security by diversifying beyond coal and reducing greenhouse gas (GHG) emissions through renewable energy sources may be limited because of water quantity or quality constraints.
• **Declining water quality will threaten access to agricultural export markets:** Dangerous levels of water pollution has broader repercussions for the economy by way of a devastated local agricultural sector and thousands of job losses, and are driving up the cost of cleaning the water (the more polluted the water, the greater the effort required to clean it). Increased requirements for water purification would increase dependency on energy, but in turn water treatment costs will increase the cost of food production and intensify the challenges faced by farmers. The most vulnerable will be the small-scale farmers who will be unable to install water-filtration devices and will have no option but to draw from increasingly polluted sources.

• **Changes in rainfall patterns:** All farmers are at risk in drought or flooding but most vulnerable are subsistence or small-scale farmers where one poor season can permanently undermine their viability, with a significant negative impact for rural food security.

• **Insufficient water access for the agricultural sector:** Decreased water availability places at risk not only on supply for irrigation but for the whole agro-industrial sector, which contributes 12% to GDP through strong forward and backward linkages. To date, the issue of job creation has complicated the process of identifying a way to make optimal use of water resources. Both the NDP and the Industrial Policy Action Plan (IPAP) propose a substantial increase in agricultural activity, despite the fact that there may not be enough water for this expansion. Moreover, such an increase would also depend on the quality of the available water because if South Africa's produce no longer meets international food-quality standards, there will be no job creation in the agricultural sector. In fact, jobs will be lost if export markets are closed to South African farmers and foreign income is lost.

• **Freshwater availability constraints impact energy security:** Although water use in energy production is poorly understood, it is clear that the water risks in the energy sector are numerous. Unless fossil fuels-based energy is substituted for sustainable energy and the transition to a less carbon-intensive electricity sector is planned alongside the implications for water requirements, the country'simpending water scarcity will pose a challenge for future power-generation plans and electricity supply. Beyond decreasing water availability, which can affect thermal power plants, fuel extraction processes can be affected due to their large water requirements; increased water temperatures can prevent power plants from cooling properly and increase the risk of partial or full shutdowns of generation facilities; rising sea levels can impact coastal energy infrastructure, and water quality can impact energy operations if it is not managed adequately.

• **Policy and planning uncertainty:** Water and agricultural policies may shift and change, posing a potential risk to future food production, as opposed to energy production. Currently, the Department of Agriculture, Forestry and Fisheries (DAFF) appears to be less empowered than the Department of Energy in the policy-making departments involved directly with the FEW Nexus and the agricultural sector stands to lose the battle with the energy sector for access to water. This will make it more difficult to solve the challenges facing the agriculture sector.
CALL TO CONVERGENT ACTION

“If the necessary transformation is to occur, it must be based on sound science, accurate data and integrated, effective national policies and regulations that are consistently enforced.”

The Food Energy Water (FEW) Nexus is not so much about the resources themselves as it is about the relationship between them. Addressing the Nexus therefore requires a quantum shift in thinking. If we are to avert a crisis in natural resource management and ensure the national security of South Africa through the provision of clean water, electricity and nutritious food, it is important that we urgently identify the trade-offs and synergies at a local, national and regional scale and recast the governance approach. If the necessary transformation is to occur, it must be based on sound science, accurate data and integrated, effective national policies and regulations that are consistently enforced.

BOX 6:

The FEW Nexus in South Africa – What we know and what we need to know

<table>
<thead>
<tr>
<th>WHAT WE KNOW</th>
<th>WHAT WE NEED TO KNOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortage and price volatility in one resource can rapidly impact other resources.</td>
<td>There is no understanding of the impact on resource intensity, price and cost dynamics, and the broader implications for social welfare.</td>
</tr>
<tr>
<td>Water quality will become a serious constraint on food security.</td>
<td>There is little understanding of the extent of loss in food production and economic losses due to loss in exports.</td>
</tr>
<tr>
<td>Food production is most water and energy intense at the production stage.</td>
<td>There is insufficient comprehension of the full lifecycle use of energy and water for the vast majority of food that we consume.</td>
</tr>
<tr>
<td>Food production is susceptible to climate risk.</td>
<td>There is little understanding of the gains and losses specific to each farming system or crop type and each province.</td>
</tr>
<tr>
<td>Waste-water recycling, desalination and interbasin transfers will become the norm when dealing with increasing water scarcity and deteriorating water quality.</td>
<td>There is no recognition or comprehension of the energy use and costs associated with these options.</td>
</tr>
<tr>
<td>There will be increased competition for water and land between sectors.</td>
<td>There is limited appreciation of the possible need to transfer land and water out of agriculture, particularly for energy production.</td>
</tr>
<tr>
<td>Energy is a major element in the competitiveness and sustainability of the farming sector.</td>
<td>There is limited appreciation of the risks that need to be anticipated and the manner in which agricultural holdings can adapt to probable future energy scenarios.</td>
</tr>
</tbody>
</table>
Land ownership represents an important livelihood, food source and asset to the poor.

There is insufficient understanding of the role smallholder farmers play in national food security or how exposed these farms are to water and energy challenges.

There will be increasing reliance on South Africa’s northern neighbours for national food security.

There needs to be a better understanding of how best to conserve water through trade with countries with more fertile soil and greater rainfall. The concept of virtual water requires a broader definition of food security beyond national boundaries.

It is clear that further research is required to compile reliable information and data to support the following and ensure the judicious allocation and optimisation of resources:

1. **Regional perspective:** A better understanding of the food system in the southern African region as a whole is necessary to understand the pressure points and impacts of unsustainable natural resource usage. Allied to this would be a better understanding of farming returns on investment and profitability with clearly identified mitigation points and strategic investments required to secure local food production.

2. **Food-price inflation:** A food-price waterfall must be developed and the economics of food production and supply must be mapped to determine influences on pricing and potential points of intervention to manage food price inflation. This is not merely a theoretical exercise; practical examples of pricing development in the supply chain must be carefully explored.

3. **Food waste and loss:** Data on food waste and loss flows should be improved through research to gain an understanding of the scale of the food waste problem and its spread across the food supply chain. Although this information would be used primarily to manage and reduce waste, the current lack of data on waste flows is the most important factor restricting the use of food waste in energy applications.

4. **Water-risk data:** A central source of water risk data, including sources and entry points of pollution, is needed. This would also include a mechanism to rigorously monitor the quality of South Africa’s freshwater resources and enforce actions within a rapid response time to prevent and stop pollution.

5. **Energy–water–energy dynamic:** A better understanding is needed of the role of energy in the water value chain, including pumping, transportation, treatment, desalination and irrigation, and the role of water in the energy value chain, including thermoelectric cooling, flue desulphurisation at coal-fired plants, fuel extraction and refinement, to understand potential sources of increased demand and determine the water resources required to meet rising energy demands.

6. **Water footprints:** Understand the water footprint of different power-production technologies, including renewable power, and the implications for local water security. This is particularly important for shale gas (fracking) prospecting areas in the arid Karoo.
Factors influencing food prices are complex and fully solving the challenge of food inflation will require action on various issues at a global level. However, the following important domestic actions can be taken to build short- and long-term resilience to food inflation in South Africa.

1. Decouple agriculture from fossil fuel-derived energy, reduce its reliance on imports and mitigate negative impacts of input cost increases.

2. Increase investment by government and by the private sector to develop sustainable small-scale agriculture. This will create a more equitable source of food security and reduce production risks. Incentives should also be provided for initiating collaborative extension services at all farming levels and across departments. These incentives should be linked to the Department of Water Affairs.

3. Enhance investment in agricultural research and development (R&D) and the associated enabling environment (for example, education and infrastructure) to increase productivity. Investment is a long-term strategy and the benefits may take a long time to materialise, but it is widely recognised to be the most effective element to raise supply and reduce prices. Investment is also critical in increasing productivity and building physical and economic security. Further wide-ranging benefits include improving nutrition, stabilising food prices, increasing social development and reducing poverty.

---

**BOX 7: What business can do to address water risk**

Recasting business strategy to include a nexus approach will make it possible to manage the links between water, energy and food at a national level and will increase the resilience of the South African economy. There are numerous opportunities in which business can take the lead, starting with operations, moving into the supply chain and landscape, and ultimately transcending national boundaries to participate in global collaborative forums.

1. Implement operational efficiency, but go beyond mere ‘good housekeeping’ as the greatest opportunities to reduce water inefficiencies and waste lie beyond the factory walls, and can be purpose-designed to address the areas of greatest impact: the production and consumption stages of a given value chain.

2. Address supply-side management by assessing risk and the potential to improve efficiency and reduce waste in the supply chain. Understand where water risk lies and what the appropriate mitigation actions are by assessing farms and facilities on www.waterriskfilter.panda.org.

3. Address demand-side management through better merchandising and consumer messaging about reduced waste.

4. Collaborate at a local level, particularly where there is shared risk in a catchment area, to improve water management and reduce risk. Water stewardship offers a clear process for private-sector players to move beyond the farm fence and engage in catchment management. Form joint collaborative and water stewardship partnerships with catchment neighbours and local agencies (e.g. Catchment Management Agencies, Water User Authorities) to enable coordinated action to address shared risks.
5. Join a global dialogue – the UN CEO Water Mandate and the Alliance for Water Stewardship are two examples of collaborative initiatives aimed at strengthening water governance and stewardship.

6. Public-private collaborations will help to unlock the long-term investment required to promote agriculture R&D, build the necessary associated capacity and infrastructure, enable the shift to less water-intensive renewable energy sources, and develop the associated enabling environment.

The FEW Nexus presents the right opportunity to put in place systemic planning and policy making that could boost integrated resource management. Optimising integrated policy and planning will require, first and foremost, that the silos between the various disciplines in government are broken down. Cooperative governance and joint compliance and enforcement are required at three levels: national, provincial and at the local land-use planning level. At the same time, there is a need to be able to plan for resource management beyond government departments through a central authority such as the National Planning Commission. This will enable the systems thinking necessary for the following actions:

- **Address the FEW Nexus and efficient resource use:** Address the Nexus to ensure food security and equitable resource access. This can be done by developing supportive and sustainable agricultural policy through optimal land-use planning, linking food systems to ecosystems, defining the role of bioenergy in rural livelihoods, improving the waste-management policy, and devising an adequate water-quality strategy.

- **Collaborate:** Implement collaborative management forums and partnerships, and enhance the functions of existing agencies that form critical organisational hubs. Catchment Management Agencies (CMAs), which manage water licences and facilitate stakeholder engagement in important water catchments, are critical to enable better integration in South Africa's agricultural landscapes.

- **Regional approach:** Adopt a regional approach to identify constraints to and synergies in solving challenges in the FEW Nexus. South Africa needs to team up with its neighbours to overcome political challenges because a regional approach to energy, carbon management, food and water could provide long-lasting benefits.

- **Enforce policies and legislation:** Better enforce existing agriculture policies and, importantly, the National Water Act. Checking the decline of water quality also requires greater commitment to the ‘polluter pays’ principle when it comes to water pollution.

- **Plan energy and water systems:** Ensure that energy-production planning takes place together with planning for water resources and water quality.

- **Promote decision-analysis tools:** Promote political and socio-economic innovation through economic and resource-mapping tools to assess the trade-offs between competing sectors of the Nexus and to provide policy recommendations to mitigate potential negative impacts.

- **Promote renewable options:** Promote technology and innovation and provide incentives for water efficiency in the supply chain. Renewable energy technology is a less water-intensive grid energy source and small-scale renewable energy-generation mechanisms can be incentivised to improve adoption at a community, farm or household level.
• Address spatial dimensions: Address the spatial dimension of development. Unless this is done, the Nexus will continue to overwhelm resources and intensify resource insecurity.

**BOX 8: Benefits to be derived from a nexus-based approach**

The University of KwaZulu-Natal and the Bremen Overseas Research and Development Association (BORDA) collaborated in the design and construction of a decentralised waste-water treatment system (DEWATS) at the Newlands–Mashu Permaculture Learning Centre. The Durban-based eThekwini Municipality is using the resources provided by treated waste water to support urban agriculture, based on organic farming principles and low input costs. This project falls under the municipality’s Agro-ecology Programme. The DEWATS, which receives up to 40 m³ of domestic waste water per day from 85 households in the surrounding residential area, runs on gravity, thus requiring no energy inputs. The system also produces biogas, which is used in the community for cooking.

**BOX 9: WWF-SA’s current nexus-related research and policy work**

WWF-SA has recognised the need to invest in a full programme of work focused on the Nexus, and to integrate a nexus or systems approach into work in agriculture, water and energy. Some of the current work in this space includes:

- **The water risk filter**: a free, online tool that allows investors and companies from all industry sectors to assess and quantify water-related risks across the globe. The tool is currently being enhanced for application in South Africa by a detailed assessment of water demands in selected farming sectors and areas.

- **Alliance for Water Stewardship**: participate in developing water stewardship frameworks and mechanisms for collaborative action.

- **Coal and water futures**: research to detail the current costs and impacts of coal mining on water resources.

- **Sustainable agriculture**: better production management in key production sectors including sugar, wine, beef and dairy to ensure better resource management and reduced negative impact on biodiversity.

- **Renewable technology**: working across government departments to support the scaling up of renewable energy provision and develop a supporting policy environment and energy planning.

- **Food transportation**: catalysing action among key actors to reduce emissions from the freighting of food, the biggest cause of freight emissions in South Africa.

- **Food-waste research**: conducting research to better understand the causes of food waste and food loss in the supply chain.

- **Lifecycle analysis**: Value-chain impact assessment to understand environmental hotspots in food product value chains.
The FEW Nexus is not just about the potential crisis that the country would have to confront. It can, in fact, be used as an economic and environmental strategy that enables the principles of sustaining ecosystem services to guide the efficient and productive use of natural resources. The nexus approach will also equip the country to deal with complex challenges of resource scarcity and climate variability. For this to happen there is a need for targeted and collaborative research comprising the following elements:

- Developing an integrated decision-analysis tool to better understand how decisions are made and to analyse the associated implications to improve not only access to nexus-related information but also confidence and coordination in investment in productive landscapes.

- Exploring the role of the farm, from subsistence through to commercial scale, in managing nexus implications. This would specifically involve improving the efficiency of water and energy use at a farm level, decoupling production from fossil-fuel dependence, reducing food waste and loss, researching synergies and trade-offs between biofuels and food production, and exploring investment approaches to improve farming resilience.

- Exploring case studies or modelling to illustrate long-term resource use in different situations and regions, with the aim of influencing investment in long-term ecological infrastructure resilience.

- Defining sustainable pathways in the agro-food sector through supply chain analysis with a focus on water and energy efficiency and with a view to developing an integrated strategic approach to waste reduction in the value chain.

- Developing a set of plausible scenarios for the future of food over the next 20 years to inform government policies and an institutional strategy towards improving food security.
FUTURE VISION

It is possible to ensure that the natural resource pillars on which our society and economy rest – clean water, energy and electricity, and nutritious food – are sufficient for our needs even with rapidly growing global demand. It will take collaborative approaches, unique partnerships and new forms of dialogue. It will take more efficient production and consumption through the wider deployment of technology and informed, smart, sustainable thinking within the private and public sectors. It will require greater governance underpinned by an integrated approach to policy, planning, management and development and, critically, appropriate institutional capacity. But ultimately, it will require a shift in how we value the finite natural riches of our planet and a new approach to living sustainably within the boundaries of natural systems.
Glossary

Acid mine drainage (AMD): a pollutant resulting from mining activity characterised by low pH, elevated heavy metals, sulphate and total dissolved solids.1

Arable land: an agricultural term referring to land suitable for growing crops.

Blue water: irrigation water withdrawn from ground- or surface-water bodies that is used by the plant in evapotranspiration or incorporated into the product.2

Eutrophication: a symptom caused by nutrient enrichment of water bodies due to effluent from waste-water treatment plants and fertilisers that can stimulate bloom formation of toxic cyanobacteria in major irrigation impoundments.3

Food access: having the ability to access the available food, including the economic, legal, political and social capacity for obtaining such access.3

Food availability: the availability of sufficient quantities of food of adequate quality.2

Food security: refers to food availability, that is, the availability of sufficient quantities of food of adequate quality.2

Food stability: stability of supply and safety from risk.2

Food utilisation: the capacity to safely and effectively utilise food, which includes having an adequate diet to maintain good nutrition, and non-food elements such as access to clean water and sanitation.2

Food waste: includes both food losses and food waste, that is, it includes all food originally intended for human consumption that is ultimately never consumed.

Fracking: the process of fracturing rock by a pressurised liquid to extract natural gas from shale rock layers deep within the earth.

Green water: rainwater (soil water) used in evapotranspiration or incorporated into the product by non-irrigated agriculture.3

Interbasin water transfers: transporting water from areas of surplus to areas where it is in critically short supply.

Virtual water: embedded water or virtual water represents the water embodied in the inputs required to produce the final product.

Water quality: the level of pollutants – salinity, sedimentation, agricultural chemicals and urban/industrial effluent – contaminating water sources.

Water quantity: volume of available water. As a semi-arid and water-scarce country, South Africa is estimated to have only 1 000 m³ of water per capita, making it the 30th driest country in the world.1

Volatile: Frequent and uncertain sharp rises or falls in price of a security, commodity or general market, within a short-term period.

---


The Food, Energy Water Nexus is central to the sustainability of South Africa’s future. Unless all three elements of the system are in balance, communities cannot flourish. However, we are now faced with a system alarmingly out of balance, and the sustainable supply of water, food and energy is becoming ever less certain. Effectively averting a crisis requires enhanced information, coordinated planning and adaptation to a resource-scarce future. A flourishing economy underpinned by resilient ecosystems that can produce sufficient water, energy and food security for all into the future, depends on it.

### AUTHORS

Tatjana von Bormann, Manager: Market Transformation, WWF South Africa  
Manisha Gulati, Energy Economist, WWF South Africa

### ABOUT THIS REPORT

Food, water and energy security forms 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 South Africa.

This report is the final report on the Food Energy Water Nexus Study. It draws on the papers commissioned in this study, the interviews conducted as part of the research process and the insights received at the workshops organised for this 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

### SUMMARY REPORTS IN THIS STUDY

1. **Understanding the Food Water Energy Nexus: Through the food and energy lens:** Manisha Gulati  
2. **Understanding the Food Water Energy Nexus: Through the energy and water lens:** Manisha Gulati  
3. **Understanding the Food Water Energy Nexus: Through the water and food lens:** Tatjana von Bormann
ACKNOWLEDGEMENTS

This report was made possible with funding from the British High Commission and the guidance and expert reviews received from the staff of WWF South Africa, including Salim Fakir, Deon Nel, Christine Colvin and Inge Kotze. We are grateful to the experts who have authored papers in this study and provided valuable inputs from time to time into the other parts of this study. We also gratefully acknowledge Carolyn Cramer, Nicola Robins, Megan Sager, Marlene Rose, Glenda Younge, Adele Faasen, Deborah Weber, Eitan Prince, Onno Huyser and Laura Tyrer for their support on various elements of this project. Ellen Davies deserves special mention for shouldering the extensive administrative work related to the study.

Finally, we would like to thank the following people and organisations that provided invaluable insights or provided data that helped shape this study and this report:

Derek Bultitude, SASOL
Suzanne Carter, British Consulate General, Cape Town
Rohitesh Dhawan, KPMG
Rebecca Freeth, Reos Partners
Jon Hanks, Incite Sustainability
Inga Jacobs, Water Research Commission
André Jooste, Potatoes South Africa
Christo Joubert, National Agricultural Marketing Council
Milla McLachan, Stellenbosch University
Colleen Magner, Reos Partners
Dhesigen Naidoo, Water Research Commission
Mark New, University of Cape Town
Steve Nicholls, NBI
Nic Opperman, AGRI SA
Johan Pienaar, AGRI SA
Anesh Surendra, Eskom Holdings SOC Ltd
Nick Vink, Stellenbosch University & Bureau for Food and Agricultural Policy

ABOUT WWF

The World Wide Fund for Nature is one of the world’s largest and most respected independent conservation organisations, with almost six 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:

For further information please contact: Tatjana von Bormann at tvbormann@wwf.org.za or Manisha Gulati at mgulati@wwf.org.za
Why we are here

wwwf.org.za

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

wwf.org.za

50% of South Africans don’t have regular access to enough food

2% of land is truly arable

86% of our energy is generated by coal

25% of South Africans are unemployed

98% of available water has already been allocated

9% of households don’t have access to clean water

UNDERSTANDING SOUTH AFRICA’S MOST URGENT SUSTAINABILITY CHALLENGE