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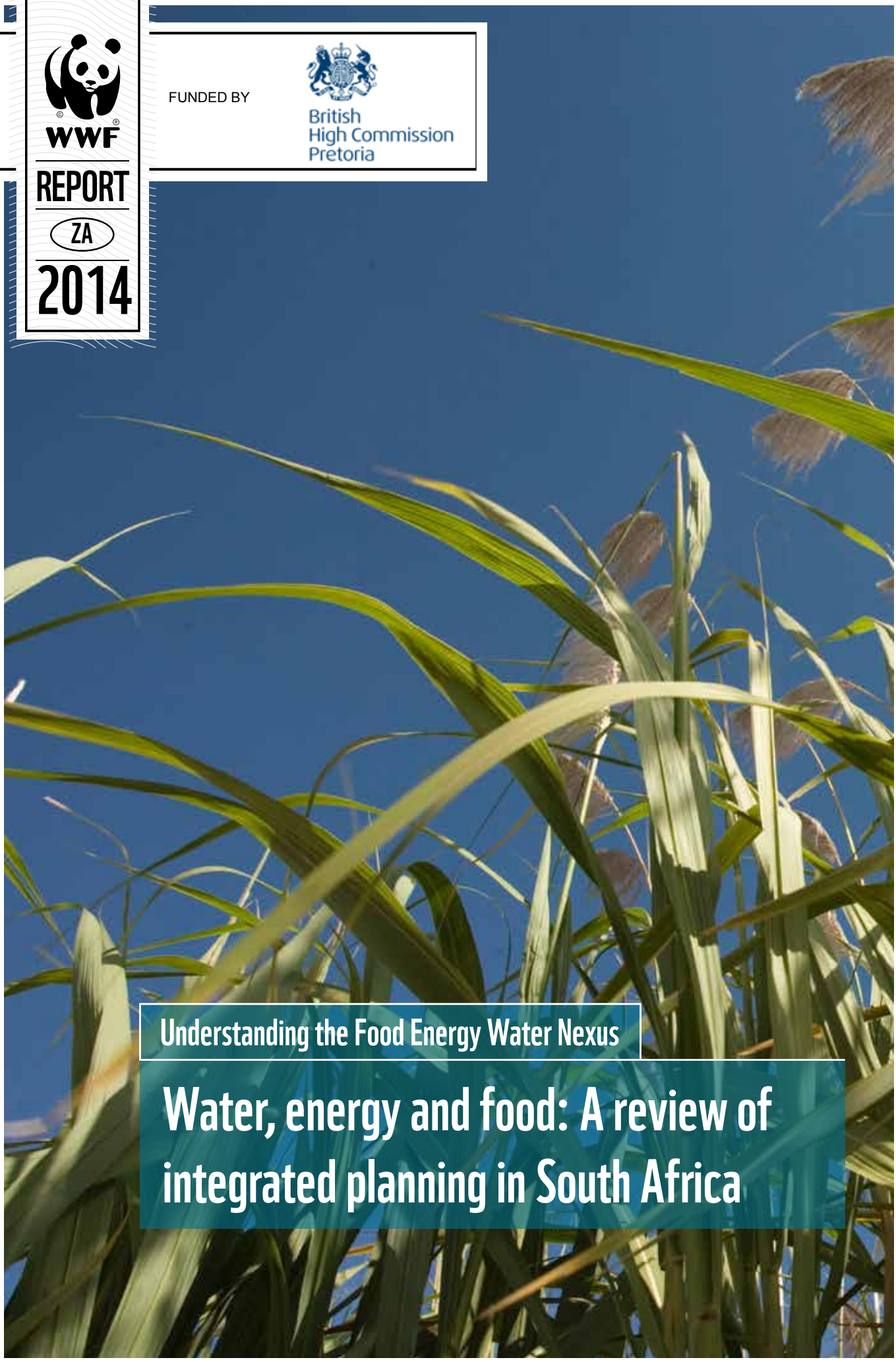

Understanding the Food Energy Water Nexus

Water, energy and food: A review of integrated planning in South Africa

AUTHORS

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ABOUT THIS STUDY

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

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

PAPERS IN THIS STUDY

1. *Climate change, the Food Energy Water Nexus and food security in South Africa:* Suzanne Carter and Manisha Gulati
2. *Developing an understanding of the energy implications of wasted food and waste disposal:* Philippa Notten, Tjasa Bole-Rentel and Natasha Rambaran
3. *Energy as an input in the food value chain:* Kyle Mason-Jones, Philippa Notten and Natasha Rambaran
4. *Food inflation and financial flows:* David Hampton and Kate Weinberg
5. *The importance of water quality to the food industry in South Africa:* Paul Oberholster and Anna-Maria Botha
6. *The agricultural sector as a biofuels producer in South Africa:* Alan Brent
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 organisations, with almost five million supporters and a global network active in over 100 countries. WWF's mission is to stop the degradation of the Earth's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

DISCLAIMER

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ABSTRACT

In this review we consider the alignment of planning and decision making by the South African government in the water, energy and food sectors in the context of climate change and South Africa's overall development challenge. The development challenge in South Africa revolves around how to grow the economy in a manner that creates jobs for a relatively poorly educated and unskilled workforce while improving livelihoods in marginalised rural areas and addressing issues of redistribution and equity within a context of abundant coal and solar energy resources, limited water resources and limited fertile land resources. This alignment is considered through the following:

- integrated planning
- coherent spatial and infrastructure development planning
- alignment of water, energy and agricultural sector planning
- institutional structuring for cooperation or coordinated decision-making
- economic and regulatory instruments
- trade, regional cooperation and foreign policy.

Integrated planning: Both the National Development Plan (NDP) and the Industrial Policy Action Plan (IPAP) call for a movement towards renewable energy that would reduce carbon emissions and be less water intensive. Furthermore, the proposed carbon tax also shows the government's intention as far as a less carbon-intensive economy is concerned. As concerns mining and shale gas exploration, the NDP is cautiously encouraging: though mining is mooted in the NDP–and this has water implications–the NDP calls for improved extraction methods that are less water-intensive. In turn, the NDP encourages exploratory drilling for recoverable coal and shale gas reserves while taking environmental concerns into account. As far as the Food Energy Water Nexus is concerned, both the NDP and IPAP propose a substantial increase in agricultural activity, despite the fact that there is not enough water available for such expansion. Therefore, at the highest level, a failure of coordination can be seen between the water and food sectors.

Infrastructure development planning: The proposed "unlocking of the northern mineral belt with Waterberg as the catalyst" poses some water challenges. The latest National Water Resources Strategy (NWRS) notes that developing the Waterberg coalfields will add additional stress to the water resources in that area, and that water will have to be brought in from other areas for proposed projects in the area.

Alignment of sectoral planning: Although water is acknowledged within the energy-planning scenarios and water use is reported, water is not properly considered in the context of full supply chain and quality impacts. The Department of Water Affairs (DWA) has gone as far as to recommend dry-cooling technology at new power plants, but it has not demanded a transition to relatively 'water-free' renewable energy technologies. In addition, while other energy initiatives like fracking and biofuels have taken into account water and food-related issues, the DWA notes that no water should be used for producing biofuels under irrigation and calls for caution as far as fracking is concerned. In general, there is a lot of discussion about moving towards renewable energy, although coal-fired power stations are still expected to play a large role in the future.

The food-water leg of the Nexus: There is a clear misalignment between agricultural planning and water planning, with agriculture seeking to increase the irrigated area substantially (for employment and rural development purposes).

Institutional structuring for integrated planning: The National Planning Commission (NPC) processes, the representation of different sectors within clusters to ensure coordinated decision-making, the interdepartmental task team processes for energy planning and the regular meetings between Eskom and the DWA (among others) all point to good structuring for integrated planning.

Regulatory instruments: The Environmental Impact Assessment (EIA) is meant to vet projects in the context of sustainable development. The process is however flawed, with a variety of concerns, including that many projects rely on employment creation as the reason for being socially justifiable. This points to the large unemployment and poverty challenges in South Africa driving decision-making processes.

Regional integration: Funding, institutional capacity challenges, the absence of harmonised policy and political hurdles all challenge regional integration. Though projects like the expansion of the Inga hydropower project in the DRC have been slow to materialise, there have been some positive movements including the signing of a treaty between South Africa and the DRC in 2013 which guarantees South Africa 2 500 MW of the 4 800 MW from the Inga 3 project.

In conclusion, South Africa has integrated development planning at national, provincial and municipal levels, and while there is reasonable vertical alignment between them, the strategic intent around water-energy-food scarcity is not necessarily coherent, nor is it horizontally as well translated into the sector-based plans that give effect to the integrated plans. Energy and water planning are relatively well aligned, but agricultural objectives are inconsistent with water and energy constraints.

KEY WORDS

Water resources, energy, food, policy, integrated planning

CONTENTS

1. INTRODUCTION

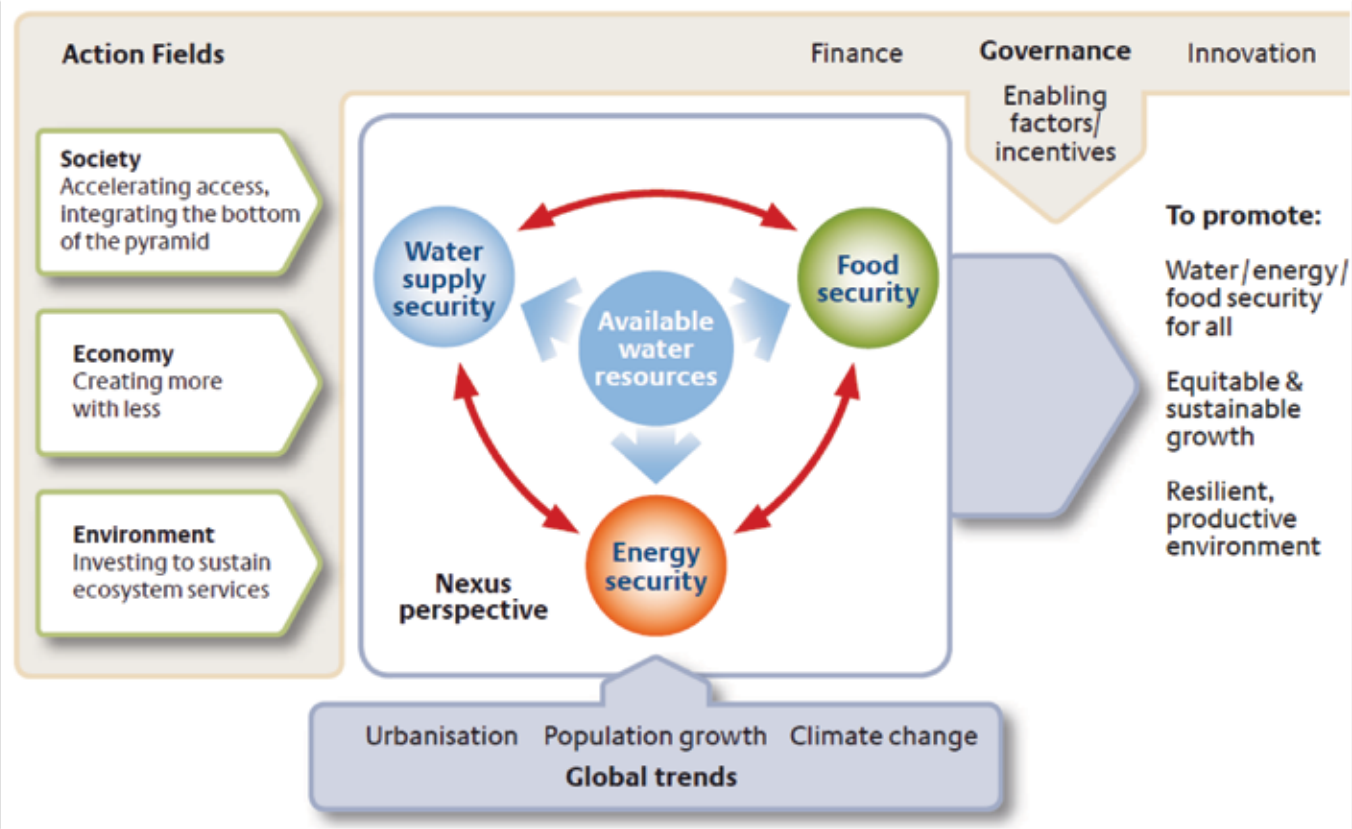
The physical scarcity of resources in South Africa means that there are significant trade-offs between food, energy and water. Water is the most significant resource constraint, since South Africa is a water-scarce country that experiences huge variations in temporal and spatial distribution of rainfall. At the same time, there is limited irrigable land and the electricity-generation sector is largely coal-fired and thus water-intensive. The energy sector is facing constraints due to water availability and international pressure regarding greenhouse gas emissions.

The concept of nexus thinking or the nexus approach is defined to be planning and management decisions that consider the interactions between these three systems (food, energy and water), in order to promote efficient, equitable and sustainable development. It has three key dimensions (Bonn):

- the social dimension: accelerating access, integrating the bottom of the pyramid
- the economic dimension: creating more with less
- the ecological dimension: investing to sustain ecosystem services.

It is interesting to note that water resources are often placed at the centre of the nexus, as shown below, due to the interaction with climate variability and the nature of water as the critical limiting local resource for energy generation and food production.

Figure 1: Food Energy Water Nexus



Source: SEI (2011)

The specific lens of this study is an analysis of the way in which the South African government aligns planning and institutional decision-making between and within the agricultural, energy and water sectors in the context of climate change. To be effective, nexus planning and decision-making needs to address the linkages between the agricultural, energy and water systems, considering the interconnections between the three domains.

This assessment thus analyses the degree to which the South African government's policy/plans and institutional/ decision mechanisms enable coherent and efficient conservation and use of land-energy-water resources to provide for food production, energy generation and water supply. This in turn supports the production of goods and services for domestic consumption or trade in order to achieve political (economic-social-ecological) imperatives while considering the natural indigenous abundance or limitations of these resources.

2. THE FOOD, ENERGY AND WATER SECTORS IN SOUTH AFRICA

2.1 WATER RESOURCES

With respect to the water supply, internationally, South Africa rates very low in terms of water availability per capita, and receives low rainfall by international standards–about 60% of the world's average. It also has one of the lowest ratios of mean annual precipitation (MAP) to mean annual run-off (MAR) in the world with only 9% of rainfall entering the rivers compared to a global average of 31% (Whitmore 1971). South Africa is described as a water-stressed country, with about 1 000 m^3 of water available per capita per annum.[1] This is supported by a highly developed water infrastructure, which enables the country to manage long periods of drought. South Africa has limited exploitable aquifers, and groundwater only makes up 13% of its supply. There is, however, potential for further use of groundwater, particularly as further research is done on groundwater availability.

South Africa shares four large river systems with its neighbouring states (Zimbabwe, Botswana, Mozambique, Swaziland, Lesotho and Namibia) and about 60% of the land surface of South Africa falls into these basins. International agreements, which are all in line with the Revised SADC Protocol on Shared Watercourses, exist in all of these basins, with basin commissions or committees in place to ensure effective liaison between the riparian states. South Africa's water policy gives international allocations of water the second highest priority, after water for basic human needs and ecological reserve.

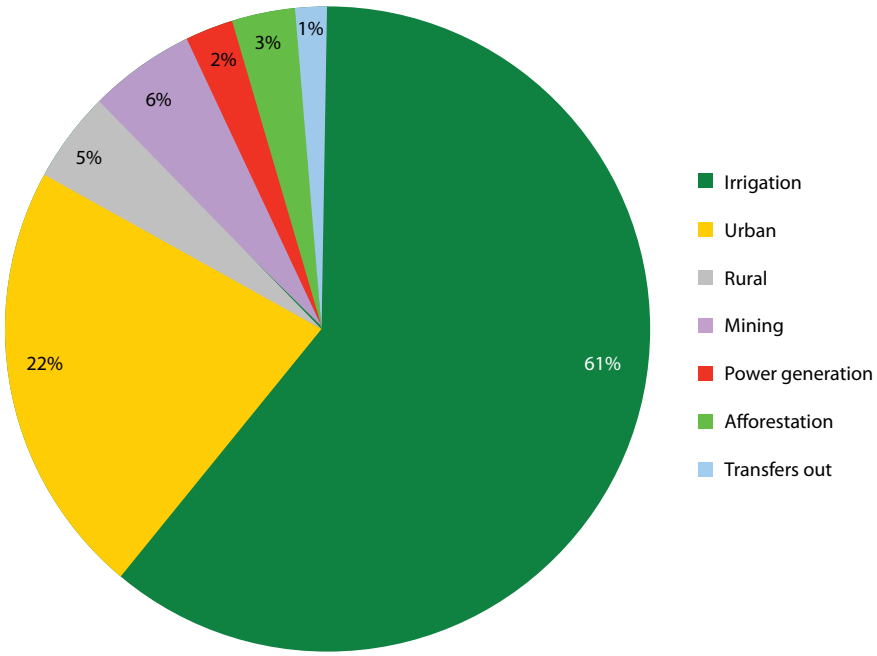
The presence of commodities such as gold, coal and diamonds has historically driven economic development in South Africa, with the result that urban development has not been aligned with the availability of water. The largest urban area around Johannesburg sits on the watershed of three catchments and is poorly endowed with water.

Under apartheid, the development of water resources infrastructure was largely aimed at the "white" economy, and to this day, access to raw water for productive purposes remains largely in the hands of the white minority. Thus, in addition to managing water scarcity and increasing water-quality problems, the South African government is faced with the massive challenge of reallocating water, or the benefits derived from water, to the poor black majority, to achieve the equity enshrined in the Constitution of South Africa, the White Paper on a National Water Policy for South Africa and the National Water Act 36 of 1998.

Current water demand across the country, illustrated in Figure 2, shows that (excluding water set aside for ecological flows) agriculture uses 61% of the water, urban households use 22% and mining and power generation use 6% and 2% respectively. Access to water services in South Africa is good, with the 2011 Census showing the number of households with no access to piped (tap) water at just 8.8%. Access to water for productive purposes, though, is highly skewed, with 95% of water used in agriculture being in the hands of white commercial farmers.

[1] http://www.unep.org/dewa/Portals/67/pdf/South_Africa.pdf

Figure 2: Current water demand in South Africa



Source: DWAF (2013)

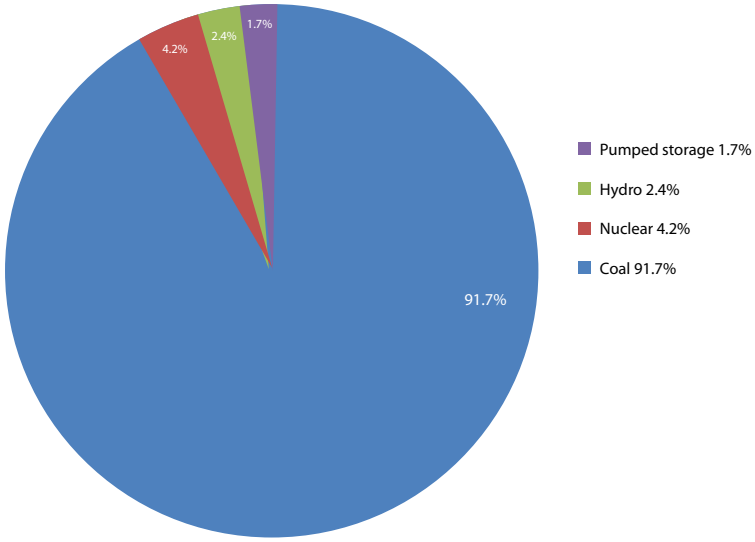
South Africa is experiencing water deficits, with deficits recorded in more than half of the 19 water management areas (WMA) (defined in the first National Water Resource Strategy (NWRS) across the country. Aside from deficits, South Africa also has a problem with water quality. Water reconciliation studies note that the main contributors to water-quality challenges are mining, including coal mining (acidity and increased metals content); urban development (salinity, nutrients, microbiological pollution); industry (chemicals, toxins); agriculture (sediment, nutrients, agrochemicals, salinity through irrigation return flows) and untreated or poorly treated waste water (DWAF 2013).

2.2 ENERGY

The Draft 2012 Integrated Energy Planning Report (DoE 2013a) indicates that primary energy supply in South Africa is dominated by coal (67%), followed by crude oil (20%). Nuclear, natural gas and renewable energy (including hydropower and biomass) play a smaller role in the total energy mix, collectively contributing the remaining 13%.

When considering electricity specifically, about 90% of electricity is generated from coal, followed by just less than 5% from nuclear energy. Other sources of electricity including hydropower, petroleum products (diesel), natural gas and other renewable energy sources (i.e. solar, wind, biomass, bagasse and landfill gas), which collectively contribute a very small proportion of the total installed capacity for electricity generation (DoE 2013a).

Figure 3: Electricity capacity generation by energy source



Source: DoE (2010)

Eskom (a parastatal power utility) generates 92% of South Africa's electricity and independent power producers (IPPs) generate 7%. The majority of South Africa's electricity is produced by Eskom's coal-fired electricity plants (as indicated in the Table 1). In addition, Eskom has two pumped storage plants. South Africa also imports hydro-electricity from the Cahora Bassa dam in Mozambique and there are other smaller coal, co-generation and pumped-storage plants that are not owned by Eskom.

The table below shows existing and committed future energy sources. Apart from hydropower, South Africa does not currently receive or generate electricity from other renewable energy sources, except where IPPs contribute electricity to Eskom's grid.

Table 1: Existing and committed Eskom power plants

Eskom Existing Plants	Capacity (GW)	Plant type	Remaining life	Year of decommissioning
Arnot	2.28	Coal	13	2023
Camden	1.52	Coal	15	2025
Duvha	3.45	Coal	22	2032
Grootvlei	0.752	Coal	19	2029
Hendrina	1.87	Coal	12	2022
Kendal	3.84	Coal	30	2040
Komati	0.202	Coal	14	2024
Kriel	2.85	Coal	18	2028
Lethabo	3.558	Coal	27	2037
Majuba	3.843	Coal	41	2051
Matimba	3.69	Coal	29	2039
Matla	3.45	Coal	21	2031
Tutuka	3.51	Coal	27	2037
Gariep	0.36	Hydro	15	2025
Van der Kloof	0.24	Hydro	17	2027
Arcacia	0.342	Diesel	21	2031
Ankerlig	1.323	Diesel	22	2032
Gourikwa	0.735	Diesel	22	2032

Eskom Existing	Capacity (GW)	Plant type	Remaining life	Year of decommissioning
Koeberg	1.8	Nuclear	37	2047
Drakensberg	1	Pumped Storage	21	2031
Palmiet	0.4	Pumped Storage	28	2038
Total	**41.015**			

Source: Eskom

Non-Eskom Existing Plant	Capacity (GW)	Plant type	Remaining life	Year of decommissioning
Coal	1.08	Coal	30	2040
Cahora Bassa	1.5	Hydro (imported)	23	2033
Other	0.5	Co-generation	30	2040
Steenbras	0.18	Pumped Storage	-	-
Total	**3.26**			

Eskom Committed Plant (GW)	Type	Projected life	Year of decommissioning
Medupi (4.332)	Coal	40	2052
Kusile (4.338)	Coal	40	2054
Ingula (1.332)	Pumped Storage	60	2073
Sere (0.1)	Wind	20	2032

Source: Eskom
Source: DoE (2012)

During the past few years the need to diversify primary energy sources and reduce over-reliance on fossil fuels for energy supply was recognised. According to the Draft IEPR 2012, both the need to reduce carbon emissions and advances in renewable energy sources are fuelling the reconsideration of energy supply. The Draft IEPR 2012 furthermore notes that "choices made in respect of energy, impact not only on the demand for energy, but also on the supply of feedstock and other resources such as water" (DoE 2013a).

Interestingly, as noted in the Draft IEPR 2012, Eskom has committed to two new large coal-fired plants, namely Medupi and Kusile, to deal with South Africa's pressing energy needs. The capacity of these two plants is expected to be higher than the capacity of all other coal-fired plants currently in existence in South Africa. Although not indicated in the Integrated Resource Plan (IRP) 2010–2030 and the Draft IEPR 2012, it was announced in late 2013 that in addition to the two new coal-fired plants, a third one named "Coal 3", will be built once Kusile and Medupi are completed.[2] Aside from coal-fired plants, Eskom has also committed to the Ingula pumped-storage plant and the Sere wind plant.

While electricity is currently mainly generated and distributed (on-grid) from Eskom's centralised power plants, the government recognises the potential for distributed generation technologies. Distributed generation is an off-grid solution using small wind, solar and micro-hydro generators of between 5 kW to 10 MW near the end-user to provide electricity. Many renewable energy solutions lend themselves to distributed generation. Small-scale generation has already been implemented in various provinces: over 2 000 clinics and 16 800 schools obtain their electricity from photovoltaic (PV) solar systems (DoE 2013a).

South Africa's main source of electricity–coal-fired power plants–has a significant impact on water, both through the use of significant amounts for cooling and through water pollution arising from coal mining. Acid mine drainage (AMD) from mines is an extensive and serious pollution issue in South Africa. It is estimated that Eskom uses 270 million m^3 of water per year for power generation, which is about 2% of the country's total water consumption.

[2] http://www.bdlive.co.za/business/energy/2013/08/23/third-new-coal-power-station-to-help-remove-energy-constraints

Current figures amount to 1.35 litres of water used to generate one kilowatt hour of electricity, but Eskom hopes to bring this down to 0.99 litres per kilowatt hour by 2030. Going forward, the Integrated Resource Plan 2010–2030 (IRP) for electricity generation provides for a diversified energy mix, although coal-powered energy production is still expected to play a large role. The IRP 2010–2030 is discussed in more detail below.

Aside from water use in the electricity-generation sector, Sasol, the huge coal-to-liquid-fuel company, is a large water user and is investigating the possible expansion of its plants. These plants require large quantities of water, and so their location will be related to accessible and adequate supplies of water.

Energy risk relates primarily to a comparison between peak demand and generation capacity, with shortages constraining economic growth. Although electrification in South Africa is generally good with an estimated 85% of households using electricity for lighting, according to the 2011 Census, South Africa has been experiencing electricity challenges due to the large demand for electricity and the disrepair of older coal-generation plants. In 2007/2008 South Africa experienced a series of rolling blackouts, which impacted heavily on the business sector in South Africa.

2.3 AGRICULTURE AND FOOD PRODUCTION

Due to the combination of climate and soil type in South Africa, only about 12% of the country is suitable for growing rain-fed crops while only about 3% of the land surface is considered truly fertile (WWF n.d.). As a result, most of the land is used for grazing and livestock farming, which is by far the largest agricultural sector in the country.[3]

Agricultural production in South Africa can be divided broadly into two categories: well-developed commercial farming and smaller-scale farming largely on communal land and predominantly in the former homeland areas. The average size of a commercial farm is about 2 500 ha. At the other end of the scale, 1.3 million small-scale farmers use about 14 million ha with an average farm size of just over 11 ha (Koch 2011).

The deregulation of agricultural markets and services and the withdrawal of state support to commercial farmers after 1994 resulted in an increase in large-scale intensive farming in high production areas and a shift from maize production to livestock production in marginal areas. Furthermore, there has been a shift from low-value/high-volume products for domestic consumption (wheat and milk) to high-value export products such as deciduous fruits, citrus and game (WWF n.d.).

Both wheat and maize production vary annually depending on rainfall, but average production has remained constant over time and wheat imports have increased hugely to meet demand. In 2011/12, 11.8 million tonnes of maize was produced. South Africa is also an important producer of fruit and citrus, more than half of which is exported. This is a growing area of the agricultural sector and brings in foreign exchange to the country.[4]

Most of South Africa's irrigable land (about 1.2% of land surface) is already cultivated with some irrigation already taking place in marginal lands. About 1.5% of land is under irrigation, and this area produces 30% of the crops (GCIS 2009). Irrigation can reduce soil fertility by contributing to salinisation, particularly in arid areas. It is estimated that about 26 000 ha of irrigated land in South Africa is affected by this problem (WWF n.d.).

Interestingly, production of maize and wheat has remained relatively constant, even though the area being farmed has decreased significantly in the last 20 years. This indicates that the intensity of production has increased significantly. Increasingly intensive farming has a range of impacts on the natural environment, including a reduction in long-term soil fertility, soil erosion, pollution of water supplies and climate change (WWF n.d.).

South Africa is a net food exporter in an average year. Agricultural exports made up 5% of the country's total exports in 2010, while agricultural imports were only 2% of total imports. While agriculture contributes a relatively small share of GDP, it brings in foreign exchange and is an important source of jobs in rural areas and in downstream value-add in the manufacturing value chain.

[3] http://awsassets.wwf.org.za/downloads/facts_brochure_mockup_04_b.pdf
[4] http://awsassets.wwf.org.za/downloads/facts_brochure_mockup_04_b.pdf

As agriculture is rural and labour-intensive it has played an important role in the South African economy. However, with farms becoming larger and more mechanised in South Africa, employment in the industry has been on the decline. While about 1.6 million people were employed in agriculture in 1971, by 2005 this number had dropped by about 1 million to 628 000 people (WWF n.d.).

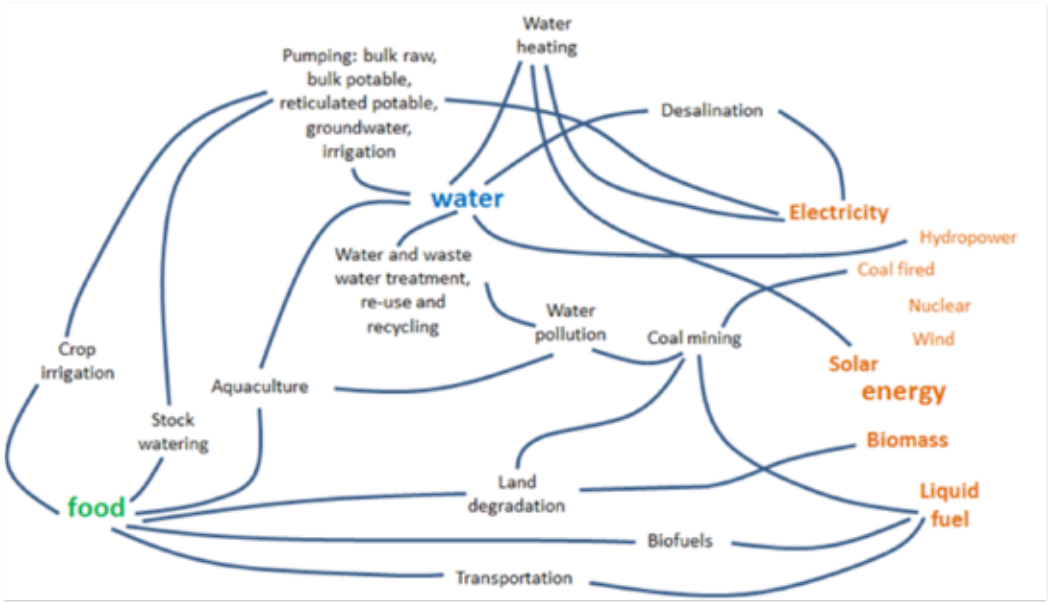
Irrigated agriculture is the biggest water user in South Africa, accounting for about 61% of national water use, as stated in the draft of the second edition of the National Water Resources Strategy (NWRS2). Climate change predictions for South Africa point to a change in the variability of rainfall, with rainfall expected to be more infrequent but also more intense. This is expected to lead to the shrinking of arable land as well as an increase in uncertainty and unpredictability, meaning that farming conditions will be challenging (WWF n.d.).

With a movement towards more intensive farming as well as the farming and irrigation of marginal areas, there has been pollution of ground and surface water, loss of biodiversity, loss of soil fertility, and erosion. The costs of these have largely not been factored into planning and decision-making in South Africa.

Food risk relates to the ability of the country to produce or import adequate basic foodstuffs to supply the consumption requirements related to the nutritional status of the population. About 20% of South Africa's population is food insecure. Inadequate access to food is particularly high in the North West province (32.9%) and the Northern Cape (29.7%). Households in Limpopo reported better access to food than any other province. Poor households that receive social grants are less likely to experience inadequate access to food. Households in urban areas with inadequate access to food are more likely to participate in agriculture than those with adequate access. But less than a quarter of households in South Africa are involved in agriculture. More than 84% of households that are engaged in agriculture do so to produce extra food for the household

2.4 SUMMARY

Figure 4: Key relationships between food, energy and water in South Africa



Source: Pegasys

Figure 4 outlines some of the key relationships between food, energy and water in South Africa. To summarise these relationships:

- *Water-dependency on energy:*
  - Pumping of water across watersheds, in municipal areas, for irrigation
  - Treatment of water and waste water
  - Heating of water for domestic and industrial purposes
- *Food-dependency on energy:*
  - Cultivation (pumping water, fuel for equipment and transportation, cold chain energy)
  - Processing and distribution
  - Cooking and food preparation at household level
- *Energy-dependency on water:*
  - Water for electricity generation, including coal-fired and hydropower
  - Water for fuel preparation, including coal washing and fracking
- *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*
  - Land and water degradation due to mining
- *Water impacts from energy generation*
  - Pollution from mining and fracking

With water being the scarcest commodity between the three elements of the Nexus, to a large extent it forms the fulcrum around which the other two pivot. Water resource-stressed countries like South Africa tend to have water challenges related to the production of food and energy, causing trade-offs in allocation.

3. THE CONTEXT OF SOUTH AFRICA'S DEVELOPMENT CHALLENGE: ALLOCATING, DEVELOPING AND PROTECTING SCARCE RESOURCES FOR GROWTH

South Africa has one of the highest wealth gaps between rich and poor in the world and suffers from immense unemployment and poverty challenges. Furthermore, there are serious geographical and space challenges, with poverty in underdeveloped and rural areas being particularly high. Thus the challenges of development in South Africa revolve around how to grow the economy in a manner that creates jobs for a relatively poorly educated and unskilled workforce while improving livelihoods in marginalised rural areas. At the same time, the critical issues of redistribution and equity must be addressed within a context of abundant coal and solar energy resources, limited water (and hydropower) resources, and limited fertile land resources.

Energy-rich but water-limited countries such as South Africa increasingly have to make water allocation trade-offs between agricultural production, energy generation and industrial development. Below we provide a summary of the challenges in each of the sectors.

Despite its large coal reserves, South Africa is facing energy constraints due to water availability in operating its coal-fired energy generation system, and international pressures regarding greenhouse gas emissions. South Africa does have options as far as renewable energy is concerned, most notably wind and solar power, and these are not water-intensive. Renewable energy options, however, are typically more expensive and need to be supported by a broader base-load energy mix. Furthermore, coal mining associated with coal-powered electricity production generates much-needed employment in the South African economy.

While agriculture typically provides the lowest economic return per drop of water, it is labour-intensive and supports rural development, both of which help to alleviate poverty in South Africa. The issue of national food self-sufficiency typically arises, often being equated to household food security, so these trade-offs have strong political overtones. Given the increasing water scarcity, the agricultural sector is constrained, though there are opportunities for desalination and the reuse of water. However, desalination is expensive and energy-intensive, making it less viable for extensive food cultivation, particularly in the context of an already stressed energy sector.

As far as water allocation is concerned, the need to provide water for sectors aligned to national imperatives of growth and job creation (mining, energy, industry, commercial agriculture) must be balanced with the need to protect water resources and provide for the previously disadvantaged in smaller-scale and subsistence farming activities, particularly in light of high unemployment.

In practice, development within a resource-constrained environment requires trade-offs in the timing of infrastructure development to achieve economic targets based on reliable water and energy supply, with access to affordable and reliable water, energy and food to the rapidly growing urban centres. Furthermore, decentralised developmental goals such as household food security and nutrition and access to safe water must also be factored in. While national development and sector infrastructure planning are adopted as the fundamental mechanism, the difficult national decisions are typically centred around the selection of a limited number of achievable priority resource development interventions with the greatest economic and social impact. Trade-offs in the allocation or management of water, energy and food resources, however, take place at a local or project level.

4. INTEGRATED NEXUS PLANNING: MECHANISMS FOR NEXUS ALIGNMENT

This section considers the mechanisms for nexus alignment in the South African context by looking at the following:

- integrated planning
- infrastructure and spatial development planning
- water, energy and agricultural sector planning
- institutional structures for coordinated planning and decision-making
- instruments for integrated planning
- trade, regional integration and foreign policy.

It is important to note that while energy and water are national competencies, the agricultural sector is market-driven, therefore government planning for developments on the ground, and the implementation of these decisions, takes place through provincial government. This is not necessarily well aligned with national planning.

4.1 INTEGRATED PLANNING

4.1.1 NATIONAL DEVELOPMENT PLAN (NDP)

South Africa recently set up a National Planning Commission (NPC) which is responsible for developing a long-term vision and strategic plan for South Africa. It does not, however, have direct authority over government departments, although the NDP is being taken as a guiding document for implementation by all government departments and the presidency is developing a plan for implementation of the NDP. After widespread consultation, the National Development Plan 2030 was published in 2012. The NDP promulgates a number of areas, including the following:

(a) An expansion of the mining and agricultural sectors

As far as expanding the mining sector is concerned, some of the proposals to boost the sector include:

- securing a reliable electricity supply and/or enabling firms to supply their own plants
- providing focused research to enable improved extraction methods that lengthen mine life, with better energy efficiency and less water intensity.

Some of the key proposals under agriculture and agroprocessing are as follows:

- a 50% increase in land under irrigation
- greater investment in providing innovative market linkages for small-scale farmers in communal and land-reform areas
- exploring innovative measures such as procurement from small-scale farmers to create local buffer stocks and community-owned emergency services.

(b) A focus on infrastructure, including energy and water infrastructure

As far as energy infrastructure is concerned, the NDP notes that when thinking about South Africa's future energy mix there is a need to:

- balance the need for a lower carbon-intensive power-generation mix with competitive prices and a reliable supply of electricity
- balance the need for a less energy and carbon-intensive economy with the need to take advantage of the country's mineral resources
- balance state ownership of energy enterprises with effective regulation and market reforms needed to stimulate competition and achieve greater private-sector involvement.

In the short term (the next five years), the NDP proposes a number of measures including investing in a new heavy-haul rail corridor to the Waterberg coalfields in Limpopo (the investment plan should address the additional water supply required); strengthening rail infrastructure in the central coal basin and the coal line to Richards Bay; exploratory drilling for recoverable coal and shale gas reserves while taking environmental implications into account; commissioning Eskom's Medupi coal power station and the Ingula pumped storage facility, and contracting at least 3 725 MW of renewable energy from the private sector.

As far as water infrastructure is concerned, the NDP notes several trade-offs including achieving a balance between water allocations for industrial and urban use and between agriculture and conservation, and advocates greater water-use efficiency in agriculture. The NDP also notes that in some rural areas (for example around the Sekhukhune District Municipality in Limpopo and Bushbuckridge local municipality in Mpumalanga), reliable water supplies can only be made available through large and costly distribution works. Decisions about such schemes must recognise that they are unlikely to be viable without substantial ongoing operating subsidies.

(c) A movement towards a less carbon-intensive energy sector

(d) Sustainable rural development

As far as sustainable rural development is concerned, the NDP notes that:

- as the primary economic activity in rural areas, the NDP sees agriculture as having the potential to create close to 1 million new jobs by 2030

- land reform is essential to unlock the potential for a dynamic, growing and employment-creating agricultural sector

- rural development requires better food security. Here, the NDP recommends that the national food security goal should be to maintain a positive trade balance and not to strive for food self-sufficiency in staple foods at all costs, though innovative measures such as procurement from small-scale farmers to create local buffer stocks could be explored. It further notes that food security should be linked to regional food security, government programmes like the Expanded Public Works Programme and the social grant system, and closing the urban-rural food price gap

4.1.2 INDUSTRIAL POLICY ACTION PLAN (IPAP)

Sectoral interventions in the IPAP that impact on the Food Energy Water Nexus include the following sectors: agroprocessing, biofuels and renewable energy, and energy-efficiency programmes. The agroprocessing sector has an impact on the water-food leg of the Nexus. In particular, some of the key constraints identified in the IPAP include the issuing of water licences and land tenure.

The biofuels sector has a bearing on the Food Energy Water Nexus as a whole. There have been several movements on the policy front in terms of biofuels. The impact of biofuels production on water resources was raised as an important concern during the consultation process. The then Department of Water Affairs and Forestry noted that much of the country is water-stressed and that there are severe limitations on the availability of additional water for allocation to new users. They noted that irrigated agriculture already uses about 60% of the total available resource, and crops for biofuels will have to find its water from existing allocations or compete for scarce new water. However, they noted that there was a move towards water allocation reform, and that biofuels feedstock production could take up water made available through this programme. They also noted the potential impacts of biofuels production on water quality (erosion and siltation, and fertiliser and pesticide run-off), and that best practice management for both land and water will have to be applied to all biofuels cropping, both irrigated and dryland (Biofuels Industrial Strategy 2007).

Despite these concerns, policy seems to favour an expansion of the biofuels industry. The Biofuels Mandatory Blending Regulations were gazetted in 2012 and requires mandatory blending of petrol and diesel with biofuels, even though the regulations have not come into effect. For example, the Department of Energy (DoE) has stated that (DoE 2013b):

> … even though the 2013 target will be missed, SA is expected to produce biofuels in excess of the originally set annual target when the overall enabling and supporting framework (mandatory blending regulations & pricing framework) takes effect. As much as the local biofuel industry is currently in its infancy stage, it does possess long-term growth potential.

The renewable energy and energy-efficiency programmes of the IPAP mainly relate to the water-energy nexus.

4.1.3 COMMENTARY

As far as the water-energy leg of the Nexus is concerned, the NDP encourages a movement towards a less carbon-intensive future through promoting renewable energies, and also calls for an interdepartmental process as far as integrated energy planning is concerned. In turn, the interventions of the IPAP highlight renewable energies and energy efficiencies.
This is encouraging since moving away from carbon-intensive energy production is in line with international movements towards reducing emissions, and–as far as the water sector is concerned–renewable energy typically requires less water.

The NDP also encourages an increase in mining activity, although the mining sector has challenged the water sector because mining activities, including coal mining, require water, and also because of the polluting effects of mining which is causing AMD problems in South Africa. However, the NDP notes that research is required to find improved extraction methods that are less water-intensive. The water-energy leg of the Nexus also comes into play as far as shale gas reserves are concerned; here the NDP encourages exploratory drilling for recoverable coal and shale gas reserves while taking environmental concerns into account.

As far as the food-water leg of the Nexus is concerned, both the NDP and the IPAP propose an increase in agricultural activity. The NDP sees the agricultural sector as having the potential to create one million new jobs by 2030 and to increase land under irrigation by 50%. Importantly, expanding the agricultural sector is seen as a mechanism to develop rural areas and create jobs, although it also notes that issues like land reform will have to be more adequately addressed in order to boost the sector. Interestingly, the NDP does not see the agricultural sector as the mechanism through which food security in South Africa should be achieved. Instead, it links food security to regional food security and government programmes such as the Expanded Public Works Programme. Aside from an increase in agricultural activity, one of the sectoral interventions of the IPAP is a promulgation of biofuels, and this impacts on the water, energy and food sectors.

The increase in agricultural production in the NDP and IPAP comes despite the fact that there is not enough water available for this expansion. Therefore, at the highest level, there is a failure of integration between food and water. Furthermore, biofuels production in South Africa, although having a lower carbon footprint than coal-powered energy generation, is not seen as feasible by the Department of Water Affairs (DWA) since the irrigation sector already accounts for a very large proportion of water use in South Africa, a country experiencing water scarcity. Comments in the NWRS are presented in section 4.3.1(a) below.

4.2 COHERENT SPATIAL AND INFRASTRUCTURE DEVELOPMENT PLANNING

The South African government adopted a national infrastructure plan in 2012. The National Infrastructure Plan identified 18 Strategic Integrated Projects (SIPs) comprising the following:

- 5 geographically focused SIPs
- 3 spatial SIPs
- 3 energy SIPs
- 3 social infrastructure SIPs
- 2 knowledge SIPs
- 1 regional integration SIP
- 1 water and sanitation SIP

The following SIPs impact on the Food Energy Water Nexus:

SIP 1: Unlocking the northern mineral belt with Waterberg as the catalyst. The first SIP envisages unlocking the mineral resources in the area. Even though there are large coal reserves, the Waterberg area is facing large challenges as far as water resources are concerned.

SIP 3: South-Eastern Node & Corridor Development. SIP 3 considers, among other things, a new dam at Mzimvubu, with irrigation systems.

SIP 8: Green Energy in Support of the South African Economy. SIP 8 covers support for green energy initiatives on a national scale as envisaged in the IRP 2010–2030 and support for biofuels production facilities.

SIP 9: Electricity Generation to Support Socio-Economic Development. SIP 9 covers accelerating the construction of new electricity-generation capacity in accordance with the IRP 2010–2030, and monitoring the implementation of major projects such as new power stations–Medupi, Kusile and Ingula.

SIP 11: Agrilogistics and rural infrastructure. SIP 11 deals with improving the investment in agricultural and rural infrastructure that supports expansion of production and employment, small-scale farming and rural development, including irrigation schemes to poor areas and expansion of agricultural colleges.

SIP 17: Regional integration for African cooperation and development. SIP 17 concerns participating in mutually beneficial infrastructure projects, e.g. electricity transmission in Mozambique could assist in providing cheap, clean power in the short term while Grand Inga in the DRC is a long-term option.

4.2.1 COMMENTARY

The most challenging SIP in terms of the Nexus is SIP 1. While unlocking the mineral belt may be good for economic growth, the Waterberg area is under stress as far as water resources are concerned: the National Water Resources Strategy (DWA 2013) notes that the Mokolo Dam is fully allocated, and although it can meet the current bulk needs, water will have to be brought in from other sources for the Medupi power station and other projects in the area. It further notes that developing the Waterberg coalfields will add additional stress to the water resources.

4.3 ALIGNMENT OF WATER, ENERGY AND AGRICULTURAL SECTOR PLANNING

4.3.1 WATER PLANS

(a) National Water Resource Strategy (NWRS)

The NWRS sets out the policies, strategies, guidelines and procedures for the management of water in the country. The second edition of the National Water Resources Strategy (NWRS2) (DWA 2013) for South Africa has just been completed and submitted to Cabinet for approval. It recognises the development challenge that South Africa faces in the context of water scarcity:

> South Africa's growing economy and social development is giving rise to growing demands for water. Water plays a central role in most of these national planning initiatives, such as agricultural development, energy security, tourism and recreation, mining, industry and municipal water supply.

Importantly, the NWRS2 recognises the pivotal role of water in the context of development together with the need to protect this resource. It lists the main objectives of the strategy as:

- water to support development and the elimination of poverty and inequality
- water to contribute to the economy and job creation
- to protect, use, develop, conserve, manage and control water sustainably and equitably.

Concerning agriculture, the NWRS2 notes that water is the major limiting factor in the growth of this sector. Poor water quality also has a negative impact on the sector. It notes that South Africa has set a target of an increase of more than 50% of irrigated land in South Africa, but that the Department of Water Affairs (DWA) assumes that water allocated for agriculture remains the same and that all land reform projects and revitalisation of smallholder irrigation schemes will use the same amount of water as before. This means that an increase in irrigation will have to come from greater water-use efficiency and there will only be a limited number of new developments, such as the envisaged new dam and irrigation systems at Mzimvubu.

According to the NWRS2, reconciliation studies show that additional water for irrigation in South Africa is very limited and–instead of allocating more water to agriculture–moving some water from irrigation to other uses must already be considered in certain areas. Furthermore, the studies show that irrigation development has been very slow since the NWRS1 due to the unavailability of cheap water. The NWRS2 makes a strong statement about potential new agriculture, noting that the reconciliation studies suggest that importing food from neighbouring countries with high food production should be broadened and explored, and that no water should be used to produce biofuels under irrigation.

The NWRS2 also speaks about allocating water for the land-reform and comprehensive rural-development programmes, noting that there is a critical need for integration of the water, land and agrarian reform programmes.

Concerning the mining sector, the NWRS2 notes that mining and related activities require significant amounts of water and have an impact on the environment, including AMD. Thus, the development of new mines in water-scarce areas requires planning. It further notes that there are new mining operations under way (coal and platinum), some of which are in water-scarce areas like Lephalale and the Steelpoort Valley, and that these would put more pressure on water resources. More generally it notes that groundwater pollution from AMD and poor sanitation is not being dealt with effectively.

With regard to the energy sector, the NWRS2 notes that this sector, including Eskom, is highly dependent on reliable supplies of water for the generation of electricity (steam generation and cooling processes). An elaborate and sophisticated network of water transfer and storage schemes has been developed to support the sector and ensure a high degree of reliability. It further notes that energy production is expected to increase. Current plans include dry-cooled, coal-fired power stations that will be more water efficient, but these stations are located in water-scarce areas and will strain available water resources. It notes that the NDP has proposed the use of renewable energy sources to mitigate emissions.

Hydropower generation, which is mentioned in the NDP and the IRP, also receives attention in the NWRS2, which notes that "hydropower is one of the renewable sources for generating electricity referred to in the Integrated Resource Plan 2010 (IRP 2010–2030) for developing South Africa's electricity generation to meet expected energy demands up to 2030".

As far as energy planning in the context of the water reality is concerned, the NWRS2 states that (DWA 2013):

> DWA will work with the DoE, Department of Public Enterprises and Eskom to ensure integration of medium-and long-term planning for the development of energy and water resources. Particular attention will be paid to the potential for desalination of seawater for supplying coastal towns and cities where there are sufficient sources of electricity to support this.

The NWRS2 considers a range of options to balance supply and demand. These include water conservation and demand management (WCWDM) and the desalination of seawater. However, desalination is an extremely energy-intensive process. As far as WCWDM in the irrigation sector is concerned, the NWRS2 notes that WCWDM needs to become entrenched in the sector and that the greatest impact can be achieved by addressing wastage from conveyance losses and the inefficient application of water. As far as water use within the energy sector is concerned, the NWRS2 notes:

- The energy sector is a relatively high water-consuming sector: implementing measures that will improve the overall efficiency of water use within the energy sector is critical.
- Eskom has committed itself to the installation of dry-cooled power stations that will drastically reduce the demand for water by these new power stations. The demand for water, however, would increase due to the measures selected to combat air pollution, as required by the National Environmental Management Act (NEMA): there is scope for research and development for alternative, less water-intensive technologies to be investigated by the power generation sector.
- There is scope for continuous improvement at existing power stations, e.g the implementation of hybrid dry-and wet-cooling systems which might require retrofitting of existing power stations to improve water efficiency. Measures such as those requiring retrofitting or even redesigning, however, would require careful planning.

In terms of future needs and associated impacts, the NWRS2 recognises trade-offs, noting that:

> South Africa's growing economy and social development is giving rise to growing demands for water. Given the limited water resources available, it is likely that it will not be easy or economically feasible to meet all the demands that may arise. In many parts of the country, we are fast approaching the point at which all our economically exploitable freshwater resources are utilised. New approaches will have to be adopted to balance demand and supply, particularly in the most-stressed inland catchments where much of South Africa's economic growth and social development are occurring. Meeting water demands is also important in rural areas to stimulate economic growth.

The NWRS2 notes that climate change in South Africa is likely to lead to a reduction of water availability, although impacts will be unevenly distributed, with the eastern coastal areas of the country becoming wetter. In the interior and the western parts of the country, climate change is likely to lead to more intense and prolonged periods of drought. In general, climate change will probably lead to weather events that are more intense and variable, such as sudden high volumes of rainfall, leading to flooding.

The NWRS2 advocates raising the water profile in development planning, and notes, for example:

- that water must be placed at the centre of integrated planning and decision-making
- that the real value of water should be reflected, taking into account that water is a scarce resource
- that water efficiency and curbing water losses should be high on the agenda of institutions
- that water management must be formally embedded in sector businesses.

(b) Water for Growth and Development (WGD): Version 7

Water for Growth and Development (WGD) (DWAF 2009) is a framework to guide actions and decisions that will ensure water security in terms of quantity and quality to support South Africa's requirements for economic growth and social development. The WGD notes that while it is recognised that a sufficient supply of water is a requirement for the country to achieve its economic growth targets, the provision of potable water to every person in South Africa is also a fundamental developmental goal. Both these goals must be achieved without compromising the ecological sustainability of water resources.

In terms of energy, the WGD notes that the Vaal River system supplies Eskom's large coal-fired power plants and Sasol's large coal-to-liquid plants, but that the scarcity of water has forced Eskom to build dry-cooled power plants. This decision has increased the cost of building and operating power stations. Like the NWRS, the WGD reiterates that the new coal plants in the Waterberg coalfields near Lephalale cannot be supplied through the Mokolo Dam since it does not have an adequate supply of water.

Regarding agriculture and irrigation, the WGD notes that the Irrigation Development Strategy proposes additional irrigation through water-loss savings and improved irrigation efficiency. It also anticipates the improvement of irrigation methods such as drip irrigation and, where possible, the conversion to appropriate crops and livestock. Importantly then, as seen through the NWRS and WGD, agricultural expansion cannot rely on additional water allocations.

The WGD talks about the issue of water quality as it relates to the Food Energy Water Nexus, and touches on both AMD and land-use practices. It notes that AMD poses a threat to water quality, and that various studies predict that AMD will entirely decant into the central basin within three and a half years. This situation threatens the environment and the structural integrity of the Johannesburg City Centre. As far as land-use practices are concerned, it notes that the use of inappropriate agricultural practices have an impact on water security. The need to rehabilitate degraded land, which benefits water, erosion, siltation and carbon sequestration, is pivotal for water, growth and development.

Concerning WCWDM, the WGD notes that the potential for water saving by implementing the latest technologies has been investigated based on theoretical irrigation application efficiency values, and shows that a 2% improvement in each of the six selected schemes in the Vaal would provide a saving of 7.3 million m^3/yr, which can be reallocated for other uses. There is, however, little incentive at present for farmers to implement more efficient irrigation systems; such incentives should be investigated.

The WGD notes that the department wishes to see several improvements with regard to the use of water by irrigated agriculture, including the following:

- The improvement of water management through water supply management, and irrigation management, to effect water-use efficiency.
- The enhanced use of 70 000 ha of underutilised irrigable land situated within government schemes and which has received water allocations.
- The revival of food plots within the former homeland irrigation schemes, as these are believed to be vital for community and household food security.
- Ensuring the sustainability and proper management of irrigation development, the department recommends that the Department of Agriculture, as the lead department, develop guidelines on all aspects of irrigation planning, development and management.

The WGD notes too that there is a need to strengthen sector-wide partnerships. The high-level recommendations from the WGD include the following:

- Mainstreaming water: placing water at the centre of all planning decisions in the country.
- Reducing the dependence on surface water, accompanied by an increase in the use of groundwater, and a significant increase in return flows through the treatment of urban and mining effluent.
- Promoting water conservation and water demand management.
- Promoting and maintaining water quality.
- Water for Development–addressing service backlogs.
- Water for Growth–changing water-use behaviour for the future. Two sets of behaviour need to be addressed, namely unlawful and damaging extraction from and pollution of the Vaal River system by commercial users, and the extent of water-use inefficiencies by commercial irrigation agriculture.

4.3.2 ENERGY PLANS

The Integrated Resource Plan (IRP) 2010–2030 shows the intent of government to diversify South Africa's energy mix away from fossil fuels. The IRP is a living plan that is expected to be continuously revised and updated when necessary.

The policy-adjusted IRP 2010–2030 shows that although the reliance on fuel is expected to be lowered by 2030, about 46% of total capacity will still be from coal-fired power stations. Nuclear power is expected to increase to 12.7%, while wind power is expected to increase to 10.3%. For the IRP 2010–2030 plans to be realised, there has to be a substantial increase in nuclear, coal-fired, wind and photovoltaic (PV) power, with smaller increases in gas-turbine, hydro-and concentrating solar power (CSP).

Table 2: Policy-adjusted IRP capacity, 2010-2030

	Total capacity		Capacity added (incl. committed)		New (uncommitted) capacity options	
	MW	%	MW	%	MW	%
COAL	41 071	45.9	16.383	29.0	6 250	14.7
Open cycle gas turbine (OCGT)	7 330	8.2	4930	8.7	3910	9.2
Closed cycle gas turbine (CCGT)	2 370	2.6	2 370	4.2	2 370	5.6
Pumped Storage	2 912	3.3	1 332	2.4	0	0.0
Nuclear	11 400	12.7	9 600	17.0	9 600	22.6
Hydro	4 759	5.3	2 659	4.7	2 609	6.1
Wind	9 200	10.3	9 200	16.3	8 400	19.7
Concentrating solar power (CSP)	1 200	1.3	1 200	2.1	1 000	2.4
Photovoltaic (PV)	8 400	9.4	8 400	14.9	8 400	19.7
Other	890	1.0	465	0.8	0	0.0
Total	**89 532**		**56 539**		**42 593**	

Source: DoE (2011)

Note: Committed generation capacity includes projects approved prior to IRP 2010

Historically, concerns about renewable energy and the increased diversity of energy supply has primarily focused on increased imports of hydro-electricity from within the Southern African Power Pool (SAPP). The major challenge to these imports is that they depend largely upon political stability in the host country. Eskom has identified several opportunities for regional imports. The IRP 2010–2030 makes provision for including a potential 3.349 MW of imported hydropower and the opportunities significantly exceed this volume. Regional intergration is considered in further detail in 4.5.4 below.

Locally in South Africa, gas resources (specifically shale gas and coal-bed methane) have recently been estimated in the southern Karoo Basin, although further exploration is required to determine the extent of the recoverable resource. There are however environmental risks associated with extracting "tight" gas such as shale since the process (hydraulic fracturing) requires large amounts of water, and the Karoo is a particularly water-scarce area. There are also environmental concerns of possible contamination of groundwater as a result of the improper disposal of fluids during the hydraulic fracturing process (DoE 2013a). In light of concerns, the Department of Mineral Resources previously placed a moratorium on the granting of licences for the exploration of shale gas[5] but in 2012, the moratorium on shale gas exploration was lifted. Companies requiring permits for shale gas exploration will be required to apply for a water-use licence.[6] A number of companies have already done so. The Department of Water Affairs has noted that government "will take every precaution to ensure that the possible impact of fracking on our water resources is carefully managed and minimised"[7] and an interdepartmental task team has been established to deal with issues related to fracking.

4.3.3 AGRICULTURE PLANS

The Strategic Plan 2012/13–2016/17 of the Department of Agriculture, Forestry and Fisheries highlights six strategic goals (SGs) for the medium term. Some of the strategies and substrategies are shown below:

- SG1: Increased profitable production of food, fibre and timber products
  - Promote efficient production, handling and processing of food, fibre and timber.
  - Coordinate government food security initiative.
  - Improve production systems of commodities with comparative advantage in each province.
  - Provide comprehensive rural development support.
- SG2: Sustained management of natural resources
- SG4: A transformed and united sector
  - Increase equity, ownership and participation of PDIs.
- SG5: Increased contribution of the sector to economic growth and development
  - Increase growth, income and sustainable opportunities in the value chain
  - Increase the level of public and private investment in the sector
  - Increase market access for South African products
  - Increase production of feedstock for the manufacturing sector.

The Strategic Plan notes a number of obstacles to increased agricultural production: with climate change, yields are expected to decrease, impacting on food security. Furthermore, the sector is also facing serious competition for the use of land and water while the rising input costs globally and domestically seriously threaten the sustainability of the sector. It notes that further substantial investments in productivity enhancement are needed to ensure that the sector meets the rising demands of the future, and that there is a need for high-value addition of agricultural produce to make farming economically viable while supplying good-quality and healthy food at affordable prices. As part of the agrarian reform programme of the sector, the Food Security Programme will be implemented to support the Zero Hunger Programme.[8]

[5] http://www.engineeringnews.co.za/article/fracking-to-require-water-use-licence-molewa-2013-09-03
[6] http://www.engineeringnews.co.za/article/fracking-to-require-water-use-licence-molewa-2013-09-03
[7] The Zero Hunger Programme aims to empower subsistence producers to start generating sustainable income through farming, and thereby become smallholder producers.
[8] The Zero Hunger Programme aims to empower subsistence producers to start generating sustainable income through farming, and thereby become smallholder producers

The vision of the Comprehensive Rural Development Plan (CRDP) of 2009 is to create vibrant, equitable and sustainable rural communities; a three-pronged strategy has been suggested, consisting of:

- agrarian transformation
- strategically increased rural development
- land reform.

As far as agrarian transformation is concerned, the CRDP suggests livestock farming and cropping and related value-chain developments. Stimulating food production in rural areas will be undertaken with a view to, among other things, improve food security.

As far as rural development is concerned, the CRDP recognises that there have been major shortcomings in the delivery of infrastructure services to rural areas. It places emphasis on the development of new, and the rehabilitation of existing infrastructure in, among other areas, dipping tanks, rural electrification, irrigation schemes for small-scale farmers and water harvesting/water basin and watershed management systems (Department of Rural Development and Land Reform 2009).

South Africa is also a signatory to the Comprehensive Africa Agriculture Development Programme (CAAPD) which recognises the need to strengthen agricultural research and innovation, supports results-based agricultural research for development and recognises the need to enhance public-private partnerships in order to improve market and value-chain cooperation and procurement for small-holder producers and traders (Department of Performance Monitoring and Evaluation 2012).

Land reform is recognised as pivotal for rural development. The Land Reform Policy Discussion Document notes that "if the tenure and access to land issues are addressed, the ability of the poor to engage meaningfully as active economic citizens becomes improved", and therefore "the implementation of the land reform will be driven within the CRDP Strategic Framework".

The CRDP sees the departments of Agriculture, Forestry and Fisheries (DAFF) and Water and Environmental Affairs (DWA), among a host of others, as critical stakeholders. The CRDP notes the provincial focus of rural development. While it sees the Minister of Rural Development and Land Reform as the national political champion of the CRDP, it also notes that provinces and local and district municipalities are key to achieving the aims of the CRDP. This touches on the difficulty as concerns planning within the food/agriculture environment. Since the food and agriculture sector is market-driven, government planning of water resources and energy at national level is much more difficult, and planning and implementation often occur at provincial and municipal level.

While water is mentioned throughout the CRDP, as far as the water-food leg of the Nexus is concerned, the CRDP does not engage with where impoverished rural populations live and what the water implications in these areas are. This is particularly important, since food (and livestock) farming is seen as one of the central tenets on which rural development is based.

The Land Reform Policy Discussion Document of 2012 notes that land reform in South Africa is intimately linked to rural development and agriculture (and is thus located within the CRDP). It further notes that the coordination of agricultural support services between departments responsible for land-reform and others–such as Agriculture, Water and Economic Development–and of related infrastructure support will be strengthened. The document envisages that the CRDP will be used to deepen support to land-reform products and beneficiaries to enable implementation of an encompassing and nationally coordinated plan.

The document also notes that sustainable land reform is a key strategy in achieving national food security. The government has thus specifically established a unit to ensure that land reform is sustainable and strategically placed to ensure national food security. To respond to the challenges of collapsing land-reform projects and defunct irrigation schemes in the former homelands, the department has introduced two strategic interventions: strategic land acquisition and the recapitalisation development programme. The objectives of these interventions are to increase production; acquire strategically located land and land above the prescribed ceiling in a given district; guarantee food security; graduate small farmers into commercial farmers, and create employment opportunities within the agricultural sector.

The Land Reform Policy Discussion Document notes that it seeks to integrate the land reform projects within the Integrated Development Plans (IDP) and Spatial Development Frameworks (SDF) of municipalities.

Since food/agricultural decisions largely happen at a more disaggregated level, it is instructive to look, for instance, at Provincial Growth and Development Strategies and Integrated Development Plans (IDP) at the municipal level. The 2012–2013 IDP for the Waterberg District Municipality, discussed here, notes that the Waterberg district is one of the major mining regions within South Africa (platinum, iron ore, coal and diamonds) and that the fertile soil in this area has led to a competitive advantage in agriculture. The Waterberg district contributes almost 30% of the agricultural activity in the Limpopo province, contributes over 4% of the district gross geographic product (GGP) and employs about 21% of the labour force. The district is, however, classified as semi-arid with poor water resources and little cropping takes place without irrigation. Cropping in the area has been affected by low international prices and overproduction, and plantings have been reduced markedly with significant employment implications.

The water challenge in the district is the inadequate supply of water to cater for communities and investment initiatives. The IDP notes that the municipalities of Lephalale and Mokgalakwena have limited water sources to cater for both communities and mining industries, and that the expansion of coal mining, energy and petrochemical developments in Lephalale requires expansion of water infrastructure to cater for these developments.

The Waterberg presents a classic case of the interplay of water, energy and food. While coal mining in the Waterberg could help boost coal-fired power generation, the fertile soil makes the area good for farming as well. However, water is a constraining factor for both energy and food production in the area. The Waterberg IDP notes that with the demand on water resources consistently increasing in the area, crop farmers will have to examine their returns on the use of water in the future (Waterberg District Municipality, 2012/13 Integrated Development Plan (IDP); ANC 2012).

4.3.4 COMMENTARY

As far as the water-energy leg of the Nexus is concerned, although water is acknowledged within the energy planning scenarios and water use is reported, water is not given sufficient focus. The IRP 2010–2030 and Draft 2012 Integrated Energy Planning Report model water-use for different future energy scenarios, but water is not properly considered in the context of full supply-chain and quality impacts. The DWA's water planning goes further in establishing the links between energy production and water need and impacts, with for example the WGD dwelling quite extensively on the AMD problem. However, because electricity is seen as a high-value economic use of water, the allocation of water to Eskom's power stations is considered as being of strategic importance and is an unquestionable priority. The DWA has gone as far as recommending dry-cooling technology at new power plants but has not demanded a transition to relatively "water-free" renewable energy technologies, a more effective and long-term solution that would have a far greater impact on alleviating water scarcity in South Africa (Wassung 2010).

However, once more, there is a clear misalignment between agricultural planning and water planning, with agriculture seeking to increase the irrigated area substantially (for employment and rural development purposes) with a statement that the water needed would come from water savings in the agricultural sector. This does not accord with the views of the water sector, who sees it as unlikely both in terms of achieving that level of savings, and the ongoing competition for limited water resources by other sectors. Thus, the DWA is quite clear that very little additional allocations of water are available for irrigation purposes–and that moving some water from irrigation to other uses must already be considered in certain areas.

4.4 INSTITUTIONAL STRUCTURING FOR COOPERATION OR COORDINATED DECISION-MAKING

The National Planning Commission (NPC) is responsible for high-level strategic national planning. The NPC is chaired by the Minister in the Presidency for National Planning, and is made up of 25 part-time commissioners. The commission is supported by a full-time secretariat of public servants. In drawing up its first National Development Plan (NDP), the NPC first published a Diagnostic Overview in June 2011. It then went through a process of intense consultation throughout the country, visited the nine provinces and hosted numerous public forums with the intention of securing broad agreement about the country's challenges. The NDP was then completed and handed to the president of South Africa in November 2011.

Extensive consultations followed with different sectors in order to seek inputs regarding the plan. The leaders of political parties were briefed regularly and all the provinces were visited again, during which members of the provincial executive committee, senior government officials, mayors and municipal managers were consulted. Furthermore, broader forums were held with labour, business, civil society, youth groups and religious groups and leaders. In August 2012 the revised National Development Plan 2030 was published and in September 2012, the Cabinet Lekgotla acknowledged the plan as the strategic framework to form the basis of future government planning, and resolved to establish a cabinet committee to develop targets and integrated implementation plans for the Forum of South African Director Generals (FOSAD).[9]

The Director Generals (DGs)–who are the most senior government officials in each government department–together form FOSAD, which is chaired by the Director General in the Presidency. Several clusters operate at cabinet level, focusing on particular aspects of decision-making. For example, there is a ministerial cluster dealing with infrastructure, an economic cluster, a social cluster, and various others. The DGs too are organised into clusters, along the lines of cabinet committees. The purpose of these clusters is to ensure coordinated decision-making on critical programmes and projects across sectors. FOSAD meets at least biannually to deal with broad issues of policy, planning and implementation of government policies and programmes, while the management committee of FOSAD meets monthly to monitor the progress of clusters and facilitate their integration.[10] We note that while energy-related decisions are likely to go through the economic or infrastructure cluster, agriculture-or food-related decisions may well go through the social cluster. At the highest level then, there is integrated planning both through institutions like the NPC and through FOSAD and cluster groups.

As far as energy planning is concerned, both the IRP 2010–2030 and Draft 2012 Integrated Energy Planning Report (DoE 2013a) note that the plans were developed in consultation with other government departments. Specifically, other government departments were represented in Working Group 2 (as part of the interdepartmental task team process) for the IRP 2010–2030 Report. At an even more disaggregated level, Eskom, the national electricity utility, has regular meetings with the DWA to ensure that there is sufficient water for current and future electricity generation. Electricity generation is considered a strategic water user and is given preferential access to water, with a higher assurance of supply than any other water for economic use.

[9] http://www.npconline.co.za/
[10] http://www.thepresidency.gov.za/pebble.asp?relid=183

4.5 ECONOMIC AND REGULATORY INSTRUMENTS

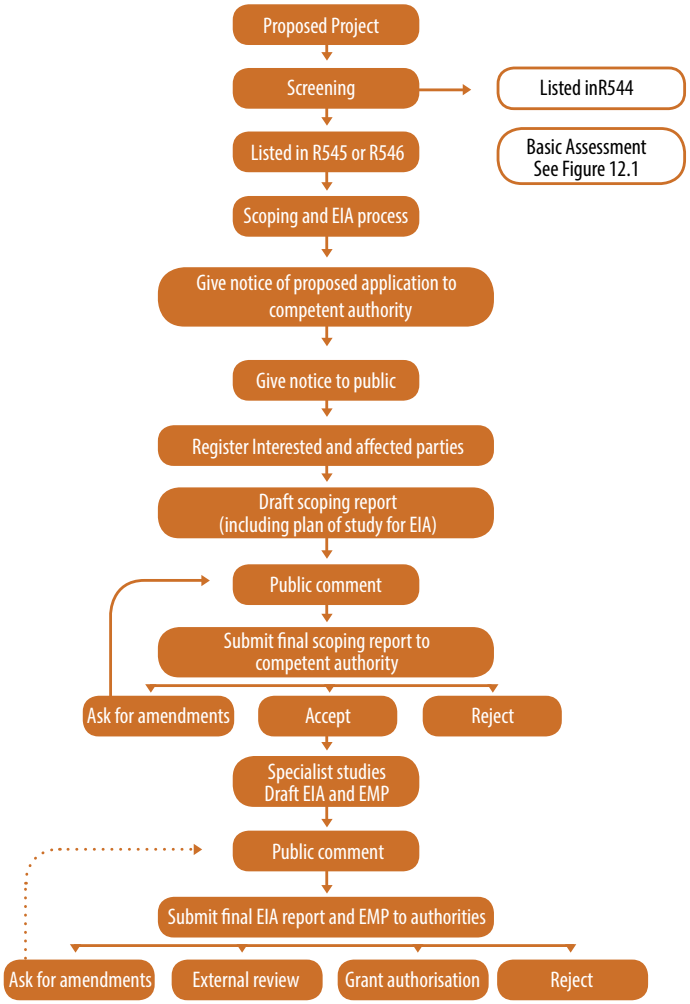
4.5.1 ENVIRONMENTAL IMPACT ASSESSMENT

The primary instrument to ensure that resources are taken into account as far as new projects in South Africa are concerned is the Environmental Impact Assessment (EIA) (Brownlie et al. 2013):

> Environmental assessment in South Africa should act to provide assurance of sustainable development and thus guide land use planning and development in such a way that it makes a positive contribution to sustainability without having significant negative impacts on those resources on which human wellbeing and economic development ultimately depends (sic).

In April 2006, old EIA regulations in South Africa were replaced by new ones in terms of the National Environmental Management Act (NEMA) of 1998. These were further amended in 2010. The regulations set out a list of activities that require a Basic Assessment Report (BAR) and EIA, and the processes that have to be followed in order to obtain an Environmental Authorisation. The scoping and EIA process is detailed, as illustrated below.

Figure 5: Scoping and EIA process



Source: Walmsley & Patel (2011)

Brownlie et al. (2013) note that although project-level EIA to some extent provides assurance of sustainable development, it is currently flawed in many respects. Among other concerns, they note that many projects are being authorised although they do not ensure sustainable development and, in many instances, rely on employment creation during the construction phase of a project as the reason for being 'socially justifiable' (Brownlie et al. 2013). This points to the challenge of sustainable development within a context of high unemployment.

4.5.2 RENEWABLE ENERGY INDEPENDENT POWER PRODUCERS (RE IPP)

While the government has been planning to move away from "dirty" to "cleaner" energy production, it has also been trying to incentivise private-sector involvement in the renewable energy space. For example, the DoE has launched the Independent Power Producer's (IPP) procurement programme which considers onshore wind, concentrated solar, thermal, solar PV, biomass solid, biogas, landfill gas and small hydropower projects.[11]

The Renewable Energy Independent Power Producer (REIPP) procurement programme involves a bidding process by independent power producers to provide renewable energy to the national grid. The power producers would be expected to enter into an agreement with the DoE, and a Power Purchase Agreement (PPA) with a buyer, namely Eskom (National Treasury 2013).

The table below shows the total allocation for each type of technology from the bids awarded in rounds one and two of the REIPP procurement process. During 2012, the government signed contracts to the value of R47 billion for 28 projects which include wind, solar and small hydropower technologies to be developed in the Eastern Cape, Western Cape, Northern Cape and Free State. The third round of the REIPP procurement process was due to close in August 2013 (DoE 2013a).

Table 3: Total allocation for renewable energy technologies through the REIPP programme

	Allocation to preferred bidders: Window 1		Allocation to preferred bidders: Window 2		Allocation per determination still availabe		MW allocation per determination
	MW	%	MW	%	MW	%	
Solar PV	632	44%	417	29%	401	28%	1 450
Solar CSP	150	75%	50	25%	-	-	200
Wind	634	34%	562	30%	654	35%	1 850
Biomass	-	-	-	-	13	100%	13
Biogas	-	-	-	-	13	100%	13
Landfill Gas	-	-	-	-	26	100%	25
Small Hydro	-	-	14	19%	60.7	81%	75
Total MW	**1 416**	**39%**	**1 044**	**28%**	**2 210**	**32%**	**3 625**

Source: DoE (2011)

4.5.3 THE NATIONAL CLIMATE CHANGE RESPONSE WHITE PAPER AND THE PROPOSED CARBON TAX

The South African government has, leading up to 2013, increasingly focused on a policy response to reduce greenhouse gas emissions. Two important developments have been the National Climate Change Response White Paper and a proposed carbon tax. The National Climate Change Response White Paper provides an overarching framework for transition towards a low-carbon economy, and among other things supports the implementation of a carbon price through a carbon tax. The National Treasury published the Carbon Tax Policy Paper in 2013, which is for public comment and outlines the context and features of the proposed carbon tax. It is proposed that the carbon tax will cover Scope 1 emissions. These are emissions that result directly from combustion and gasification, and from non-energy industrial processes (National Treasury 2013).

The proposed tax policy has the following key features: i) a percentage-based threshold on actual emissions, below which the tax will not be payable for the first five years; ii) consideration for sectors where the potential to reduce emissions is limited for technical or structural reasons (these could include cement, iron and steel, aluminium and glass); iii) graduated relief for trade-intensive sectors; iv) variable offset limits based on the mitigation potential of the sector; v) an overall maximum tax-free threshold limited to 90% except for those sectors that are completely excluded: agriculture, forestry, land-use and waste sectors will be excluded for the first five-year period. It is proposed that the tax-free percentage thresholds and offsets for the different sectors remain fixed for the first five-year period from 2015 to 2019.

The proposal is that the tax should be introduced at R120 per tonne CO2eq and should be increased at a rate of 10% per annum until 31 December 2019. Complementary initiatives that are either already being implemented or considered are: rebates for carbon capture and storage; free basic electricity; energy efficiency and demand-side management; renewable energy and a more intensive move towards public transport together with a shift of freight from road to rail (National Treasury 2013).

4.5.4 TRADE, REGIONAL INTEGRATION AND FOREIGN POLICY

Globally, the threats posed by climate change have been seen to bemost critical in the water sector, with expectations of increased floods and droughts. Food security driven by changing rainfall patterns and increased aridity will also be affected. These challenges highlight the need to develop regional strategies in order to cope with issues of water management, food security and energy generation. To this end, a workshop was held in South Africa in May 2011 called "Regional food and water security in the face of climate challenges: Identifying critical issues for Southern and Eastern Africa, exploring cooperative strategies and enhancing collaboration".

Among the aims of the workshop were the following: to improve the understanding of regional and intersectoral dimensions of food and water security; to identify opportunities for regional and intersectoral strategies for addressing food and water security challenges and to identify immediate opportunities for projects.[11]

It was noted that increasing water demands in South Africa rather than climate change were the major challenge in the medium term, and that since agriculture was the lowest-value user in South Africa, going forward, there would be pressure on agricultural users to release water for other sectors. The rest of the region thus provides a potential for the production of staple crops for the South African market. Thus, greater agricultural cooperation in the region could mean more water for other users in South Africa while not compromising South Africa's food security. It was also noted that there was a need to consider climate change impacts at the catchment level and that changes in the variability of rainfall and stream flow would be important going forward. As far as variability is concerned, it was noted that the amount of water required for irrigation (the highest water user in South Africa) was expected to increase in many parts of South Africa and that increased variability would thus impact on farming, and particularly on small farmers. Challenges to greater regional integration are in the form of funding, institutional capacity challenges and the absence of harmonised policy, regulation, procedure, technical standards, and environmental and safety requirements (DBSA & GWP 2012).

A regional bio-energy programme was put forward as an example of what the region could pursue, though it was noted that such a programme would face challenges in the form of financial constraints and regional coordination. NEPAD's Comprehensive Africa Agricultural Development Programme (CAADP) was taken into account, but it was also noted that to achieve the potential benefits from increased food supply, attention will also have to be given to rural infrastructure, marketing and finance. Water resource development schemes involving hydropower and urban water supply were regarded as attractive since they are partially self-funding (DBSA & GWP 2012).

It was noted that substantial opportunities had already been lost. The "implementation of the Inga 'super-projects' in the Congo, which could generate all sub-Saharan Africa's electricity needs, was not likely to be politically feasible in the short term", for example and though there are "numerous other hydropower projects in Angola, Zambia and Mozambique that could have contributed to meeting South Africa's electricity demand", because of a lack of preparation South Africa has proceeded with the construction of coal-fired power stations and is considering nuclear power (DBSA & GWP 2012).

The general sense was thus that regional integration–in the short term at least–was facing many challenges (DBSA & GWP 2012):

> However, from the evidence presented, it appears unlikely that rapid progress will be made in integrating food markets to achieve more effective use of the regions' available land and water resources or to mobilise their energy potentials. There are substantial barriers to be overcome before these opportunities can be unlocked.

[11] http://www.gwp.org/gwp-in-action/News-and-Activities/Regional-Approaches-to-Food-and-Water-Security-in-the-Face-of-Climate-Challenges/

A commitment was however made to take up specific recommendations through appropriate channels, and in particular, the SADC Water Stakeholders meeting and the South African National Planning Commission's planning processes (DBSA & GWP 2012).

In 2013, there were some positive movements regarding the Inga hydroelectric project in the DRC: South Africa and the DRC signed a Memorandum of Understanding (MOU) and finalised the Grand Inga Project Treaty, and in February 2013 South Africa's Finance Minister set aside R200 billion[12] to develop the project. The purpose of the treaty is to develop an enabling framework to allow for the two countries to jointly explore economically feasible options for the development of the project, which aims to increase hydroelectric power supply to the South African market. To facilitate this supply, it will be necessary to strengthen the Inga-Kolwezi and Inga-South Africa interconnections.

The treaty guarantees South Africa 2 500 MW of the 4 800 MW from the Inga 3 project (there could potentially be eight Inga hydropower plants). For Inga 3, the DRC will construct 1 841 km of high-tension lines to its border with Zambia, and South Africa will install 1 540 km of lines from Zambia through Zimbabwe to Witkop. South Africa is leading the activity in developing the new facility, although this project is in the early stages of planning.

5. CREATIVE SOLUTIONS

Governments and development agencies are recognising the need to harness the innovation and resources available to the private sector through partnerships in order to achieve developmental outcomes in countries with limited capacity and resources.

At the local level, there is an excellent example of the benefits to be derived from a nexus-based approach. The University of KwaZulu-Natal and the Bremen Overseas Research and Development Association (BORDA) have been collaborating in the design and construction of a decentralised waste-water treatment system (DEWATS) at the Newlands-Mashu Permaculture Learning Centre. The 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 m^3/d of domestic waste water from 85 households in the surrounding residential area, runs on gravity, requiring no energy inputs. Instead of using energy, the system produces biogas which is used in the community for cooking.

An innovative project involving old mines and energy generation is being tested by VIASPACE[13] /Selectra[14] in South Africa.[15] The aim of the project for Selectra is to remediate and produce energy on land that has been altered by gold mining in South Africa. Selectra's goal is to use Giant King™ Grass as a feedstock for either anaerobic digestion or direct combustion to produce electricity and therefore create value from these mine dumps, or "slimes dams", for themselves and their partner gold-mining company. Mine dumps or slimes dams are composed primarily of crushed rock. They contain minimal organic matter, and traces of chemicals and contaminants from gold processing. It is thought that the Giant King™ Grass may take up heavy-metal contaminants from the slimes dams and contribute to remediation.

The Bottom Line: South Africa has integrated development planning at national, provincial and municipal levels, and while there is reasonable vertical alignment between them, the strategic intent concerning food-energy-water scarcity is not necessarily coherent. Also, horizontally it is not as well translated into the sector-based plans that give effect to the integrated plans: energy and water planning are relatively well aligned, but agricultural objectives are inconsistent with water and energy constraints.

[12] http://www.bdlive.co.za/business/energy/2013/03/24/concern-over-sas-billions-in-drc-inga-project
[13] VIASPACE grows renewable Giant King™ Grass as a low-carbon fuel for clean electricity generation, for environmentally friendly energy pellets, and as a feedstock for bio-methane production and for green cellulosic biofuels, biochemicals and biomaterials.
[14] Selectra is a private South African company working in the water, waste and energy nexus in Africa.
[15] http://online.wsj.com/article/PR-CO-20130606-905383.html

6. CONCLUSION

Physical scarcity of resources in South Africa means that there are significant trade-offs between food, energy and water. Water is the most significant resource constraint, with South Africa being a water-scarce country that experiences huge variations in the temporal and spatial distribution of rainfall. At the same time, there is limited irrigable land. The largely coal-fired electricity-generation system is facing constraints due both to water availability and international pressures on carbon emissions.

There are a number of processes in South Africa that should result in integrated planning approaches between the three elements of the Food Energy Water Nexus. These include the institutional structure for coordinated planning and decision-making in the form of the National Planning Commission, which has developed a National Development Plan, and the clustering of government departments. Furthermore, there are also Provincial Growth and Development Strategies and Integrated Development Plans at municipal level.

Despite this, the national planning process in the form of the NDP contains a target of a 50% increase in the area under irrigation in South Africa, even though there is not enough water available for this expansion. So, at the highest level, there is a failure of integration between food and water planning. It is also important to recognise that the NPC has limited jurisdiction over government departments, and limited capacity. While the Indian NPC, for instance, has national authority and a budget that it can disperse to state governments and use as leverage for actions to be taken at state level, the South African NPC does not have that authority or power.

As far as sectoral policies are concerned, once again agricultural expansion is a focus of the Department of Agriculture while the Department of Water notes that there is little additional water for irrigation. In the same vein, while other energy initiatives like fracking and biofuels have taken water and food-related issues into account, the DWA notes that no water should be used for producing biofuels under irrigation and calls for caution as far as fracking is concerned. On the plus side, there is strong engagement between the water and electricity sectors in South Africa, particularly regarding electricity generation. This has led to new coal-generation facilities being dry-cooled rather than wet-cooled, bringing about a substantial reduction in the amount of water that will be used in the cooling processes. Furthermore, there is a focus on a substantial movement towards renewable energy production in the IRP 2010–2030, although coal-fired energy generation still has a fairly large role to play. However, it is important to note that the DWA has not demanded a transition to relatively "water-free" renewable energy technologies.

The DWA has also called for far greater engagement as far as conserving water and using it more efficiently is concerned, both in the energy and food sectors. It is also voicing concern about the quality of water due to mining and land-use practices. It appears that the energy and food/agriculture sectors need to engage further with these issues.

It has been found that while South Africa does have instruments to ensure sustainable development–most notably the Environmental Impact Assessment process to provide assurance of sustainable development–the process is flawed in many respects and many projects rely on employment creation as the reason for being socially justifiable (Brownlie et al. 2013). This points to the huge unemployment and poverty challenges in South Africa, which drive decision-making processes.

South Africa has recognised the need for regional economic integration in the SADC region. Food, energy and water needs are to some extent seen within this context, rather than purely on the grounds of internal self-sufficiency. Thus the discussion of "virtual water"–importing crops and products from countries with greater water availability and more productive land–has been part of the debate in the DWA for many years. This is seen more recently in the NDP in the recognition of the need to strengthen regional cooperation in food, water and energy markets (NDP 2012).

However, there are large challenges to regional integration in the form of funding, institutional capacity and the absence of harmonised policy, regulation, procedure, technical standards, environmental and safety requirements (DBSA & GWP 2012), and political hurdles. As far as food security is concerned, the push towards a regional solution seems to come on the back of a number of challenges faced by the large-scale farming sector in South Africa, including water scarcity; the prospect of increasing variability in rainfall in South Africa; irrigation already occurring on marginal land; the increasing intensity of farming and other challenges.

In general, there is little evidence of strong engagement with the implications of the three-way Food Energy Water Nexus. Where engagement does occur, it appears to be about the level of water availability rather than water quality, but this is also an issue that should be factored into the debate. The NWRS2 advocates raising the water profile in development planning, and notes, for example, that water must be placed at the centre of integrated planning and decision-making; that the real value of water should be reflected, taking into account the fact that water is a scarce resource; that water efficiency and curbing water losses should be high on the agenda of institutions, and that water management must be formally embedded in sector businesses.

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