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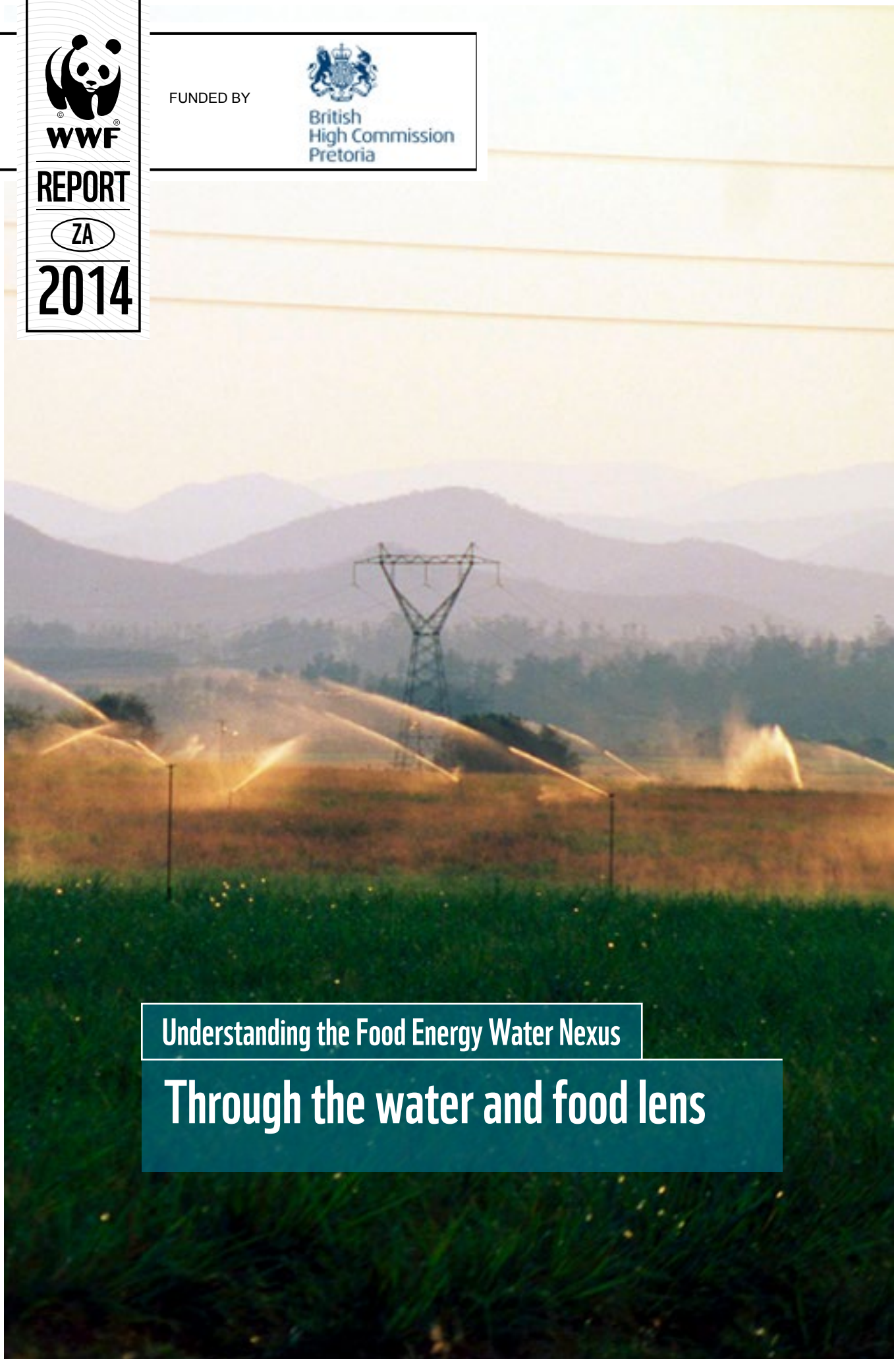

Understanding the Food Energy Water Nexus

Through the water and food lens

AUTHOR

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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 three summary papers based on nine reports in the Food Energy Water Nexus Study. The three summary papers are:

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

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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SUMMARY

Water is crucial for development, and access to clean water is fundamental for a healthy life. In South Africa, water is a scarce resource that needs to be judiciously allocated to ensure domestic supply security and, crucially, food and energy security. This interconnection of resources is referred to as the Food Energy Water Nexus and its effective management is the foremost challenge about sustainable developmental in South Africa.

Although energy, water and food sustainability are often perceived as separate challenges in South Africa, these are, in fact, highly coupled and interdependent problems. Efforts to secure energy, water and food sustainability are complicated by the reality that the systems are linked and interdependent. Water is needed, for example, to process coal and to generate thermo-electric power, whereas energy is required for the production of food and the treatment of waste water. Although water could be viewed as the central element in the Nexus – because it is inextricably linked to climate variability and it is a critical limiting local resource for energy generation and food production (Goga & Pegram 2014) – the very real threats to our water resources and the possible adverse effects on the food industry in South Africa have been realised only in the last two decades (Oberholster & Botha 2014).

Population increase, climate change and the increasing competition between food and fuel production create enormous pressures on both water and energy availability (Olsson 2012). In South Africa, and the SADC region more generally, the scarcity of resources means that there are significant trade-offs between food, water and energy. Water is the most significant resource constraint because South Africa is 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 electricity-generation sector is largely coal-fired and, therefore, water intensive. As a result, this sector is facing constraints due to water availability and also international pressures to reduce greenhouse gas emissions (Goga & Pegram 2014).

There is increasing consensus in South Africa's business and development community that water scarcity and water-quality issues will increase dramatically in the near term. This will have profound social, economic and political consequences, with impacts on food, energy, trade, the environment and, potentially, regional relations, as water-scarce nations increasingly search for ways to ensure their long-term growth and sustainability (Pegram et al 2011).

The South African economy is delinked from water in the industrial (in many cases) and tertiary sectors, in that most sectors do not depend on large quantities of fresh water to manufacture goods or provide services. This is not the case in agriculture, however: although the agricultural sector consumes 60% of all water abstracted in South Africa, it contributes only about 3% to GDP. The energy sector, by contrast, uses only 2% of abstracted water but contributes about 15% to the GDP.

Nevertheless, agriculture remains a vital sector that makes a significant contribution in terms of economic support for social benefits such as employment and rural upliftment. Ultimately, the value of agriculture to the South African economy cannot be considered in terms of GDP alone, but needs to be evaluated in the light of other factors such as employment, support to the rural economy, food security and foreign exchange earnings through exports (Baleta & Pegram 2014).

There are a number of risks associated with agriculture and water security. These range from declining water quality and the assurance of supply for irrigators, to the increasing cost of water due to the stress on the resource. The threat of climate change adds additional uncertainty, and how to adapt to this situation requires planning. Lastly, when planning ahead, one needs to consider how shifting water and agricultural policies may affect future production and, hence, food security (Baleta & Pegram 2014).

The relationship between water and food production, through irrigated agriculture, is considerably easier to demonstrate than the relationship between water and energy production. Different energy options have different

levels of impacts on water systems. For instance, while the water consumption of coal-fired power stations is relatively modest, the mining of coal has potentially devastating impacts on South Africa's water resources. The current acid mine drainage (AMD) in the Olifants River pollution crisis is testament to this. The argument for a judicious reduction of our reliance on coal therefore becomes more than a climate-change or carbon-emissions argument – it becomes one, perhaps most crucially, about water (WWF-SA 2012).[1]

Potential renewable energy options, particularly those derived from biofuels, need to be considered very carefully in the context of water resources and food production in South Africa. Renewable energy sources, such as solar energy (particularly photovoltaic) and wind, have negligible impacts on water and food production, which make them very attractive sources of energy within the Food Energy Water Nexus (WWF-SA 2012).[2]

Ultimately, the challenges posed by resource constraints point towards a coming crisis, one that will impact directly on the social security of our nation. The correct level of response to ward off this eventuality must be at a scale that allows for national and regional integration and recognition of the necessary spatial trade-offs. This response must focus on effective management of the resources, enabled by wider technology use and greater governance underpinned by the appropriate institutional capacity.

This report seeks to summarise the interlinkages and interdependencies in food production from a water perspective and touches more broadly on implications within the Food Energy Water Nexus. It examines the scale of the problem to determine the immediate risks, as well as those that we may have more time to address. It identifies some of the steps towards a resilience-based, integrated framework, and the key stakeholders in the process. The aim is to support the increased understanding of the interactions between the three systems in the FEW Nexus in order to promote efficient, equitable and sustainable development.

1. DEFINITIONS

Acid mine drainage (AMD): a pollutant resulting from mining activity characterised by low pH, elevated heavy metals, sulphate and total dissolved solids (Oberholster & Botha 2014).

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

Blue water: irrigation water withdrawn from ground- or surface-water bodies that is used by the plant in evapotranspiration or incorporated into the product (FAO 2013).

Eutrophication: a symptom caused by nutrient enrichment of water bodies due to effluent from waste-water treatment plants and fertilisers that can stimulate bloom formation of toxic cyanobacteria in major irrigation impoundments (Oberholster & Botha 2014).

Food access: having the ability to access the available food, including the economic, legal, political and social capacity for obtaining such access (FAO 2006).

Food availability: the availability of sufficient quantities of food of adequate quality (FAO 2006).

Food security: Food security refers to food availability, that is, the availability of sufficient quantities of food of adequate quality (FAO 2006)

Food stability: stability of supply and safety from risk (FAO 2006).

[1] http://www.wwf.org.za/?5560/South-Africas-water-future-in-a-crowded-connected-and-complex-world=

[2] http://www.wwf.org.za/?5560/South-Africas-water-future-in-a-crowded-connected-and-complex-world=

Food utilisation: the capacity to safely and effectively utilise food, which includes having an adequate diet to maintain good nutrition, and non-food elements such as access to clean water and sanitation (FAO 2006).

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

Green water: rainwater (soil water) used in evapotranspiration or incorporated into the product by non-irrigated agriculture (Oberholster & Botha 2014).

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

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

Water quantity: volume of available water. South Africa is a semi-arid and water-scarce country (DWA 2013). It is estimated to have only 1 000 m^3 (Claasen 2010) of water per capita, making it the 30th driest country in the world.

2. SCALE OF THE PROBLEM

Water is an important input into the food value chain as well as a prerequisite in energy production, but there are a number of factors impacting on South Africa's water security.

2.1 WATER QUANTITY

South Africa is considered a dry country (450 mm per annum on average compared with the global average of 860 mm). South Africa is also a net importer of water (Eskom 2009), which means that water availability is the fundamental determinant for development. As a result, water allocations need to be made to maximise efficiency and productivity. Declining water quality and policy uncertainty also contribute to food price volatility.

As it currently stands, calculations of run-off, yield and water use indicate that South Africa has enough water to meet the nation's needs in the immediate future. However, as the South African population increases, water resources are becoming more pressured, hence balancing water supply and water demands is a mounting challenge (Oelofse & Botha 2010). Out of the 19 water-management areas in South Africa, five were already experiencing water shortages by 2000, while 10 areas broke even. Only four areas enjoyed a surplus of water (WRC 2009). The Department of Water Affairs estimates that, by 2025, South Africa's water shortfall will be 1.7% based on current water usage and population growth, resulting in less assurance of supply for irrigators.

South Africa's commercial agriculture production is heavily dependent on irrigation. About 12% of South Africa's land is considered suitable for growing rain-fed crops while only about 3% of the land is considered truly fertile. There are currently 1.3 million ha of land under irrigation; 30% of output is produced on only 1% of the land. Irrigation accounts for 90% of vegetable, fruit and wine production and 12% of the total area under wheat is irrigated (irrigated wheat contributes 30% of national production). It is also worth noting that, while equitable access to water services in South Africa is improving at a household level, access to water for productive purposes is highly skewed – 95% of the water used in agriculture is in the hands of white commercial farmers (Goga & Pegram 2014).

As far as the energy sector is concerned, the Department of Water Affairs National Water Resource Strategy (NWRS2) notes that the energy 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 and that current plans include dry-cooled coal-fired power stations that will be more water efficient. However, these power stations will be located in water-scarce areas and will strain available water resources. It notes that the National Development Plan (NDP) has proposed the use of renewable energy sources to mitigate emissions from coal-fired power stations (Goga & Pegram 2014).

Aside from water use in the electricity-generation sector, Sasol, South Africa's 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, so they will be located near accessible and adequate supplies of water (Goga & Pegram 2014).

2.2 WATER QUALITY

The quality of freshwater resources in South Africa has been on a steady decline as a result of increased pollution. Forty per cent of South Africa's freshwater systems are now in a critical condition, while 80% are threatened. This is further exacerbated by water scarcity. As 98% of the available water resources are already allocated, South Africa has no spare capacity for the dilution of pollutants, so all pollutants and effluent streams will have to be treated to ever-higher standards before being discharged (Turton 2008).

Numerous anthropogenic sources put the food sector at risk. These include:

(a) heavy-metal contamination from mining and smelting operations
(b) effluent in untreated and partly treated sewage from several point sources, exacerbated by a lack of human capacity and the maintenance of treatment systems
(c) coal-fired power plants and industrial activities, which ultimately contribute to acid rain and pollution by high deposition levels of oxides of sulphur and nitrogen that can change the chemical structure of agriculture soils
(d) industrial effluence
(e) cultured eutrophication (Oberholster & Botha 2014)
(f) run-off from poorly serviced informal settlements.

All these sources of pollution present a significant risk, particularly in view of South Africa's overstrained and undermaintained water-treatment infrastructure.

2.3 CLIMATE CHANGE

Variation in weather patterns is predicted to have a significant impact on South Africa's water resources. Increasing temperatures and changing rainfall patterns will affect both the quantity and the quality of our freshwater resources (DWA 2013).

This is expected to shrink arable land and increase uncertainty and unpredictability, which means that farming conditions will become more challenging (WWF 2012). 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 cost of these negative impacts has generally not been factored into planning and decision making in South Africa.

2.4 WATER PRICE

It is expected that there will in future be a fuller cost recovery of the actual cost of water throughout the value chain. On the one hand this may have a marginal negative impact, but on the other hand, and more importantly, it is an opportunity to drive better behaviour and improve the measurement and management of water resources. It may also have a positive knock-on effect towards better planning as better measurements will make allocations more accurate.

2.5 FOOD WASTE

The scale of the water management problem is undoubtedly exacerbated by food wastage. Food waste represents a significant economic and social cost – the cost of the energy and water required to produce food that is never eaten is estimated to be in the order of R2 billion per annum. Although there is a lack of information specific to South Africa, indications are that the level of water and energy embodied in food losses is extremely high and represents a massive overconsumption that should urgently be addressed. Water extracted to produce food that is never consumed every year equates to 600 000 Olympic-sized swimming pools (Notten et al. 2014).

Expert commentary on the issue of food wastage points to a level of unconscious behaviour in the South African population, who fail to see how the interconnections within the resources function at an individual level. There is a lack of recognition of the fact that wasteful consumption habits in the affluent sector of society has a direct negative impact on what others have access to.

2.6 POLICY AND PLANNING

Lastly, policy and planning with regard to water and agricultural policies may shift and change, posing a risk, more probably, to future food production than to energy production. The relationship between water and food security is rooted in an understanding of the economic and social development goals for South Africa (Baleta & Pegram 2014). This adds a further level of complexity because each scale (national and household) of food security has different characteristics, including different relationships with the risk of water insecurity.

The political nature of agricultural policy, water pricing and the reliance on food imports for national food security all need to be considered in order to fully understand the complex nature of food security. Therefore the concept of food security is heavily embedded within, and impacted by, the policies and politics of South Africa's development objectives.

As far as the alignment of sectoral planning is concerned, 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 coal-fired power plants but it has not demanded a transition to relatively 'water-free', renewable energy technologies. In addition, the DWA notes that no irrigation should be used in the production of biofuels and calls for caution as far as fracking is concerned. In general, there is much discussion about moving towards renewable energy, although coal-fired power stations are still expected to play a large role in the future. As far as the water–food lens of the Nexus is concerned, there is a clear misalignment between agricultural planning and water planning, with the agricultural sector seeking to increase substantially the areas under irrigation (for employment and rural development purposes) (Goga & Pegram 2014).

So, while 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 food–energy–water scarcity is not necessarily coherent, nor is it well translated horizontally 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 (Goga & Pegram 2012).

3. IMMEDIATE RISKS

The world is transforming at an unprecedented rate – we have not experienced this level of change in society since the Industrial Revolution. Our diets have changed more in the last century than they did in the previous 10 000 years, when agriculture was introduced, and in the next 50 years we have to produce as much food as we produced in the last 10 000 years. We shall experience as much change in the next 10 years as we did in the last 50 years. Within this context the response to the immediate risks must be swift and at scale.

3.1 WATER QUALITY AND THE RISK TO MARKET ACCESS

Discussions with stakeholders and expert research point directly to water quality and, more specifically, to the state of water infrastructure and the associated skill set to manage this as the single biggest threat to food security.

Considering that a large number of commercial and subsistence farmers in South Africa still rely directly on rivers to irrigate crops and that contaminated water has been linked to contaminated produce, the quality of South Africa's water is a serious concern that must be addressed (Britz & Sigge 2012a). The urgency of this problem is escalated by evidence that many of South Africa's rivers are heavily polluted and not suitable for irrigation purposes (Britz & Sigge 2012b). If the issues of polluted irrigation water and the consequent safety of agricultural produce are not addressed, South Africa's agricultural sector (which has contributed approximately 7% to the country's total exports since 2005) and its access to export markets will be severely affected (Britz & Sigge 2012a). A pertinent example occurred in the Western Cape, which accounts for 25% of the agricultural sector's total gross income and more than 50% of the exported produce of the country. It has approximately 23 000 ha under irrigation, which produce a gross farm-gate value of approximately R1.3 billion. During the 2004/05 export season, the Western Cape agricultural sector came under threat when microbial pollution surfaced and overseas retailers threatened to cancel fruit imports. The cost of the estimated loss of export markets by this region could have been anything between R190 million and R570 million. This would have devastated the local agricultural sector, resulted in thousands of job losses and impacted the country's economy as a whole (Oberholster & Botha 2014).

Furthermore, the costs of meeting international export standards will only increase with declining water quality. As levels of water pollution rise, the cost of water treatment increases (Claasen 2010), which in turn increases the cost of production and reduces profitability. Water treatment will require energy, which will not only be an extra cost but will also place additional pressure on South Africa's already overburdened energy resources. Farmers are already struggling to remain in business as a result of the high costs of electricity and fuel and the newly introduced minimum wage. Add to these the additional water-treatment and associated electricity costs and many farmers will be pushed out of business.

Energy production also impacts on water quality, not only through the obvious AMD and water-quality impacts of return flows from energy generation but also from a landscape perspective. A proportion of South Africa's coal reserves overlap with the country's highest rainfall areas, water-supply areas which are of critical national strategic importance from a water security point of view. Indiscriminate development of these coalfields will place our national water security at significant risk (WWF 2012).

3.2 WATER QUANTITY AND THE RISK TO ACHIEVING DEVELOPMENT GOALS

Inextricably linked to the issue of quality is that of quantity. There may still be numerous opportunities for efficiency measures but, in the short term, the assurance of supply for irrigators is a significant risk. This is particularly evident when viewed in conjunction with South Africa's development goals, which impact heavily on the planning decisions made about agriculture.

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. At the same time, it is a priority to improve livelihoods in

marginalised rural areas while addressing issues of redistribution and equity within a context of abundant coal and solar energy resources, limited water resources and limited fertile land resources (Goga & Pegram 2014). Whether driving social development through expanding agricultural employment or driving economic growth by moving towards a service-based urban economy, there are particular water implications that need to be considered.

Many of the suggested strategies of the National Development Plan (NDP): Vision for 2030 (2011) will impact water availability, food production or food security in some way. One of the major objectives highlighted in the NDP is to support an economy able to create more jobs. Labour-absorbing industries (such as agriculture and agroprocessing) and increasing exports are suggested to increase employment (implying a growth in this sector). Approximately 8.5 million people rely on agriculture, either directly or indirectly, for employment or income. Furthermore, strong forward and backward linkages into the economy mean that the agro-industrial sector actually contributes approximately 12% to the country's GDP (Johnston et al. 2013). A positive trade balance for primary and processed agricultural products is an additional target for 2030 (Baleta & Pegram 2014).

To date, finding a way to make optimal use of water resources has been complicated by the issue of job creation. Both the NDP and the Industrial Policy Action Plan (IPAP) propose a substantial increase in agricultural activity, despite the fact that there may not be enough water for this expansion. Moreover, such an increase would also depend on the quality of the available water because, as was outlined earlier in the paper, if South Africa's produce no longer meets international food-quality standards, there will be no job creation in the agricultural sector. In fact, jobs will be lost if export markets are closed to South African farmers and foreign income is lost.

The challenge remains to find ways of using the land and other resources in a way that benefits the many rather than the few. The DWA's National Water Resource Strategy 2 (NWRS2) makes reference to allocating water for land reform and comprehensive rural development programmes, noting that there is a critical need to integrate water, land and agrarian reform programmes (Baleta & Pegram 2014). Because South Africa does not have sufficient arable land, the only feasible way to create jobs in agriculture is through irrigation. The NDP proposes a target of an increase of more than 50% of irrigated land. But as the institutions responsible for the required infrastructure are resisting investing – specifically in new dam construction – this target remains unreachable (Vink, N. pers. comm 2013).

At the same time, farming trends are increasingly moving towards industrialised agriculture and fewer jobs. Given that irrigation targets remain unreachable, there is currently no indication that the country will be able to check the decline in employment in the agricultural sector.

Energy production also requires access to water and the trade-offs for water availability or allocation between food and fuel production are real and cannot be ignored. A recent example of such trade-offs comes from India. In 2012, a district administration in the state of Karnataka restricted farmers from drawing water from the Krishna River because there was a shortage of water in the river due to extensive sand mining along the river basin. This restriction was put in place to ensure that water reached the Raichur Thermal Power Station, a coal-based power station with installed capacity of 1 470 MW. Strong planning and institutional capacity, as well as clear data on resource availability are required to avoid water scarcity that can ultimately translate into a food security threat.

As it stands, the gap between planning and reality demonstrates that, at the highest level, there is no coordination between the water and food sectors in South Africa (Goga & Pegram 2014).

3.3 INSTITUTIONAL RISK

The final imminent risk arises from the fact that policies of relevance to the sectors of agriculture, energy and water provide for very little integration or harmonisation between them. This lack of integration and communication between the various entities that have strategy and management responsibilities is primarily an institutional risk. Moreover, South Africa's NDP 2030, which is considered to be the planning roadmap, provides no guidance on integrating the Food Energy Water (FEW) Nexus into planning and policies. Regarding water–energy trade-offs and

requirements in policy formulation, the Department of Agriculture, Fisheries and Forestry (DAFF) appears to have considerably less influencing power than the Department of Energy (DoE). Furthermore, while concerted efforts are being made to demonstrate resource couplings, government and related institutions are unable to take an integrated risk perspective because of the way in which departments and decisions are compartmentalised.

In general, there is little evidence of strong engagement with the implications of the three-way FEW Nexus. Where engagement does occur, it appears to be about the level of water availability rather than about water quality, which should also be factored into the debate.

4. SECONDARY CONCERNS

Pricing is a low-risk factor in terms of food and water security. Although an increase in the price of water will have a large effect on maize production (for example), the government will most likely manage this so as not to negatively impact food security. Either more efficient crop production will bring in additional foreign exchange, or subsidies may be put in place to protect the food-producing farmers. In general, however, the price of food is variable and affected by a large range of factors such as markets, policies, politics and economics, which outweigh the potential impact of an increase in the price of water (Baleta & Pegram 2014).

The threat of climate change is an additional uncertainty that requires planning. Globally, the threats posed by climate change have been seen to be most critical in the water sector, with expectations of increased floods and droughts, which will affect food security (Baleta & Pegram 2014). However, as predictive models of the impact of climate change are complicated or rendered inaccurate by the fact that changing weather patterns can be detected only at the macro- (continental) or micro- (farm) level, their usefulness in food production projections is questionable.

Climate change remains an ever-present concern but this is secondary to the need to address issues of water efficiency and water quality, actions that will help to improve ecosystem resilience.

These challenges highlight the need to develop regional strategies to cope with issues of water management, food security and energy generation.

Similarly, far more needs to be done in a regional context to effectively assess the impact of the virtual water trade. Currently, there is a net loss of blue water within the Southern African Development Community (SADC) trade and the worst impact is on South Africa. Analyses of food crop trade data show that South Africa is currently a net exporter of blue water and that this is increasing over time. What is disconcerting is that South Africa is exporting crops with a high blue-water content – crops such as maize, one of the highest export crops – into countries that grow the same crops with a comparatively lower blue-water content. So the net loss of blue water within the SADC trade is impacting on South Africa, one of the most water-scarce countries in the region (Dabrowski 2014).

The question of conserving water through trade requires that the concept of national food security stemming from internal production alone needs to be expanded. However, as far as regional integration is concerned, funding, institutional capacity challenges, the absence of harmonised policy, and political hurdles all challenge regional integration.

Another concern associated with both agriculture and energy is the use of limited water and land to produce biofuels. However, research shows that biofuels, in themselves, pose little sustainability risk to food production in terms of land and water resources. Rather, the current practices of the agricultural sector, such as water pollution, loss of biodiversity, loss of soil fertility and erosion, overshadow the potential risks of biofuels production. That said, in the business-as-usual approach the production of biofuels is one of the most water-intensive ways to produce energy. Expanding biofuels production in a sustainable manner requires that the conservative policy approach to biofuels should be extended to the agricultural sector as a whole to minimise risks (Brent 2014).

5. RECOMMENDATIONS/POSSIBLE APPROACHES/TOWARDS A RESILIENCE-BASED INTEGRATED FRAMEWORK

The challenges posed by resource constraints point towards a coming crisis, one that will impact directly on the social security of the nation. The correct level of response to ward off this eventuality must be at national and regional scale. The tools required are most obviously effective management of the resources, wider use of technology and greater governance underpinned by the appropriate institutional capacity.

5.1 QUANTITY

Responses to these risks range from increasing efficiency to trading and expedient institutional arrangements. These are useful tools the food and water sectors could use to improve resilience against an increasingly uncertain future. However, it is necessary to do additional research on these suggested opportunities to build food-security resilience against future water stress. The scope for future research includes gaining a better understanding of the coping mechanisms farmers use during times of water stress. Possible research topics include the potential for increasing water efficiency (and the affordability thereof), trading water rights (and the legislative environment thereof), improving water resources management and governance (and the data or information requirements to inform these).

In order to meet the future demand-and-supply gap, an increase in irrigation efficiency is required. Improvements in agricultural practices are anticipated to close 30% of the demand-and-supply gap by 2030. However, due to the nature of agricultural markets, the return on investment (ROI) of some crop types makes it unviable to improve the efficiency of increasingly expensive irrigation infrastructure. For example, increasing water prices will have a significantly different effect on irrigated maize farmers on the Highveld than on farmers of non-irrigated sugarcane in KwaZulu-Natal. In-depth analysis needs to be done before enforcing a nation-wide irrigation efficiency target as this may jeopardise not only food production but also the additional social benefits which agriculture brings, such as employment (Baleta & Pegram 2014).

The NWRS2 advocates raising the water profile in development planning and notes the following, among other things (Goga & Pegram 2014):

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

Perhaps the greatest gains are to be made through better integrated planning, land use and sustainable rural development. For example, it is no longer good enough to think only of maximising food production on agricultural land. We need to be thinking about how we optimise the best overall food, water and energy benefits from a piece of land. Intelligent planning and design of agricultural land can reduce impacts on freshwater ecosystems, such as wetlands and rivers that purify and control the flows of water for the benefit of the farm as well as downstream users. Delivery of such multifunctional landscapes with multiple beneficiaries is going to require carefully constructed partnerships between the private and the public sectors. To this end, the Land-user Incentives Programme recently launched by the Department of Water and Environmental Affairs is a great example (WWF-SA 2012).[3]

A shift to renewable energy sources for energy generation would also be supported in an integrated planning approach. To date the development of the renewable energy sector has been viewed as an important response to managing carbon emissions. Energy production viewed through the lens of the water–energy leg of the FEW Nexus elucidates the water intensity of coal-fired stations as opposed to the relatively low water requirements of renewables. So, the transition to a clean-energy infrastructure might be more successfully motivated by water scarcity than by the promise

[3] http://www.wwf.org.za/?5560/South-Africas-water-future-in-a-crowded-connected-and-complex-world=

of reduced carbon emissions (Wassung 2010).
Addressing the issue of food waste is possibly the least controversial action. What data exists indicates significant levels of food loss and waste that should urgently be addressed, starting with a better understanding of where in the supply chain, and to what extent, these are occurring and how these impact on blue- and green-water supplies.

5.2 QUALITY

Strategies must be developed as a matter of urgency to tackle the major sources of water pollution, namely, effluent from urban areas and industry, high salinity from irrigation return flows, run-off from mining operations and run-off from inadequately serviced informal settlements. Strong national government intervention is needed from a policy norms and strategic planning level, but crucial in tackling the problem is strategic planning – and, most importantly, the effective implementation of these strategic plans – at local level. Action must be taken to:

- drastically improve the infrastructure of waste-water and sewage reticulation plants throughout the country and tackle the capacity problems at local government level
- provide, at the very minimum, basic sanitation and waste-management services in informal settlements, not only to address water pollution but also to ensure that all South Africans can live in conditions conducive to health, well-being and personal dignity
- strictly enforce the "polluter pays" principle with an emphasis on mining (including past polluters), industry and large-scale irrigated agriculture
- formally protect existing natural water resources such as wetlands and rivers
- establish and enable the role of Catchment Management Agencies (CMAs) to fulfil their mandate in development planning
- rigorously monitor the quality of South Africa's freshwater resources.

In addition, food safety requires the gathering of data to construct comprehensive dose-effect curves for different crop species to formulate guidelines about toxic metals and contaminated soils that can be used by the different food industries (Oberholster & Botha 2014).

5.3 SOCIO-POLITICAL FACTORS

As has been discussed, 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, while still guaranteeing 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 the fundamental mechanism is infrastructure planning for national and sectoral development, the difficult decisions at national level are typically about selecting a limited number of achievable priority resource development interventions that will bring the greatest economic and social impact. Trade-offs in the allocation or management of water, energy and food resources, however, take place at all levels and good data is required for these decisions to be made in order to optimise resources.

As far as current institutional structuring for integrated planning is concerned the following, among other things, all point to good structuring for integrated water management planning:

- the National Planning Commission (NPC) processes
- representation of different sectors within clusters to ensure coordinated decision making
- interdepartmental task team processes for energy planning
- regular meetings between Eskom and the DWA (Goga & Pegram 2014).

There is an excellent example of the benefits to be derived from a nexus-based approach in South Africa. 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 Durban-based eThekwini Municipality is using the resources provided by treated waste water to support urban agriculture, based on organic farming principles and low input costs. This project falls under the municipality's Agro-ecology Programme. The DEWATS, which receives up to 40 m^3/day 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 (Goga & Pegram 2014).

There is a clear opportunity for the private sector to take the lead in responding to the challenges and opportunities involved in addressing coupled resources, such as energy and water and food and water. A few forward-thinking or risk-exposed businesses, particularly retailers and food-and-beverage companies, have committed themselves to taking action, not just to address operational efficiencies in energy and water but also to look through the value chain to address carbon emissions, water conservation and biodiversity to determine resource hotspots. The breakthrough actions are those that look beyond factory walls to the areas of greatest impact, those at the points of production and consumption.

6. A CALL TO ACTION: TARGET AUDIENCES

6.1 GOVERNMENT

Addressing issues of complexity requires wide participation but, depending on the scale of the focus on food security and water scarcity, there are a number of institutions or groups particularly suited to better inform the challenges faced and the potential responses to these. The government is central to this process because a market mechanism alone would not support the critical social elements of both access to water and adequate food (Baleta & Pegram 2014).

- National Treasury: government priorities are governed by fiscal policy and job creation.
- Department of Water Affairs (DWA): monitors and regulates water.
- Department of Trade and Industry (DTI): determines import tariffs that, although constrained by numerous trade agreements, could help to support farmers and protect poor consumers.
- Department of Agriculture, Forestry and Fisheries (DAFF): manages agricultural extension services.
- National Planning Commission: ideally placed to play a key leadership role in developing integrated planning approaches that can deal with these multi-variant interrelationships in an explicit way.
- Competition Commission: regulates unfair pricing practices.
- National Energy Regulator (NERSA): determines energy prices.
- South African Reserve Bank: determines monetary policy, which impacts on inflation and exchange rates.
- Department of Social Development: responsible for social welfare via the South African Social Security Agency.
- Catchment management agencies: coordinates collaborative local level efforts to ensure effective water management in a catchment.

6.2 STATE-OWNED ENTERPRISES AND PRIVATE SECTOR

Markets are important in driving optimal water use through the supply chain and promoting informed consumer decisions (which take into account the water intensity of growing particular crops) both of which may help to reduce the pressure on farmers to produce under inadequate conditions.

An agribusiness dialogue may also help to unlock necessary innovations and mitigation strategies. This would need to include:

- the big resource users such as Eskom and ArcelorMittal South Africa
- industry associations representing growers, food producers and retailers
- unions representing employees and labour.

6.3 ACADEMIA AND CIVIL SOCIETY

Alongside markets, civil society is important to drive societal change. Historically marginalised people must be involved and heard. The dialogue between business and the government must also provide a forum where ordinary people can articulate their views and discuss what the interconnected food–energy–water risk means to them in terms of their livelihood, jobs and well-being. Similarly, civil society and academics must be given the opportunity to articulate the reasons why we should change our thinking about ecosystem services. By creating a forum in which people can speak out, it might be possible to get the government to understand that taking action on environmental issues is what the people want, at all levels of society.

A transition to an equitable system that recognises both the trade-offs and synergies within the resources can only be achieved if grounded in sound science. Academic research plays a key role in determining a sustainable trajectory for achieving South Africa's development goals.

6.4 A COLLABORATIVE CALL TO ACTION

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

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