NATIONAL SCIENCE AND TECHNOLOGY FORUM (NSTF)
DISCUSSION FORUM
WATER-ENERGY-FOOD NEXUS: TOWARDS EFFICIENT NATIONAL PLANNING

Amanzingwe Lodge and Conference Centre
23–24 October 2018

Table of Contents

DAY 1: 23 October 2018

Opening and welcome (Ms Jansie Niehaus, Executive Director: National Science and Technology Forum)

There has been a great deal of discussion about the water-energy-food nexus. There is a need to highlight the important issues and reach consensus on the priorities. Issues identified during the discussion forum will be passed to the relevant government departments as inputs to decision-making and policy development.

The NSTF represents a wide range of stakeholders in science, engineering and technology. Apart from arranging these discussion forums, the NSTF awards have been running for 20 years. These awards encourage and reward excellence and are the only national 'open science' awards where nominations are open to the public.

Ms Niehaus introduced Dr Gerda Botha, chairperson of the South African Council for Natural Scientific Professions (SACNASP). The council is a statutory body that registers natural scientists in 25 fields and runs a continuing professional development (CPD) programme. For registered scientists, CPD points are available for attendance at this discussion forum.

Assessing the state of the water-energy-food nexus in South Africa (Prof Sylvester Mpandeli: Water Research Commission)

The presentation is based on a report with the same title, copies of which would be circulated after the presentation. Prof Mpandeli explained that this report is based on the work of a Water Research Commission (WRC) flagship programme. In assessing the state of the water-energy-food (WEF) nexus in South Africa, controversial issues were encountered. The research programmes of the WRC are based on national priorities, but the WRC is also responsible for benchmarking its work against international research.

Interest in the WEF nexus was initiated at the 2011 Bonn Conference on 'Water, energy and food security nexus: solutions for the green economy', which brought together political, social and scientific perspectives to highlight the pressures on water, energy and food through issues such as population growth, climate change, migration to urban areas and incorrect agricultural practices.

The nexus is broadly defined as an approach that considers the interactions, synergies and trade-offs of water, energy and food when undertaking the management of these resources. These three sectors have traditionally operated as silos, which has led to the duplication of activities and failure to recognise the role played by other sectors. In assessing the nexus, each resource sector has an equal weighting. The WEF nexus provides an opportunity for policy-makers, researchers and development agencies to integrate across disciplines and maximise outputs.

The work of the WRC is aligned to the Sustainable Development Goals (SDGs) with particular focus on Goal 2 (Zero hunger), Goal 6 (Clean water and sanitation) and Goal 7 (Affordable and clean energy). Recently, in light of the importance of land in South Africa, Goal 15 (Life on land) was added, since land expropriation is accompanied by questions regarding the allocation of water.

The aim of the study was to conduct a review of available information and knowledge about the WEF nexus in South Africa and specifically to conduct a state-of-the-art literature review on past, present and ongoing work on the WEF nexus, focusing on the current status, and the potential, challenges and opportunities for inter-sectoral WEF nexus planning. The study also proposed a framework for linking the WEF nexus to the SDGs.

Water scarcity is not unique to South Africa. It is a global phenomenon, with the ratio of withdrawal to supply ranging from less than 10% to an extreme high of 80% in various countries across the world. For South Africa, inter-basin water transfers are essential for addressing water security, and it is also essential to build relationships beyond national borders. The water-scarcity situation in South Africa emphasises the importance of maintaining the existing infrastructure used to transport, transfer and treat water. The WRC believes that the WEF nexus provides a sound focal point for addressing socio-economic challenges, especially job creation. There are opportunities in all three of the nexus sectors to create jobs and to address poverty and inequality in South Africa. Numerous dams will be built or enlarged during the next decade to service the needs of the increasing population.

Another important issue is the overlap between arable land and mining rights. The challenge of mine-polluted water, particularly in Mpumalanga, creates unnecessary tension between farming and mining. There is a clear need to balance these activities, as mining makes an important contribution to the economy, while agriculture produces food for people. There has been some progress with mining companies using polluted water to irrigate potato crops, but much more needs to be done.

There has been considerable discussion regarding the use of nuclear energy, but the WRC believes that it is important to look at the whole energy mix, which includes renewable energy. The WRC is funding some renewable energy projects at universities and driving a biogas project with the Agricultural Research Council and the University of KwaZulu-Natal. The WRC believes that biogas provides an answer to key issues. Firstly, it provides an opportunity for smallholder farmers to generate an income; secondly, it is constructed by local people and therefore boosts the local economy; and thirdly, it represents savings to households, which can use biogas for heating, cooking and lighting rather than relying on electricity.

Undernourishment is prevalent in southern Africa, and the statistics show that one in four people in South Africa is food insecure. Undernourishment is linked to crop failures and to the way in which agriculture is being driven in the country. The quality of food is critical, and it is important to ensure that the food produced is nutritious.

Climate change has impacts on agriculture, but of South Africa’s farmers have low adaptive capacity. There is an urgent need to provide smallholder farmers with climate-change adaption strategies that can be implemented immediately. It is clear that the current business-as-usual strategies cannot continue. Several government departments are developing response strategies to climate change, but these strategies need to be harmonised to maximise the benefits to the country.

With regard to legislation, policy and strategies for the water sector in South Africa, much needs to be done to effectively address the issues of the WEF nexus. This is also true for the energy sector. Policy in the energy sector has been driven by the need to promote industrialisation and economic development, and the prioritisation of energy generation has often created new conflicts. An example of this is the expansion of coal mining in Mpumalanga, which threatens food production and the broader environment. There is a need for greater alignment. The WEF nexus could be applied to align policies in the energy sector and improve sustainability. The most vulnerable people are those who are most affected, for example, by electricity price hikes. Socio-economic challenges in rural areas have to be addressed to avoid migration to cities with insufficient infrastructure. Agricultural strategies and policies must be aimed at increasing production and food security. The issue of land distribution must include policies to maximise the production of food.

There is a need for everyone to take responsibility to ensure the continuity and coordination of projects that are started. South Africa has developed good policies, but very often implementation is a problem. Some of the challenges facing the WEF nexus in South Africa include poor education, urbanisation and poverty, the silo approach, political dynamics, the lack of proper coordination and harmonisation of activities across sectors, and poor policy implementation across government departments.

In linking the SDGs to the WEF nexus, for Goal 2 (Zero hunger) it is essential to support initiatives to promote sustainability and to provide opportunities for the provision of food. For Goal 6 (Clean water and sanitation), the WRC believes that combined efforts can address water quality issues. For Goal 7 (Affordable and clean energy), it is essential to consider the whole energy mix. In the water sector it is not enough to focus only on rainfall. Groundwater options and even the perhaps controversial issue of desalination also need to be considered. There is a need to look at land issues under Goal 15 (Life on land), and it is important to develop a framework and mechanism for the allocation of water. It is important to learn from experience, for instance with respect to irrigation schemes, very few of which are successful despite considerable investment by government.

The application of the nexus is particularly relevant when considering the recent proposed policy shift on land expropriation. Currently the various government departments approach resource management in isolation without considering the usage of water, energy and land by other sectors. There is a corps of technical-level scientists working together to address the nexus, but at the political level politicians need to be educated regarding synergies, inter-sectoral linkages and sustainability. There are major challenges in policy development, especially when considering the country's limited water availability, the scarcity of high-potential arable land, and the reliance on fossil-fuel based energy generation. It is predicted that climate change will have a negative impact on the availability of resources in South Africa.

The WRC has seven programmes in various thematic areas. Some of the projects are related to the nexus, including catchment-based assessment of selected water management areas; an assessment of the potential impact of climate change on water availability, energy generation capacity and food production; development of a roadmap to achieve SDGs 2, 6 and 7 by 2030; water usage per energy-generation technology type; the tipping point for fossil-fuel based energy security and food security in South Africa; a WEF nexus city-based metabolism study for Cape Town; potential sector-specific policy harmonisation to promote a WEF nexus approach; a study of practical household-level application of the WEF nexus approach in South Africa; water and land requirements for bioenergy implementation; a review of the availability of WEF nexus data at different spatial and temporal scales within South Africa; the development of a WEF nexus index; a study of water-scarcity implications and a review of the applicability of available WEF nexus models.

These projects represent the focus of the WRC for the coming years and will be updated annually. There is some funding available, and calls for proposals are posted on the WRC website. In addition national issues are linked with the SADC secretariat initiatives, and the WRC has been presenting at international conferences over the last five years, building a community of practice with a pool of experts who will drive the WEF nexus and perhaps also be able to tap into funding from international organisations.

Discussion

Question: There is a great deal of focus on system efficiency enhancement, but there are other ways to mitigate the problem of resources. For example, if growing wheat requires the use of extra water, it might be worth considering importing wheat and thus saving water.

Response: This is an issue to be considered. The WRC took a decision to include land in considerations related to water and food in order to make progress.

Assessing the water-energy-food nexus in the context of the sustainable energy for all initiative: report by the UN Food and Agriculture Organization of the United Nations (Dr Lewis Hove, Coordinator: Resilience Work in Southern Africa, Food and Agricultural Organisation

The Food and Agriculture Organization (FAO) looks at the nexus from the starting point of food and has as a vision of a world free from hunger and malnutrition, where food and agriculture contribute to improving the living standards of all, especially the poorest, in an economically, socially and environmentally sustainable manner. The three goals of the organisation are the eradication of hunger, food insecurity and malnutrition; the elimination of poverty; and the sustainable management and utilisation of natural resources. The five programmes that address the strategic objectives are: assisting countries to eliminate hunger, food insecurity and malnutrition and develop policies and strategies; making agriculture, forestry and fisheries more productive and sustainable; the reduction of rural poverty; the enabling of inclusive and efficient agricultural and food systems; and increasing the resilience of livelihoods to threats and crises. Climate change, gender issues and governance are mainstreamed across all objectives.

For the FAO, the WEF nexus entails the understanding and management of often-competing interests whilst ensuring the integrity of ecosystems. The FAO is not a research or donor organisation, but can initiate discussion and bring nations together. The FAO also works with scientists and academics on providing evidence on the WEF nexus and on developing scenarios and designing and appraising response options. Very importantly, the FAO supports multi-stakeholder dialogue. The existence of silos may be inevitable, but ways should be found to facilitate cooperation. In this respect dialogue is critical.

What has emerged from interactions across the globe is that the nexus seems to make most sense in relation to resource use optimisation at a technical or practical level, and conflict resolution and dialogue at a political or higher level. There is a need to focus on the process of thinking, talking and deciding on water, food and energy issues to get results.

The available resource base comprising land, water, energy, capital and labour is often characterised by competing social, economic and environmental interests and goals. Drivers of the competing goals include population growth, diversifying and changing diets, cultural and societal beliefs and behaviours, technology, innovation and urbanisation. Issues such as governance, sectoral policies, vested interests, international and regional trade, industrial development, agricultural transformations and climate change also impact on the resource base. In managing the nexus, it is essential to provide evidence of what is happening and where, and how matters could be improved, which would provide a base for stakeholder dialogue, the development of scenarios and response options, and the efficient use of resources.

Guidance is provided by the National Development Plan a national level, and the Sustainable Development Goals, which were agreed by all United Nations members in 2015, at international level. The SDGs that are most directly related to the WEF nexus are Goal 2 on agricultural production, Goal 6 on water and Goal 7 on Energy. The SDGs provide an important target for people and the planet. Some countries will meet the targets that have been set, while others will not. The SDGs are a UN initiative aimed at stimulating national systems. It is hoped that international progress towards meeting the SDGs will be made by the target date of 2030.

The aim of the FAO is to have a small water footprint and to use water efficiently for food production. Fortunately, a healthy diet generally has a smaller water footprint, so the use of a diversity of foods and fresh produce rather than processed food must be promoted. The introduction of reliable clean energy solutions for water management is also important, such as solar irrigation. There is a need to change thinking. Southern Africa must move from overreliance on maize. The quality of food is critical. In terms of energy usage, animal protein is less acceptable that vegetables.

The notion of the interconnected nexus is a logical means of dealing with the complexity of the world. However, when it comes to putting the nexus into action (walking the nexus talk), it is not so easy. The FAO found two very different ways through which the nexus came to life; firstly through a clearly defined practice or technology such as solar irrigation, water/energy audits for large-scale irrigation schemes, desalinisation and sludge treatment; and secondly through policy dialogue and coordination.

The cost of solar pumps is decreasing, making this technology more readily available and bringing down costs to farmers, but there are issues of how to regulate water usage when pumping is essentially free. The over-pumping of groundwater resources is often a result of the cost savings, and policy issues arise that need to be considered depending on the context of the particular area of operation. In Morocco, subsidies for solar systems are allocated only to farmers who use efficient irrigation technologies, and in India solar energy cooperatives have been formed where any excess power that is not required for irrigation can be sold back to the grid.

The FAO is working with stakeholders to develop strategic plans and policies for improving water management, building on ongoing initiatives. The challenges that the world faces are well known. The world population is projected to grow from 7.2 billion to 9.6 billion by 2050. The agriculture of the future will need to meet increasing demands for food, animal feed and non-food products. Significant socio-economic transformations are evident. There is increasing migration to cities, accompanied by decreased employment in agriculture worldwide. These changes have significant implications for environmental resources and ecosystems. Although most agro-ecosystems have dealt with human pressure, it cannot be assumed that they will continue to meet the growing demands. Natural resource stresses, in particular water scarcity and land degradation, and climate change all add to the challenges.

In recognition of these challenges, the FAO has reviewed its various projects and programmes on crops, livestock, forestry, fisheries and aquaculture. The FAO works through sectoral approaches such as sustainable forest management or the ecosystem approach to fisheries and has developed cross-sectoral approaches such as climate-smart agriculture, the regional Water Scarcity Initiative in the Near East and the Global Soil Partnership to effectively manage the challenges facing agriculture. The FAO starts by looking at the nexus from the food perspective, but there are other entry points, such as groundwater management, irrigation modernisation and the intensification of livestock production.

The rationale and added value of a nexus approach is the increasing pressure on resources for socio-economic development. There is a growing and competitive demand for water, food and energy, and the natural resources are stressed. Policies and development strategies tend to be sector driven. It is difficult to change public policy, and it is therefore critical to provide policy-makers with evidence of the limitations of non-integrated approaches, and to emphasise the need for cross-sectoral dialogue. Important topics that need to be addressed for agriculture include bioenergy, irrigation modernisation, wastewater reuse, intensive livestock production or aquaculture, hydropower, and food waste.

There is a need to integrate nexus thinking in broader processes related to sustainable development and natural resource management at all levels: internationally, regionally, nationally and sub-nationally. Even though governments are signatories to international initiatives, impetus at the local level is often what brings about change. There is also a need for more focused interventions on specific technological, managerial and operational issues. Scientific evidence on the WEF nexus must be documented and disseminated.

The water-energy-food nexus in South Africa's water governance (1910–2008) (Prof Johann Tempelhoff, Extraordinary Professor, South African Water History Archival Repository, North-West University)

The water-energy-food nexus is a smart term, but there is now talk of a sub-nexus related to activities such as mining. The word 'nexus' comes from Greek. The concept of the WEF nexus was promoted by the World Economic Forum in 2008, and Germany then took the lead in preparing for the Bonn Conference on 'Water, energy and food security nexus: solutions for the green economy' in 2011.

Basic thinking about long-term water cycles was shaped by the notion of panarchy, a conceptual framework to account for the dual, and seemingly contradictory, characteristics of all complex systems – stability and change. It is the study of how economic growth and human development depend on ecosystems and institutions, and how they interact. Panarchy is symbolised by the infinity symbol and it is based on resilience thinking; one moves from an alpha phase to a kappa phase by remembering. Another tool that is used to consider water in the long term is the 'hydraulic missions' conceptualised by KA Wittfogel, related to the manner in which a governance authority chooses to prioritise the use of its water resources.

The period between 1910 and 1942 was characterised by the irrigation food nexus. In 1910 the Union of South Africa brought together the former British colonies and the former Afrikaner republics. Irrigation was a new technology that brought progress to the South African farming sector. The Department of Irrigation was established with the main purpose of providing and conserving water in the interests of food production. This led to the promulgation of the Irrigation and Conservation of Water Act (No. 8 of 1912).

In the post-World War I depression, the government considered the establishment of an electricity supply commission, but this did not happen until 1922 at the time of the Rand strike. This was one of several drivers of an industrial revolution in South Africa. An example of private sector involvement was dam building by a syndicate in 1922. The first dam was built using mainly manual labour, followed by government's use of mechanisation in the construction of Lake Mentz on the Sundays river. Another major dam project was the Hartbeespoort dam, which was started in 1912–1914, but only completed in 1925 for political reasons. This dam was built to provide farming opportunities to poor whites and eventually to provide water to Pretoria.

The post-World War I depression brought about intermittent industrial development. In 1924 the Pact Government (an alliance between the Nationalist and Labour parties) came to power, with a somewhat socialist mindset combined with Afrikaner nationalism. 'The poor white problem in South Africa: report of the Carnegie Commission' was published in 1932. The recommendations of the report drew on the experience of poor whites in the deep south of the USA. President Roosevelt's New Deal between 1933 and 1936 was a series of programmes, public work projects and financial reforms and regulations that were focused on getting people back to work, and dam construction and irrigation projects were seen as a vehicle for achieving this. These recommendations and initiatives gave South Africa a model to work on and brought with it the second golden period of dam construction from 1929–1938 before the outbreak of World War II. The construction workers on these projects were predominantly white. Those that showed potential were chosen to become farmers and given opportunities for further study. The first phase of the Vaal dam was constructed between 1933 and 1938, connecting the dam with the Vaalharts irrigation scheme.

In South Africa, the industrial energy hydraulic mission started in about 1942 with the first multi-purpose water transfer scheme, which was built in Saldanha bay. During World War II the government of General Smuts was passionate about industrialisation. Planning for the CSIR began during the war, and the organisation was established in 1945. The CSIR became the guardian of knowledge on South Africa's water and is still active in this field.

The growing need for energy broadened the platform for water consumption between 1947 and 1956. Water from the Vaal river was now also required for the Free State goldfields, which meant that there was less water available for irrigating farm land.

In 1956 the Water Act (No. 54 of 1956) was passed. This was the era of African decolonisation. In 1948 the United Nations published the Declaration of Human Rights. In South Africa, the Freedom Charter of 1955 demanded that 'the people shall govern'. The Sharpeville massacre occurred in 1960 during riots protesting against the pass laws, a system designed to restrict the movement of people and racially segregate the South African population.

Urban growth and development led to increased demand for energy, and the drought of 1958–1966 highlighted the weaknesses of South Africa's water supply. It had been assumed that building enough large dams would meet South Africa's water needs. There was considerable interest in hydropower during this period. In 1960 the then Southern Rhodesia completed the Kariba project, and planning for the Cahora Bassa project began. South Africa wanted to be part of the movement and launched its first foray into hydropower through the Orange river development project, which was started in 1962 and completed in 1978. At the Gariep dam, a cornerstone of the Orange river scheme, one of the first major hydropower plants was built; and another is at the Vanderkloof dam.

At the peak of the industrial energy hydraulic mission in South Africa, water planning became deterministic. Some impressive water transfer schemes were developed, namely the Drakensberg hydropower scheme and the Sterkfontein dam, and hydropower was being used effectively. The energy crisis of 1973 was a game changer. It coincided with peak gold production and prompted the building of the Sasol 2 and 3 plants, which used fossil fuel. Then came the drought of 1978–1987.

All these events created memories. According to panarchy theory, people should learn from the past in order to improve in the future. Part of the deterministic approach was a plan to pump water upstream through a series of large weirs in order to ensure the water supply to Sasol. Fortunately it was never necessary to implement this process.

The social-ecological hydraulic mission started in South Africa in about 1994 and continues to the present. In terms of South Africa's Constitution of 1996, the water resources of the country belong to all its citizens. In the 1980s due to increasing isolation, South Africa was not aware of international trends in thinking about water, and awareness of the environment was only stimulated after 1992 when South Africans could once more attend international events and interact with international specialists. The Convention for a Democratic South Africa (CODESA) of 1991–1995 included a committee working on water resources, the Standing Committee on Water Supply and Sanitation (SCOWSAS). After the end of apartheid, South Africa's newly elected government inherited huge services backlogs with respect to access to water supply and sanitation. According to one source, about 15 million people were without safe water supply and over 20 million without adequate sanitation services in 1990. The new government set a target to eradicate poverty, which initiated the emergence of a social-ecological turn-around in South Africa’s water governance in which water was foregrounded.

During the Reconstruction and Development Programme (RDP) period of 1994–1999, a number of presidential lead projects were initiated and new legislation affecting water was passed, the Water Services Act (No. 108 of 1997) and the National Water Act (No. 36 of 1998). In terms of the legislation, the people of South Africa own the water, but the state is the custodian. Citizens have a right to clean drinking water and an environment conducive to health. The approach to water provision changed; free basic water was provided and affected parties were included in the discussion and development of plans to deal with the drought of 1988–1993.

In the 21st century, issues of security and resilience with respect to the WEF nexus are receiving attention. Several questions need to be posed. The first phase of the Lesotho highlands water project was built between 1986 and 2004, and planning for phase 2 started in 2014. It needs to be asked why implementation has not yet begun. The resilience of the current water mission also needs to be questioned, and whether enough provision has been made for drought.

The following historical timeline can be observed in South Africa in relation to the nexus:
- 1912–1942: The food-water-energy nexus started with irrigation.
- 1956–1990: Considerations related to energy were predominant; hence the nexus during this period could be called the energy-water-food nexus. The 1950s marked the start of rapid but unsustainable industrial growth in the county, accompanied by a deterministic assumption that it would be possible to take control of nature.
- 1994–2008: Issues of water became more urgent, hence the water-energy-food nexus.

The following were significant points of serious collapse of the system:
- 2008: Load shedding from which South Africa has not yet fully recovered.
- 2017: Drought in the Western Cape and its impact on food production

A possible third collapse might be allowing land expropriation to take precedence over addressing food shortages.

Discussion

Chair: South Africa has an uncomfortable history, but it is informative to look at social aspects and the significant influence of politics and economics. It is also important to take note of the collapses and remember these in the future. When a society is at peace development take place, science flourishes and infrastructure is developed.

Research and development needs in the water-energy-food nexus in South Africa (Dr Emmanuel Mwendera, Research Team Manager: Water Science, Agricultural Research Council)

It is extremely important for South Africa to consider the steps that the nation needs to take to contribute to the food and water sector. The usage of water in the agricultural sector and the environment are two key areas.

The linkages and relations of the water-energy-food nexus are affected by everyday activities. Water for energy includes the growing of crops for biofuel production, and water use for hydropower and thermoelectric power. Important issues in relation to water for food and land are consumption of soil moisture and freshwater by agriculture, and water used for food processing. In the relationship between energy and water, it is important to consider the development and use of water resources that need energy such as desalination and groundwater pumping. Issues of energy in relation to food and land include the transportation of food products and food processing. The linkages between food and energy include the use of biomass as a domestic energy source, and the use of land for mining, biofuel, wind and solar energy. The linkages between food and water include agricultural intensification that impacts on runoff and water quality, and mining activities that result in the loss of fertile soils.

Agriculture accounts for 70% of global water withdrawal. The equivalent figure in South Africa is 60%, and 62% when forestry is included. Roughly 75% of all industrial withdrawals are used for energy. This is an area that needs to be considered in relation to the nexus. Food production and supply chain account for about 30% of water withdrawals, and 90% of global power generation is water intensive. Global water demand is projected to increase by 55% by 2050, mainly due to growing demand for manufacturing. More than 40% of the global population is projected to be living in areas of severe water stress by 2050. South Africa is a water-scarce country and needs to take this challenge seriously. By 2035, water withdrawals for energy production could increase by 20% and consumption by 85%.

In relation to water management to enhance the water-energy-food nexus, the Agricultural Research Council has been considering rainwater harvesting and conservation (RWH&C) in croplands and rangelands for food and renewable fuel (biogas) production.

More than 1400 households in rural communities in Thaba ’Nchu (Free State), Lambani (Limpopo) and Krwakrwa (Eastern Cape), where the majority of community members live below the poverty line, have been empowered to implement and apply RWH&C practices in their homestead gardens and croplands to improve their household food-security status. The increase in crop yields with these technologies ranges between 10% and 70% depending on management practices. These approaches have also helped to increase income, social well-being, crop diversity and hence nutritional status. This has been achieved with simple and easily implementable practices with low maintenance costs.

Water is shared by several economic sectors (agriculture, industry and mining) in rural and urban areas. Agriculture takes the lion’s share at 60% and the power generation system uses only 2% of the water. However, the impact from the power generation sector is high, as much of the return flow from the generators cannot readily be used by others in the ecosystem.

The ARC has researched and implemented change-adaptation strategies in relation to climate change, including a biogas project that will reduce farmers’ dependence on wood and gas for heating, and reduce overall emissions of methane, a greenhouse gas, from cattle farming. The ARC is also involved in a cropping system project to improve food and nutrition security under changing climatic conditions, which involves crop rotation of maize with legume crops. Reduced tillage has also been introduced.

There is a drive to improve water storage in South Africa and much has been done with regard to dam capacity, but further improvement is needed. The investment in increasing water storage capacity must be prioritised in order to meet the needs of the growing population. The purpose of water storage in South Africa is to meet the needs for irrigation, which takes the largest amount of water, followed by municipalities and industry. Domestic water use and flood control are low users, as is mining but this sector has a high impact in terms of its footprint because of the quality of water discharged from mines.

Potential nexus relationships that might be important to consider include:

- In the water domain, desalination and the withdrawal of groundwater require energy. Energy is also needed for waste water treatment, and water for sanitation competes with water for food.
- In the energy domain, water reservoirs are needed for energy production. Fracking and other types of energy generation require water. Bioenergy crops need water and compete with food crops for land.

- In the food domain, crops need water. Food production could lead to water pollution. Water is used in processing. Energy is used for fertiliser and pesticides, farm mechanisation, in the food chain and for transportation.

The following questions need to be researched with respect to managing the water-energy-food nexus:

- How are mutual WEF inter-linkages expressed in resource, institutional and security terms?
- How does governance impact on the nexus?
- How can farmers be mobilised to use water and energy more efficiently?
- How could resource use, productivity and efficiency be improved? How could incentive structures, governance and institutions be used to improve water, energy and food security?
- How do the effects of climate change, as well as the measures and policies designed to address it, impact on food, energy and water stresses?
- How could the WEF nexus be viewed through multiple domains of resources, institutions and security?
- How could resource recovery be brought about in the interests of operationalising the WEF nexus?
- What kinds of up-to-date accounting and auditing of available water resources and water use could be applied in all economic sectors?

Society is changing, and the way in which water is used is also changing. The changes and their impact on the resources must be captured so that actions are informed by the current reality rather than knowledge based on the past.

It is important that the results of the research being undertaken reach farmers for implementation.

Discussion

Question: It is said that we need to increase water storage per capita by increasing the capacity of large dams. Blocking rivers with large dams is like deep vein thrombosis for the ecology. Do we really need to continue building more dams? Should we not rather move to agro-ecological systems?

Response: The issue of dams has always been controversial with regard to the environmental impact. Small unregistered dams were not included in the study and generally these are unsustainable. It is important to balance environmental considerations with the socio-economic needs of the country when building dams, but it is essential to provide sufficient storage to mitigate the impacts of drought.

Comment: With regard to dams, every effort is made to consider environmental constraints and ecological claims, but water storage is critical. There are limited suitable dam sites in South Africa, so we are looking at importing water from other countries and also at the further exploration of groundwater. A mix of options for water resource development is necessary.

Question: Has there been a start to desalination in the coastal provinces?

Response: The ARC would like to see desalination moving forward. It is expensive to install, but South Africa needs to invest in it. The Department of Water Affairs and Sanitation needs to provide information on how far we have progressed.

Comment: Desalination is part of the broader context in terms of water research management. There are currently 29 desalination plants in operation, four more under construction and 19–20 in the planning stage. Water treatment to reuse impaired water is another part of the water management plan.

Question: Is the government taking water harvesting seriously, and is the ARC working with government to demonstrate that it works?

Response: The Water Research Commission has supported the ARC's work on water harvesting. The groundwork and research are complete, and the ARC is moving to the upscaling and outscaling phase. The technology has to be spread to as many farmers as possible.

Question: What is the capital outlay for resource-poor farmers to install a biogas system?

Response: The design criteria for a biogas system include that it must be affordable for small-scale farmers.

Question: I am not confident that efficiency and productivity gains will lead to more water, from savings, for other sources. If there is no active market for selling saved water, then farmers will just expand to use the water. Incentives could perhaps change the behaviour of farmers such as paying a premium for products that use water sustainably and efficiently. Who would be prepared to pay the surcharges?

Response: With regard to incentives for farmers to use water more efficiently, and whether saved water could be marketed, transforming irrigation systems would mean that the Department of Water and Sanitation could allocate less water to the more efficient farms. This would result in less water being allocated for agriculture. The savings would be at a national level. Incentives or demand management strategies would indeed motivate farmers.

Comment: In the work that the WRC did with the University of KwaZulu-Natal, two approaches were used for constructing the biogas systems. The brick-and-mortar system was very cheap at R2 500 per system and also had the benefit of using local contractors. The plastic system was more expensive at R8 200 per system and had the disadvantage of requiring specialist contractors for construction and trouble shooting.

Comment: On the issue of dam capacity vs inhabitants, South Africa does not have any new dam sites available so we need to look at other mixes of water systems including groundwater. There is also a question of scale and a need to test people that rely on other sources of water, because not all are situated around large-scale enterprises. There are some 3000 small dams that provide water and food security to communities.

Response: The indicator of the volume of water in the country per population head is used internationally. Most stored water is in big dams, as many of the small dams are not registered. The indicators provide an idea of the current situation.

Opportunities for the science, engineering and technology community to host international conventions (South African National Convention Bureau)

No presentation was made, but Ms Niehaus explained that the South African National Convention Bureau (SANCB) can provide assistance in organising international conferences. The NSTF is in contact with the bureau, and contact details can be obtained from Ms Niehaus.

Breakaway sessions

Group A: Water and energy relationship
Group B: Food and its water and energy requirements

Feedback from the breakaway sessions was presented during the plenary session of Day 2.

DAY 2: 24 October 2018

Welcome (Ms Jansie Niehaus, Executive Director, NSTF)

Ms Niehaus welcomed everyone to the second day of the discussion forum.

Water resource planning and management for water security in South Africa (Mr Patrick Mlilo, Director: National Water Resource Planning, Department of Water and Sanitation)

The Department of Water and Sanitation (DWS) is responsible for water resource management and the supply of water to all South Africans.

South Africa is a country of high inequality, and water is a vehicle for development. South Africa is among the five most unequal societies in terms of the Gini coefficient, and the country needs to think critically about the challenges of inequality, unemployment and poverty.

The National Water Resource Strategy has been developed, and the 2063 goal of the macro plan is affordable and reliable access to sufficient and safe water and hygienic sanitation for socio-economic well-being with due regard to the environment. The focus is on water supply, water quality, water eco-protection and sanitation. Drivers of the plan include the Sustainable Development Goals (SDGs), the National Development Plan, legislation and climate change. South Africa is a water-scarce country, and scarcity and variability drive planning imperatives. Other sources of water must be explored to meet requirements.

The characteristics of South Africa's water resources include water scarcity, uneven temporal and spatial distribution, internationally shared surface and groundwater, pollution of water resources from agricultural runoff and urban discharge, highly regulated water resources, high competition among users, and transitioning to a mature phase of development. Water scarcity in South Africa could deteriorate further as the supply contracts and demand escalates as a result of population growth, urbanisation, inefficient use, the degradation of wetlands, water losses and reduction in yield due to climate change.

Rainfall distribution is uneven in space and time. South Africa's mean annual precipitation is 465 mm per annum compared with the world average of 860 mm. Surface water resources are also unevenly distributed. The DWS is launching a study to confirm the figures that are currently available. With regard to groundwater, the mean annual potential recharge is 21,100 m^3 with the mean annual contribution to rivers being 4,800m^3 per annum; the utilisable groundwater exploration potential is 7,500m^3 per annum and current use is 3,000m^3 per annum.

Four of South Africa's main rivers are shared with six neighboring countries. The international basins cover 60% of South Africa's land area and contribute 45% of the country's total river flow. These areas support approximately 70% of gross domestic product and a similar proportion of the population. Several international inter-catchment transfers and inter-country systems have been introduced (including the Lesotho highlands water project). Resources are shared with other countries in the Southern Africa Development Community (SADC).

There are increasing pollution threats to the water-energy-food nexus. Agriculture is recognised as a major source of pollution of the water resources. In the Vaal system, the issue has been dealt with by the release of water from Lesotho to improve water quality, but dilution is not a solution to pollution. More sustainable ways of dealing with pollution need to be developed.

South Africa has very advanced water infrastructure with large water storage capacity. The large dams used for storage include the Vaal, Jozini and Vanderkloof dams. Agriculture is the biggest user of water resources, followed by municipal and domestic users, industrial users, and the lowest users namely the power generation and mining sectors. However, the discharge from power generation and mining is not easily reusable and is also a source of pollution to the environment. The DWS will be launching a study to verify the usage figures.

South Africa is in transition from a developmental environment to a mature phase, and is experiencing competition for water between agriculture, industry and urban uses. The transition needs to be recognised in policy decisions and strategy development. In order to meet the demands for water, it is critical to generate revenue to finance new developments and rehabilitate ageing projects. The growth in water demand across different sectors needs to be controlled, and a conflict resolution mechanism needs to be put in place. The governance of water resources is critical to South Africa. National, provincial, catchment and ultimately local level governance must be coordinated by planning together to maximise resources.

With regard to water resource planning, a key message is the need for adaptive management. Different policy responses are required for the changing context of South Africa's water resource management. It is also important to realise that in water resource planning there is a tendency to respond to requests. There is a need to become more proactive rather than reactive.

Water planning has common characteristics with planning in the domains of energy and food, in that it is capital intensive with long lead times and large initial costs. The low levels of capital redemption make water unattractive to private equity investment. The situation is somewhat different in the energy sector with the introduction of independent power producers. The service life of infrastructure is long, and once built it is difficult to change and retrofit for other uses. At the planning level, there are opportunities in terms of the water-energy-food nexus to plan together and improve coordination. There is a high degree of uncertainty in planning, with horizons of 25 to 40 years.

There are several complementarities and linkages across the water-energy-food nexus, including water infrastructure being used in energy generation, water being used for hydro-power generation and returned to rivers for irrigation for food production, and power being used for running irrigation pumps. Furthermore, crops such as sugarcane are used for renewable power generation in the form of biomass. These complementarities and linkages make it important to coordinate activities and plan for the co-location of renewable energy plants and desalination plants. Studies associated with the reconciliation strategy are the outputs of planning and follow the process of determining needs, developing scenarios and recommending future actions. The DWS focuses on water, but water balance studies and planning involve all sectors.

The major metropolitan areas are key demand centres where it is essential to maintain the water balance. In metropolitan areas, the water infrastructure is increasingly connected, and management becomes more complex. Wide options are considered in focused planning to meet the water needs of different sectors at local level.

In looking at the linkages between water and energy, it is essential to consider the Integrated Resource Plan developed by the Department of Energy and to include the energy sector early in the planning process (unlike in the past). Since about 1880 when coal from Vereeniging was supplied to the Kimberley diamond fields, coal has dominated the energy supply sector in South Africa. At present, 77% of South Africa's primary energy needs are provided by coal. The Government Gazette of 6 March 1923 announced the establishment of the Electricity Supply Commission (Escom, renamed Eskom in 1987). The first hydro station was built on the Sabie river and came into commercial operation in mid-1927. The Hendrik Verwoerd (re-named Gariep in 1996) hydro power station started feeding into Eskom's transmission system in 1971. A similar hydro power station was commissioned at Vanderkloof in 1977 as part of the Orange river project.

In the 2018 Integrated Resource Plan (IRP), the Department of Energy set targets for the energy mix of the country, including nuclear, fossil fuel and renewable energy. The White Paper on Renewable Energy (2003) set a target of 10,000 gigawatts of energy to be produced from renewable energy sources (biomass, wind, solar and small-scale hydro) by 2013. If the Department of Energy proceeds with the development of the renewable energy strategy, achieving this target will add about 1.667 megawatts of new renewable energy capacity, with a potential net impact on GDP of R1,071 billion per annum. This could potentially create additional government revenue of R299 million, additional income to low-income households of up to R128 million, and over 20,000 new jobs. Water savings of 16.5-million m^3 could be achieved.

According to the Integrated Resource Plan, electricity consumption is declining. Four scenarios and their impact on the future energy mix were considered, namely an electricity-demand scenario, a gas scenario, a renewable-energy scenario and an emissions-constraint scenario. It was also recognised that the pace and scale of new capacity development needs to be curtailed in relation to the IRP 2020 projections. According to the IRP, the energy mix for 2030 would entail decommissioning the coal-power fleet reaching the end of its lifespan and transitioning to a low-carbon economy. No additional nuclear would be added to the mix. Elements of various strategies are incorporated in the reconciliation strategies at local level, informed by the IRP. Key questions raised by the IRP include the role of the Mokolo and Crocodile River (West) Water Augmentation Project in improving the assurance of supply for Matimba and Medupi power stations, which rely on surface water; the status of the proposal to import power from the Grand Inga Project on the Congo river; and plans for hydropower using DWS infrastructure.

Renewable technologies that could be included in the energy mix include solar, biomass, hydropower, wind, ocean and pumped storage technology. The least-cost plan involves only photovoltaics, wind and gas, and some new technologies would not be deployed as projected in the IRP for 2010. The annual build limits on renewables will not impact the total installed capacity of renewable energy technology leading up to 2030.

Considerations to be taken into account in developing a strategy to expand irrigation areas include the use of agricultural mechanisation, and meeting food and agricultural production requirements. In setting water tariffs, the competing needs to produce food and biomass will have to be taken into account. Using localised resources such as aquifers will have to be considered, as well as the issue of diffusing pollution from agricultural land. Planning decisions will have to be taken in relation to providing water for irrigation and food production, or for industry.

Potential water savings could be achieved in irrigation systems and schemes by using improved operating systems and upgrading infrastructure. According to the National Development Plan, the area under irrigation could be expanded by 500,000 ha, but the second National Water Resource Strategy makes provision for expanding agriculture by only 80,000 ha. It is clear that water for the expansion of irrigated agriculture will have to come from savings within the sector.

Strategies to meet the demand for food include the expansion of rain-fed lands, the reclamation of soils, the prevention or reduction of erosion, increasing water productivity, and upgrading areas by enhancing the management of rainwater. It will also be necessary to increase annual irrigation water supply by developing new surface-water storage facilities and increasing groundwater withdrawals and the use of wastewater. Increasing water productivity in irrigated areas and the value per output of water by integrating livestock and fisheries into irrigated systems and agricultural trade will also assist in meeting the demand. Key factors will include deducing the food demand by influencing diets, and reducing post-harvest losses, and industrial and household waste. The competition between food production and mining will have to be managed.

In maximising water security within the nexus, the key issue will be to consider strategies and coordinate planning across the water, energy and food sectors. The broad interventions required to meet water needs include broadening the water-resource supply mix, water conservation and water demand management across water-use sectors, and developing the remaining surface and groundwater potential. Water transfers across political and international boundaries will also be important, as well as strengthening and improving the water measuring and monitoring network. Gaps in implementing these interventions include inadequate research and development for cheap technologies to harness and create new water, the lack of implementation plans and enforcement, insufficient knowledge about groundwater, and agreements not yet being in place for source areas such as Zimbabwe.

The future trends for meeting water requirements will necessitate diversification and giving preference to non-traditional sources. It will be critical to limit expansion across water use sectors. Further development must come from increased efficiency within each sector.

Water is a vehicle for achieving equality. Planning is needed to broaden the water-resource mix, as there are only limited opportunities for further surface-water developments. Many options must be considered in focused planning to meet the water needs of the various sectors at local level. Planning should be coordinated across the water, energy and food sectors. Dams and inter-basin transfers are inevitable in certain areas, but these are very expensive.

It is essential that adequate funds are made available for planning activities across sectors to avoid costly mistakes. It might be appropriate to consider a three-sector Resource Planning Task Team involving the departments of Water and Sanitation, Energy, and Agriculture, Forestry and Fisheries to strengthen coordination and planning across sectors.

Finally, it must be noted that operating rules and penalties are imposed on the system during droughts, for example in the recent drought in the Western Cape where food production was penalised. It must also be remembered that nexus planning and thinking are relevant to both the long term and the short term.

Relevant research for the WEF nexus (Dr Graham von Maltitz, Natural Resources and the Environment, CSIR)

The CSIR has worked on issues related to the water-energy-food nexus for many years. The current focus is on the linkages between the various aspects and making recommendations for the future.

In the scientific field, the WEF nexus is considered a difficult problem, coupled with socio-environmental systems, complex feedbacks and unexpected outcomes. It is important to avoid going beyond the thresholds and tipping points that the system can afford.

Different organisations have different ways of addressing the WEF nexus. Nexus science is developing, and one view is simply to take a nexus way of thinking. Nexus tools have been developed to stimulate discussion; for example, highly complex modelling, science–policy interfaces, science–industry interfaces, futures and scenarios as well as several tools at the social level.

In a nexus view of the world, taking complex feedbacks into account, it must be borne in mind that actions in one area could have unintended feedbacks in other parts; for instance, mastering energy supply at the expense of negative impacts on climate change. Feedbacks tend to be slow, which makes planning complex.

An environmental envelope approach is a good way to think about problems. This approach includes defining the size of the environmental envelope in which developments are conducted, growing the envelope and making trade-offs to optimise social benefits. Inputs need to be evidence based, with an understanding of the tipping points and not exceeding critical thresholds. Risks must be reduced and an adequate buffer allowed for uncertainty.

It is also important to understand the bounding of the system. It is not possible to consider water, energy and food alone. It is essential to look at the whole system including issues such as biodiversity, tourism, fibre production (e.g. forestry, cotton, wool), the ability to absorb waste and pollutants, and climate feedbacks.

Another issue is spatial bounding, which is often only evident at global level. If national food targets are not being met, and if money is available, food can be bought from another country, thus moving the problems across boundaries.

In achieving sustainability, there is a new way of thinking driven largely by remaining within the environmental envelope. In this approach, the three pillars of sustainability (namely the economy, environment and society) are incorporated in embedded social-ecological systems. This underlines that all economic activity is embedded in a complex social-ecological landscape. Societies cannot thrive without functioning life-supporting ecosystems, and economies cannot thrive without functioning social structures and institutions. Solutions can be found to most ecological problems, but these are often not only complex but also expensive.

The CSIR has contributed to many international assessments including the assessment of land degradation and restoration (including the Africa assessment initiatives) of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the special report of the Intergovernmental Panel on Climate Change (IPCC) on the impacts of global warming of 1.5°C, and the World Atlas of Desertification. It is clear that the window for action is closing. The need for rapid action is imperative, and fixing the problems will be far more expensive than preventing them.

Changes in land productivity will have considerable effect on the nexus. A study using long-term satellite imagery of central Africa showed that land and vegetation productivity have dropped. This drop is driven by climate change and suggests that a threshold has been exceeded. Africa is not performing well in terms of the human appropriation of net primary production indicator, but the performance of the Indian sub-continent is worse.

Climate change must be considered in planning decisions, but human demography also has considerable impact. In the 1950s there was an even split between the urban and rural populations in South Africa, but in the future the rural population will comprise a small proportion of the total. The growth of mega cities is accompanied by increased demand for food, water, fibre, energy and waste disposal. The issues extend beyond the water-energy-food nexus and include climate, health and air quality.

eSwatini case study

A case study was conducted in eSwatini, which has less complicated infrastructure than South Africa. The study looked at climate change and the impacts on water availability and water demand. The water demand structure is simple, with water required for subsistence maize production or modern sugar production. Sugarcane is a high driver and is responsible for 16% of the national economy. eSwatini is a food- insecure country. Climate change is impacting on crops and water, and the country is susceptible to changes in global markets. The subsidies that the country used to receive for sugar production from the European Union have stopped and sugar prices have halved, while fuel prices have increased.

Water availability was considered with respect to land use. Land use issues include stream-flow reduction due to forestry, water extraction for irrigation, extraction for urban areas and industrial use, and water storage. The impacts of climate change mean that the crops of the future will be different from the crops of today, and the ability to deal with drought must also be considered. Water demand must be seen in light of other factors including the impacts of various types of irrigation, the crop yield based on unconstrained or constrained use, and crop yield under climate change.

One of the biggest problems related to climate change is the huge uncertainty. Some trends are evident from climate modelling, one of which is the occurrence of big storms. Far less rainfall is expected, but the rain that does fall will be in the form of concentrated storms. Trade-offs are possible in the sugarcane production area, including the trade-off between producing sugar for human consumption, or for fuel and electricity.

The case study showed the importance of decision support and of making information available to policy-makers. Accessing full baseline data is difficult even in a small country such as eSwatini, so it was necessary to use a spatially explicit tool to drag and drop land-use information on a scalable interface such as Google Earth. The land-use information was then overlaid with a complex query-building tool using Cube-type logic.

Conclusion

A key issue in moving towards a nexus approach is to break the silos by getting different departments, and sometimes different sections within departments, to talk to one another. This involves trade-offs and sound economic and social decisions, for which evidence-based tools are required. Integrated assessment models are important, as well as empirical evidence to understand the linkages, and policy instruments for planning and implementation.

It is essential to grow the environmental envelope by using technologies that enable more to be achieved using less. An example of this is the Working for Water Programme, in which water availability is increased by removing alien vegetation. The programme also has social impacts such as job creation. Crop efficiency, smart mining, reducing waste and recycling also have positive feedbacks. Eating less red meat can assist in growing the envelope.

The issues regarding the nexus require long-term decision-making related to the areas in which government and the private sector should and should not invest. Risk profiles are expected to change substantially in future.

Mine-impacted water: a resource for the circular economy in South African mining communities (Mr Dheepak Maharajh, Head: Biometallurgy, Mintek)

In trying to turn problems into opportunities, a concept has been developed to show how mine water could contribute to the circular economy.

South Africa is a water-scarce and water-stressed country. The mining sector does not necessarily use a large percentage of the available water, but the water use behaviour of this sector in relation to the country needs to be considered.

On average, South Africans use 60% more water than the global citizen. Moreover, South Africa receives only about half the global average rainfall. According to statistics from the USA (South African statistics would be similar), mining pollutes about 20 million gallons of usable water per annum. If this water were put into half litre bottles and stacked, it would cover the distance of 54 trips to the moon and back. Water stress in South Africa is compounded by poor water behaviour.

The challenges facing the mining sector include the need to reduce the utilisation of key resources such as energy and water, to reduce the environmental impacts of the operations and waste production, to ensure sustainable mine closure and to create new employment to make way for mechanisation. The mining industry understands the mistakes that the sector is making and is striving to address the challenges.

The impact of a weakening mining sector was considered from a socio-economic perspective. The South African economy is very dependent on mining, but the remaining lifespan of the mining industry is estimated to be only 30 years. Many parts of the country, such as Limpopo province, are affected by poverty and are reliant on mining, and mine closures would exacerbate poverty levels. It would be possible to extend the lifespan of mines through the introduction of mechanisation, but that would be accompanied by job losses and socio-economic problems. A complex model has been developed to address the needs of the nexus within the mining industry. There are many such models, but in this initiative an effort has been made to focus not only on sustainability but also on reuse. This model is underpinned by Mintek’s available technology offerings and other technologies that could help.

Mintek’s flagship acid mine drainage system, the biological sulphate reduction system, is currently being piloted at a coal mine and there are plans to roll it out to other mines. This technology makes badly polluted water reusable, but not potable.

The Mintek SAVMIN™ process, which was patented in 1988, is a three-stage process that potentially gets polluted water to a potable stage. This process has been piloted, and the initial costs have been significantly reduced. These two technologies provide partially cleaned water for possible reuse.

Additional technologies for integration into the model include algal technologies, which could provide significant value. Water that has been treated by other technologies but is not quite clean enough could be completely cleaned with algal technologies. A further advantage is that secondary algal water treatment would produce biomass. Algae could provide a solution to the diesel problem. A mine uses about 70 million litres of diesel a year; if this could be replaced by biodiesel it would represent a significant saving.

In agriculture, partially treated mine-impacted water could be used to irrigate crops, and such activities could be developed around mines in the future. Food crops for communities and biofuel crops for mine vehicles could be a source of income for communities. Mine-related products such as the guar bean, which is required in mine flotation systems and is currently imported from India, could be cultivated using mine-impacted water. The development of agricultural activities would contribute to job creation.

Acid mine drainage water could not be directly used for aquaculture or animal husbandry, but cleaner water could be produced by using algal culture. Algal protein is a feed source, and water from aquaculture could be returned to an anaerobic digester system. For livestock farming, algal protein could provide a feed source; the livestock could be sold for profit; and the manure could feed into the anaerobic digester system.

Anaerobic digestion could become a household technology in the future. Waste could be used as a solution to the provision of energy in the nexus domestically, industrially and in the mines. The focus of the Mintek model is mining, but it could be adapted for any other sector.

Concentrated solar power that generates considerable heat could be used not only to supply power to communities, but also to assist in mining processes. The heat could be used to pre-heat smelter materials, which would reduce costs considerably. Desalination is costly, but waste heat from concentrated solar power could be used in the evaporation process. It is also necessary to consider cooling, which is an important part of both desalination and mining systems.

A technology that uses mine-impacted water for carbon capture and storage is the early stages of development. This technology could play a part in reducing South Africa’s carbon dioxide emissions.

The model that has been developed is a means of addressing the problem of mine-impacted water and demonstrating how the problem could become a positive contribution to the circular economy. The aim of this model is to minimise the impact of polluted resources and help to create community value through job creation. The model could be adapted to other industries.

It has been estimated that, depending on the size of the mine, the implementation of this model could create between 500 and 2000 direct jobs. There is a need to implement this system urgently so that it is already entrenched when mines close and the community is left with a solution rather than a gaping environmental problem.

Report back from breakaway groups

Group A: Water and Energy Relationship (Chairperson: Ms Rebaone Gaven)

Two presentations were made:

- Water needs of the nuclear industry (Nuclear Energy Corporation of South Africa)
- Water needs and trade-offs of coal-generated and renewable energies (Mr Nanda Govender, General Manager: Water and Environmental Operations, Eskom)

Recommendations:

- Under climate-change scenarios, the water mix for power generation must be diversified away from freshwater to desalination, wastewater treatment and water efficiency technology.
- Floating photovoltaic solar panels should be installed on open-water spaces to potentially reduce water evaporation losses and create an energy source.
- There is a need for an integrated water resources and infrastructure plan that makes integrated generation developments possible. The draft National Water and Sanitation Master Plan and the reconciliation strategies of the Department of Water and Sanitation need to support the integrated plan.
- Power plants should be placed adjacent to the sources of fuel, and water needs to be augmented or treated to support energy developments. A pebble bed modular reactor is an example of a technology that does not need water and could be installed wherever it is needed.

Mr Govender made extensive recommendations for behavioural-based teaching to educate South African children about wastefulness.

Group B: Food and its Water and Energy requirements (Chairperson: Ms Jansie Niehaus)

Two presentations were made:
- Climate change adaptation through the water-energy-food nexus in South Africa (Prof Sylvester Mpandeli, Research manager: Water Utilisation in Agriculture, Water Research Commission)
- Challenges in providing food security for South Africa, in relation to water and energy (Prof Linus Franke, Head of Department: Soil, Crop and Climate Sciences, University of the Free State)

Prof Mpandeli focused on projects implemented by the Water Research Commission and highlighted the following issues:
- The duplication of programmes by various government departments should be avoided. Several departments are working on food security, for example. These initiatives should be merged under the Presidency.
- A regional approach is recommended, because countries in the region experience similar needs and challenges to South Africa.
- Politicisation is unhelpful. Because resources are very limited, sensible decisions regarding the management of these resources are essential.

Prof Franke discussed studies on potato cultivation with a focus on water use. Potatoes have high yield potential, but also a high need for water and nutrients, and are disease prone. Four regions were studied and it was shown that the best crops were attained through efficiency. The studies looked at the leaching of nutrients into the soil through over-irrigation, which indicated that the irrigation water quantities should be carefully monitored. Areas with sandy soils are unsuitable for potato cultivation due to leaching.

Small-scale farmers producing potatoes have low levels of efficiency, and the question is how to convert these into highly efficient farms by providing advice and support. With regard to the effects of climate change, higher levels of carbon dioxide could help some crops. With increased levels of carbon dioxide, potato crops become 29% more water efficient, cassava crops become 100% more water efficient, but there are only small increases in water efficiency for cereal crops.

Prof Franke mentioned that water-efficiency software is available to help farmers, but small farmers are at a disadvantage in accessing such software. Extension services are important for guiding farmers.

During the discussion, the issue of ensuring that decision-makers are provided with the outputs of research was raised. This is linked to the mandate of the NSTF and there are ways of making such links, but government departments tend to follow their own agendas and work in silos.

There is a need for marketing of decision-support systems and useful apps to the people that most need them, as well as training in order to use them effectively.

Water-use efficiency in farming, mining and other sectors is very important and could help in addressing the challenges. The issue of consuming food efficiently is also viewed as very important.

Discussion

Question: The issue of economic scarcity was raised in relation to water scarcity. Is this related to the lack of maintenance of water supply infrastructure?

Response: There are significant financial and economic challenges. Many South African communities do not have water metering or associated cost-recovery and revenue streams. If there is no revenue to provide income for asset maintenance, the assets will deteriorate. The question of how to address that challenge arises, possibly through metering, measuring and collecting revenue. This is one of the challenges that the Department of Water and Sanitation faces, but it also affects municipalities and the water user associations. Ways of recouping the losses are being considered. Trade-offs will be required, but the question is whether society is willing to pay the cost.

Consolidation of comments, notes and trends (Ms Debbi Schultz, communications, NSTF)

High-level points from the two-day discussion forum were collated as follows:

- The various presenters had different definitions of the nexus, which is broadly defined as an approach that considers the interactions, synergies and trade-offs between water, energy and food. Similar definitions but different complexities were given by the Water Research Commission, the Food and Agriculture Organization and the CSIR.
- There is a drive to assign equal weight each resource sector, but this is not how they are treated by stakeholders. There are also big differences in usage by the various economic sectors. The various views of the nexus include nexus thinking, envelope thinking and systems thinking. It was also mentioned that it is important to consider issues other than water, energy and food (e.g. tourism) in order to avoid cracks.
- The nexus could possibly present opportunities for integration between sectors in order to maximise use, synergies or trade-offs and to minimise conflict. The Water Research Commission proposes an integrated model for assessment, a possible WEF database and a WEF policy, but it is not certain that integration would be possible given the silo thinking that prevails. The FAO stated that it is more productive to focus on discussions about specific technologies or systems, but suggested that nexus thinking should address both specific and broader issues. There is a need to avoid duplication. The FAO believes that integration can only happen on certain levels, but other presenters highlighted the need to consider a regional approach to integration.
- Alignment is required between water, energy and food sector policies for sustainability. There is also a need for alignment with the SDGs and proper coordination and harmonisation of activities across sectors. This issue is raised at every discussion forum. The DWS presenter suggested common planning characteristics and a possible nexus task team for coordinated planning.
- Strategies are not necessarily integrated among the different departments, and not all stakeholders are included in discussions at an early stage. It is important to involve all parties, policy-makers, researchers and other stakeholders when policies are developed for integrated sustainable resource management. Policies and strategies for land reform should include nexus thinking; private sector investment is essential; and the silos need to be dismantled.
- There is a need to disseminate WEF nexus knowledge among South African citizens and academics. It is only important to share information from a research or government perspective, but also to involve communities and citizens from a public perspective. Knowledge should also be shared at school level.
- The allocation of adequate funds for planning activities across the sector is very important to avoid costly mistakes.
- At this point and at this stage, information-sharing is critical. It is important to understand the positions of other stakeholders in moving forward and taking action. Action is being taken in various places and at different levels, but taking the nexus into consideration requires more sharing, greater knowledge of what the various parties are doing, and building of human infrastructure.
- Global assessments show that the window for action is closing and that there is very little time for action. Climate change must be brought into all discussions. Fixing the problem is far more expensive than prevention, and action needs to happen now. However, South Africa is still talking about putting coal into the energy mix.
- Both the WRC and the ARC have indicated areas that need to be researched. Mintek showed an evidence-based example of research output. In presentations it is helpful to give examples of what has worked.
- Evidence-based examples are important, but most presentations do not show their sources of information. It is important to show where the evidence comes from.

This outline of the trends from the main thrusts raised during the discussions would be circulated, and the issues raised would be passed on to the relevant authorities.

Closure

Ms Niehaus thanked everyone for their contribution and outlined the logistics for the visit to Necsa during the afternoon.

APPENDIX 1: LIST OF ACRONYMS

ARC	Agricultural Research Council
CSIR	Council for Scientific and Industrial Research
CPD	Continuing professional development
DWS	Department of Water and Sanitation
FAO	Food and Agriculture Organization
IRP	Integrated Resource Plan
NDP	National Development Plan
NSTF	National Science and Technology Forum
RWH&C	Rainwater Harvesting and Conservation
SDG	Sustainable Development Goal
UN	United Nations
USA	United States of America
WEF	Water-energy-food
WRC	Water Research Commission

APPENDIX 2: LIST OF DELEGATES

Name	Organisation
Mrs Nadia Algera	Academy of Science of South Africa (ASSAf)
Dr Tebogo Mabotha	ASSAf
Miss Adela Itzkin	Association for Water and Rural Development (AWARD)
Mrs Mariana Purnell	Agricultural Business Chamber (Agbiz)
Mr Thabiso Mudau	Agricultural Research Council (ARC)
Dr Emmanuel Mwendera	ARC
Mrs Nikki Funke	Council for Scientific and Industrial Research (CSIR)
Prof William Stafford	CSIR
Dr Inga Jacobs-Mata	CSIR
Dr Emma Archer	CSIR
Dr Graham von Maltitz	CSIR
Mr Richard Meissner	CSIR
Mr Mathala Mokwele	Department of Agriculture, Forestry and Fisheries (DAFF)
Ms Vivian Mosoma	DAFF
Miss Osenkeng Maboe	DAFF
Mrs Daphney Marabe	DAFF
Mr Mapatla Sethekge	DAFF
Mr Thabiso Mbatha	DAFF
Mr Maruping Kodisang	Department of Planning, Monitoring and Evaluation (DPME)
Mr Phendukani Hlatshwayo	DPME
Mr Selby Modiba	Department of Science and Technology (DST)
Miss Karabo Mphogo	DST
Dr Simphiwe Chabalala	DWS
Mr Patric Mlilo	Department of Water Affairs and Sanitation (DWS)
Mr Corne Du Plooy	Eskom
Dr Kaajial Durgapersad	Eskom
Miss Petro Hendricks	Eskom
Miss Ntobeko Mkhonza	Eskom
Mr Nandha Govender	Eskom
Miss Nirvashnie Bagirathi	Exarro Resources
Mr Lot Mlati	Food and Agriculture Organization (FAO)
Mr Hove Lewis	FAO
Mr Raymond Ntshangase	FAO
Miss Alina Datz	German Embassy
Dr Lisette Andreae	German Embassy
Dr Palesa Sekhejane	Human Sciences Research Council (HSRC)
Mr Lavhelesani Managa	Human Sciences Research Council (HSRC)

Name	**Organisation**
Mrs Tarren Bolton	Interact Media Defined
Mr C. Claassens	Institute for Agricultural Engineering (IAE)
Mr Nirdesh Singh	Council for Mineral Technology (Mintek)
Dr Mokae Bambo	Mintek
Miss Lufuno Nemadodzi	Mintek
Miss Mariekie Gericke	Mintek
Mr Dheepak Maharajh	Mintek
Mr Thato Motaung	Nuclear Energy Corporation of South Africa (Necsa)
Miss Rebaone Gaven	Necsa
Mr Phumzile Tshelane	Necsa
Dr Mpho Lekgoathi	Necsa
Miss Hilda Jaka	North West University (NWU)
Miss Janine Möller	NWU
Prof Elvis Fosso-Kankeu	NWU
Prof Johann WN Tempelhoff	NWU
Mr Francois Van Wyk	Rand Water
Dr Gerda Botha	South African Council for Natural Scientific Professions
Miss Sinenhlanhla Nyembe	State Security Agency
Dr Neill Goosen	Stellenbosch University (SU)
Miss Alice Thomson	SU
Prof Ashok Kumar Chapagain	University of the Free State (UFS)
Dr Henry Jordaan	UFS
Prof Linus Franke	UFS
Dr Tafadzwanashe Mabhaudhi	University of KwaZulu-Natal (UKZN)
Miss Wendy Geza	UKZN
Dr Anja du Plessis	University of South Africa (Unisa)
Prof Diane Hildebrandt	Unisa
Prof Lise Korsten	University of Pretoria (UP)
Dr Lizyben Chidamba	UP
Prof Sylvester Mpandeli	Water Research Commission (WRC)
Miss Tove Nordberg	WRC
Dr Shafick Adams	WRC
Dr Sylvester Mpandeli	WRC