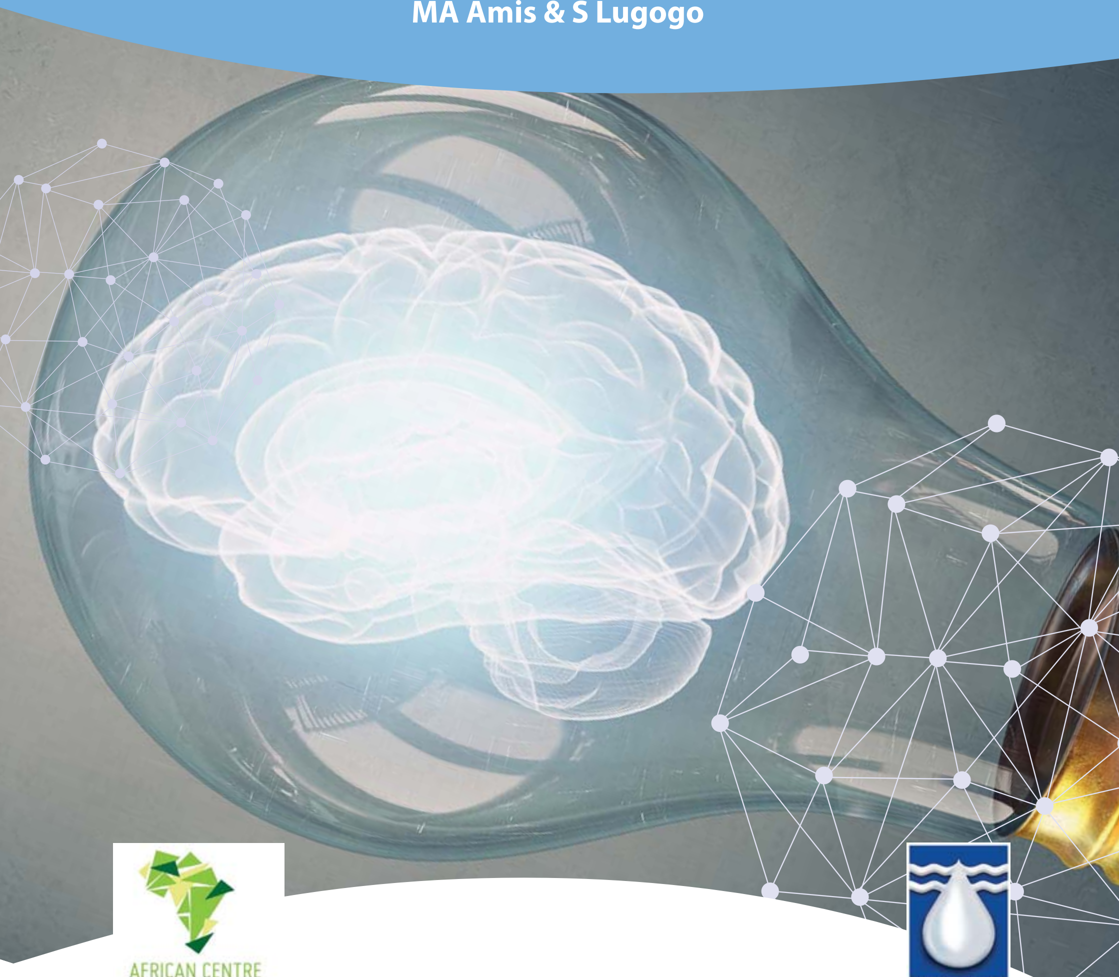
THE SOUTH AFRICA WATER INNOVATION STORY

MA Amis & S Lugogo



AFRICAN CENTRE FOR A GREEN ECONOMY

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LIST OF ACRONYMS

AMD	Acid mine drainage
CSIR	Council for Scientific and Industrial Research
DSS	Decision support systems
DST	Department of Science and Technology
EFC	Eutectic freeze crystallisation
GDP	Gross Domestic Product
IAPS	Integrated algae ponding
ICT	Information and Communication Technology
Miwatek	Mine water treatment technologies
MWA	Mine water atlas
NACI	National Advisory Council on Innovation
NSI	South African National System of Innovation
O&M	Operations and maintenance
R&D	Research and development
RO	Reverse Osmosis
SASS	South African Scoring System
SFPs	Social franchising partnerships
TIA	Technology Innovation Agency
TOR	Terms of reference
WRC	Water Research Commission
WEROP	Wave Energy Reverse Osmosis Pump

FOREWORD

South Africa is a water scarce country. Survival and development has demanded water innovation. From the earliest of times, the Khoi San had developed methods to detect and harvest water under the desert floor, then store the precious liquid in emptied out ostrich eggshells for their long journeys across the Kalahari. This culture and spirit resurfaced repeatedly in our modern history from dam-building for agricultural growth to inter-basin transfers to enable mining and industrial development. South Africa has boasted world firsts like the reverse osmosis membrane and dry-cooled electricity generation.

As we face an increasing water stressed future in the wake of much larger populations, higher levels of development and global climate change; our future water security depends on much higher levels of innovation and ingenuity. We need to span the range from the highest levels of ICT and artificial intelligence tools to manage our water systems, to the most local innovations to ensure universal access to safe water and sanitation in the most deprived urban neighbourhoods and deep rural areas.

The WRC and its many partners across the stakeholder groups, local and international, will continue to strive to develop better, safer and smarter ways to manage our water resources with a hope that our legacy will be higher water security for future generations.

Mr Dhesigen Naidoo
Water Research Commission CEO

SOUTH AFRICA'S WATER SITUATION

Introduction

The current global water crisis is creating a heightened level of awareness around the need for effective water management. Policy makers, private companies and consumers are starting to realise the need for immediate and sustained action. Even though water is widely recognised as being essential for life, its management has seldom been truly effective. In addition, the value of water is not adequately reflected through its cost to consumers. The significance of water to everyday life only becomes apparent during periods of acute water shortages, such as droughts and other natural disasters that threaten the assurance of supply.

Water is a strategic resource, critical for basic human needs and for powering key economic sectors, including agriculture, food processing, manufacturing and resource extraction. Water scarcity, defined as the lack of available water resources to sufficiently meet human and environmental needs, has been ranked among the top three global risks over three consecutive years (World Economic Forum, 2016). This risk evaluation is partly attributed to increasing consumption patterns, demographic changes and ineffective management practices, all of which pose significant challenges to human wellbeing and the environment.

Water scarcity in South Africa

South Africa is classified as a water scarce country. With an average rainfall of 450 mm per year, South Africa receives almost 50% less rainfall than the global average of 860 mm per year. The availability of water across the country faces three major challenges:

- The first is the spatial distribution (where it rains), which is extremely uneven, as 43% of rain falls on just 13% of the country, as well as the seasonality of rainfall (when it rains).
- Secondly, the relatively low water flows in rivers limits the proportion of water that can be used.
- The third factor considers the location of major urban and industrial developments in water scarce regions. This necessitates large-scale water transfer schemes across borders, which is very costly (Department of Water Affairs, 2012). Continuing industrialisation and urbanisation is expected to place further pressure on South Africa's water sources unless appropriate corrective action is taken (Department of Water Affairs, 2012).

Historically, the management of water resources has focused on supply rather than demand management. This necessitated a strong focus on the development of 'hard infrastructure', which included the construction of large dams, reservoirs, tunnels and pipelines, weirs, pump stations and irrigation canals. However, with escalating water demands threatening to surpass supply, South Africa is now faced with an urgent need for holistic water management efforts that places equal emphasis on demand management as well as new infrastructure, maintenance and operations. The emphasis of building new infrastructure, often with minimal operations and maintenance budgets, has contributed significantly to the complex water challenges South Africa faces.

Addressing water innovations in South Africa

South Africa is ranked 19th in the world for its contribution to published research related to water and wastewater (Pouris, 2013). However, translating this world-class research into innovations that address the current and future socio-economic challenges remains a challenge (Rose & Winter, 2015). Innovation is one of the critical success factors central to identifying solutions for addressing the systemic water challenges and interrelated socio-economic transformation. It requires concerted effort from government, the private sector and civil society to build a robust innovation ecosystem. Although South Africa has been developing innovative technologies in the water sector for decades, with many of these innovations being adopted globally, the country still faces significant water challenges. Solutions that help to improve access to water for impoverished rural communities, leakage detection and the treatment of water and wastewater are all needed for effective management of water resources.

To enhance the development and deployment of water innovations the South Africa government, private companies and various funding bodies have substantially increased the funds made available for water-related research. Funding for this research has increased from R1.4 billion in 2000 to R2.1 billion in 2014 (Pouris, 2015). The Water Research Commission (WRC) has shown commitment to driving water innovations forward and remains the main funder for water-related research in South Africa – supporting up to 65% of water-related research in 2014 (Pouris, 2015). The Department of Science and Technology (DST) together with its agencies, such as the Technology Innovation Agency (TIA) and the Council for Scientific and Industrial Research (CSIR), among others, are mandated to drive the South African National System of Innovation (NSI). In recent years, the Industrial Development Corporation and the Public Investment Corporation have initiated the development of their own water strategies and project-funding mechanisms. Other institutions in South Africa have yet to prioritise water innovations or expedite the deployment of such technologies.

Developing an innovation ecosystem to effectively respond to South Africa's water challenges

The water sector in South Africa is arguably one of the most active in innovation activity. The strong legislative framework which has led to the setup of institutions such as the WRC has ensured that the water sector is given high priority for research and development. The adoption of the NSI approach and the development of the National Water Research, Development and Innovation Roadmap are some of the interventions that have been developed to address water challenges in South Africa.

To become a knowledge-based economy, South Africa was one of the first countries globally to adopt the NSI approach – first articulated in the Science and Technology White Paper (1996). The South African NSI specifically acknowledged the need for a transition into a low-carbon economy, in recognition of sustainability challenges caused by climate change, population growth and environmental degradation. The country has made some progress in transitioning into a low-carbon economy as well as improving the governance of innovation ecosystems since 1994 (Zhang, 2012). This is evident in strategies, socio-economic policies and government interventions that have emerged in the country, including:

- Spending R24 billion a year on research and development (0.76% of Gross Domestic Product (GDP), with future targets of achieving an Research and Development (R&D) intensity ratio of 1.5% by 2019 (Pouris, 2015).
- The development of policies and strategies to focus on innovation were further boosted by the establishment of the National Advisory Council on Innovation (NACI) in 2000. NACI was established to advise the government on wide matters pertaining to innovation systems in South Africa (Marais & Pienaar, 2010).
- Establishment of organisations such as the TIA leading to the development of public funding mechanisms for stimulating and supporting innovation in South Africa.

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[1] The innovation ecosystem is a term used to describe the large number and diverse nature of participants and resources that are necessary for enabling technology development and innovation. The actors in the innovation ecosystem include material resources (funds, facilities etc), and the human capital (researchers, entrepreneurs, students, industry researchers etc), that make institutional entities participating in the ecosystem (for example universities, colleges of engineering, business schools, business firms, venture capitalists, funding agencies, policy makers etc). It comprises knowledge economy, which is driven by fundamental research and the commercial economy which is driven by the market place (Jackson, 2011).

CASE STUDIES OF SELECTED WATER INNOVATIONS IN SOUTH AFRICA

Overview

This section provides an overview of selected water innovations in South Africa, with a focus on:


Sanitation


Water quality


Resource recovery


Resource recovery


Decision support tools for water supply and management

The case studies track the 'journey' of various water-related innovations in South Africa from research and development to commercialisation, so as to understand the effectiveness of the South African innovation ecosystem. More specifically, the case studies unpack the experiences of individual innovators (this is explored more in the larger document of this report), including challenges encountered and the kind of support they require or have received.

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[2] The challenges and experiences of individual innovators in developing these innovations are explored in more detail in the larger document of this report, which is obtainable from the Water Research Commission.

Innovations in rural water and sanitation

There is significant concern related to the provision of adequate sanitation particularly in rural areas and informal settlements of South Africa. Community Survey 2016 revealed that nationally the percentage of households with access to improved sanitation facilities increased from 62.3 % in 2002 to 80 % in 2015. However large variations still exist between rural and urban areas in terms of access to sanitation facilities. 5.6 % of rural households still lack sanitation services, compared to only 1.1 % of urban households (Statistics South Africa, 2016). Currently a range of toilet technologies in South Africa are used to address the sanitation backlog, these include:

- Bucket system
- Chemical toilets
- Pit toilets
- Ventilated improved pit toilets (VIPs)
- Dehydrating and composting toilets
- flush toilets

Despite the progress made in addressing the sanitation challenge, in some rural areas and informal settlements people still practice open defecation. This practice does not only affect their health and their environment, but it strips the people of their dignity. Therefore, the provision of safe and adequate toilet facilities that are accessible to all South Africans can significantly decrease burdens of disease and therefore health costs. Also, the introduction of water efficient toilet technologies can reduce the amount of water used for flushing toilets in urban areas. The case studies below discuss some of the sanitation solutions that have emerged in South Africa to address the sanitation challenge.

Case study 1: Pour – Flush Toilet

A pour-flush toilet is similar to a full flush toilet except that there is no water tank, cistern, flusher or liquefier with water poured in by the user. The incoming water forms a water seal in the bend portion of the pipe to prevent any odour from the pit coming back up into the toilet. The leach pit is not visible to the toilet users and is located away from the toilet structure, preventing any danger or health hazard. The pour-flush toilet is designed to have fewer parts which can break or block.

The idea of the pour-flush toilet originated in Asia. Originally designed for use when squatting, with water used for cleaning purposes, the system had to be adapted to suit South African conditions where people sit down on the toilet and use toilet paper or alternatives for cleaning purposes.

The WRC appointed Partners in Development (Pty) Ltd (PID) to design, develop and test pour-flush toilets in a South African context. Following successful piloting of the pour-flush toilets in 2010 and 2011 in KwaZulu-Natal. These pilot projects saw strong support from government institutions, municipalities and civil-society organisations, Environsan Sanitation Solutions provided expertise and support for upscaling the project in 2012 and have since commercialised the pour-flush toilet. To date, over 3000 pour-flush toilets have been installed in South Africa.

A fully constructed pour flush toilet

Case study 2: Arumloo

The Arumloo is patented to Isidima Design and Development. The company is committed to providing solutions for water and sanitation challenges facing South Africans residing in urban settlements. The development of the Arumloo was inspired by Jonny Harris when working with the WRC to install pour-flush toilets in dense settlements in the Western Cape in 2013. The success achieved in installing the pour-flush toilets in this province inspired Harris to develop the micro-flush toilet. The WRC provided funding for the first prototype of the Arumloo.

A prototype of the Arumloo has been successfully developed and tested, and has passed the international maximum performance tests used for toilets. Further production and development of the Arumloo has been limited due to the unavailability of funding and non-commitment from potential manufacturers. Currently, the developers of the innovation are in discussions with potential investors and other manufacturers.

The Arumloo

Case study 3: Social franchising

Social franchising involves small enterprises which enter into a business partnership as franchisees with a franchisor, using a "tried and tested" approach for undertaking the activities required to ensure that sanitation, water facilities and other systems are operating in a reliable manner and to suitable hygiene standards (Wall & Ive, 2013). This business model enables these franchised small businesses to operate sustainably by providing training and support and offers entrepreneurship opportunities for local communities. The social franchise supports small enterprises for the provision of appropriate locally-based service solutions by ensuring quality and reliability of services, peer learning, skills transfers as well as health and safety training.

Franchisee at work

Local franchisees at work in Butterworth

The development of Social Franchising Partnerships (SFPs) emanated from a research study funded by the WRC and led by the CSIR and Amanz` Abantu Services. The research found that the social franchising concept could be critical for improving the institutional models for operations and maintenance of public sector sanitation and water-service infrastructure. In 2008, Amanz` Abantu Services developed Impilo Yabantu (isiXhosa for "hygiene of the people") to act as a franchisor to develop SFPs in the Eastern Cape to assist in the operations and maintenance of public sanitation and water-service infrastructure.

The Eastern Cape Department of Education was the first to adopt SFPs and approve a pilot project. To date the SFP model has created employment, developed small enterprises through training and has also improved operation and maintenance for site sanitation systems in rural villages, schools and peri-urban areas. Considerable interest has been shown by many metropolitan municipalities in South African to adopt the SFP model. There is a need to develop the commercial enterprises and models that allow social systems to be replicated across provinces, the African continent and across other sectors and services.

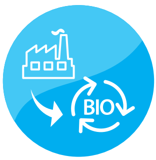
Improved wastewater management

Poor sanitation and management of wastewater treatment plants results in the contamination of water supply systems. It has been estimated that up to 90% of sewage generated in cities in developing countries is discharged untreated (Corcoran et al, 2010). While the problem is less concentrated in South Africa, the trend in recent years is showing deterioration in our management of sanitation services and wastewater treatment plants. Numerous innovations have emerged to address the wastewater management challenge in South Africa, as shown by the following example.

Case study 4: Integrated algae ponding system

The integrated algae ponding system (IAPS) is based on the algal integrated wastewater ponding systems designed by Prof William Oswald of the University of California, Berkley. The system consists of primary facultative pond containing a fermentation pit followed by a series of high rate algae ponds. The technology was first introduced in South Africa in 1996, with the first pilot project designed and commissioned for Bellmont Valley waste water treatment works in Grahamstown. The first pilot was commissioned by Rhodes University with the support of the WRC and received significant support through industrial partnerships to support the development of the system in South Africa. Since then, IAPS have been deployed across South Africa by various industries.

The IAPS is a cost-effective wastewater treatment technology for small- to medium-sized communities located in small towns and cities in South Africa. The system produces three by-products:



energy from biomass

biomass to be used as fertiliser

effluent suitable to be used for irrigation or direct discharge into the river

With conventional wastewater treatment, large amounts of electrical energy, mechanical equipment and chemical treatments are required to operate a plant effectively. Specific skills are also required to ensure efficient and effective operation of the system. IAPs could be a more cost-effective wastewater treatment option to construct, operate and maintain and may require less specialised skills. Other benefits of implementing IAPS rather than conventional wastewater treatment plants include:

- Using biological processes and micro-organisms which occur naturally in all sewage treatment processes
- Producing an effluent that meets general authorisations
- Less need for external electricity supplies
- Reduction in sludge handling
- Limiting the need for highly skilled operators (easier to operate and maintain)
- Can be scaled up
- Reuse of water and products (e.g. algae) for fertiliser

A lack of access to potable drinking water

Access to safe drinking water is a fundamental human need and a basic right (World Health Organisation, 2003). The lack of potable water of adequate quality is widely recognised as being a major barrier to health and economic development in most developing economies. In South Africa, everyone has a right to access sufficient water. However, despite the significant improvements made by government in water-services provision people are still dependant on untreated water from rivers and other sources, particularly in some rural areas and informal settlements in South Africa. The two examples of innovations that represent progress in addressing this challenge include the Vulamanz rural water filter and the Hippo Roller.

Case study 5: Vulamanz rural water filter

The Vulamanz filter, also known as the Woven Fabric Microfiltration Gravity Filter, plays a critical role in the short- to medium-term provision of safe drinking water to rural areas in South Africa and other developing countries, where communities rely on untreated water extracted from rivers, dams and/or boreholes.

The technology was developed in 2008 and has since been tested, refined and transformed into a successful product. This research was led by Prof Lingam Pillay based at the Water Technology Group at the Durban University of Technology at the time. The main aim of the research was to develop a point of use rural household water treatment unit using membrane technology.

The Pilot of the Vulamanz technology in Limpopo Province

Prototype of the Vulamanz Technology (Credit: Water Research Commission)

The module consists of a PVC frame incorporating a permeate outlet, two sheets of fabric glued to either side of the frame, and a spacer between the sheets of fabric to facilitate fluid flow to the permeate outlet. The operation of the unit is simple to use, the user pours raw water into the tank, the tap is then opened and filtered water can be collected. This innovation does not require electricity as the treatment is gravity driven. The simplicity of the design does not require significant infrastructure for construction, operation or maintenance.

In 2014, Vulamanz Water Systems (Pty) Ltd was set up to pursue commercialisation of the technology. However, the system is yet to be commercialised as there is still an ongoing project funded by the WRC/DST to pilot the innovation in selected rural areas in South Africa.

Case study 6: Hippo Roller

Community members using their Hippo Rollers (Credit: Hipporoller.org)

The Hippo Roller is a barrel-shaped container that has a handle attached to it, making rolling easy. It is made from a low-density polyethylene for handling rural road conditions. It has a proven 5-year lifespan and can carry up to 90 litres of water. It was developed to be user-friendly for men, women, children and individuals with limited strength as the roller does not require much effort to be pushed or pulled when transporting water.

The Hippo Roller was invented by South Africans Johan Jonker and Pettie Petzer. It was developed as a solution for people in rural areas who struggled to carry water in buckets on their heads. The entire process of developing the technology was self-funded, although once developed, the technology received significant support from the public and private sectors and civil-society organisations.

The Hippo Roller has been distributed in 29 countries around the world (mostly in Africa), with over 55 000 units allocated. The Hippo Roller business model relies on donor funding and sponsorship to provide the rollers to those in need. The model for individual purchases of the Hippo Rollers in a retail environment has not been tested although there appears to be demand for the product.

Women using their Hippo Rollers for the first time (Credit: Inhabitat News, 2008)

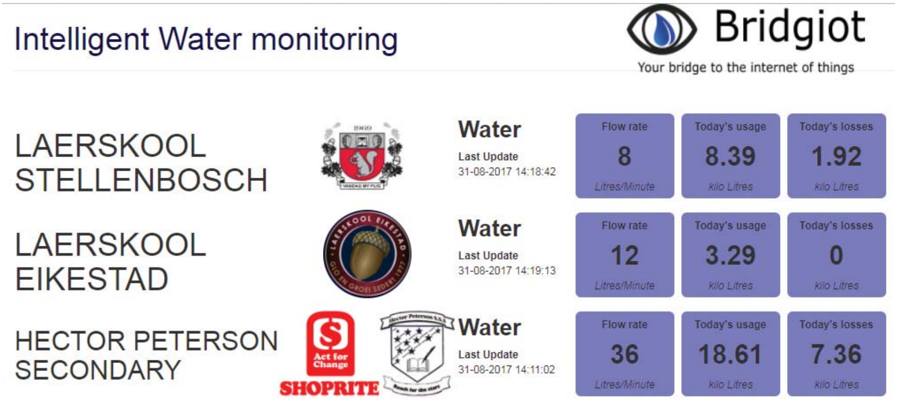
Water efficiency

Many water-supply systems in South Africa are compromised by huge losses of water – referred to as non-revenue water, estimated at 36.8% of water use (Makenzie et al., 2012). Much of this water is lost through dilapidated municipal water systems, leaking toilets, sinks and rusting steel pipes located on domestic properties. Other inefficiencies in the water supply arises from poor operational service delivery and a lack of technical capacity and the knowledge needed to obtain financing for required interventions. Ageing infrastructure accompanied by theft and vandalism of infrastructure, present huge challenges for municipalities and the government in South Africa due to the costs of maintenance and replacement of stolen infrastructure (Parliamentary Monitoring Group, 2015). Innovations that have emerged to address the challenge of water inefficiency are addressed below.

Case study 7: The Geasy

The Geasy is an intelligent geyser-management system. It provides full control of the geyser via any internet-connected device, optimising energy usage and monitoring water flow. The innovation allows the user to detect bursts and shuts off the water supply and electricity when a burst is detected. The Geasy contains a sim card and a modem and collects data which is processed and shared with the user.

The Geasy devise (Credit: Dr Thinus Booysen, Stellenbosch University)



The Geasy daily monitoring report for three schools in Stellenbosch, Western Cape (Source: Bridgiot)

The Geasy was developed by Dr Thinus Booysen and a team of engineers at Stellenbosch University in the MTN Intelligence Lab, with significant funding support from the WRC, TIA, and the DST. Initially, the concept was a device that could monitor energy consumption. Through engagement with funders and other researchers, the idea of a device measuring both energy and water consumption attracted significant attention. The Geasy has been commercialised by Bridgiot at the University of Stellenbosch, and is an example of a water innovation that has successfully reached deployment stage through the assistance of structures developed in universities to drive innovation development and commercialisation.

Case study 8: AquaTrip

The AquaTrip is a permanently installed leak-detection system with an inbuilt control valve. It monitors the flow of water in commercial, industrial and domestic properties. The AquaTrip automatically shuts the water supply off if the tap is left running or if leaks or a burst pipe are detected. This technology aims to provide users with significant cost-saving benefits by limiting property damage in cases of burst pipes as well as by saving water by preventing wastage.

Image of the AquaTrip (Credit: Chris De Wet Steyn, AquaTrip)

Image of an installed AquaTrip (Credit: Splash Plumbing)

The AquaTrip is a patented innovation co-developed between researchers in South Africa and Australia. The technology was brought to South Africa by Mr Chris De Wet Steyn, a local expert on water wastage. The main aim of introducing the innovation to South Africa was to address the issues of water wastage, specifically through leakages. This innovation has been successful deployed across South Africa and is being introduced into Namibia and Botswana as well as to some parts of east Africa.

Water recovery and energy

Water and energy are interconnected. At the heart of this interconnected relationship is the interdependence of resources – how demand for the one can drive the demand for the other. Similarly, the cost of one resource can determine the efficiency of production of the other.

In South Africa, electricity generation and large industries account for between 6 to 8% of water use (Pouris & Thopil, 2015). These plants are often located within moderately and severely constrained water management areas. As demand for water and energy increases due to population growth and demands from the economy, alternative, sustainable sources of water and energy are needed. Innovations that are addressing water demands include Wave Energy Reverse Osmosis , Eutectic Freeze Crystallization and VitaSOFT technologies.

Case study 9: Wave energy reverse osmosis pump

The Wave Energy Reverse Osmosis Pump (WEROP) is a technology that has the potential to provide clean, safe drinking water and electricity from renewable resources. The WEROP is a patented, locally built unit that sits on the seabed between 500 m and 1,5 km out to sea. The pump uses wave power to force water through an undersea pipe to a land-based unit that can be configured to run either through a reverse osmosis unit to produce fresh drinking water or through a turbine to produce electricity or both. This water can also be pumped at high volume for land-based seawater mariculture. The innovation offers a sustainable, cost-effective and environmentally friendly option compared to current desalination technologies.

WEROP unit (Credit: Impact-Free Water)

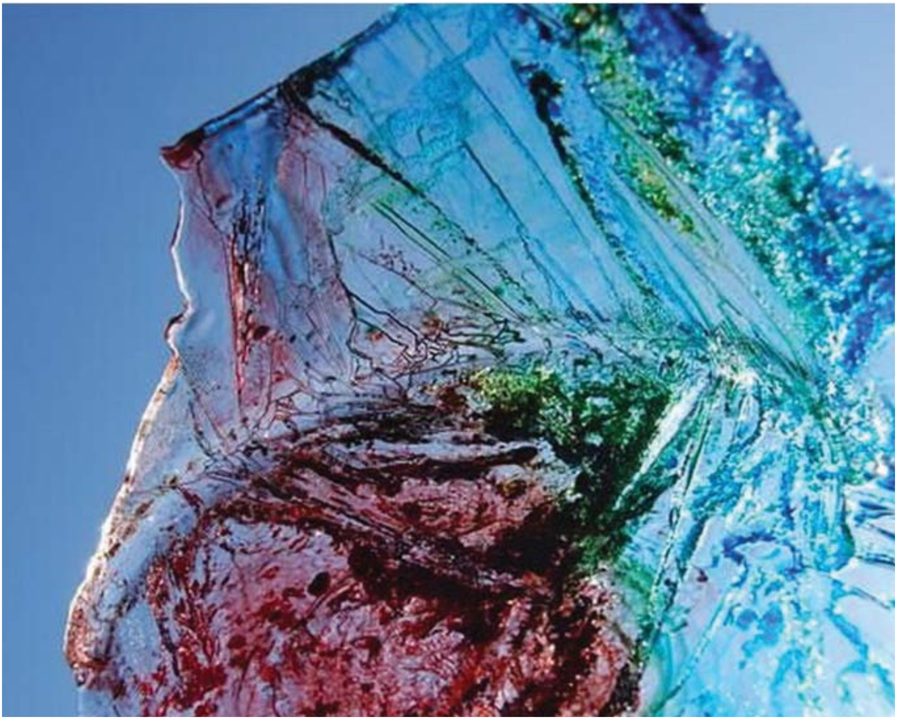
Setting up the WEROP unit off the Simonstown coast, South Africa (Credit: Impact-Free Water)

The development of the WEROP started in 2002 based research by Simon Wijnberg at the University of Cape Town. The aim of the research was to design and develop a system that could capture wave energy and force seawater through a purifying reverse osmosis filter to provided rural coastal communities with drinking water and energy.

Despite successful trials off the Simonstown coast between 2009 and 2016 the innovation has not been commercialised yet due to funding challenges faced by the innovators. However, the project is in the final research and development stages which aim to test the feasibility of the technology at a larger scale.

Case study 10: Eutectic freeze crystallisation

Eutectic freeze crystallisation (EFC) offers a waste-management solution for saline brines which result from the use of desalination technologies. The technology offers a novel, sustainable method for treating brines and concentrates previously discharged to evaporation ponds. The innovation is cost-effective to implement (a sixth of the cost of thermal evaporation) and offers a sustainable solution to wastewater treatment. Through the use of EFC clean water as well as pure salt can be recovered from brine streams, considerably reducing highly saline effluent volumes (Department of Water Affairs, 2012).



The EFC innovation was based on a research carried out at the Tu Delft (Netherlands) and further developed through the research conducted by the Crystallization and Precipitation Unit under the Department of Chemical Engineering at the University of Cape Town. The research team that developed the innovation was led by Professor Alison Lewis who has considerable experience in the research and design of cleaner products made by cost-efficient processes. The EFC technology has been commercialised and has been deployed in South Africa, although only in certain industries. Therefore there is a need for further uptake of this innovation.

Water quality management

Water quality in South Africa is affected by different anthropogenic factors, including urbanisation, agricultural activities and extractive operations e.g. mining. The mining industry is a major contributor to water pollution. Acid mine drainage (AMD) is one such effect on the quality of water. It is argued in Joubert and Pocock (2016) that the South African government requires a long-term sustainable solution to AMD, not only in the Witwatersrand, where treatment of up to 250,000 m^3/d of AMD is needed, but also in the coal fields of Mpumalanga and KwaZulu Natal.

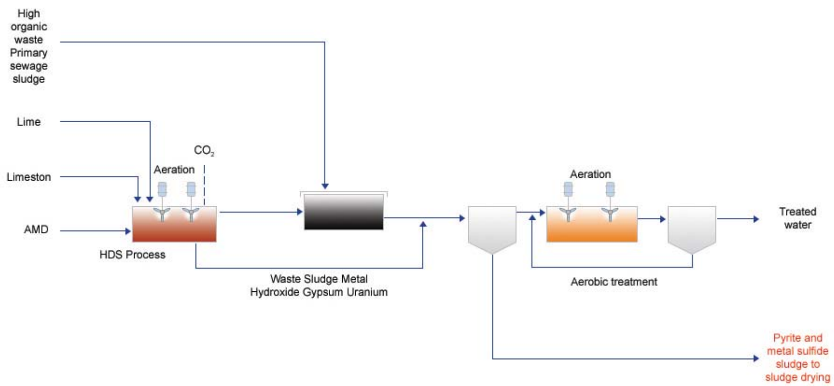
It should be noted that water quality in South Africa is not only threatened by AMD. There are water quality and environmental health issues in general that are a direct threat to water quality and river ecosystems in South African rivers and dams. Innovations that have emerged to address the challenge of water quality are addressed below:

Case study 11: VitaSOFT

The VitaSOFT process is an active biological treatment of acid mine drainage (AMD). It integrates four active biological processes, including biological sulphate reduction, with various chemical processes to achieve water quality of potable standard, converting an environmental threat into a valuable water resource for domestic and irrigation purposes while producing valuable by-products. Biological processes tend to be much more sustainable in terms of lower chemical usage and reduced electrical power requirements.

The process is unique in its design compared to other AMD solutions developed in South Africa. The VitaSOFT process can effectively replace high-density sludge processes by removing heavy metals using the alkalinity and sulphides generated in the biological sulphate reducing reactors, greatly reducing the amount of sludge produced (Joubert & Pocock, 2016).

The VitaSOFT technology was developed by Dr Gina Pocock and Mr Hannes Joubert of VitaOne8 (Pty) Ltd. The VitaSOFT process was developed through both laboratory and pilot testing in response to previous research needs. Currently the VitaSOFT technology has not been commercialised due to shortage of funding. The process has been successfully demonstrated on a small-scale pilot plant at VitaOne8's research and development facilities in Pretoria using synthetic water resembling that found in the Witwatersrand Western Basin.



Case study 12: Alternative reverse osmosis

Alternative reverse osmosis (RO) is a treatment technology for the desalination of AMD which offers a medium- to long-term solution to meet water supply and demand needs in some sectors and areas. Government investigations into the feasibility of various options for the long-term management of mine water on the Witwatersrand has identified the potential of the alternative RO process for mitigating the effects of AMD in that region. The alternative RO uses two variations;

- The RO desalination process receives AMD direct from underground with-out pre- treatment.
- Pre-treatment is provided for metals reduction by dosing with hydrogen peroxide or other oxidants at a low pH. (Department of Water Affairs, 2013).

The innovation is, however, a new technology that has not yet been fully tested and is undergoing further research and development.

The alternative RO technology was developed by Mine Water Treatment Technologies (Miwatek). Miwatek have developed treatment solutions to produce reusable waste through cost-effective solutions for the treatment of both mine-impacted water and industrially impacted water. The alternative RO innovation was piloted and demonstrated on the Western Basin by Miwatek in partnership with other various stakeholders such as the WRC. The technology was successfully designed and demonstrated at a small-scale and a simpler version has been deployed in Ghana. The company requires further funding for testing the innovation at a larger scale.

Case study 13: miniSASS

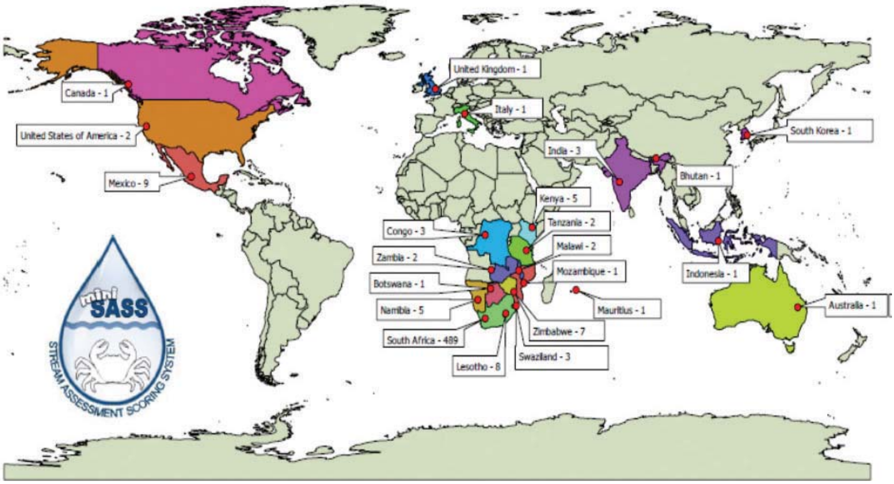
The development of the miniSASS methodology was derived from the South African Scoring System (SASS), developed by aquatic ecologist Mark Chutter in 1998. The SASS is a relatively simple technique used by trained practitioners used to identify the health of water bodies based on the identification of up to 90 invertebrate families (Graham et al., 2004). With the rising concerns of river health due to pollution, there was a need to develop a simplified version of the SASS.

The miniSASS is suitable for both non-scientists and scientists and offers an opportunity for local communities to have a voice in the governance of water resources. The method is scientifically robust and an inexpensive participatory technique to monitor water quality in rivers and streams. It also allows for understanding of the successful, but technically complex, macroinvertebrate bioassessment technique to monitor the SASS (Graham et al., 2015). The miniSASS was developed by reducing the 90 aquatic invertebrate taxa used in traditional

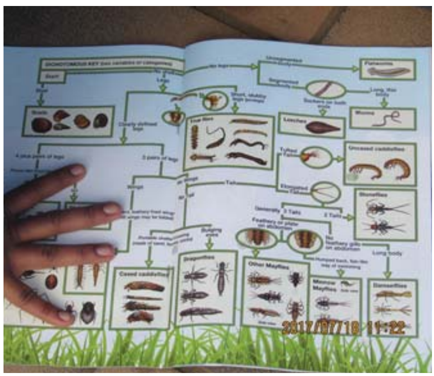
SASS assessments into just 13 groups to produce citizen-science data and provide an

Ecological category (Condition)	River category	
	Sandy Type	Rocky Type
Unmodified (NATURAL condition)	> 6.9	> 7.9
Largely natural/few modifications (GOOD condition)	5.8 to 6.9	6.8 to 7.9
Moderately modified (FAIR condition)	4.9 to 5.8	6.1 to 6.8
Largely modified (POOR condition)	4.3 to 4.9	5.1 to 6.1
Seriously/critically modified (VERY POOR condition)	< 4.3	< 5.1

The color range of ecological category (condition). (Source: Minisass.org)



Number of miniSASS studies undertaken in countries around the world (Source: minisass.org)



indication of river health.
The miniSASS model has been deployed throughout South Africa and other countries across the world. The methodology does not lend itself to commercialisation, but rather the promotion of citizen science in monitoring the health of rivers and streams and to contribute to environmental education across South Africa. The wider uptake of the innovation is driven by government departments, public institutions and non-governmental organisations.

Case study 14: Local fish biotelemetry system

The biotelemetry system involves the use of transmitting devices to monitor the behaviour and physiology of aquatic animals in their natural environment over time. Used internationally, the system is a combination of remote and manual tracking and monitoring systems as well as smart tags or transceivers. The tags are attached to the aquatic organisms being monitored, after which they are released back to their natural environments to re-establish normal behavioural patterns.

Water Research Group student holding a tiger fish carrying a transmitter (Credit: wrc.org)

The development of the local fish biotelemetry system emerged from a series of studies funded by the WRC before the system was finally developed and tested in 2012. The successful development and testing of the biotelemetry system in the field was made possible by the collaborative efforts between the research organisations, academic institutions, biotelemetry system specialists and programme funders. Since its development the technology has been helping aquatic scientists understand animal behaviour in water. The technology is playing an important role towards conservation of South Africa`s rich aquatic biodiversity.

Management tools and decision-support systems

Decision Support Systems (DSSs) include frameworks, protocols, processes, methods, tools, and models for integrated water resource management to improve decision making (Stewart et al., 2000 in CPH Water, 2001). DSS can assist water service providers to improve their water management, water and wastewater treatment operations, water distribution and infrastructure asset management. In addition, DSS helps water stakeholders with critical issues such as managing budgets for water treatment, efficient management of water services, and provide the municipalities with crucial information and knowledge about budget allocations for making decisions about which water services should be prioritized in the municipal budgets. Examples of DSSs innovations that have been mapped in this book include the following;

Case study 15: DRIFT methodology

The DRIFT system is a programme for managing knowledge on the links between river flow and ecosystem functioning based on a range of client-selected water development scenarios. Using a combination of data, knowledge and experience of researchers and local stakeholders, the DRIFT predicts how a river ecosystem will change over time if there is a development along a particular water course e.g. building a dam along a river. These predictions are valuable for discussions and negotiations between governments and other stakeholders.

Prof Cate Brown, Dr Alison Joubert and Prof Jackie King of Southern Water Ecological Research and Consulting developed the DRIFT system. Its development began in 1998 and, to date, it is still being developed. The DRIFT system has been deployed in South Africa and further afield. It was first deployed successfully in 1998 for the Lesotho Highlands Water Projects. Since then, it has been recognised by major organisations as a good-practice methodology.

Case study 16: Mine Water Atlas

The Mine Water Atlas is the first of its kind to be developed globally. The innovation introduces mine water in geological, hydrological and legal contexts, while also examining geographical foundations of water quality, quantity and distribution. It is envisaged that the innovation will also provide insights into the challenges and opportunities facing South Africa regarding the quantity, quality, protection and use of its water resources.

The launch of Mine Water Atlas (Credit: Water Research Commission, 2017)

In 2014, the WRC called for proposals to produce a Mine Water Atlas (MWA) that would map the environmental vulnerability and mining activity for all Water Management Areas in South Africa, and then overlay these with ecological risk assessments. Golder Associates was awarded the contract by the WRC to develop the MWA. The atlas is not a commercial venture and can be accessed from the WRC free of charge. Available formats include digital and hard-printed copies, an online web map portal and as a fully interactive digital database of spatial information for GIS users.

Case study 17: WATCOST

WATCOST is a costing manual for predicting the cost for the operation, maintenance, and management of water-supply systems. It estimates the cost for all stages of the drinking water supply process from the base supply, water treatment, and water storage, through to the distribution of drinking water. Since its development in 2013, WATCOST has been used by various stakeholders in the water sector. The technology is not intended for commercial purposes and is freely available from the WRC. The WATCOST model was developed by Swartz Water Utilisation Engineers with funding support from WRC.

Case study 18: W2RAP guidelines

The W2RAP is a means of managing and identifying risks and offers a valuable solution to enhance municipal water and wastewater service delivery. The W2RAP includes all the steps in the wastewater value chain from the production of water to discharge or reuse in a particular catchment area. The W2RAP draws its principles and concepts from other existing risk management approaches, more especially from the Water Safety Planning Process, Hazard and Operability Study Hazard Analysis and Critical Control Points (van der Merwe-Botha & Manus, 2011).

Developed by Dr Marlene van der Merwe-Botha the W2RAP guidelines emerged at a time when the Department of Water and Sanitation needed to develop a programme to improve wastewater treatment services in South Africa. At the time when many municipalities were not prioritising, managing or monitoring their wastewater treatment works effectively. The Green Drop Incentive-based regulation was developed by national government to address this issue, comprising of a set of criteria to audit municipalities annually to determine their performance and compliance to wastewater legislation and best practice. The development of W2RAP was largely stimulated by the development of the Green Drop Incentive-based regulation. The innovation has been successfully deployed across South Africa and has received support from both the private and public sectors. Private companies and institutions have shown interest in participating in the Green Drop audits which is a DWS tool to carry out incentive risk-based regulations for water and wastewater treatment works in South Africa) as well as developing their own W2RAPs.

EMERGING TRENDS IN THE WATER INNOVATION ECOSYSTEM IN SOUTH AFRICA – AN INNOVATORS PERSPECTIVE

South Africa faces significant water challenges, ranging from poor water quality to dysfunctional wastewater management. Further burdening the water challenges are the locations of key economic hubs, such as Cape Town and Johannesburg, located in water-management areas where demand for water has outstripped the current supply. The country has a strong scientific and research community that is capable of developing water innovations to tackle many of these water crises. The main challenge faced by many innovators and some stakeholders are the lack of available funds to finance and support innovation from the research and development phases through to commercialisation and scaling up. Political processes associated with setting up small businesses and the poor existing linkages to industry have further hindered potential innovations that could have been successfully deployed in the water sector for the benefit of the country. Some of the key emerging trends include the following:

Limited links between various actors and institutions

South African universities have spearheaded water innovations, with several centres of excellence and research chairs located across the country. However, the linkages between the universities and other sectors of the economy that are key to the commercialisation of water innovations are often not sufficiently developed despite the recently established Technology Transfer Offices. As a result, many innovations that could be commercialised or widely deployed have not made it to market beyond the concept stage.

Intellectual property related challenges

South Africa has adequate intellectual property rights and policies to promote innovations, research and development and technology transfer to support a growing, sustainable economy. During the engagements with the relevant stakeholders and innovators it emerged that in South Africa there is a lack of understanding and awareness around intellectual property policies and this has had significant negative impacts on the transfer of innovation.

Inadequate support for new innovations

Many municipalities in South Africa play an important role in the successful deployment of innovations, working closely with their appointed consultants to ensure project success. In some cases, they can resist the introduction of radical innovation which hinders success. Currently, collaboration between municipalities, universities and other research institutions is insufficient to optimise water innovation that aims to improve services and efficiencies in South Africa.

Funding challenges for water innovations

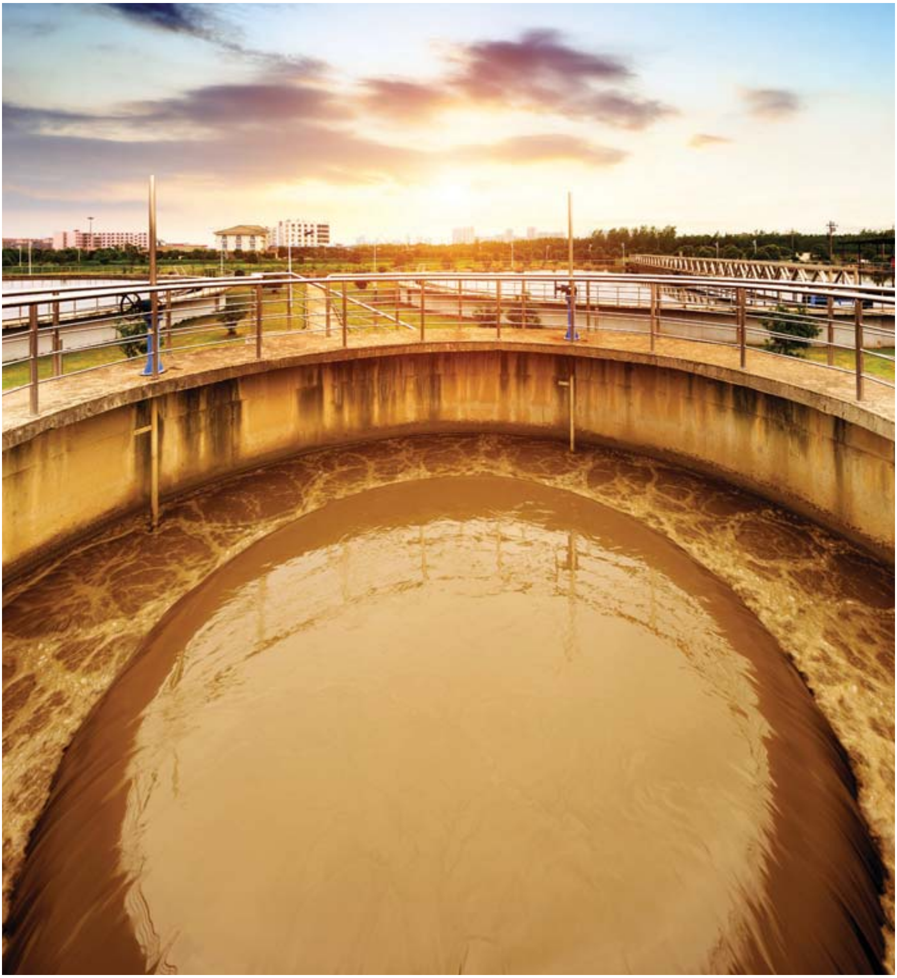
South African institutions have significant funding available for the research and development of water innovation, with the WRC and National Research Foundation championing research and development in the water sector. One of the major challenges experienced by innovators is the lack of funding availability beyond the research and development stage, when innovations move into the commercialisation stage beyond proof of concept. This is not unique to the water sector, and is prevalent in many initiatives seeking to commercialise. The solution is to earmark bridging finance to target projects that are at an intermediary stage and may require a mix of grant type research funding and commercial financing mechanisms.

Lack of access to markets for emerging innovations

Lack of access to markets presents a real challenge for many innovations in South Africa. The products and technologies are often niche with small potential in current markets or under circumstances where intense competition already exists. Investors are also risk averse and may be disinterested in supporting initiatives that cannot demonstrate potential for commercialisation and a return on investment. Additionally, many water innovations in South Africa have originated in universities and research institutions, and many of the innovators do not understand markets or have the skills for entrepreneurship.

Engaging with key local communities and stakeholders

Here is a great need for researchers and innovators to engage with communities and industry to find out what the most pressing problems are which require solutions. Innovations should not be imposed on communities due to their real or perceived lack of knowledge and information. An approach that has been forced on communities may result in reluctance to try out emerging innovations that seek to address water challenges.



CONCLUDING REMARKS AND RECOMMENDATIONS

South Africa's water sector is faced with many challenges due to natural and manmade causes. These complex and often interrelated issues provide an opportunity for the development of a wide range of innovations which are crucial for sustainable water management and socio-economic development. Engagements with innovators and some stakeholders have shown that despite the robust research and development of water innovations in South Africa, many of these innovations have struggled to move beyond the research and development stage due to various challenges that are encountered by those involved in the innovation ecosystem. There is a need to ensure that innovation receives the necessary support from the research and development stages through to commercialisation.

Limited linkages between the actors in the innovation ecosystem, as well as access to sufficient funding for innovations remain the main challenges hindering the success of water innovations in South Africa. A very strong legislative framework has ensured that water is given high research priority, and although policies and strategies are well structured, the implementation and performance of these are not always truly reflected.

Despite the concentrated efforts shown by different parties involved in supporting water-related innovation in South Africa there is still a lack of coordination between the various stakeholders in the innovation ecosystem. There is a need to build more inclusive collaborations across enabling partners to facilitate opportunities provided by water challenges in South Africa.

As a way forward, the following steps are recommended as possible solutions to accelerate the deployment and application of water innovations in South Africa:

- Build more partnerships between various actors involved in the innovation ecosystem to solidify linkages between these stakeholders. Government should aim to drive this coordination, through the development of enabling policies and the provision of the necessary support.
- Partnerships important in making innovations commercially viable, to benefit established businesses, innovators and the public. Collaborations between incubators and investors who have the capacity and financial ability, as well as between researchers, public institutions and businesses, can play a critical role in driving the development of water innovations forward.

- Being the major funder of water related research and development, the WRC should ensure that mechanisms are put in place to follow the progress of previously funded water innovations. This will help with accelerating the deployment of water innovations in the country through understanding the key barriers hindering the deployment of current and future water innovations.
- Writing case studies about innovations that have failed to reach the deployment stage, may present valuable learning material and opportunities for other innovators.

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