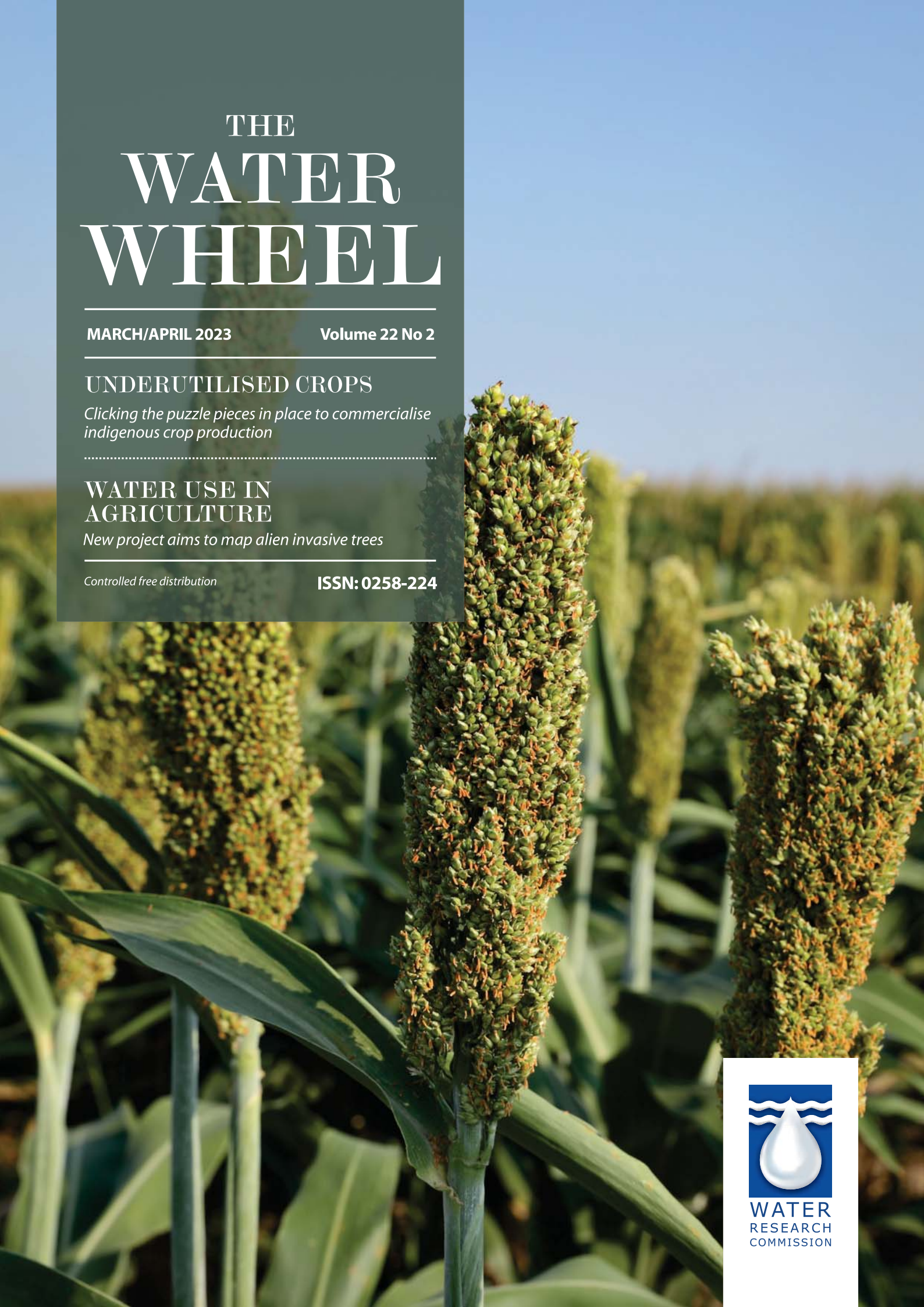

THE WATER WHEEL

MARCH/APRIL 2023 Volume 22 No 2

UNDERUTILISED CROPS

Clicking the puzzle pieces in place to commercialise indigenous crop production

WATER USE IN AGRICULTURE

New project aims to map alien invasive trees

Controlled free distribution

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WATER RESEARCH COMMISSION

Contents

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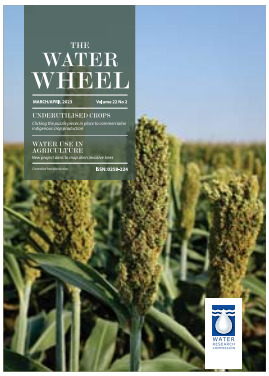


A study funded by the Water Research Commission has provided another key piece to the puzzle in understanding underutilised crops. See article on page 10.

NEWS

Government remains main funder of research in South Africa

Government remains the main funder of research and development (R&D) activities in South Africa. This is according to the 2020/21 National Survey on Research and Experimental Development, which was released in January.

The government sector (including science councils and universities' own funds) contributed 56.3% of R&D funding in the country, while business contributed 26.9%, foreign funding 13.3% and other South African sources 3.5%. Higher education and the science councils are the main beneficiaries of government funding.

The R&D survey is undertaken annually by the Human Science Research Council on behalf of the Department of Science and Innovation. The resulting statistics provide important evidence on the size, growth and composition of R&D expenditure and human resources devoted to R&D.

Gross domestic expenditure on research and development (GERD) for 2020/21 was R33.541 billion. GERD as a percentage of gross domestic product was 0.61%. Medical and health sciences account for the majority of R&D expenditure (22.1%), followed by social sciences (19.7%) and engineering sciences (12.9%). Research in environment-related areas showed gains along with space science research. Research on communicable diseases (TB, HIV/AIDS and malaria) continued to increase.

- To download the survey, Visit: https://www.dst.gov.za/index.php/documents/r-d-reports/13-rd-statistical-report-2020-21/file

UCT study delves deeper into Khayelitsha's water woes

Doctoral research from the University of Cape Town (UCT) found that treating water as an economic good creates an unjust distribution pattern in which paying customers are prioritised over those who cannot. Consequently, it socially affects how the residents in informal housing engage with the city when complaining about a broken communal standpipe.

"Commodification of water goes hand in hand with the capitalist mode of production on natural resources and treats residents as consumers instead of beneficiaries of the state's provision of a fundamental human right," maintains PhD graduate Minga Mbweck Kongo. Kongo graduated in December with a PhD in Social Anthropology.

By framing residents as consumers and users, Kongo said the city creates a hierarchy whereby the residents who meet their obligations by paying for water are prioritised over those who cannot afford to pay for water. "In areas such as Khayelitsha, this social structure is complicated by the challenges caused by inadequate infrastructure."

Titled 'Water and sociality in Khayelitsha: an ethnographic study', the research looked into how inequalities related to access to water in Cape Town are produced by inequitable development patterns. It also explored the challenges of inadequate water access experienced by residents in less-provisioned areas.

Due to economic challenges, noted Kongo, households in the formal area also struggle to meet their financial obligations for water. "They are forcefully equipped with water management devices that make access to water impossible without payment. For those residents in informal areas, the commodification of water enforces a culture of complacency where the residents do not feel entitled to services because they are not consumers. As such, they feel alienated that they cannot hold the local authorities accountable for poor water service delivery because they are not paying for these services."

To access Kongo's study, visit: https://open.uct.ac.za/handle/11427/37360

Source: UCT

BACK TO TOP

New Deputy Vice Chancellor for Sol Plaatje University

Prof Debra Meyer has been appointed the new Deputy Vice-Chancellor: Teaching and Learning at Sol Plaatje University.

She will be responsible for the management of the core academic functions of the university over the next five years.

To fill this position, the university sought an outstanding and experienced academic leader who understands the local and international higher education arenas; who has the leadership abilities to devise sophisticated curricular and co-curricular strategies; and who has the capabilities to design and develop innovative systems and approaches in the university context, said the university in a statement. "We are fortunate that Prof Meyer, who meets all these requirements, has agreed to fulfil this role for Sol Plaatje University."

She holds a PhD degree in Biochemistry and Molecular Biology from the University of California, Davis and a Master of Science degree in Biochemistry from the former Rand Afrikaans University (now University of Johannesburg). Prof Meyer leaves her current position as Executive Dean of the Faculty of Science at the University of Johannesburg.

DBSA launches water and sanitation project in Zambia

The Development Bank of Southern Africa (DBSA) – as the implementing agent of the South African Development Community (SADC) Water Fund – has launched an €8.8-million basic water and sanitation project in Kazungula.

The Zambian Government, with the support and cooperation of the German government and Kreditanstalt für Wieferafbau (KfW) is co-financing the project. "This is a significant investment towards sustainable development of the water sector in SADC," noted Chuene Ramphele, Group Executive of the Infrastructure Delivery Division at the DBSA.

The first phases of the project include the construction of a new intake structure to abstract water from the Zambezi River upstream of the Kazungula bridge. This phase will also include construction of a new treatment plant, larger storage reservoirs, construction rehabilitation and the extension of water transmission and distribution pipelines. This infrastructure is set to significantly improve access to potable water and ensure reliability of supply to Kazungulu town. The second and third phases will focus on improving the sanitation system.

"We are excited to launch the start of the construction of this regional project as it will make a positive impact on the lives of the people in Kazungula," said Ambassador Margi Hellwig-Boette, German Ambassador to Botswana and Special Representative to SADC.

Added Ramphele: "This project highlights the importance of developmental financial partnerships in the realisation of SADC's regional integration agenda, which seeks to provide quality water and sanitation service," Ramphele concluded.

SA launches new agriculture-focused microsatellite

Minister of Higher Education, Science and Innovation, Dr Blade Nzimande, has welcomed the successful launch of the EOS SAT-1 (AgriSat-1/ZA-008), the first imaging satellite to be built by South African company Dragonfly Aerospace. The satellite was launched in the USA on 3 January.

The launch of the 170 kg microsatellite follows last year's successful launch of three locally produced nano-satellites by the Department of Science and Innovation and its partners. The EOS SAT-1 satellite is the first of a seven-satellite constellation in low-Earth orbit for customer EOS Data Analytics. The remaining six satellites of the constellation will be deployed over the next three years.

EOS-SAT is reported to be the world's first agriculture-focused satellite constellation, providing the agriculture and forestry industry with high-quality data to support efficient and sustainable practices. Images from the satellites will deliver valuable information for applications such as harvest monitoring, seasonal planning and assessments to analyse information such as soil moisture, yield prediction and biomass levels. This data will support growers with reducing carbon dioxide emissions and help them to develop (and implement) sustainable agriculture methods.

Source: DSI

BACK TO TOP

GLOBAL

2022 confirmed as one of warmest years yet

The year 2022 has been declared the sixth warmest year on record by the World Meteorological Organisation (WMO).

According to the agency, 2022 was also the eighth consecutive year that global temperatures rose at least one degree Celsius above pre-industrial levels, fuelled by ever-increasing greenhouse gas concentrations and accumulated heat. The cooling effect of the La Niña phenomenon – now in its third year – prevented 2022 from being the warmest ever.

"This cooling impact will be short-lived and will not reverse the long-term warming trend caused by record levels of heat-trapping greenhouse gases in our atmosphere," the WMO warmed in a statement, adding that there is a 60% chance that La Niña will continue until March 2023.

The past eight years were the warmest on record globally, fuelled by ever-increasing greenhouse gas concentrations and accumulated heat, according to six leading international datasets consolidated by the WMO.

Dams to lose more than a quarter storage capacity by 2050 due to sedimentation

Trapped sediment has robbed roughly 50 000 large dams worldwide of an estimated 13% to 19% of their combined storage capacity, and total losses will reach 23% to 28% by 2050, UN research warns.

The global loss from original dam capacity foreseen by mid-century – from around 6 300 billion m^3 to 4 650 billion m^3 in 2050, a difference of around 1 650 billion m^3 – roughly equals the annual water use of China, India, Indonesia, France and Canada combined.

UN University's Canadian-based Institute for Water, Environment and Health applied previously-determined storage loss rates in various areas worldwide to large dams in 150 countries to forecast cumulative reservoir storage losses by country, region and globally. The United Kingdom, Panama, Ireland, Japan and Seychelles will experience the highest water storage losses by 2050 – between 35% and 50% of their original capacities – the study shows. By contrast, Bhutan, Cambodia, Ethiopia, Guinea and Niger will be the five least affected countries, losing less than 15% by mid-century.

"The decrease in available storage by 2050 in all countries and regions will challenge many aspects of national economies, including irrigation, power generation and water supply," says Dr Duminda Perera, who co-authored the study published in the journal, ***Sustainability***.

"The new dams under construction or planned will not offset storage losses to sedimentation. This paper sounds an alarm on a creeping global water challenge with potentially significant development implications."

In Africa, 2 349 dams across 44 countries have lost about 702 billion m^3 or 15% of their original storage capacity. By 2030 and 2050, cumulative storage losses are estimated at 17% and 24%, respectively.

- To view the original article, Visit: https://www.mdpi.com/2071-1050/15/1/219

BACK TO TOP

New water safety plan manual available

The second edition of the water safety plan manual is now available from the International Water Association (IWA).

Water safety planning is a systematic process that is widely recognised as the most reliable way to manage drinking-water supplies for the protection of public health. The manual provides practical guidance, examples and tools to support water suppliers in developing and implementing water safety plans (WSP) to help protect the health of all users.

The manual presents a broad range of examples and case studies from lower-to-higher income settings, highlighting practical solutions to real-world challenges from around the globe to help readers apply the guidance in diverse contexts.

This edition of the manual also integrates considerations of equity and climate resilience into the water safety planning approach. These aspects support access to safely managed and resilient drinking-water supplies for all users, despite future uncertainties, including those arising from climate variability and change.

To access the manual Visit: https://iwa-network.org/wp-content/uploads/2023/02/WHO_WSPManual2ndEd_final.pdf

Lead ammunition banned from European wetlands

Using lead shot ammunition in wetlands has been declared illegal in all 27 European Union (EU) countries, as well as Iceland, Norway and Lichtenstein. The law came into force in February following a two-year period given to EU countries to prepare for the change.

With this law in place, the lives of an estimated 1 million waterbirds which currently die of lead poisoning in the EU, will be saved and the perpetuation of extreme poisoning of wetlands will be tackled "once and for all", noted Birdlife International in a statement. Exposure to lead can also have severe consequences for people should they be exposed to it, especially children.

Lead shot cartridges consists of hundreds of tiny round lead projectiles. The ammunition is used to hunt waterbirds and other small animals. Lead shot is particularly problematic for waterbirds that ingest lead pellets, making them for grit. The ban will also decrease the secondary poisoning of raptors and scavengers, which are regularly poisoned while eating prey contaminated with lead shot.

"This is huge," noted Barbara Herrero, Senior EU Nature Policy Officer from Birdlife Europe. " Despite banning lead from paint, petrol and virtually everything else several decades ago, it was still allowed to poison our shared environment – even when alternatives exist. With this ban, the EU has addressed a significant part of the problem. We now call on EU countries to make sure the ban is enforced."

BACK TO TOP

OBITUARIES

South African water sector mourns the passing of three doyens

David le Maitre – a giant in invasive alien plant impact

On 8 December renowned South African researcher, David Le Maitre passed away after a battle with cancer. He was 67.

Le Maitre had worked for the CSIR in the Sustainable Ecosystems Impact Area. Following his retirement in 2020, he took up the position of Professor Extraordinaire in the Department of Conservation Ecology and Entomology at Stellenbosch University. He had more than 30 years of experience in the ecology of Cape fynbos vegetation, as well as fire ecology and management. His work focused on assessing the hydrological and ecological impacts of alien plants and in the dynamics of invasion processes. In particular, his area of interest lay in the impacts of invasions on river and wetland systems and the ecosystems services they generate.

According to Prof Brian van Wilgen of Stellenbosch University, Le Maitre was "an unassuming scientist" who made significant contributions in his field. "David's most notable contributions came from switching his focus to the effects of vegetation cover on water resources. He played a leading role in the team that developed models to estimate the reductions of surface water runoff as a result of the invasion of catchments by alien trees. He went on to become one of the key scientists that provided support to the Working on Water Programme over the next 25 years."

He also contributed substantially to the identification of strategic water resource areas in South Africa, both in terms of surface and groundwater. This understanding has formed the basis for prioritising and managing the land to protect water resources, which in turn is vital in a dry country such as South Africa.

Former CSIR colleague, Dr Lindie Smith-Adao says "it was a privilege and honour to work with Le Maitre during my 18 years at the CSIR. He was an inspiration in my life, and I will never forget the valuable lessons he taught me."

Over his career, Le Maitre co-authored over 200 publications, and his work has been cited over 13 000 times. In October last year, his contributions were recognised with an Eco-Logic Gold Medal in the Water Conservation category.

He is survived by his children and grandchildren.

Geoff Pegram – Grand master of hydrometeorological engineering

On 16 January Prof Geoffrey Pegram passed away, two weeks before his 84th birthday.

At the time of his passing, he was an Emeritus Professor and Senior Research Associate in the Civil Engineering Programme of the University of KwaZulu-Natal (UKZN).

He was considered a master of hydrometeorological engineering. His work helped pave the way internationally for multifaceted advancements in the monitoring, understanding and modelling of hydrological and hydraulic processes, radar-rainfall modelling and hydrometeorology.

Pegram started teaching at UKZN in 1968 and continued to do so for nearly forty years. He was well revered by all his students and is remembered for the clarity and beauty of his explanations. "He was an inspirational teacher whose love and enthusiasm for fluid mechanics and hydrology were infectious," noted former student and now Professor Emeritus at UKZN, Derek Stretch.

He achieved numerous awards throughout his illustrious career, including a Water Research Commission (WRC) Legend Award in 2021, a medal from the South African Society of Atmospheric Sciences in 2016, and a WRC Knowledge Tree Award in 2015, to name a few.

In 2020, at the age of 81, Pegram reached the pinnacle of his academic career when he attained a Doctor of Science degree in Engineering – a qualification that ranks higher than all previous degrees. His unsupervised DSc thesis is a selection of his published papers, summarising his

BACK TO TOP

contributions to hydraulic engineering and stochastic hydrometeorology.

Among his many achievements is the adapting and synthesising of computer code for multisite reservoir modelling along the Vaal River system, developed during one of South Africa's worst droughts in the 1980s. Software developed at that time is still being used by consultants today.

He also had a lifelong interest in the application of weather radar data. His work addressed the shortcomings of the technology, including radar-rainfall image repair techniques. In addition, Pegram's work led to the extension of the useful range of radar data for rainfall estimation. His ideas on improving the information obtained from radar-rainfields has been used in European Union projects in which he partnered, helping in knowledge transfer for the beneficiation of flood prevention methodologies.

Pegram is survived by his wife and children.

To read more about Pegram and his achievements, see the Water Research Commission book, ***Legacy – Celebrating SA's water pioneers, pathfinders and mavericks,*** (Visit: https://bit.ly/3Qm4FtL)

George Ekama – World captain of wastewater treatment research

The water sector was shocked to hear of the passing of global wastewater expert, Prof George Ekama, on 19 February.

While retired at the time of his passing, Ekama had 40 years of research experience into bioprocess engineering of aerobic and anaerobic wastewater and solids treatment systems at the University of Cape Town, the last years of which was spent with the title of Emeritus Professor. He had been at the forefront of developments in biological nutrient removal (BNR) activated sludge systems modelling, filamentous bulking, secondary settling tank design and modelling and anaerobic systems, having written over 170 research papers on these subjects. Ekama was a National Research Foundation A1-rated scientist from 2006 and he was listed among the most cited academics in the world.

In 2020, Ekama co-edited the second edition of the book, ***Biological wastewater treatment – Principles, modelling and design,*** with international colleagues. The book is used worldwide, and has been translated in a number of languages.

Numerous awards were bestowed on Ekama throughout his career, including the South African Presidential Order of Mapungubwe, Silver, which he received in 2013 for his innovative solutions to enhance and improve wastewater treatment, and so helping the country find solutions to water scarcity. In 2017 he was mentioned as one of the 'Legends of South African Science' by the Academy of Science of South Africa, and in 2021 he received a WRC Legend Award. In January this year a gala dinner was held in his honour by the 8th IWA Water Resource Recovery Modelling Seminar in Somerset West.

More than his expertise and knowledge, Ekama was well known for his integrity, empathy and generosity of spirit. He always remained modest about his achievements.

To read more about Ekama and his achievements, see the Water Research Commission book, ***Legacy – Celebrating SA's water pioneers, pathfinders and mavericks,*** (Visit: https://bit.ly/3Qm4FtL)

WATER DIARY

Water
22-24 March
The 2023 Water Conference will be held in New York.
Visit: https://sdgs.un.org/conferences/water2023

Aquatic science
25-29 June
The annual Southern African Society of Aquatic Scientists (SASAqS) Congress will be held in the Western Cape with the theme 'Managing aquatic ecosystems in an age of climate uncertainty'.
Visit: www.riv.co.za

Dams and hydropower
10-12 July
The Africa conference of the International Commission on Large Dams will be held in Lake Victoria, Uganda. The theme is 'Water storage and hydropower development for Africa'.
Visit: https://www.hydropower-dams.com/africa-2023/

Urban water management
13-15 September
The International Water Association (IWA) Efficient urban water management conference, dubbed 'Efficient 2023', will be held in Bordeaux, France. The conference will gather urban water and wastewater professionals ready to share their expertise and to present solutions for the new challenges in urban water management.
Visit: https://efficient2023.org/

Groundwater
18-24 September
The International Association of Hydrogeologists will be hosting its 50th Congress in Cape Town. The theme of the event is 'Groundwater – A matter of scale'.
Visit: https://iah2023.org.za/

BACK TO TOP

UNDERUTILISED CROPS

Clicking the puzzle pieces in place to commercialise indigenous crop production

Tomatoes, potatoes, onions, spinach and bananas are likely food items in homes all over South Africa but, millions also browse the options at bustling roadside stalls for home-grown crops such as nightshade, pumpkin leaves, lablab and Bambara groundnuts. Once, a helping of amaranth would have been common but our dinner plates are now piled with widely available, commercially produced exotic produce like corn and rice. It's little wonder that our local crops are dubbed 'forgotten', so writes Petro Kotzé.

Yet, many still remember. "Their documentation has been neglected, but for consumers, they are very relevant," says agricultural economist and senior lecturer at the University of South Africa (UNISA) Graduate School of Business Leadership, Dr Binganidzo Muchara. They lack scientific scrutiny in comparison to conventional and commercial crops, he explains.

However, on a mission to help ensure that each South African has access to sufficient, safe and nutritious food for active and healthy lifestyles at all times, the WRC has turned back to South Africa's agricultural roots. For decades, the organisation has geared significant funding towards filling the scientific knowledge gaps in the way of the uptake and commercialisation of indigenous crops. This January, another integral piece of the puzzle has been slotted into place, documenting a major aspect of our domestic 'super foods' for the first time.

What we know, and what we need to know

So-called 'neglected and underutilised' crops refer to those edible plants that were once popular within certain geographies and communities but have since been displaced by mainstream crops (as reported in the March/April 2022 edition of The Water Wheel, ***Why 'forgotten' foods are a key ingredient to food security***). They include serials like sorghum and tef; legumes like Bambara groundnut, lablab, cowpea and Marama bean; roots and tubers like taro and sweet potato; and, leafy vegetables

BACK TO TOP

like Jews mallow, spider plant, amaranth, nightshade and wild watermelon.

Numerous research projects have proven the value of these crops. We now have empirical evidence that many of them are more drought and heat-stress-tolerant than commonly available commercial crops. They are often exceptionally nutrient-dense and offer elements essential to people's survival. We also know that most of these crops will be able to expand into new production areas and that there will be some gains in yield and water productivity under predicted future climate conditions. A list of 13 priority underutilised crops with the most potential for success has already been identified. The underutilised crops identified by the WRC are not easily attacked by diseases and pests so far, they use less water but produce high yields.

"From the laboratory perspective, we understand what the nutritional values are and what the agronomic water use at the farm level is," Muchara says. "But none of those studies yet pursued the post-harvest value chain." The most recent project, for which Muchara was the project leader, dug into that. The project (WRC project no. K5/2715/4), titled 'Water use in food value chains of indigenous crops with special focus on production and post-harvest handling of food products' was undertaken by the Independent Institute of Education MSA (IIE-MSA) in collaboration with researchers from Cape Peninsula University of Technology (CPUT) and UNISA.

The researchers were Muchara, Morris Fanadzo, Bimo Nkhata and Linda Downsborough with contributions from Derek Mavesere, Joseph Kamfwa and Tshepiso Sithole.

The objectives of the project were to provide a detailed review of water use in the production, use and post-harvest handling processes and value chains of indigenous crops, specifically legumes, tubers and leaf vegetables. Another was to understand how the crops are handled, marketed and consumed. The last was to develop an action plan to enhance the uptake, commercialisation and use of the crops in South Africa.

"If we understand the production patterns, post-harvest issues and what the value chain looks like we can better advise farmers and policymakers about how the economy and specific producers can benefit," Muchara says. If we understand this value chain, we can see how and where farmers can access markets, and further grow the uptake of the crops locally, nationally, regionally and internationally. The impact, he says, will then be improved nutrition and food security and resilience to climate change.

However, being a relatively 'new' field of formal scientific study, there is precious little published data to lean on. If you expect to find data on the yield of an indigenous crop the same way that you would find some for, say, tons of maize in a certain silo, you will be disappointed, Muchara notes. However, the problem is not a lack of information, he adds, but that it just has not been captured in a scientifically robust format. Instead, the data sits in the minds of the people and the communities.

"Most of these underutilised crops are managed by farmers with their own traditional way of understanding agricultural activities or management, but this kind of knowledge is not documented," confirms Prof Sylvester Mpandeli, Executive Manager for Water Utilisation in Agriculture at the WRC. Not only is this challenging from a research perspective, but it has become hugely problematic when older generations pass away and this knowledge is lost, he explains. "We have decided to start documenting this indigenous knowledge so that the future generations would be able to access it too, and, to combine this traditional knowledge with conventional research in order to make it scientifically robust."

Combining conventional and traditional knowledge

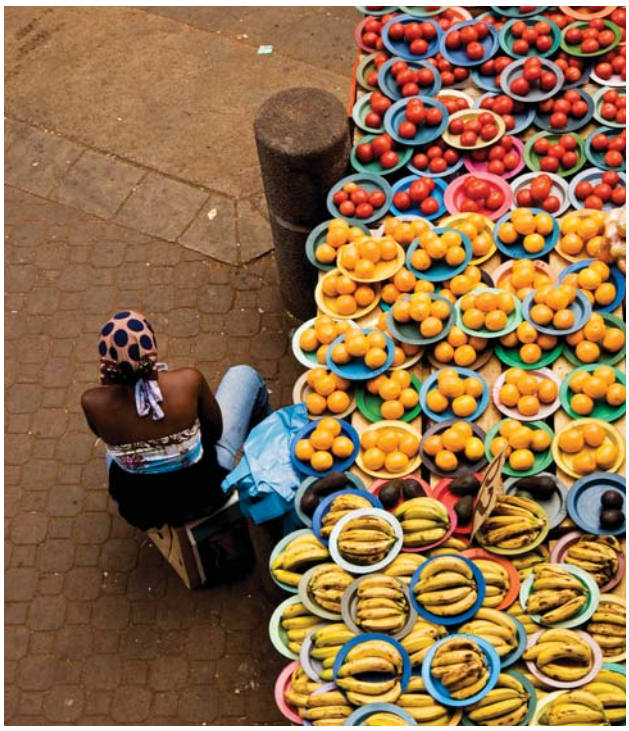
For their data, the research team had to go directly to the people that grow and manage the crops. They conducted their work with the Ha-Mapila and Luvhada communities in the Vhembe District in Makhado, Limpopo and Dingleydale and New Forest communities in Bushbuckridge in Mpumalanga. Data for leafy vegetables, including Chinese mustard, black nightshade, jute mallow and pumpkin leaves, were collected mostly from the Limpopo sites, while data for legume and tuber crops were gathered from the Mpumalanga sites.

"We took the time to go into the field and understand what is actually happening," Muchara says. First, they had to introduce themselves to the Agricultural Extension Officers, who then introduced them and their objectives to community members. The project also employed local matriculants and unemployed

Brand SA

A strong case is being built for indigenous crops to contribute to South Africa's future food security.

Brand SA



Exotic crops have become staples of our meals, but we are missing out on the multiple advantages of indigenous crops.

graduates to help with translation, tabulation, interviews and questionnaires.

In order to define the water use along the value chain, the project team needed to understand the activities that take place after the crops have been harvested and the produce is taken by the farmers or traders, or sold at the farm gate. Most of the crops are often simply picked from the wild, Muchara says, but they also worked with farmers that are growing the crops under irrigation. Their fieldwork thus entailed time spent in communities, smallholder irrigation schemes and selling points, and speaking to and observing growers, traders, sellers, and middlemen. This allowed them to document activities from the farm gate, to where the produce is moved to a trading stall by the roadside or market and eventually bought by the final user.

The post-harvest value chain of indigenous crops in South Africa

In terms of fertilisers, producers of black nightshade and Chinese mustard mainly used conventional fertiliser to supplement soil nutrients while those that produced pumpkin leaves and jute mallow used organic fertilisers such as compost and manure. In addition to the above, Limpopo farmers who produced Chinese mustard and nightshade under irrigation accessed their inputs from retailers around Thohoyandou and Makhado towns.

The study revealed that the major motives for growing and marketing indigenous crops among smallholder farmers are for home use and to potentially sell for extra income. When sold, the vegetables are harvested from the fields to various markets, to consumers. Several actors participated in the post-harvest value chain from production to marketing. For leafy vegetables, people mostly use informal channels whereby the producer sells directly to the customer and incurs lower transaction costs. Because the value chain is short and informal, the produce was not processed.

About 54% of farmers in Limpopo sold their leafy vegetables to hawkers, who are the biggest actors in the post-harvest value chain apart from farmers themselves. Pricing is determined by both farmers and hawkers. Although the quality required by hawkers is not as high as that for formal retailers, they do give preference to farmers who produced better quality vegetables. Most hawkers used water for cleaning and maintaining value at their respective selling points, and most of the water was reused throughout the day as hawkers tried to sell all their stock. Cassava and Bambara nuts were rarely washed before being sold.

The distance from the farm gate to the market affected the amount of water used. Farmers who travelled longer distances by public transport and those that used wheelbarrows often used water during the transportation of their stock from the farm gate to the market. Most hawkers, however, used public transport to carry their vegetables to the market.

The formal channel is dominated by retailers such as Pick 'n Pay, Spar, Shoprite and Choppies. Farmers delivered their own products to shops at an agreed market price. Consumers, the final link in the value chain investigated, purchase vegetables either from the roadside, farm gate or retailer. They are mostly individual households in rural and urban areas.

Mapping the movement and players involved in the production of the crops allowed the researchers to identify various bottlenecks and opportunities to improve along the way.

For one, farmers say that seeds are not commonly stocked by retailers and can be difficult to come by. Post-harvest losses were another common concern. There is also a lack of appropriate market infrastructure for handling perishable produce and weak links between supply chain actors, including input suppliers, producers and markets. High transaction costs result from unreliable market information and support systems, no guaranteed market prices, farmers' low bargaining power and institutional policies that do not effectively enhance production and marketing.

Over and above, the study has also highlighted the huge scope for market expansion, with both Mpandeli and Muchara pointing out the large potential for producing and marketing processed goods derived from the crops.

Looking beyond water for a food secure future

Mpandeli says it is apt to wonder why the WRC is funding projects that seem to reach so far beyond traditional freshwater issues. "The Water Research Commission has decided to go beyond its traditional scope of funding research, in order to make a real impact, and change the lives of South African people," he says. "Whatever research we derive must create job opportunities for people too." It is believed that the indigenous crops if marketed properly could create job opportunities for our people, stimulate local economy and also improve the livelihoods of our people.

Over and above that, Mpandeli points out statistics that show

BACK TO TOP

*Black nightshade (*Solanum retroflexum*) is an annual herb-like plant that originated in South Africa. It is also known as sunberry, nastergal, Umsobo, muxe, umsobo wesinja, umosobosobo and lintsontso.*

how many South Africans go to bed with empty stomachs. According to Statistics South Africa, food insecurity in the country is increasing, and almost 23.6% of South Africans in 2020 were affected by moderate to severe food insecurity, while almost 14.9% experienced severe food insecurity.

Instead of looking at conventional crops to meet that need, Mpandeli says, "let's rather try to come up with alternative and practical solutions, and diversify in order to also minimise risk to climatic variability and change."

Our aim at the WRC has expanded, he adds. Over and above aiming for a water-secure future, we want to help ensure that each and every household has access to sufficient, healthy nutritional food. The organisation believes unlocking the potential of indigenous crops will help them get there.

For more information, refer to **WRC Report No. 2715/1/22**, *Water use in food value chains of indigenous crops with special focus on production and post-harvest handling of food products.*

International Institute of Tropical Agriculture) / Flickr

Cowpea pods ready for harvesting.

Flying the banner for South Africa's indigenous natural heritage

The WRC is funnelling substantial funding towards unlocking the potential that lies in our indigenous crops, trees, and livestock. The WRC's Prof Sylvester Mpandeli explains that the organisation follows a three-pronged approach. The first focuses on underutilised crops, and research projects are now ongoing in all nine provinces in order to cover all agroecological zones.

A second focus is on indigenous livestock, such as traditional goats, which also potentially offer resilience against the detrimental impact of climate change in future.

The third component entails research on indigenous fruit trees. For example, ***Water Use and Yield of Selected Indigenous Fruit Tree Species in South Africa*** (**WRC Report No. 2720/1/22**) was completed in August 2022. The project aimed to quantify water use by selected species and to understand how these respond to variables, including soil conditions and climate so recommendations could be made on species suited to specific areas. Results indicated that some indigenous fruit trees use less water than the exotics in commercial orchards.

Other projects are investigating the medicinal value of certain plants and trees and the potential for agro-processing (deriving processed goods from agricultural materials). Extensive research has already been conducted and, Mpandeli says WRC are now pulling results together to see how they can be applied. Among other goals, "we want to make sure that our communities are aware of the opportunities to make edibles or other products that can be taken to formal markets," he says.

BACK TO TOP

URBAN WATER MANAGEMENT

Study explores stormwater's potential as an alternative water supply

Can stormwater harvesting provide a viable source of water for municipal supply? A project funded by the Water Research Commission (WRC) used an urban catchment in Cape Town to explore the possibilities. Article by Sue Matthews.

Sue Matthews

The increasingly harsh water restrictions in Cape Town over the year-and-a-half before early winter rains broke the three-year drought in 2018 raised the ire of local residents. Accusations of incompetence and some rather pie-in-the-sky solutions littered the comments section of online articles. Some of these bemoaned the fact that any little rain that did fall in the city was allowed to flow down stormwater channels and out to sea, rather than being captured by the municipal authority.

By then, scientists and engineers from the Future Water Institute at the University of Cape Town (UCT) had already been investigating the potential of stormwater harvesting for a few years. One such study was Dr John Okedi's WRC-funded research project, titled 'The viability of stormwater ponds in the Zeekoe catchment as water resources for Cape Town', South Africa, for which he was awarded his PhD in 2019. The catchment has more than 60 stormwater ponds within its 89 km^2 area, as well as three large but shallow lakes – Zeekoevlei, Rondevlei and Princess Vlei.

Through desktop research and a modelling approach, Okedi initially assessed the extent to which water from stormwater ponds could meet the demand for non-potable uses in the form of irrigation and toilet flushing. Given that Cape Town lies in a winter rainfall area and water for irrigation is mainly needed in the dry summer months, creating a mismatch between supply and demand, some means of storing stormwater would be required. Land is at a premium in most urban environments and there is limited space to build new storage facilities, but

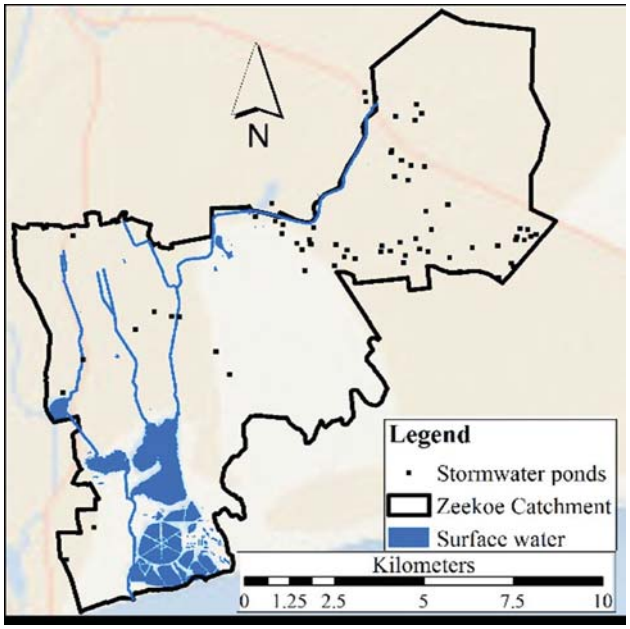
BACK TO TOP

real-time control – commonly referred to as RTC – offers a way of optimising storage in the existing stormwater ponds.

First implemented in the USA in the 1960s, RTC allows water levels in urban drainage systems to be dynamically controlled. At its simplest, it might entail somebody being on site to monitor incoming flow and water levels at particular ponds, and then open or close sluice gates according to operational rules. Advanced RTC would rely on a network of automatic rain, flow and water-level gauges, and even radar-based rain forecasts, with data fed into predictive models that issue alarms and instructions for remote control through a SCADA (Supervisory Control and Data Acquisition) system. Regardless of the complexity, the aim would be to manage the drainage system so that it fulfils its flood-prevention role while also ensuring the maximum amount of stormwater is captured and stored instead of being lost to the sea, known as spillage.

The total capacity of the stormwater ponds in the Zeekoe catchment represents about 5.5% of the catchment's modelled mean annual volume of stormwater, estimated at 18 Mm^3, or 18 000 Megalitres. Okedi assessed three demand options for non-potable water – Sc1 for agricultural irrigation, Sc2 for residential garden irrigation and toilet flushing, and Sc3 for residential garden irrigation, toilet flushing and irrigation of public open spaces. He found that even with the use of RTC, the storage in the ponds was only able to supply 40%, 60% and 58% of the demands of Sc1, Sc2 and Sc3, respectively. Much of the mean annual stormwater volume would still overflow the ponds and be lost as spillage.

Next, Okedi considered making use of the vleis for additional storage. This would allow 22% of the modelled mean annual stormwater volume to be stored, with 70%, 79% and 76% of the Sc1, Sc2 and Sc3 demands being met.



The project focused on the Zeekoe catchment, which contains more than 60 stormwater ponds. The main drainage channel is the Great Lotus, which rises in the precinct of the Cape Town International Airport and flows into Zeekoeivlei, as does the Little Lotus. The Southfield Canal discharges into Princess Vlei and then Rondevlei. Discharge to the sea is via the Zeekoe Canal, which receives treated effluent from the Cape Flats wastewater treatment works oxidation ponds just upstream of the outlet.

"If you converted the vleis to reservoirs, they would provide a significant amount of storage, but the issue is practicality," says Okedi. "They are used for recreation and have ecological value, so not many people would be happy if their existing function was taken away!" Both Rondevlei and Zeekoevlei form part of the False Bay Nature Reserve, which was declared a Ramsar wetland site of international importance in 2015, while Princess Vlei forms the core of the Greater Princess Vlei Conservation Area and was designated a provincial heritage site in September 2020.

Thus, the water levels in these permanent waterbodies should not be overly manipulated on a frequent basis – currently, periodic 'drawdowns' are done for ecological purposes and to lower water levels enough for mechanical removal of accumulated sediment and encroaching reeds. But what if water was simply abstracted from the vleis, pre-treated and then pumped approximately 30 km to the Faure water treatment plant, where it could be fully treated to potable standard and then piped through the existing water distribution network? Because while stormwater harvesting for non-potable uses such as irrigation and toilet flushing would theoretically reduce pressure on the six dams of the Western Cape Water Supply System, which currently provides 98% of Cape Town's potable water, it would necessitate installing a dual reticulation system. Laying all those extra pipes to transport the non-potable water would be extremely expensive, not to mention disruptive to all.

The study found that it would indeed be more cost-effective to harvest stormwater for potable water, which is needed throughout the year, unlike irrigation water (toilet flushing, although year-round, makes up a very minor portion of total demand). Besides, there are health risks associated with consuming fruit and vegetables irrigated with untreated stormwater, which is typically highly polluted, not only through faecal contamination – as evidenced by the excessively high ***E. coli*** counts – but also by heavy metals and hydrocarbons. The findings showed, however, that it would be difficult to abstract water from the vleis, treat it and supply it at a rate that would minimise spillage.

A better option would be to take advantage of the underground storage potential of the Cape Flats Aquifer, through managed aquifer recharge (MAR). The predominantly unconfined aquifer is close to the surface here, occurring in sandy sediments that were once windblown coastal dunes. The aquifer is already the main source of water for the Philippi Horticultural Area, where farming of vegetables and livestock takes place on approximately 2 000 hectares (roughly 20 km^2) of farmland, most of it falling within the Zeekoe catchment.

Okedi investigated the MAR that could be achieved if the stormwater ponds were adapted to promote infiltration into the aquifer. About 70% of the stormwater ponds in Cape Town are detention ponds – unlined earth basins constructed to hold stormwater for short periods during rainstorm events, after which the water flows away slowly, evaporates or infiltrates into the ground. The modelling study assumed that the detention ponds could be converted to bio-retention cells, typically

Sue Matthews

Most of the stormwater ponds in Cape Town are detention ponds that hold water for short periods during rainstorms but are dry for most of the year. Many are used as play-arks or informal sport grounds.

composed of a vegetated surface layer, a middle soil layer with organic matter or fly ash mixed with a filter media, and a deeper storage layer consisting of crushed stone or gravel, with a drain at the bottom.

Groundwater flow and abstraction were also modelled, and water quality considerations assessed. The results indicated that the proposed MAR would allow the Zeekoe catchment to support 140 boreholes, each pumped at 3.5–8.1 litres per second to ensure that the flow fields were drawn largely from the areas around the stormwater ponds. This would provide a combined mean annual groundwater yield of 29–33 Mm^3, of which approximately 30% would be attributable to stormwater infiltration. Water quality would improve somewhat during the time in storage, with natural die-off of pathogens, although disinfection treatment would still be needed for potable uses.

Okedi had planned to follow up this theoretical research, which drew upon available data from previous studies for the modelling, with a postdoctoral project to do experimental work and ground-truthing. But soon after completing his PhD he was appointed to an academic position in UCT's Civil Engineering Department, so a PhD student has recently been recruited to conduct this research. He will be working on a specific stormwater pond, measuring rainfall and incoming flow, monitoring groundwater levels, modelling it all and calibrating the model with his data.

Okedi is excited to see whether this research will show that the concept is practically possible. His own economic analysis on the viability of stormwater harvesting – comparing surface water and groundwater sources for potable and non-potable supply and including capital, operation and maintenance costs – indicated that the most cost-effective option would be MAR for potable water supply using the existing water reticulation system.

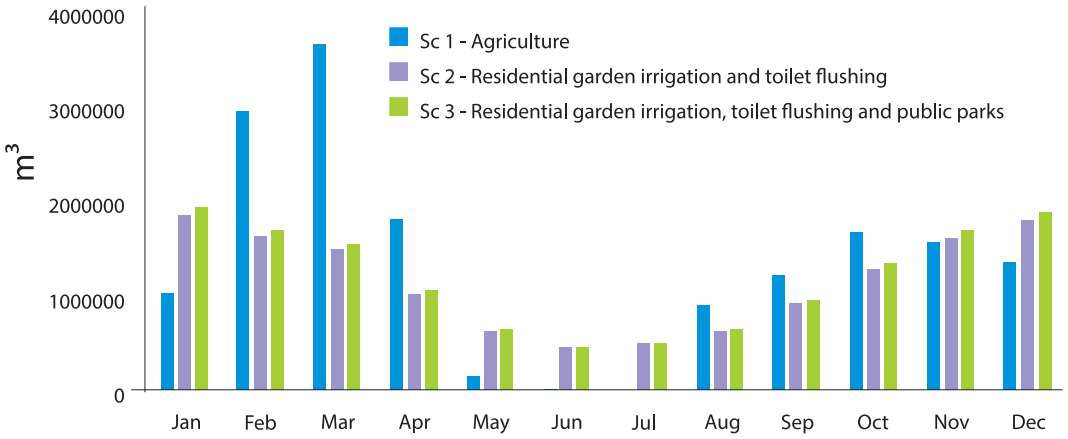
However, although the City of Cape Town committed in its water strategy, approved in mid-2019, to make "optimal use of stormwater and urban waterways for the purposes of flood control, aquifer recharge, water reuse and recreation", it has since revealed the intention to use treated wastewater effluent, rather than stormwater, for MAR of the Cape Flats Aquifer. For more than 40 years, it has used both stormwater and treated wastewater to recharge a similar sandy aquifer on the west coast through a series of infiltration ponds and recharge basins that form part of the Atlantis Water Resource Management Scheme.

In the case of the Cape Flats Aquifer, the potential of using treated wastewater effluent for MAR was thoroughly investigated in a long-running WRC-funded project during the

Sue Matthews

Zeekoevlei is a popular recreational area and forms part of the False Bay Nature Reserve, which must be taken into consideration if used for stormwater harvesting.

BACK TO TOP



The estimated mean monthly demand values for the three water demand options assessed in the project.

1970s, 'The reclamation, storage and abstraction of purified sewage effluents in the Cape Peninsula', led by the CSIR. But the aquifer was not developed as a municipal water resource, and over the years additional research indicated that it was under increasing threat of pollution from wastewater treatment works (WWTW), leaking sewers, informal settlements, solid waste sites, cemeteries, as well as industrial and agricultural areas.

The 'Day Zero Drought' provided the incentive that was needed to refocus on the Cape Flats Aquifer, which now features strongly in the City of Cape Town's New Water Programme, designed to fulfil the commitment made in the 2019 water strategy to develop 300 Megalitres per day of additional water supply capacity by 2030. The first wellfield, Strandfontein West, is almost complete and will start contributing to the municipal supply by mid-year. The abstracted groundwater will be treated on site in a package plant with a capacity of five Megalitres per day before being introduced directly to the potable distribution network. The MAR component of the Cape Flats Aquifer Project is only planned to be operational by 2026/7, although construction of the pre-treatment plant for treating wastewater effluent to a high standard before it is injected into the aquifer is expected to be completed in 2024.

Other projects within the New Water Programme, which will require an investment from the City of Cape Town totalling some R4.7 billion, include the Table Mountain Group Aquifer Project, the refurbishment and expansion of the Atlantis Aquifer scheme, the Berg-Voelvlei River Augmentation Scheme, the Faure New Water Scheme – a water reuse scheme that will treat effluent from the upgraded Zandvliet WWTW for potable supply – and desalination.

Okedi says that City of Cape Town water staff had explained that the reason for choosing treated wastewater effluent over stormwater for the Cape Flats Aquifer MAR was due to variability in both quality and quantity. "They would rather work with wastewater because they are sure of the water quality – it's not very variable compared to stormwater, and with their testing regime they don't have a good handle on what's in stormwater, in terms of heavy metals and emerging contaminants. But I would argue that with wastewater we don't know what people are doing in their homes, like taking drugs or discarding substances down drains, and those things are not tested for in the existing regime. Wastewater is not just sewage and grey water, but what you don't test you don't know, and what you don't know won't scare you!" he quips.

"The other issue is reliability, which I do agree with, because stormwater is only really available in the winter rainy season in Cape Town, while wastewater flow is quite consistent year-round." What's more, the variability in stormwater flows is likely to increase in future, as climate change is predicted to cause more extreme events, such as droughts and floods.

Okedi assessed the impact of climate change on demand and stormwater yield in the Zeekoe catchment using modelled data provided by UCT's Climate Systems Analysis Group. The data suggested an annual mean reduction in rainfall of 40–200 mm by the year 2100, along with a 3–5°C rise in mean daily temperature, which will increase evapotranspiration. This will likely result in a 15–50% decrease in stormwater yield in the catchment, but it will be more than offset by the increase in hard, impervious surfaces that can be expected with land-use change. Should the mean imperviousness of the entire study area increase from the current estimate of 45% to 75% as developments replace agricultural land and other open spaces, a 91% increase in stormwater yield is predicted.

"If we are able to capture that water, it would make a significant contribution to future water security and be very useful for sustainability," says Okedi. "Sustainability is not about going many kilometres away to the mountains to get water and then whatever falls on our city is drained off to the sea. We could augment the city to become a giant catchment so that any rain that falls here is infiltrated into the ground and stored there for later use. So it's vital that we protect our greenbelts and ponds, as these will be our access to the unconfined aquifer to preserve water for the future."

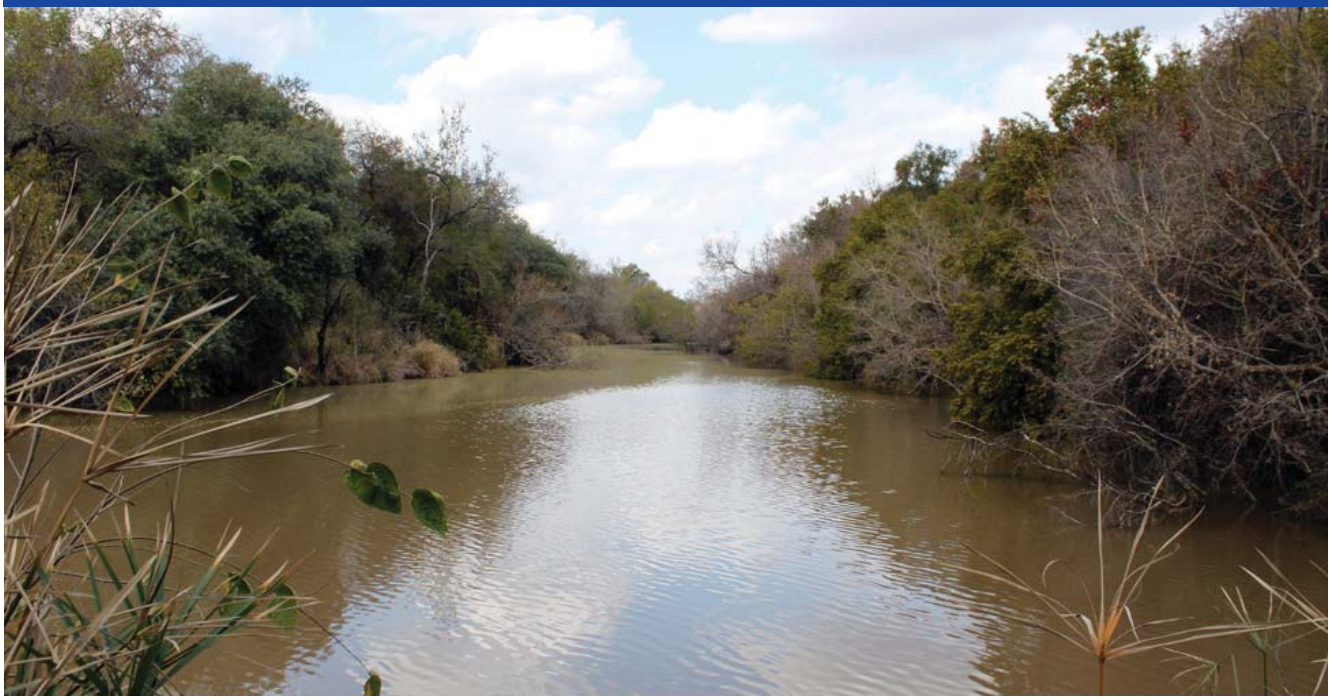
To download the final report, ***The viability of stormwater ponds in the Zeekoe catchment as water resources for Cape Town, South Africa*** (**WRC report no. 2526/1/22**) Visit: https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/2526.pdf

BACK TO TOP

WATER ECOSYSTEMS

Free-flowing rivers and their importance to people, economies and nature: Prioritisation and targeted interventions to maintain ecological integrity

Chantel Petersen, Heidi van Deventer, Lindie Smith-Adao and Jeanne Nel from the CSIR report on initiatives to conserve South Africa's last free-flowing rivers.



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Free-flowing rivers (FFRs) are river systems that have remained connected from source to sea (longitudinally within the channel), latitudinally (connected to floodplains), and vertically (surface-groundwater interaction), allowing for functional biodiversity. Few countries still have FFRs, allowing for connectivity where ecosystem services and functions such as the movement and exchange of water, energy, material, and species within the river system and surrounding floodplains occur, assist with resilience to climate change and anthropogenic impacts and food security among others.

Free-flowing rivers are threatened by instream obstructions such as dams and weirs, pollution, and climate change. A global study by Grill et al. (2019) showed that less than 50% of rivers remain free-flowing, and most of these occur in remote regions of the world, and on the African continent, only 47% of large rivers are still free-flowing.

In 2011, researchers at the CSIR, with funding from the Water Research Commission, completed the first countrywide freshwater conservation plan, the National Freshwater Ecosystems Priority (NFEPA) project, for South Africa. Free-flowing rivers were identified from the 1:500 000 DWAF (2006) spatial rivers layer, was used a basis for establishing river ecosystem types, river condition and FFRs as different spatial layers. An approach of knowledge co-production was followed where an array of researchers, decision-makers, and other stakeholders, at various levels, in the water sector were consulted as a means to validate the information portrayed. A range of different levels of relevant information through several stakeholders from diverse

BACK TO TOP

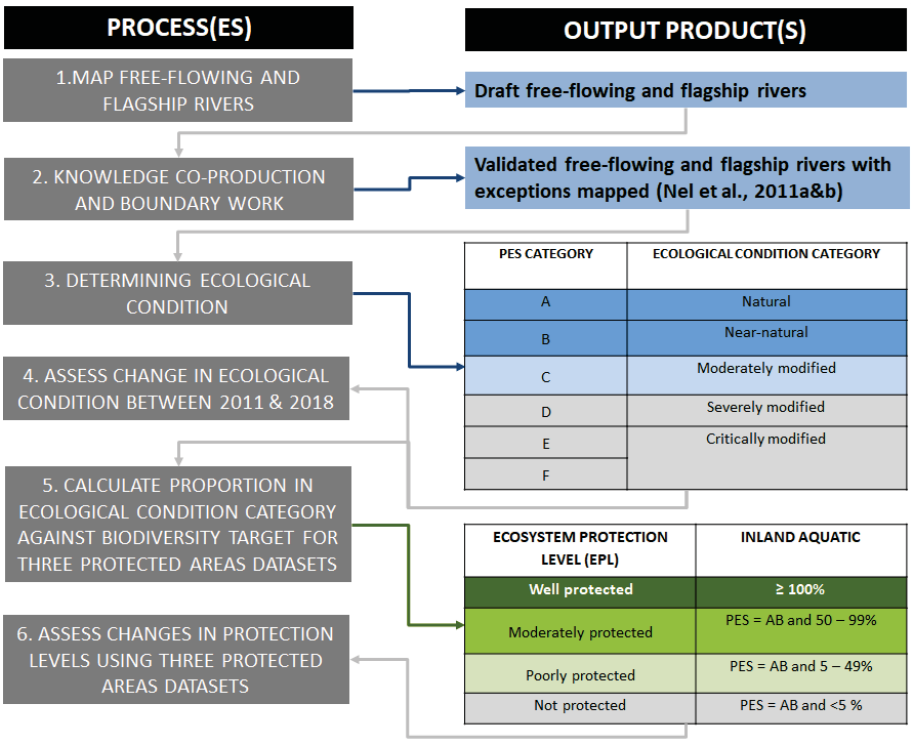
knowledge systems were applied and transformed into co-produced knowledge. The co-produced knowledge also assisted in developing criteria for the identification and selection of the 62 FFRs, including a subset of 19 priority FFRs, termed 'flagship FFRs'.

Reporting on FFRs to global biodiversity targets

The Convention on Biological Diversity (CBD) signatories agree to global targets for freshwater biodiversity and ecosystems. These include the Aichi targets for reporting by the year 2000 (CBD, 2016), and post-2020 Global Biodiversity Framework targets for 2030 (CBD, 2021). The importance of water ecosystems is also recognised in the Sustainable Development Goals (SDG), with SDG 6.6.1 monitoring changes in the extent of wetland ecosystems. (UN, 2021). The Aichi Target 11 of 2020, focused on the extent of protection afforded to water-related ecosystems (CBD, 2016). SDGs 6 and 15 monitor and report on changes in the extent of ecosystem protection, including freshwater ecosystems. Goal A of the post-2020 Global Biodiversity Framework requires reporting on targets related to changes in ecosystems' extent, connectivity, and integrity, listing twenty-one action-orientated targets to be achieved by 2030 to reach outcome-orientated goals by 2050. However, FFRs are not explicitly reported to any global targets currently. In South Africa, the protection, planning, monitoring, and assessment of changes in the ecological condition and protection status of FFRs are reported in the National Biodiversity Assessment (NBA), which is led by the South African Biodiversity Institute (SANBI) with re-evaluation occurring every five years.

The NBA 2018 reassessed the ecological and free-flowing status of the 62 rivers identified by the NFEPA project during 2011, the first countrywide freshwater conservation plan in South Africa. The ecological status was assessed using the Present Ecological State (PES) data and the FFR status was assessed for connectivity with the presence of instream dams using the dams register and the updated artificial wetlands layer (Van Deventer et al., 2019). Between 2011 and 2018, 14 FFRs lost their status as FFRs, of which ten resulted from a deterioration in ecological condition and four were due to the presence of dams in the mainstem river. However, the prioritised flagship rivers remained intact in ecological condition and longitudinal connectivity due to the adoption and championing thereof by national, provincial and local government authorities and by their inclusion in conservation planning (Van Deventer et al., 2019). This can be directly attributed to the efforts of the NFEPA project (Nel et al., 2011b; Nel et al., 2016), and the success of targeting attention and initiatives to manage these systems.

Furthermore, subsequent to the NBA 2018, work on the FFRs was extended to assess the success of the Protected Area Expansion Strategy (RSA, 2010). The protection levels of free-flowing and flagship rivers were quantified according to the percentage of river length occurring in formally National Protected Areas (NPAs). This included the NPA Geographical Information Systems (GIS) spatial layers of 2008, 2018, and the Protected Areas Expansion Strategy (NPAES) and the projected protected areas by 2024 (Figure 2). The results were published a scientific publication entitled "Incorporating free-flowing rivers into global biodiversity targets: Prioritisation and targeted interventions to maintain ecological integrity" (Petersen et al., 2023). Adequate conservation of rivers is often assumed when occurring in protected areas without taking cognisance of river connectivity (i.e. longitudinal, lateral, vertical and temporal linkages) or catchment disturbances. Results from Petersen et al. (2023) showed that the inclusion of FFRs in future NPAES plans (2016 and 2024) increased the



Flow diagram of the methods followed to achieve the ecological condition categories and protection levels for free-flowing rivers. Biotic response attributes of a river relative to the natural ecological condition drive present Ecological State (PES) categories.

BACK TO TOP

Ossewa / Wikimedia Commons

A dolomitic eye of the Groot Marico River which pours crystal clear, pristine waters into the start of the river. This is the only free flowing river left in the arid region of the country and the North West Province.

representation of freshwater ecosystems throughout all ecoregions and increased the protection level to 59% in a well-protected category. In addition, the study proposed that the loss of the extent of FFRs in a natural and largely natural ecological condition be reported to SDG 6; whereas changes in the connectivity of FFRs be included in the post-2020 Global Biodiversity Framework targets; and lastly, changes in protection levels of FFRs reported to SDG 15.1.2 (Petersen et al., 2023). Currently rivers are not reported under any SDG.

A comparison between the free-flowing rivers of the NFEPA project, as updated and used in the NBA 2018, showed a marked difference to that of the global mapping of FFRs by Grill et al. (2019) (Figure 4). The global assessment mapped a total extent of 225 192 km of FFRs for South Africa in comparison to the most recent NBA 2018 which mapped 164 018 km extent of FFRs (Figure 4b). The global study showed a 27% more in extent of FFRs than the extent used to apply in South Africa's countrywide scale assessments.

When the global free-flowing rivers are also considered for change detection and reporting to the global targets, one of the major concerns are in the representation of pressures at a global scale. The global dataset showed extensive extent of FFRs, because it was automatically derived in GIS from a digital elevation model, and mapped the presence of FFRs, irrespective of the flow, hydrological period or damming in the tributaries of these systems. In contrast, the South African dataset showed a selection and prioritisation of <100 FFRs, which offers a more feasible means of monitoring, prioritisation and management at a countrywide scale. Priority was given to permanent and seasonal mainstems and tributaries in South Africa, because these systems experience high anthropogenic pressure and showed a larger degree of transformation, compared to the arid ephemeral systems.

Implementation and uptake

The Petersen et al, (2023) was published at an opportune time as the 15th meeting of the Conference of the Parties to the UN Convention on Biological Diversity met over a two-week summit during 7-19 December 2022 in Montreal, Canada. According to the GEO BON (Group on Earth Observations Biodiversity Observation Network) and FWBON (Freshwater Biodiversity Observation Network) (2022) science brief for COP15, inland waters are not explicitly included in Targets 1 and 3 of the post-2020 Global Biodiversity Framework. The published paper was included in the South African delegation to COP15 and was, therefore, pertinent to the efforts to achieve the goals of the

BACK TO TOP

post-2020 Global Biodiversity Framework.

The WWF currently spearheads the Iconic Free-Flowing Initiative, which promotes the free-flowing nature of rivers by strengthening policies and promoting laws to protect such rivers, prevents the building of dams that would negatively affect humans and wildlife depending such rivers. It will assist local leaders to develop sustainable energy plans limiting the need for hydropower and assist in reconnecting rivers by removal of dams together with other restoration projects and initiatives (https://www.worldwildlife.org/pages/free-flowing-rivers). Furthermore, awareness was also created with the development of an augmented reality free-flowing river app available for download on a mobile device (https://www.worldwildlife.org/pages/explore-wwf-free-rivers-a-new-augmented-reality-app). This app puts an entire landscape in your hands. You can immerse yourself in its incredible virtual world, where you'll meet the people and wildlife that live there. Through this in-depth, interactive storytelling experience, you can learn how wildlife, people and entire landscapes depend on healthy, flowing rivers. You can for example dam the river to see what happens, and then try a sustainable energy mix that keeps the river connected but still satisfies growing energy demands.

Explore WWF Free Rivers, a new augmented reality app (After https://www.worldwildlife.org/pages/explore-wwf-free-rivers-a-new-augmented-reality-app).

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BACK TO TOP

CITIZEN SCIENCE

Building confidence, hope and dignity in communities through citizen science

Up to her elbows in Limpopo groundwater, an anthropologist ponders pluralism, 'a secular form of enchantment', proselytises for public engagement and spins a yarn on citizen science. She spoke to Matthew Hattingh about her work and a new report published by the Water Research Commission (WRC).

"Quit mystifying science, rendering it accessible only to academics." That's the message from anthropologist Prof Jacqueline Goldin to water researchers and practitioners who need to change the way they work with and talk to communities. "If you are going to make a better world, where people are managing their planet in a wiser and better way, you have to use different tools," said Goldin.

The process of research must be "shared with people who are going to make a difference… ordinary people who are going to look after rivers and groundwater. They want to be part of the solution."

Goldin, who was speaking to the ***Water Wheel*** after the January 2022 publication of her WRC-funded report, ***Polycentricity, pluralism and citizen science: A nexus approach to water resources management*** (**WRC report no. 3042/1/22**), advocates "slow science".

Researchers, especially in the social sciences, should take time finding out who to talk to and about what. They must engage with society and build trust. She pointed out that you wouldn't barge into a government minister's office without an appointment; It might take months to set up a meeting. Researchers must develop a similar patience and respect when

BACK TO TOP

dealing with other sources of authority and structures on the ground, such as traditional leaders, who can be hard to access. Goldin called for "much more thinking than helicopter-ing into communities". Helicopter science is a pejorative applied to researchers from wealthier countries or regions who fly in and out of developing countries and, in a great hurry to publish, eschew meaningful engagement and collaboration with locals.

"It does not work that way where you are trying to build trust with communities," said Goldin, "let us take our time to do it properly… go in there and do thoughtful stakeholder engagement."

She doesn't really blame researchers who remain aloof from communities or pay lip service to engagement. "They don't know how to talk to people. You don't learn about public engagement in academia; you learn about your precious discipline."

Goldin was speaking by phone from Utrecht University, where she has an association with its International Development Studies section. She spends about half the year in the Netherlands and the balance back home at the University of the Western Cape, where she is an Extra-ordinary Associate Professor in the Centre for UNESCO Chair for Groundwater in the Faculty of Natural Science.

Her recent research work is in the Hout River catchment area, north-west of Polokwane, the Limpopo capital. It's here, from 2019 to 2022, that she ran a citizen science groundwater monitoring project. Twenty-five monitors were taught to measure groundwater levels and rainfall using drip meters and rain gauges and to upload the data to a shared platform by smartphone. The work was something of a first and Goldin said it provided lessons that would be useful to projects in other catchment areas and to citizen science projects unrelated to water.

She traced her "passion" for water research to the 1990s when she worked on the Working for Water, alien invasive removal project, with Guy Preston, the highly-regarded conservationist, academic and later senior government official. A "numerate anthropologist", who serves on an interim committee to foster South African citizen science, Goldin said her interest in encouraging public participation in research stemmed from her 2005 doctoral thesis. It focused on trust and shame and how "technical talk" by academics, engineers and the government made ordinary people "feel ashamed".

She was at pains to point out that the people in question, with their unique insights and local knowledge, were anything but "ordinary". They also offered a hard-to-beat way of tapping "huge amounts of information" in poor and remote places (like the 2 480 km^2 Hout catchment) that exceed the reach of researchers and the government.

Beyond the data it produced, the project was "all about the transformative process" for the citizen scientist-monitors. "They are getting confidence, dignity and hope," she said. Goldin has secured additional funding from the National Research Foundation to continue her work in the Hout. She will now be teaming up with schools, and the plan is to get 210 citizen scientists to measure river water quality.

It will be a continuation of the work already done on her 'Diamonds on the soles of their feet' project. The name echoes the famous Paul Simon song while reflecting the great store Goldin sets by citizen science and what it's achieved in Limpopo. Here water sparkles or lies buried at the feet of citizen scientists, who are themselves "diamonds", holding as they do "much richness and value to environmental preservation".

Why the focus on groundwater in the initial project?
Goldin and her co-authors, Innocent Muchingami, Thokozani Kanyerere and Tapiwa Hlatywayo (who Goldin credits with the project's technical, water know-how) note that groundwater is limited. Drawn by boreholes out of aquifers, from between soil particles and fractures of gravel, sand and rocks, groundwater has been heavily used, especially for irrigation. It has been polluted by farming, mining and industry. And demand from all sectors is only likely to increase as surface water resources are stretched further.

For these and other reasons, the authors believe everyone using water should be monitoring it – more so the invisible rivers under the ground.

Why the Hout? The area is semi-arid, with an average yearly rainfall of only 407 mm, so groundwater is vital to the people who call it home. These are a complex mix of often poor black people and relatively rich white commercial farmers – who rely on centre pivot irrigation to water their crops, notably potatoes. All this makes for fertile ground for study and intervention.

The report seeks to analyse and understand the project in theoretical terms. It begins by looking at the geography of the area and its context as well as surveying the big players. By this the authors mean the institutions, agencies, government departments and others with links to water monitoring as well as the municipal authorities and tribal chiefs who hold sway over large parts of the Hout (and more than 40% of South Africans).

An overview of the laws and regulations around monitoring groundwater shows just how many layers there are and the complexities of working with people governed by many different rules, some very formal, others less so. The next part, which lends the report its title and its meat – deals with what the authors regard as complementary concepts: nexus, citizen science, pluralism and polycentricity. It considers what these concepts mean and how they might help us fashion a conceptual framework to better understand groundwater monitoring and citizen science.

Nexus is about how natural resources – land, water and energy – are interlinked and need to be managed together for the common good. The authors bring in this nexus to warn against seeking simple quick-fixes and when trying to understand a landscape – its geography, its politics and its people.

Citizen science, increasingly in recent decades, has involved thousands of lay volunteers 'collecting, commenting, transcribing

BACK TO TOP

Photo supplied

Citizen scientists using a dip meter to measure water levels of boreholes in Limpopo's Hout catchment area.

and analysing data', usually working with professional scientists. Mostly this has been in the natural sciences and concerned with the study of physical and natural phenomena. It has proved especially useful in studying large-scale patterns in nature (bird migration for example) which required the collection of lots of data across various places and habitats and over, sometimes, many years.

A modest 11% of citizen science concerns the social sciences and humanities. But this was changing, with technology helping make communication and the sharing and management of data easier. And the authors have high hopes for citizen science in their field. "The educational aspect underpins the volunteer experience and in the case of our project, literacy about groundwater is empowering and although encouraging citizen participation in data collection and analysis, we see it is primarily a means of meaningful education with huge emancipatory and transformative potential."

For Goldin, citizen science is about taking science out of the library, out of the laboratory and into real life. The authors view pluralism as a "process, not a product", "an interaction between conflicting and competing positions", about recognising diversity and coexistence. This chimes with the feminist thinking they cite, with its notion of an "ethics of care" and focus on justice and the need to acknowledge diversity.

It is not just about managing water – it's about getting to a more just and transformed society, said Goldin. The authors suggest we draw from many perspectives. Whether a farmer, an engineer, a government official, or a local chief is right or wrong in doing something depended on an understanding or agreement with his or her culture and not on basic moral demands that apply to everyone. In this view, "pluralism is an infusion of value in our lives – an interminable quest for ethical orientation. It is a secular form of enchantment".

The report holds that decentralisation and a few simple tendencies or rules provide the conditions for harmonised local behaviour, rather than centralisation and many complex rules. "People are powerful because they control various resources" and "powerful when their power is recognised".
Goldin said she steers away from the overused idea of "empowering people at the grassroots". Rather, she believes people are "full of power", but often trampled on and ignored. "What matters is to provide spaces where their power is heard."

Polycentrism concerns itself with systems that do without central control and instead have "multiple governance units at multiple scales". How do polycentrism and plurality apply to groundwater monitoring? The authors observe that "work on citizen science has not yet provided a theoretical frame that is explicit about equity, social justice and the human right to know". They hope their work with these concepts will help remedy this.

Next, the report offers a meditation on "meshwork". "Meshwork explains more the entanglement of individuals – full of loose ends and always on the move. In a world of life – knotting is the fundamental principle of coherence. It is the way forms are held together and kept in place within what would otherwise be formless."

BACK TO TOP

Spinning their textile metaphor out further, the authors explain how rather than rigid social structures, it's the contrary forces of tension and friction, pulling tight, that give the fabric of society its form and strength. "Meshwork-thinking may provide an appropriate framework… for exploring the social relations within the diverse context of the catchment." Also touched on is the notion of yarning – "from the verb 'to yarn', which means to tell a story – but also to twist fibre to give it strength and durability".

Nexus, citizen science, pluralism and polycentricity. None is a new concept, or at least not very new. But their application in combination to the study of people and water is recent and believed to be novel. This is the first time, the authors said, that these concepts have been brought together and "woven" into the field of water resources management in general and groundwater in particular.

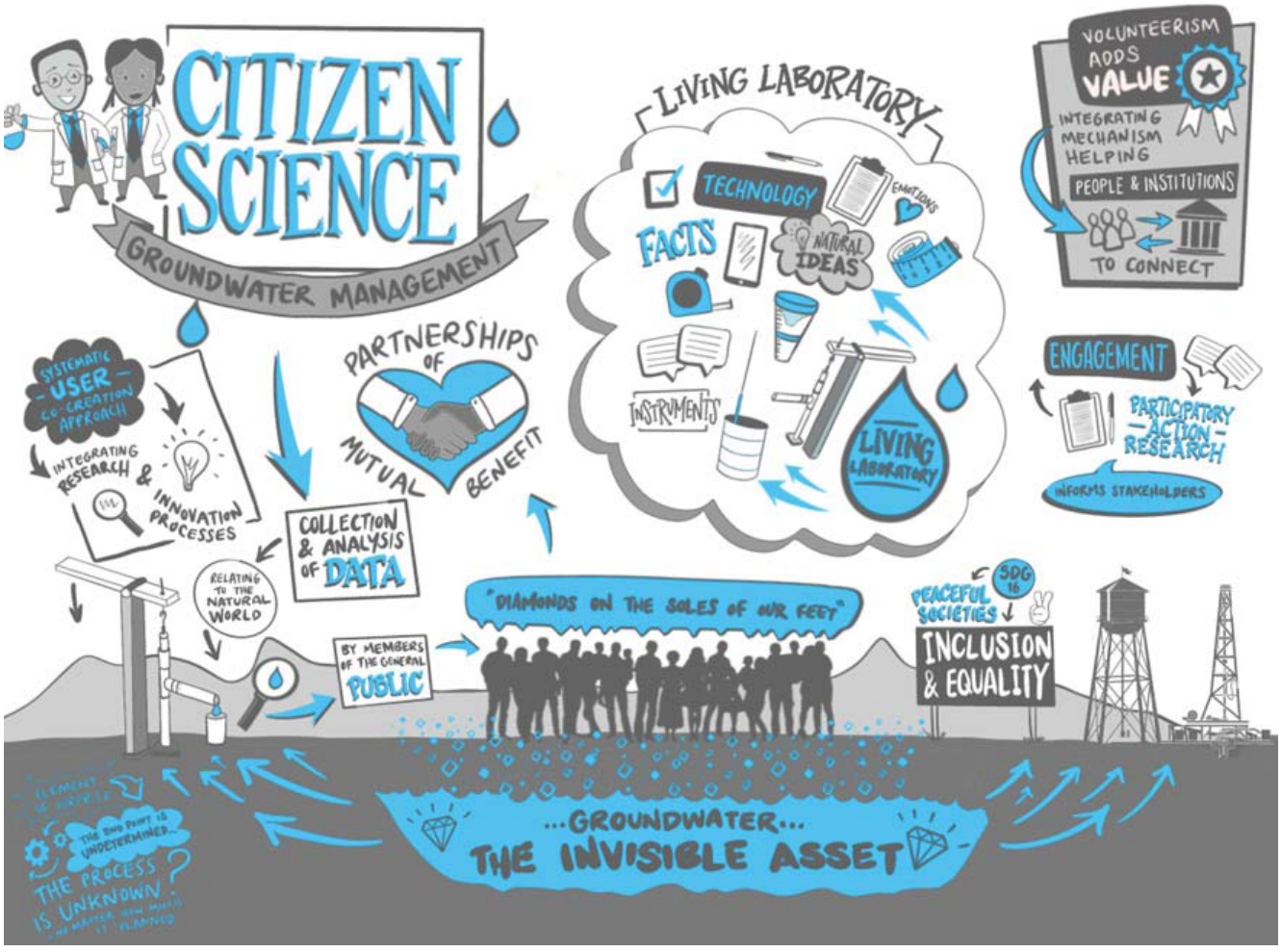
Put simply, they advance the idea that there are many sources of power and authority and they are related to each other and overlap in complicated ways. This is seen as a good thing. Like citizen science, it's democratic, "messy" and "knotty".

The report seeks to show how entangled many of the people, institutions and concepts it discusses are and "how yarning binds disparate ideas and encourages a package that is… forever on the move".

To help readers through the tangle of concepts and parties to their monitoring yarn, the report highlights key concepts in blue text. It also uses creative illustrations as well as storyboards, which combine words and graphics to represent how polycentrism, pluralism and citizen science might be brought together to aid water monitoring.

Goldin told ***Water Wheel*** she is a great believer in the power of art to break down barriers and overcome confusion. "With art you can emphasise new ways of learning and communicating science and a more just world. I believe in creativity. People can see things… it helps them dream and be a part of the solution."

To access the report, ***Polycentricity, pluralism and citizen science: A nexus approach to water resources management*** (**WRC report no. 3042/1/22**), Visit: https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/3042.pdf



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Storyboarding is a technique used in the visual arts and has been adapted for research and community development. The authors see it as another manifestation of yarning – as in 'telling a story'.

BACK TO TOP

WATER USE IN AGRICULTURE

Study builds knowledge around more sustainable beef production

In the first study of its kind in South Africa, a Water Research Commission (WRC) funded study investigated the water use of cattle feedlots in South Africa with the aim of making this industry increasing water wise. Article by Petro Kotzé.

At the start of 2022, a special group of young cattle, a combination of Ngunis, Bonsmaras and Simmentals, were delivered to the Animal Nutrition section of the Agricultural Research Council – Animal Production (ARC-AP) in Pretoria. Their home for the next five or so summer months were single feeding pens, a small simulation of a large and booming industry in South Africa – beef cattle feedlots. In South Africa, up to a 100 000 head of cattle can be kept in a feedlot, but the small group of 33 animals that spent the summer of '22 at the ARC helped examine a key question about this industry: how much water is used in the process?

The answer is of national importance. Eighty per cent of the cattle herds in South Africa are for beef production (the remaining 20% is for dairy), and our appetite for it is growing, fueled by a growing population and expanding urbanisation.

It is the second-fastest growing industry after poultry in our agricultural sector. According to the national figures available, the industry saw a gross value increase of 135%, from R13 billion in 2006/07 to R30.6 billion in 2015/16, averaging R19 billion per annum.

However, we do not know what the related price tag in water is or how beef production could contribute to the country's water scarcity problem. Previous research has run simulation models to do the math but now, for the first time in South Africa, the data has been validated, says project leader Prof Bohani Mtileni from the Department of Animal Sciences at Tshwane University of Technology (TUT).

In a first-of-a-kind for the WRC, the organisation funded the project ***Sustainable application of livestock water footprints in***

BACK TO TOP

different production systems and regions of South Africa. The final report (**WRC Report No. 2964/1/22**) was published in January and is the starting point of many questions that remain to be answered, says Prof Sylvester Mpandeli, Executive Manager for Water Utilisation in Agriculture at the WRC. However, the results already indicate the potentially vast amount of water that can be saved should beef production be approached from a water-wise angle.

How to measure the water in a kilogram of beef

The study aimed to evaluate the water footprints of cattle raised in South African feedlots, an intensive production system that grows and fattens the animals in high densities until they reach the right weight for slaughtering. Feedlots are usually large, fully mechanised and geared to optimum performance. Grazing is replaced with a feed mixture to obtain optimal growth until the animals are sent for slaughter and consumption as beef and hides.

The practice is well established in countries like the US and Canada and is rapidly growing in other regions like South America, Asia and Africa as demand for beef rises. An estimated 2% of the global cattle population is kept in feedlots to produce roughly 7% of the world's beef.

To measure the water footprint of beef cattle feedlots in South Africa, researchers from TUT, Botswana University of Agriculture & Natural Resources and the ARC-AP unit considered blue, green and grey water. This includes the water the animal drinks over its lifetime, the water contained in the food it ate and the water that is used when the meat is processed in the abattoir, explains Mtileni, a geneticist by training. The amount of irrigation water used to produce the feed is something that they would like to include in future but was not considered here.

The project team's objectives were to investigate the water footprints of different sizes of cattle; the degree to which the volume of water varied during their growth after weaning; the relationship between the volume of water used and carcass characteristics; and the amount of water consumed per kilogram of feed by the different breeds considered.

Of the herd of 33, eleven were Nguni cattle, the smallest breed; another eleven were Bonsmara cattle, a medium breed, and the last 11 were Simmental cattle, which has the largest frame size. During their time at the ARC the cattle were given free rein to water and food, a mix of hominy chop, grass hay (***Eragrostis***), soya oilcake, molasses, limestone, urea, salt and a premix of vitamins and minerals. The animals were weighed at the start and then every two weeks, and their feed and water intake were recorded daily.

Ultrasound transducers allowed researchers to investigate the boundaries between the animals' hide, fat and muscle layers to allow for the measurement of the various carcass traits and estimate retail yield and meat quality. Common traits include rib eye area (measured between the twelfth and thirteenth ribs, it gives an estimate of the amount of muscle and lean product in the animal), backfat (an estimate of the percentage external fat on the animal), rump fat and percentage intramuscular fat (an objective measurement of marbling, the main trait used to determine the meat's quality grades). When the cattle reached market weight, they were slaughtered for further analysis.

A typical South African feedlot.

BACK TO TOP

Which frame-size animal performed the best?

The study provided numerous insights. The frame size of the animal significantly influenced many of the factors measured. These include the amount of water consumed in the feed, the water intake, water consumption, the water-to-feed ratio, the service water used and the water footprint. Researchers also considered the water intake efficiency (WIE), the ratio of water intake to the live weight gain of the animal and water consumption efficiency (WCE), the kilogram of weight gained per litres of water consumed.

Beyond the results

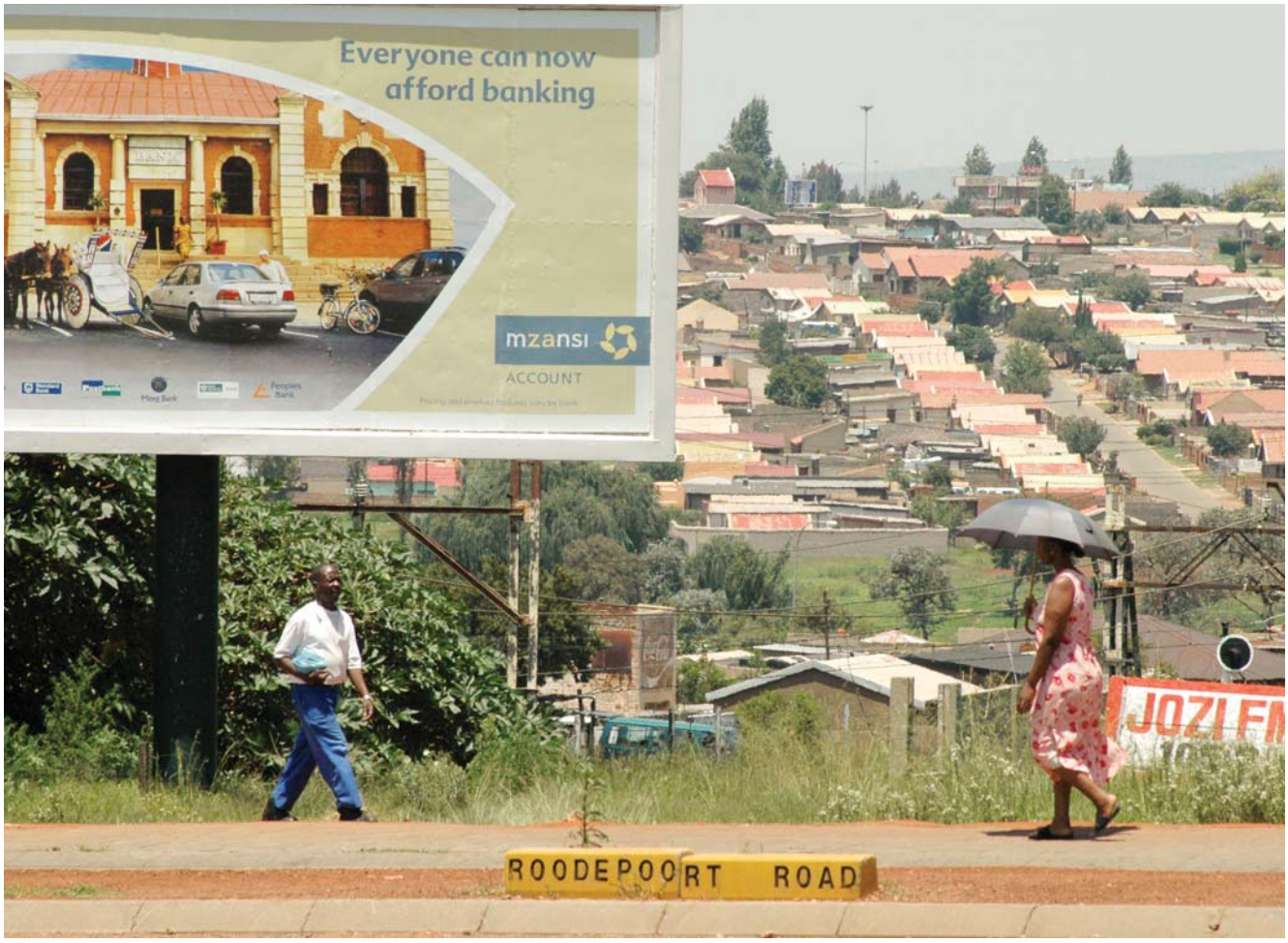
Over and above the reported findings, the project team also developed indicator traits of water footprints for intensive livestock production in South Africa, something that is currently lacking in livestock genetic improvement programmes here and in many countries of the world. As a result, we now have baseline information on WIE and WCE as potential indicator traits – an output that is of special importance to feedlots, breed associations, farmers, and policymakers.

Results showed that the Nguni, the smallest frame-size, performed better than the medium Bonsmara and large Simmental in terms of water consumption efficiency for post-weaning growth performance under the intensive production system. A small frame-sized beef breed would be best in areas where water scarcity is common, they concluded.
However, the picture changes when the quality of the meat is taken into consideration and, results show, this was also significantly influenced by the size of the breed. Measured by fat and fat code, the small and medium breeds performed better, but the eye muscle area was higher for medium and large-framed breeds than for the small-framed breed.

In conclusion, the results suggest that the medium frame size breed (in this case, the Bonsmara) performed better in terms of water footprint whilst also providing comparable carcass characteristics to the large frame size in the intensive production system.

"So, we recommend that farmers in water scarce areas keep the smaller frame sizes because they use less water to produce a similar yield than the larger size," Mtileni says. "With large frame sizes, water is being wasted, while it doesn't result in better quality meat." However, farmers can best work with the medium frame size because it's a combination of all that is needed, he says.

Petro Kotzé



Our growing appetite for beef is fuelled by an expanding population and urbanisation.

BACK TO TOP

Nguni cattle is one of the species investigated as part of a study on water use of beef produced in feedlots.

Why do we need to know?

"It's critical to find the relationship between water intake, economic output, post-weaning growth and meat characteristics," Mtileni says. "If we don't know how much water is needed to produce a kilogram of meat we won't consider how much water is being wasted along the pipeline of producing a full-grown animal to market age. If we benchmark and document the information on how much water is needed to produce a kilogram of meat, we can put a projection together taking the amount of available water in the country in mind. We can compare the water being used vs the products yielded."

The potential water savings in question can be enormous. Mtileni says it amounts to a difference of around 500 litres and more between a small and large breed of cattle, per animal. According to figures by the South African Feedlot Association, South African cattle feedlots combined accommodate about 460 000 head of cattle. Seeing as the standing period for one cycle at a feedlot is about 100 to 120 days, three cycles can be completed each year, resulting in about 1.68 million cattle slaughtered annually.

However, Mpandeli points out that this was, for the moment, a scoping study and that results can be swayed by many factors, including the season, geographical location of the feedlot and weather conditions at the time. Hopefully, more detailed studies can look at different livestock in future. As a start, the WRC is planning an "exciting" project focusing on indigenous goats and water use efficiency for 2024.

Mtileni adds that other important study subjects would be on commercial and exotic breeds of cattle and small-holder farming operations instead of intensive production systems. However, the most important, he says, is to find out next if the indicator traits (see earlier text box) can be manipulated under genetic control.

"We need to look at factors that might affect our farming in future," Mtileni says. This project considered water scarcity and the health of our water resources, he says, but also the increasing demand for food that needs to be produced with the same, scarce resources. "We need to use water wisely, without sacrificing the end products of our produce." In the end, he says, we need to know how to strike that balance.

For more information, refer to WRC Report No. 2964/1/22, *Sustainable application of livestock waterfootprints in different production systems and regions of South Africa*.

BACK TO TOP

NEW MOU AIMED AT EMPOWERING COMMUNITIES IN LIMPOPO

Mopani municipal manager, Tshepo Mogano and WRC CEO, Dr Jennifer Molwantwa, signing the memorandum of understanding.

The Water Research Commission (WRC) and its partners hosted a three-day knowledge transfer products expo in Giyani, Limpopo from 28 February to 2 March.

The event was held as part of the Giyani Local Scale Climate Resilience Programme, which is funded by the Government of Flanders and the Water Research Commission (WRC), with partners Tsogang Water and Sanitation, the Association for Water and Rural Development (AWARD), and the University of the Western Cape (UWC). The programme aims to, among others, create an enabling environment whereby local authorities, institutions, communities, tribal authorities and market players are mobilised to improve climate resilience and water utilisation.

The event demonstrated water-wise technologies which can improve emerging farmers' resilience to climate change and increase agricultural production. The event was held at the Mopani Farmers Association Distribution and Packhouse Centre in Nduhambi Village located in the Dzumeri Tribal Authority. Farmers and local entrepreneurs were treated to training and demonstration on the technologies. The event also provided an opportunity for the WRC team to engage with other stakeholders in technical discussion sessions and brought awareness of innovative farming practices, new agricultural opportunities and optimal irrigation management.

A highlight of the event was the signing of a memorandum of understanding between the WRC and the Mopani District Municipality. The purpose of this MoU is to establish an overarching framework for strategic collaboration between MDM and the WRC. Among other key areas, the two parties will collaborate in building and strengthening an enabling environment whereby local authorities, institutions, communities, tribal authorities and market players are mobilised and formalise planning to improve climate resilience and water utilisation. "This partnership is crucial to the WRC goal of ensuring that innovations and science-based knowledge developed through Commission funding actually reach the communities they are intended for and empower them," said WRC CEO, Dr Jennifer Molwantwa.

Celebrating the start of a successful partnership.

BACK TO TOP

DEEPLY ROOTED IN SOUTH AFRICA WATER SOCIETY

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The Water Research Commission not only endeavours to ensure that its commissioned research remains real and relevant to the country's water scene, but that the knowledge generated from this research contributes positively to uplifting South African communities, reducing inequality and growing our economy while safeguarding our natural resources. The WRC supports sustainable development through research funding, knowledge creation and dissemination.

The knowledge generated by the WRC generates new products and services for economic development, it informs policy and decision making, it provides sustainable development solutions, it contributes to transformation and redress, it empowers communities and it leads various dialogues in the water and science sectors.

The WRC Vision is to have highly informed water decision-making through science and technology at all levels, in all stakeholder groups, in innovative water solutions through research and development for South Africa, Africa and the world.

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THE POWER OF KNOWLEDGE TO THE PEOPLE