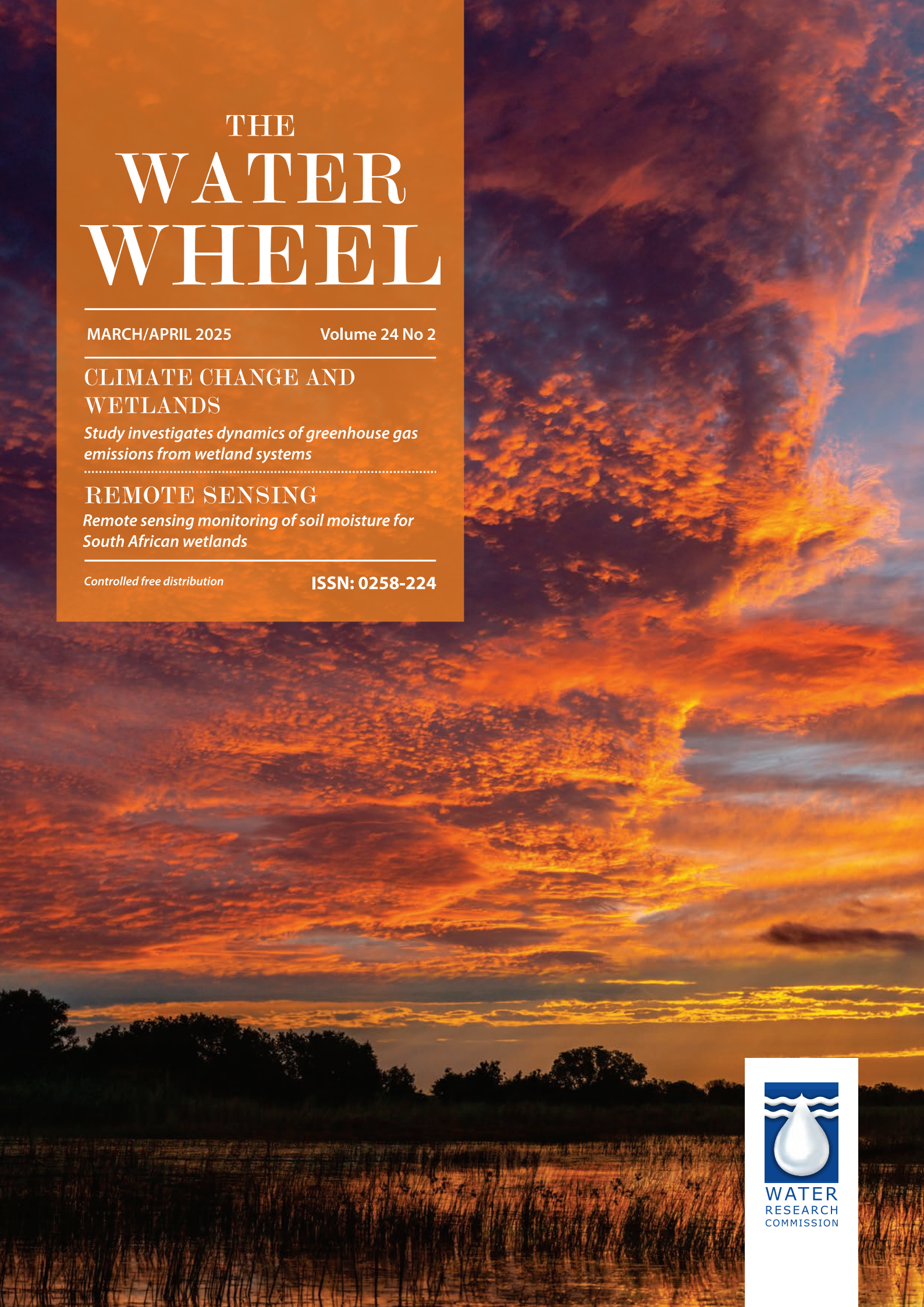

THE WATER WHEEL

MARCH/APRIL 2025 Volume 24 No 2

CLIMATE CHANGE AND WETLANDS

Study investigates dynamics of greenhouse gas emissions from wetland systems

REMOTE SENSING

Remote sensing monitoring of soil moisture for South African wetlands

Controlled free distribution

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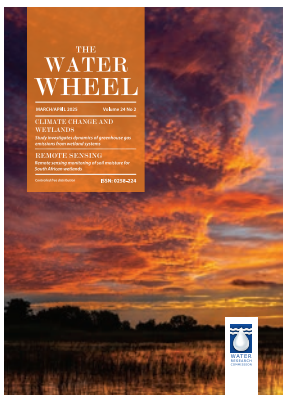

What is the correlation between wetlands and climate change? This was the subject of a recently completed Water Research Commission funded study. See page 10.

NEWS

Tshwane children celebrate World Wetlands Day

Over 80 children visited the Colbyn Wetland Nature Reserve in Pretoria on 1 February to learn about wetlands and why we need to restore and protect them.

A number of environmental professionals and students volunteered as leaders and students volunteered as leaders and facilitators at the event, which was aimed at children aged 8-13 years, drawn from various school and youth groups across the city.

The day's activities were designed to create awareness about the value of wetlands, how they are formed, how they function and how to protect them. Participants were taken on a wetland discovery walk; built a simple model to show how wetlands work; became 'citizen scientists' by performing miniSASS (mini-stream assessment scoring system) to classify the water quality of a stream based on the kind of invertebrates that they found living there; and got to show off their new-found knowledge by competing in a wetland quiz.

This was the tenth event of its kind in the reserve since 2014, held to celebrate World Wetlands Day, a global event held on 2 February. The day was hosted by the WESSA-affiliated Friends of Colbyn Valley and the Agricultural Research Council, assisted this year by the Southern African Young Geomorphologists (SAYG) and BirdLife Northern Gauteng, and sponsored by Ocean Breeze Food Merchants.

The Colbyn Valley Wetland is situated in the heart of Pretoria. Although it is vulnerable to a number of impacts due to its urban location – such as pollution, poaching, uncontrolled fires, and the spread of invasive alien plants – it remains a valuable biodiversity and water resource, as well as offering residents a unique educational and recreational site. The wetland includes area of peat, a relatively rare occurrence in South African wetlands.

Lesotho tunnel maintenance on track – minister

Water and Sanitation Minister, Pemmy Majodina, has expressed her confidence that the maintenance work currently underway at the Lesotho Highlands Water Project (LHWP) tunnel in Clarens, Free State, will be completed within the scheduled timeframe of six months.

Minister Majodina and Deputy Minister Mahlobo were on an oversight visit to the Ash River Outfall in Clarens in February to assess progress on the work underway at the tunnel. The ministers were accompanied by Deputy Minister of Performance, Monitoring and Evaluation, Seiso Mohai, Free State Premier Maqueen Letsoha Mathae, and Free State MEC for Cooperative Governance and Traditional Affairs, Saki Mokoena, as well as the Executive Mayor of Thabo Mofutsanyana District Municipality.

The maintenance and refurbishment of the 37 km-long water tunnel started in October 2024. The Trans Caledon Tunnel Authority (TCTA) is undertaking repair work on the South African side of the border, while the Lesotho Highlands Development Agency (LHDA) is undertaking out the maintenance on the Lesotho side. The repair work in the tunnel includes mechanical, electrical, civil and general works as well as repairing of water ways steel linings to protect the corrosion of the tunnel.

Majodina has lauded the progress on the South African side and indicated that Lesotho is also equally committed to finish the maintenance work of the tunnel within a stipulated timeframe, despite the challenges they are facing. "I am satisfied that the maintenance work has advanced very well on the South African side, and I know that our counterparts in Lesotho are doing everything they can to ensure that we meet the deadline set for 31 March."

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Scientists tackle one of Africa's most destructive invasive trees

A major new book on the ecology and management of one of the most destructive invasive weeds in Africa, is now available online.

The book, ***The ecology and management of invasive Prosopis trees in Eastern Africa***, is the outcome of a large, decade-long collaborative research project, involving six universities and eight institutes from Ethiopia, Kenya, Tanzania, South Africa, Switzerland and the United States.

Between the 1970s and 1990s, several Prosopis species, originally from the Americas, were introduced on a large scale to countries in Eastern Africa by international aid agencies to provide benefits such as timber, fodder and shade and to combat desertification. One of the those species, ***Prosopis juliflora***, subsequently became invasive and is now regarded as a classic example of a well-intentioned action gone wrong. In 2006, the detrimental effects of Prosopis invasions made international headlines when community members from Baringo County in Kenya brought a toothless goat to Nairobi goat as evidence of one of the many impacts of Prosopis pods on their livestock.

Prof Brian van Wilgen, one of the editors of the book and emeritus professor in invasion biology at Stellenbosch University, says to date this tree has invaded close to ten million hectares of land in eastern Africa. "Although these trees were initially introduced for the benefits that they could provide, these benefits have subsequently been cancelled out and are now considerably exceeded by negative impacts."

The negative effects of this 'conflict' species are so encompassing that people are forced to leave their land to try and make a living elsewhere. The trees fundamentally change the structure and functional of communal rangelands, croplands, wetland and protected areas. Open savannas become dense, impenetrable stands of trees with little to no grass below them. In densely invaded areas, Prosopis can consume about 50% of the annual rainfall of the region, thus severely depleting groundwater resources and exacerbating the effects of a changing climate.

To access the book, visit: https://www.cabidigitallibrary.org/doi/book/10.1079/9781800623644.0000

Diary

Water reuse
16-20 March
The 14th IWA International Conference on Water reclamation and Reuse will take place in Cape Town under the theme 'Overcoming the barriers for reuse of water'.
Visit: https://iwareuse2025.com/

Aquifer recharge
28 April – 2 May
The 12th International Symposium on Managed Aquifer Recharge will take place in Stellenbosch under the theme 'From theory to implementation and operation'. For more information,
visit: https://ismar12.org.za/

Irrigation
13-15 May
The symposium of the South African National Committee on Irrigation and Drainage (SANCID) will take place in Bloemfontein. For more information,
visit: https://www.sancid.org/

Large dams
15-23 May
The 28th Congress and 93rd Annual Meeting of the International Commission on Large Dams will be held in Chengdu, China. For more information,
visit: https://www.icold-cigb.org/

Municipal engineering
29-31 October
The 88th IMESA conference will take place in East London under the theme 'Sustainable Engineering Solutions'. The call for abstracts is open until 10 April 2025. The main themes for the conference include buildings, structures and housing; ecological, environmental and social; electrical and electronic; financial, legal and regulatory; transport, roads and stormwater, as well as water and sanitation.
For more information, visit: https://conference.imesa.org.za/call-for-papers/

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GLOBAL

One quarter of freshwater animals at risk of extinction – IUCN

The largest global assessment of freshwater animals on the IUCN Red List of Threatened Species to date has revealed that 24% of the world's freshwater fish, dragonfly, damselfly, crab, crayfish and shrimp species are at high risk of extinction, according to an analyses published in ***Nature*** in January.

The IUCN co-authored study recommends targeted action to prevent further extinctions and calls for governments and industry to use this data in water management and policy measures.

"As the IUCN Red List celebrates its 60th anniversary, it is a stronger barometer of life than ever. Lack of data on freshwater biodiversity can no longer be used as an excuse for inaction," noted Catherine Sayer, IUCN's Freshwater Biodiversity Lead and lead author on the paper. "Freshwater landscapes are home to 10% of all known species on Earth and key for billions of people's safe drinking water, livelihoods, flood control and climate change mitigation, and must be protected for nature and people alike. The IUCN World Conservation Congress this October will guide conservation for the next four years. This information will enable policymakers and actors on the ground to plan freshwater conservation measures where they are most needed."

The study found that at least 4 294 species out of 23 496 freshwater animals on the IUCN Red List are at high risk of extinction. The greatest number of threatened species are found in Lake Victoria, Lake Titicaca, Sri Lanka's Wet Zone and the Western Ghats of India, according to the study.

To access the study, visit: https://www.nature.com/articles/s41586-024-08375-z

Bacteria can 'eat' forever chemicals

In the quest to take the 'forever' out of forever chemicals, bacteria might be our ally, according to a new study.

Most remediation of per- and polyfluoroalkyl substances (PFAS) involves absorbing and trapping them, but certain microbes can actually break apart the strong chemical bonds that allow these chemicals to persist for so long in the environment. Now, researchers have identified a strain of bacteria that can break down and transform at least three types of PFAS and, perhaps, even more crucially, some of the toxic byproducts of the bond-breaking process.

Published in ***the Science of the Total Environment,*** the study found that Labrys portucalensis F11 (F11) metabolised over 90% of perfluorooctane sulfonic acid (PFOS) following an exposure of over 100 days. The F11 bacteria also broke down a substantial portion of two additional types of PFAS after 100 days: 58% of 5:3 fluorotelomer carboxylic acid and 21% of 6:2 fluorotelomer sulfonate.

"The bond between carbon and fluorine atoms in PFAS is very strong, so most microbes cannot use it as an energy source. The F11 bacterial strain developed the ability to chop away the fluorine and eat the carbon," said corresponding author Diana Aga, a professor and chair in the chemistry department at the University at Buffalo.

The bacterial strain used in this study was isolated from the soil of a contaminated industrial site in Portugal and had previously demonstrated the ability to strip fluorine from pharmaceutical contaminants. However, it had never been tested of PFAS.

Research collaborators from the Catholic University of Portugal placed F11 in sealed flasks with no carbon source aside from 10 000 micrograms per litre of PFAS. Following incubation periods of between 100 to 194 days, the samples were then shipped to UB, where analysis revealed that F11 had degraded some of the PFAS.

The elevated levels of fluoride ions detected in these samples indicated that F11 had detached the PFAS' fluorine atoms so that the bacteria could metabolize the carbon atoms.

To access the original study, Visit: https://www.sciencedirect.com/science/article/abs/pii/S0048969724085061

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Scientists discover unique microbes in Amazonian peatlands that could influence climate change

Complex organisms, thousands of times smaller than a grain of sand, can shape massive ecosystems and influence the fate of Earth's climate, according to a new study.

Researchers from Arizona State University, along with their colleagues from the National University of the Peruvian Amazon, have identified an unknown family of microbes uniquely adapted to the waterlogged, low-oxygen conditions of tropical peatlands in Peru's northwestern Amazonian rainforest.

The new research shows these microbes have a dual role in the carbon cycle and the potential to either moderate or intensify climate change. This process can either stabilise carbon for long-term storage or release it into the atmosphere as greenhouse gases, particularly CO_2 and methane.

Under stable conditions, these microbes enable peatlands to act as vast carbon reservoirs, sequestering carbon and reducing climate risks. However, environmental shifts, including drought and warming, can trigger their activity, accelerating global climate change.

And, continued human-caused disruption of the natural peatland ecosystem could release 500 million tons of carbon by the end of the century – roughly equivalent to 5% of the world's annual fossil fuel emissions.

"The microbial universe of the Amazon peatlands is vast in space and time, has been hidden by their remote locations, and has been severely under-studied in their local and global contributions, but thanks to local partnerships, we can now visit and study these key ecosystems," noted Hinsby Cadillo Quiroz, corresponding author of the new study and a researcher with the Biodesign Swette Centre for Environmental Biotechnology at ASU. "Our work is finding incredible organisms adapted to this environment, and several of them provide unique and important services – from carbon stabilization or recycling to carbon monoxide detoxification and others."

The study, appearing in the journal, ***Microbiology Spectrum***, emphasises the importance of protecting tropical peatlands to stabilise one of the planet's most significant carbon storage systems and underscores the subtle interplay between microbial life and global climate regulation.

To access the original study: visit: https://journals.asm.org/doi/10.1128/spectrum.00387-24

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NEW WRC REPORTS

SA water compendium

There is an understanding that the South African government cannot achieve a water secure nation without the active participation of its citizens. Communities have valuable insights into local water challenges and provide crucial input to decision-making processes. Citizens can play a crucial role in water security by understanding South Africa's precarious water situation, actively participating in water conservation practices, engaging in decision-making processes related to water management and monitoring water quality within our communities. This booklet is aimed at raising awareness regarding South Africa's water resources, promoting active participation in water conservation and citizen science efforts, and empowering local communities to engage positively with decision-makers regarding policies and actions to promote water sustainability and responsible water management. Also available in hard copy.

WRC report no. SP175/24
Link: https://bit.ly/41C7YoU

Sludge management: A research strategy towards innovative and sustainable practices and technologies

The continuous advancement of sludge treatment processes is critical to municipal wastewater treatment operations and the healthy development of the sewage treatment industry. The last 30 years have shown a global diversification of sludge management, processing, and treatment technologies. Even though the three main treated sludge disposal routes are still dominant (i.e., land application, landfill, and stockpiling), new approaches are emerging that cover using sludge for recovering resources (hydrogen, biochar, nutrients) and energy. The overarching aim of this project was to analyse the latest trends and advances in municipal wastewater sludge management research, development, and innovation. The research report covers shifts in technology, practice aligned to the climate agenda and related legislation, sludges as a resource, breakthrough innovations, and management processes. This report provides a high-level strategic pathway for research investment in wastewater sludge treatment.

WRC report no. TT 946/24
Link: https://bit.ly/43aG2Kd

Drone adaptation and configuration to sensor apparatus for on-site, real-time digitalised water quality test application

This report describes the development of an integrated water quality test platform that will expand the University of Johannesburg (UJ) mobile laboratory systems with new DronePort system technologies. This system can support various applications for tasks related to water quality testing protocols used to evaluate bacterial, chemical, metal and other content in water as well as expanding its scope in tasks related to security and resource management surveillance, mapping and other defined aerial imagery scopes. The mobile laboratory system provides for multiple test/analytical equipment and consumables to conduct onsite remote water quality tests and analysis. The DronePort technology embedded in the proposed mobile laboratory system supports drone operations for digitalized testing using test probes inserted directly into a water source.

WRC report no. 3180/1/24
Link: https://bit.ly/4hXBrj9

From drought response to drought preparedness and mitigation: Drought monitoring for extensive livestock farming in the Northern Cape

The main aim of this project was to develop one of the most important building blocks for the National Drought Disaster Risk Reduction and Management Plan, namely, an indicator framework for drought monitoring for reference farms in the extensive livestock sector. The project also developed a computerised reporting and data capturing system for extensive livestock reference farms based on the drought monitoring indicator framework as well as contingency plans for the different drought categories for the extensive livestock sector. This report comprises two distinct parts. The first report, herein presented, details the research outcomes from the project. The second part, the project management report, addresses various administrative aspects, including capacity building, the financial management of the project, and the challenges encountered.

WRC report no. 3175/1/24
https://bit.ly/41itm1h

Transforming the future of Durban Bay: Strengthening socio-ecological resilience

The Port of Durban, South Africa, situated in a deepwater estuarine bay, faces significant environmental challenges, including plastic pollution from local rivers, exacerbated by urbanisation and climate change. Despite the ecological importance of the Bay, over 90% of its habitats have been lost, including a complete loss of seagrass beds and significant constriction of both mangroves and sandbanks, negatively impacting water quality and biodiversity. This translates into a loss of essential ecosystem services, the ecosystem's contributions supporting human well-being. Plastic waste is a complex problem, spanning the full landscape-seascape continuum manifesting at the nexus between social, ecological, and economic. This situation necessitates a comprehensive understanding of the interactions between river catchments and port activities to identify key areas to lever sustainable change. A socio-ecological system (SES) model allowed for a comprehensive analysis of the interconnectedness of ecosystems and socio-economic systems

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within Durban Bay, using a cross-disciplinary approach, fostering stakeholder collaboration, and enhancing both environmental health and economic resilience, aiming for a sustainable and improved system.
WRC report no. TT 945/24
Link: https://bit.ly/4bhKwkd

Policy brief: Advancing water and income security in the unique Maputaland Coastal Plain: A strategic decision support tool to explore land use impacts under a changing climate
Land is a major factor in production, as it provides economic and social benefits. Land use choices can impact ecosystems and water resources, which lead to feedbacks that influence both environmental and economic outcomes. Climate change will also have direct impacts on ecosystem services and land-based production. Land use choices made now, and in the past, will either exacerbate vulnerability due to climate change-related threats to water security or may assist in the reduction of such impacts. A recently completed Water Research Commission-funded project evaluated land use dynamics around Lake Sibaya and how climate change will impact current and future socio-economic opportunities in a quest to build resilience and sustainability.
Link: https://bit.ly/4h4ldn4

Feasibility of using seawater to flush toilets in the African context
One-third of the world's population is estimated to live in water-stressed regions by 2025. Climate change increases temperature, frequency of heatwaves, mixed precipitation, and frequency of extreme drought, which threaten the management of freshwater supply. Cape Town has a permit to discharge up to 55 ML/d of untreated wastewater through its marine outfall sewers. Consequently, the potable water used to flush toilets is effectively lost from the urban water supply system, including the opportunity for reuse. This study investigated the environmental impact of using alternative water sources for flushing toilets using life cycle assessment (LCA) analysis. It estimated the willingness to pay using a discrete choice experiment in Hout Bay, Cape Town.
WRC report no. 3177/1/24
Link: https://bit.ly/4i0FF9M

Further assessment of barriers to improved uptake of irrigation water efficient technologies by small-scale farmers in Limpopo and Mpumalanga provinces
The agricultural sector is the biggest user of water. Therefore, it is important to improve the efficiency of water use in this sector. Within the agricultural sector, it is particularly essential to improve the efficiency of water use within smallholder irrigation. This will require the adoption of efficient irrigation technologies. However, smallholder farmers face numerous challenges in adopting these technologies. This study was undertaken to identify barriers to the adoption of water-efficient irrigation technologies by smallholder farmers in two provinces in South Africa, namely, Limpopo and Mpumalanga. The main aim of the study was to identify factors influencing the adoption of water-efficient irrigation technologies in smallholder irrigation in the two provinces.
WRC report no. 3176/1/24
Link: https://bit.ly/4ii2iWR

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click on the web link provided, email:
hendrickm@wrc.org.za or visit: www.wrc.org.za

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CLIMATE CHANGE AND WETLANDS

Study investigates dynamics of greenhouse gas emissions from wetland systems

A project funded by the Water Research Commission (WRC) investigated the dynamics of greenhouse gas emissions from wetland ecosystems. Article by Sue Matthews.

Althea Grundling

Tshifhiwa Malise records plant species in a sampling plot in the Waterkloofspruit peatland system at Kgaswane Mountain Reserve.

In June 1992, South Africa joined more than 150 other countries in signing the United Nations Framework Convention on Climate Change (UNFCCC), and subsequently ratified it in August 1997. The following year, the country's first national greenhouse gas (GHG) inventory was prepared, using 1990 data. Since then, the inventory has been revised and updated eight times, with the most recent version – reflecting data for 2022 and trends since 2000 – submitted to the UNFCCC Secretariat in December 2024.

At the same time, South Africa's First Biennial Transparency Report was submitted in accordance with the Paris Agreement, which aims to keep the global average temperature rise this century as close as possible to 1.5°C above pre-industrial levels. Apart from including a summary of the GHG inventory, the report covers South Africa's efforts over a two-year period from January 2021 to implement its Nationally Determined Contribution (NDC) – the climate action plan outlining the country's mitigation and adaptation contributions – as well as financial, technical and capacity matters.

In the latest inventory, considerably more attention is given to wetlands as a source of GHG emissions in the form of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). However, there is no distinction between coastal and inland wetlands, and all were assumed to be on mineral soils, because the area of organic soils is relatively small. This allowed emissions to be determined using the methodology for inland wetland mineral soils provided in the 2013 Wetland Supplement published by the

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Intergovernmental Panel on Climate Change (IPCC). Since that does not include a method for estimating N_2O emissions from wetlands themselves, the inventory deals only with N_2O from nitrogen mineralisation or immobilisation associated with loss or gain of soil organic matter, as well as N_2O from biomass burning.

More importantly, the inventory uses the default CH_4 emission factor provided in the IPCC supplement for inland wetland mineral soils in temperate regions, derived from 20 studies primarily carried out in the northern hemisphere. The emission factor is three times higher than the country-specific one used in the previous inventory, for 2020. Admittedly, that was based on a 2012 study that measured methane emissions in only two southern Drakensberg wetlands a kilometre apart on a weekly basis over the early summer of 2010. Use of the IPCC's emission factor is the main reason why wetlands as a source of GHG emissions, expressed as gigagrams of carbon dioxide equivalents (Gg CO_2e), increased in South Africa's inventory submissions from 1 193 in 2020 to 9 678 in 2022.

In the IPCC's Sixth Assessment Report, the Working Group 1: Physical Science Basis noted that there is robust evidence and medium agreement that freshwater wetlands are the single largest global natural source of CH_4 in the atmosphere, accounting for about 26% of the total CH_4 source. There are still large uncertainties in emission estimates and how wetland GHG fluxes will respond to climate change, though, due to spatial and temporal variability in inundated land area, air temperature and microbial activity. While warmer temperatures may stimulate microbial activity, fluctuations in soil moisture caused by precipitation, evapotranspiration, permafrost melt and human-induced impacts on flooding or drying of wetlands also play a role. This is because methanogenesis – the production of methane by certain microorganisms during the decomposition of organic matter – is a strictly anaerobic process, taking place in the absence of oxygen. Inundation or saturation of soil creates such anaerobic conditions, hence increasing methane emissions from a wetland area, while drying aerates the soil and favours bacterial decomposition processes that release CO_2. Of course, CO_2 is also released through the respiration of wetland biota and taken up by photosynthetic biota, adding to the complexity of estimating GHG fluxes for the world's wetlands.

In an effort to increase understanding of such flux dynamics locally, the WRC funded a research project led by Dr Mokhele Moeletsi from the Soil, Climate and Water unit of the Agricultural Research Council's Natural Resources and Engineering division (ARC-NRE). The research team also included members representing the North West Parks & Tourism Board, and the Applied Behavioural Ecology and Ecosystem Research Unit at the University of South Africa. PhD student Mr Tlotlisang Nkhase was responsible for the main component of the project, in which CO_2, CH_4 and N_2O emissions were measured at two wetland study areas, one in the Colbyn Valley Nature Reserve in Pretoria and the other just over 100 km eastward in Kgaswane Mountain Reserve near Rustenburg. Both wetlands are also peatlands, a type of wetland in which partially decomposed plant material accumulates as organic matter called peat.

The research team first identified four different zones in both study areas – the terrestrial zone and the temporary, seasonal and permanent wetland zones – according to the wetland hydrology and extent of saturation. Soil sampling was then conducted in each zone for physicochemical and bulk density analyses. Since GHG sampling would rely on the chamber method, four soil collars were pre-installed 30 m apart in each zone before the start of the growing season. This ensured that soil disturbance would be minimised during placement of the chamber, which was made from a transparent acrylic tube.

Initially the GHG sampling focused on CO_2, with data collected at two- to three-week intervals from June 2022 to May 2023. This entailed enclosing vegetation within the chamber for five to 15 minutes at a time, depending on the season, and measuring the concentration of CO_2 at 21 second intervals with a respiration meter. Additional CO_2 readings were taken after covering the chamber to exclude light, thereby preventing photosynthesis. This allowed for calculation of net ecosystem exchange (NEE) – essentially, CO_2 uptake through photosynthesis minus CO_2 release through ecosystem respiration. A negative NEE indicates that the ecosystem is a CO_2 sink, while a positive NEE indicates that it is a CO_2 source. The results showed that both wetlands are sinks when considered over all seasons, although there are periods during the year when certain zones act as sources because more CO_2 is being released through respiration than absorbed through photosynthesis.

Similar chambers were then deployed for CH_4 and N_2O sampling, using separate trace gas analysers that measure at one-second intervals, and with the chamber closure period being 25 minutes for CH_4 measurements and 45 minutes for N_2O measurements. Data was collected at two- to three-week intervals from June

Google Earth

The Colbyn Valley wetland, located in the heart of Pretoria, is surrounded by urban development.

The Waterkloofspruit peatland system lies in the Kgaswane Mountain Reserve, near Rustenburg in North West Province.

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2023 to January 2024. The results showed that the permanent wetland zones of both the Kgaswane and Colbyn wetlands were CH_4 sources all year round, while the terrestrial zones were CH_4 sinks. The temporary and seasonal zones revealed more variation, as can be expected in response to seasonal climatic conditions and flooding. In the case of N_2O, all zones at both wetlands had fluctuating fluxes with very low emissions and no clear pattern.

The research team recognise the limitations of chamber measurements, which also have the disadvantage of requiring extensive time in the field.

"Fluxes change drastically diurnally, and since it is not feasible to have continuous chamber measurements, this is a major constraint for the evolution of fluxes," they note in the final report. "Instantaneous measurements can be misleading since changes in the weather can influence GHG fluxes."

They therefore investigated a machine learning approach to estimate NEE, using Artificial Neural Networks and Random Forest. Of the dataset collected for the permanent and seasonal wetland zones, 80% was used to train the model and the remainder for testing it. The inputs were photosynthetically active radiation (PAR), soil temperature, day length, air temperature and water level, and all were found to have a good correlation with NEE. A prototype of a web-based program, linked to the ARC climate database, was also developed so that the model can be used with weather station data to estimate NEE on a real-time basis. The research team recommended, however, that the two study sites be equipped with automatic weather stations, given that GHG fluxes are highly influenced by rainfall and temperature. The rainfall and temperature data used in the study were from weather stations 5 km and 20 km away from the Colbyn and Kgaswane wetlands, respectively.

"It is further recommended that static chamber measurements be complemented by an eddy covariance system for completeness," they added. Eddy covariance (EC) systems are instrumentation towers equipped with gas analysers and sonic anemometers to measure the vertical exchange of gases, water vapour and heat between the ecosystem and atmosphere. "The data from the two systems could be correlated and erroneous data could be patched to provide a complete overview of GHG fluxes within the wetland system."

Another aim of the research project was to estimate the distribution of sequestered carbon in a wetland ecosystem. It is widely reported that wetlands cover 6–9% of the Earth's land surface but store about a third of global terrestrial carbon. Of the various wetland types, peatlands are particularly impressive in this regard, having the highest carbon storage capacity per unit area of all terrestrial ecosystems. Indeed, it is said that they cover only 3% of land but contain more carbon than the world's entire forest biomass!

The Waterkloofspruit peatland system in the Kgaswane Mountain Reserve was therefore selected for a study on the relationship between vegetation, soil organic carbon and water levels, since it is the slow decomposition of plant matter under waterlogged, oxygen-poor conditions that accounts for the high carbon storage capacity of peatlands. This component of the project was the responsibility of master's student Ms Tshifhiwa

Althea Grundling

Key members of the research team included (from left to right) Jason le Roux, Tshifhiwa Malise, Tlotlisang Nkhase, Dr Mokhele Moeletsi and Prof Leslie Brown, as well as Althea Grundling, who took the photograph.

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The research team identifies wetland zones at the Waterkloofspruit peatland system. (Photo by Althea Grundling)

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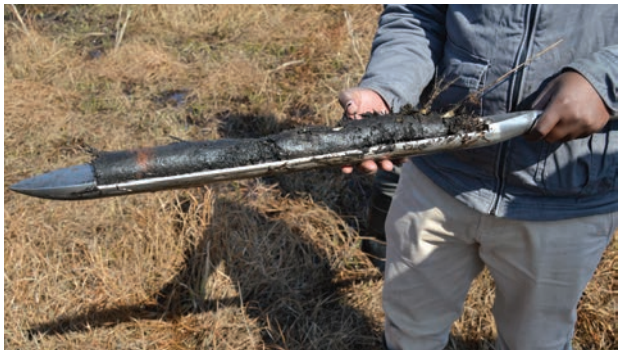
Althea Grundling



Peat is extracted from the Wterkloofspruit peatland system using a peat auger.

Project team

Boardwalks were constructed to minimise disturbance of the wetland ecosystem during greenhouse gas sampling.

Malise, who was supervised by Prof Leslie Brown (UNISA) and Dr Althea Grundling (ARC-NRE). Ms Malise is a longtime employee of the North-West Parks and Tourism Board, the management authority for the Kgaswane Mountain Reserve.

Over the summer of 2022/23, a vegetation classification and mapping exercise was undertaken by plotting out quadrats of homogeneous vegetation within the various delineated units of the wetland. In a total of 53 plots, 107 plant species from 30 different families were recorded. Five plant communities with the following dominant species were identified: ***Verbena bonariensis*** (forb) – ***Imperata cylindrica*** (grass) along the channel wetland, ***Cyperus esculentus*** (sedge) – ***Pteridium aquilinum*** (bracken fern) on the seepage areas, ***Leersia hexandra*** (grass) – ***Bolboschoenus maritimus*** (sedge) at the valley bottom adjacent to central basin reeds, ***Hyparrhenia dregeana*** (grass) – ***Miscanthus junceus*** (grass) in the channel wetland and ***Thelypteris palustris*** (forb) – ***Phragmites australis*** (reed) in the unchanneled valley bottom.

Next, the focus shifted to soil organic carbon and water levels. Soil sampling, soil descriptions and water level measurements were done for each of the 53 plots during both the wet season in April 2023 and the dry season in August 2023. The results showed that soil organic carbon varied within the five plant communities, with higher values recorded where the water table is nearer to the surface and smaller fluctuations across the wet and dry seasons. While the soil organic carbon values ranged from 2–30% depending on the soil form, the water levels did not vary considerably between the wet and dry seasons, indicating a relatively stable system.

"Through the establishment of baseline data on the vegetation and distribution of soil carbon, subsequent monitoring will allow for the assessment of ecosystem health and effects of environmental changes," note the research team. "By monitoring changes in vegetation and carbon stocks over time, management authorities can identify areas at risk and implement appropriate management strategies to maintain or enhance carbon storage capacity."

Of course, quite apart from their carbon storage capacity, wetlands have a vital role in mitigation and adaptation to climate change impacts through the various other ecosystem services they provide. These include water retention and flow regulation that enhance water security during droughts and reduce the risks of flooding, water purification through filtration, as well as habitat provision that supports biodiversity and sustains human livelihoods.

Although South Africa's first NDC, updated and submitted to the UNFCCC in September 2021, does not specifically mention wetlands, the Biennial Transparency Report of December 2024 lists wetland protection and habitat restoration among South Africa's adaptation actions, and includes some existing efforts to rehabilitate wetlands, such as invasive alien plant removal projects.

The research team suggest, however, that a collective mindshift is needed if wetlands are to be given the protection they deserve.

"Practices and behaviours deeply rooted in people, communities and cultures must be changed to ensure sustainable use of wetlands," they conclude. "The information obtained from this study will provide a better understanding of wetland functioning and composition to enable scientifically sound management of these endangered ecosystems in the reserves as well as in similar systems elsewhere in the region."

Related report, *Measurement of greenhouse gas emissions from wetland ecosystems* (**WRC report no. 3168/1/24**) authored by ME Moeletsi ME, T Nkhase, T Malise, JP le Roux, AT Grundling, LR Brown, T Seloane and SM Mazibuko.

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SCIENCE AND THE PUBLIC

Water concerns underscored in enlightening first survey on South Africans' relationship with science

South Africa's first comprehensive survey of science knowledge, attitudes, and engagements highlights our concerns and commonalities and offers sage advice on improving our relationship with science. Article by Petro Kotzé.

South Africans have thoughtful, balanced views on science and technology and evidence-based perspectives. The public rated their interest in and knowledge of clean and better water supply and concerns about water shortages highly. These are some of the findings of the South African Public Relationship with Science (SAPRS) survey, many of which she says left principal investigator Dr Vijay Reddy amazed.

The survey was commissioned by the Department of Science, Technology and Innovation (DSTI) and led by the Human Sciences Research Council (HSRC). The 2019 White Paper on Science, Technology and Innovation required the survey, stipulating that South African society needs to understand and value science, engineering and technology for national prosperity and a sustainable environment.

The first comprehensive survey to measure South African science knowledge, attitudes, and engagements, conducted in 2022 (to be repeated every five years), was published in December 2024.

It was no small undertaking. Conceptualising the study, developing the instruments, collecting and analysing the data, and writing the report took more than four years.

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The final SAPRS survey instrument was based on seven themes: scientific knowledge and literacy, scientific interest, promise and reservation towards science, trust in science and science institutions, access to S&T information, science engagement behaviours and views of pride and promise towards science. From these 200 items related to the topic (including five SKA items fielded only in the Northern Cape), and 28 demographic and contextual items were constructed.

Then, between November 2022 and January 2023, nearly 6 000 people from 500 areas across the provinces, considered a representative sample of the national population, were interviewed in the official language of their preference.

The data analysis and interpretation were approached with rigour, nuance, and a genuine desire to uncover meaningful insights that could inform policy and public engagement. Reddy, who led the HSRC research team, says it took two years to write the full report. She added that she wanted to go beyond simplistic reporting of percentages and look at the variation of views and attitudes within the population. The project team tried to understand the findings within the broader context of South African society and people's lived experiences, she says. Accordingly, the report first presents the average views of the public for each measure and then analyses how the responses varied across the population.

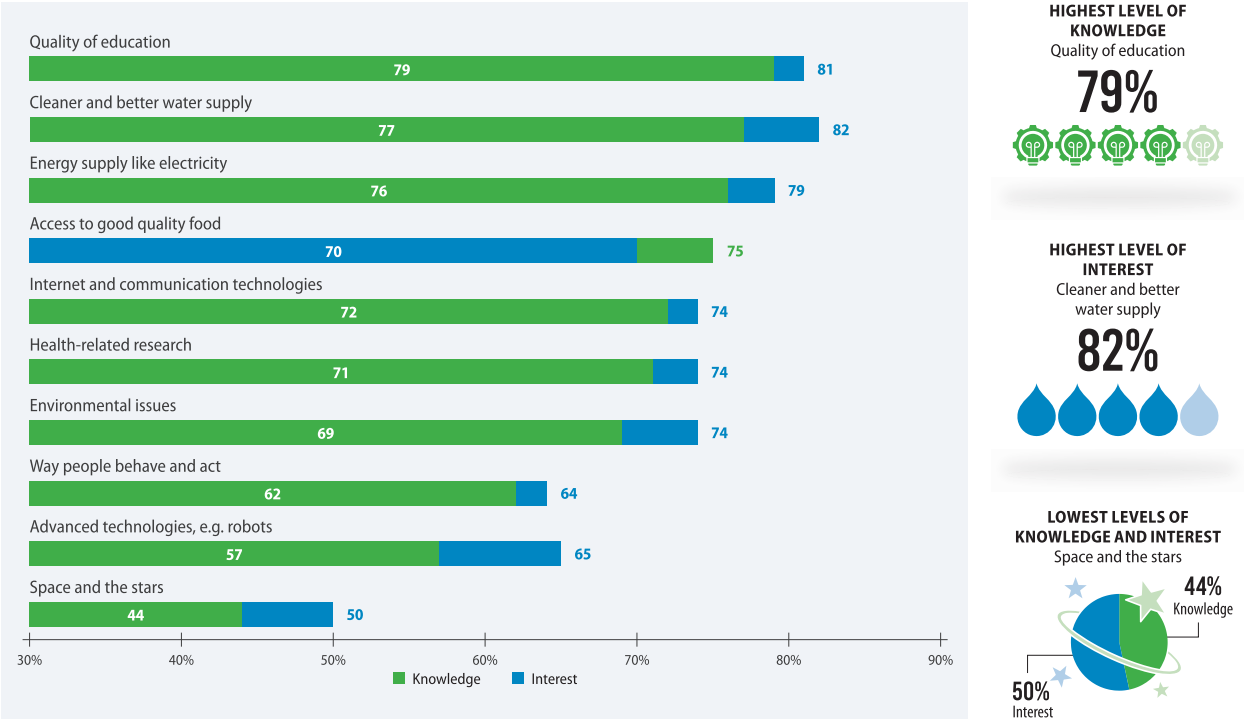
The average views of the public for selected measures

Many of the findings reflect the public's lived experiences, and freshwater-related needs and concerns are featured prominently.

For example, cleaner and better water supply scored highly in the indicator 'Knowledge about and interest in priority science areas.' The topic scored the highest interest among participants (82%) and also scored highly (77%) in participant knowledge. (Refer to the figure below.)

In fact, Reddy says the top four choices for knowledge and interest in research priorities reflect the public's lived experiences and unmet basic needs related to service delivery. They are: quality of education, cleaner and better water supply, energy supply like electricity and access to good quality food. "These are important and urgent needs," she notes.

SAPRS 2022/HSRC



Public awareness and knowledge of and interest in priority science areas: The survey explored the public's knowledge of and interest in contemporary societal challenges that require an S&T response. 'Interest' is defined here as wanting to know more, knowledge as the information already possessed, and awareness as being informed, though not necessarily with understanding.

The public is also highly concerned and knowledgeable about environmental matters. Close to three-quarters reported being, at least "somewhat" knowledgeable about water (79%) and air (77%) pollution, droughts and water shortages (77%), as well as floods (75%). Similarly, the public was at least "somewhat" concerned about water pollution (84%), air pollution (80%), droughts and water shortages (79%), and floods (76%). A slightly fewer percentage of people reported being at least "somewhat" knowledgeable (63%) and concerned (68%) about soil erosion. Close to half of the public were "very" concerned about water pollution (54%), air pollution (47%), droughts and water shortages (48%), as well as floods (47%) – these are catastrophic events that significantly impacted many parts of South Africa in the years leading up to the survey round.

Reddy says this tells us that the South African public is aware of events around them and that even though they may not have formal knowledge, they are concerned.

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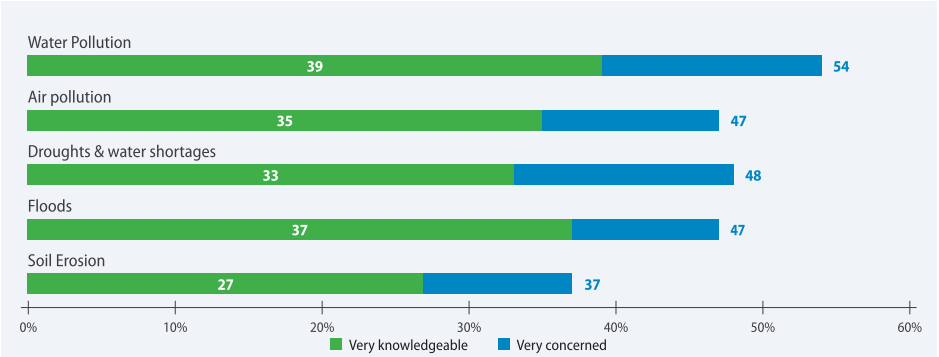
SAPRS 2022/HSRC

Percentage of adults who were 'very knowledgeable' and 'very concerned' about environmental events



3 in every 4

adults had at least some knowledge and concern about environmental events

HIGH KNOWLEDGE OF AND CONCERN
Environmental events

47% Concern

34% Knowledge

Characteristics of those with higher knowledge and concern about environmental events

- The average scores, by sub-group, were between 56 and 74 (out of 100) for environmental knowledge, and between 62 and 83 for environmental concern.
- Adults who were more knowledgeable and concerned about environmental events:
  - had a post-secondary education, and experienced higher home education support,
  - were from richer SES homes, and
  - lived in urban formal and rural areas.
- White and Indian/Asian adults had higher knowledge about environmental events while White, Black African, and Indian/Asian adults had higher concern about environmental events.

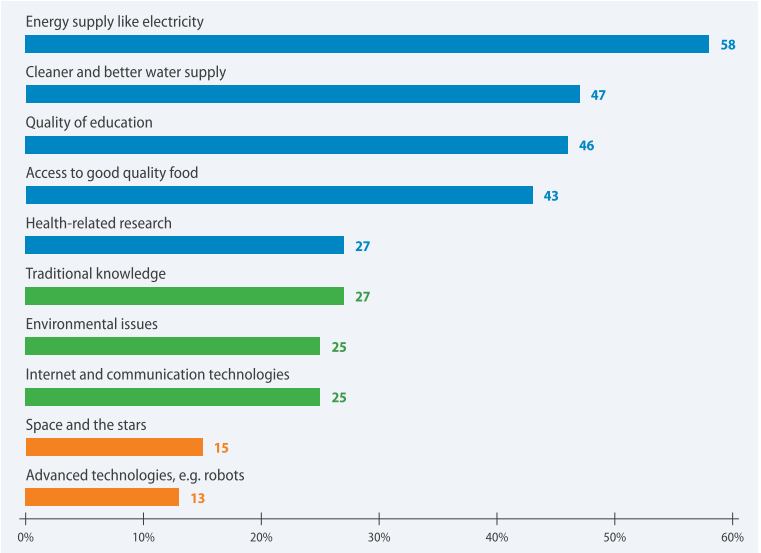
Public knowledge of and concern about environmental events.

When asked to rank funding priorities, cleaner and better water supply was one of the top priorities for the public, along with energy supply and quality of education. According to the final report, even in the Northern Cape region, where the Square Kilometre Array (SKA) telescope is located, people's biggest concerns were mostly around water shortages and droughts.

SAPRS 2022/HSRC

From the list of contemporary S&T priority topic areas, the public selected the four research areas that they felt the government should continue to fund. The highest priorities related to energy supply, water supply, and the quality of education; while the lowest priorities were space and the stars, and advanced technologies, such as robots.

South African research priorities for future research funding (%)



HIGHEST PRIORITY
Energy supply
58%

LOWEST PRIORITY
Advanced technologies, such as robots
13%

- The top five research priorities for future funding (blue bars), chosen by the public are considered 'urgent and important'. They represent contemporary societal challenges, the effects of which form part of the lived daily experiences of the public.
- The second set of priorities (green bars) could be categorised as 'important, but not urgent'.
- The third set of priorities are more likely to fall into the "blue-sky" research category, where real-world applications are not immediately apparent to the public.

Cleaner and better water supply was one of the top priorities for the public.

The report notes that the two areas with the lowest levels of knowledge and interest were far removed from the daily lives of most of the public: the study of space and the stars and advanced technologies like the 4IR. Half of the public (50%) were at least "somewhat" interested in space and the stars, while close to two-thirds (65%) were at least "somewhat" interested in advanced technologies. A slightly lower 44% and 57% reported being "somewhat" or "very", respectively, knowledgeable about these areas.

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A glimpse into what unites and divides us

Reddy says she was blown away by the analyses of how the responses varied across the population. They revealed that the public displayed similar views for close to half the measures (promise, pride, and trust), irrespective of their socio-demographic backgrounds. She says she was surprised that the data did not align with the common assumption that those with lower education or socioeconomic status would have more negative attitudes towards science. In fact, South Africans have fairly similar views and attitudes towards science and technology.

Regardless of their education or socioeconomic status, for example, the public trusts information from universities and the work of scientists the most. The findings revealed that South Africans have thoughtful, balanced views on science and technology, not based on superstition but on evidence-based perspectives. This data challenges assumptions and provides a more positive, egalitarian portrait of South African attitudes towards science and technology.

For the other measures, there were variations among the public mainly due to differences in educational attainment, socioeconomic status and access to resources, population group identity and, in some cases, age and geographical location. (Refer to the figure below.)

SAPRS 2022/HSRC

INDICATOR	SUB-INDICATOR MEASURES	AVERAGE SCORE	VARIATION (DIFFERENCE BETWEEN HIGHEST AND LOWEST SCORES)
Interest	Environmental concern	72	21
	Interest in science areas	67	22
	General interest in S&T	58	26
Knowledge	Environmental knowledge	67	18
	Perceived knowledge of science areas	61	25
	Formal science knowledge	60	23
Promise & Reservation	Reservation of S&T	69	12
	Promise of S&T	68	10
	Promise of traditional S&T	62	21
Trust	Trust in S&T information from universities	68	15
	Trust in work of scientists	69	13
	Transformation of cultures in science organisations	59	9
	Trust in S&T information sources	58	13
	Trust in government evidence-based decision-making	50	17
S&T Information	Daily usage of the internet	50	70
	Exposure to S&T news	42	29
	Consumption of S&T news	39	20
Science Engagements	Exposure to school science	56	68
	S&T information sharing	37	28
	Use of online apps	32	45
	Community-based engagement	23	25
	Attraction-based event attendance	23	36
Pride & Promise	Promise of S&T skills for young people	78	12
	Pride in South African S&T achievements	66	19
	Valuing S&T experiences	67	15
	Government spending on R&D is too low	49	37
	South African achievements better than rest of world	36	11

The fingerprint of the South African public relationship with science: For each of the 27 identified sub-indicators, an average index score (out of 100) and the score variation were computed. Conversely, the distribution of scores was highest for the daily use of the internet (70) and the exposure to school STEM subjects (68); and was lowest for the trust, promise, and reservation attitudes measures. A narrow score variation, which was termed an egalitarian measure, implies that the public's views are similar, irrespective of the socio-demographic diversity. A wide score variation, termed a diverse measure, indicates the inequality due to the socio-demographic diversity of the adult population. A unique "fingerprint" for the South African public relationship with science was then created by plotting the average score and the score variation for each measure, which captures the diversity in our science knowledge, attitude, and engagement measures.

Recommendations from the report

Experts and managers can garner multiple messages from the report to improve South Africans' relationship with science.

For one, science communication needs to be improved. Institutions can better communicate their water-related research findings and make the information more accessible to the diverse South African population, especially those without easy access to the internet.

The research must be translated into multiple languages to reach a diverse population and be accessible. Different formats like videos, radio, and community engagement must be employed. The information must also be made available through popular media sources like television and radio that reach a broad audience, not just online. As the survey found, the public trusts S&T news presented by television and radio but is cautious about news on social media. Thus, S&T information should be communicated in easily understandable ways on television and radio. This will facilitate greater public exposure to water-related research and information to increase awareness and engagement.

At the same time, the research findings must be relevant to people's lived experiences and immediate needs around water access and quality. According to the report, the key is to tailor communication approaches to the diverse needs and preferences of the South African

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population rather than adopting a one-size-fits-all approach.

Getting this right is integral to all South Africans. As Prof Blade Nzimande, Minister of Science, Technology and Innovation, states in the introduction to the final report, "…democracy could only fully succeed if citizens were science-literate and able to form their own opinions on science and related matters."

A snapshot of the survey results
The survey was constructed around seven indicators or impact themes and 27 measures. Selected highlights from indicators are included here.

Knowledge of, and interest in, science and technology and the environment
Studies worldwide show that people's knowledge of, and interest in, science and technology (S&T) reveal important aspects of how the public relates to science and further influences the extent of science engagement. The SAPRS found that:

- 60% of South Africans were aware of science and technology in South Africa, 56% were aware of S&T internationally and 66% were interested in S&T in general.
- Of the priority science areas queried, most South Africans (79%) had knowledge about the quality of education, and the highest percentage (83%) had an interest in cleaner and better water supply
- 'Space and stars' scored the lowest in terms of knowledge (44%) and interest (50%)

Knowledge and concern about environmental events
Given the national and global importance of environmental challenges, the survey included items that focused on the public's knowledge and concern about current natural and environmental events facing South Africa. We report on percentage of those very knowledgeable and very concerned.

- 'Water pollution' is the environmental event that was listed highest in terms of knowledgeable (39%) and concerned (54%)
- The second highest score was for air pollution (35% knowledgeable and 47% concerned)
- Droughts and water shortages were the third highest (33% knowledgeable and 48% concern), followed by floods (37% and 47%, respectively) and soil erosion (27% and 37%, respectively)

Promise and reservation attitudes towards modern and traditional S&T
Interviewees responded to sets of items that asked about their attitudes toward promise (potential benefits) and reservation (concerns, fears, and risks) related to modern and traditional science (TS).

- 78% of respondents thought S&T make the way of life change too fast
- 76% said S&T are making lives healthier, easier and more comfortable

Promise and reservation attitudes towards traditional science
Traditional knowledge is the knowledge and skills passed on from generation to generation within a community.

- 64% said traditional small-scale farming provides healthy food for many South Africans
- 63% said traditional knowledge provides solutions to improve the quality of life
- 55% said they follow the advice of medical experts over traditional healers or home remedies
- 53% said they trust more in modern science than in traditional and cultural practices

Trust in science, scientists and science institutions
For scientific advice to be accepted, the public needs to trust science and scientists and have confidence in institutions that produce such knowledge.

- The category achieved a 69% mean score for trust in scientists
- 76% of respondents said scientists make life better for people
- concerningly only 51% said scientists are honest about their work
- 71% said there is so much information about science that it is hard to know what to believe

Confidence in S&T information from different institutions

- Universities and research organisations were the most trusted (71%).
- Local government was the least trusted (32%)

S&T information: access, exposure, consumption and trust
A good relationship between science and society requires communicating S&T information and ensuring that the public can access and trust this information.
The digital space is now the most popular source for accessing and communicating information. A description of the levels of access to this space, especially in low-income, unequal societies, provides a picture of one of the prerequisites for access to S&T information

- 94% have access to a cell phone and 61% have access to a smart phone
- 31% use the internet for four hours or more on most days.
- Regarding exposure, the most popular source of S&T news was television (60%), followed by internet-based websites (52%) and radio and social media, which both scored 51%.

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These reports are available here:
https://hsrcpress.ac.za/saprs-2022/

WATER REUSE

Sipping the light fantastic - Demonstration project reveals more about the potential for water reuse

Direct potable reuse promises a top-up for our scarce drinking water supplies. A report on a new demonstration project is encouraging, but there's still work to do. Matthew Hattingh reports.

During commissioning it was noted that the pumps feeding the Granular Activated Carbon GAC filters were too small and this caused the GAC pumps to trip often. This was subsequently corrected.

A delightful beer ad on British television in the '80s, parodied ***My Fair Lady***. In it a posh young woman battles with elocution lessons, making no progress until offered a can of Heineken. Crack, hiss… a single sip does the trick. Instantly shedding her cut-glass accent, she pours out her lines in the desired Cockney, to her tutor's delight. "The wa'ah in madge orca don't taste like wot it or'ah." (The water in Majorca [Mallorca] don't taste like what it ought to.)

Some things can be hard to get your tongue around (or swallow) without some help. We've long been able to treat wastewater to a high (drinkable) standard but have yet to acquire an appetite for it. Direct potable reuse is about treating wastewater to a potable standard and then putting it to good use directly, rather than discharging it into the environment.

In South Africa, finite water supplies are overstretched by a growing and increasingly urban population; demand from industry and agriculture is rising; while rainfall, particularly in the west of the country, is low. Droughts are frequent and evidence suggests climate change will worsen matters, while our water sources are being contaminated at a "deplorable and unsustainable rate".

Treating wastewater for direct reuse reduces demand on surface water. It cuts the amount of waste we discharge into our rivers and seas.

Over the past 15 years a handful of direct reuse projects have been brought into service in South Africa, including in Beaufort West and south Durban, where residential and industrial

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wastewater, treated to near-potable standards, supplies a Mondi paper mill.

But there's still much to learn. With this in mind, uMngeni-uThukela Water commissioned a direct potable project, an extension of its Darvill Wastewater Treatment Works in Pietermaritzburg, which was undergoing a major upgrade. This demonstration project is a way for the water utility, others in the sector and academics, to learn how to squeeze more out of the technology, and identify areas needing attention or research. As a bonus, it slashes the wastewater plant's municipal water bill.

President Cyril Ramaphosa and the then Minister of Water and Sanitation, Senzo Mchunu, opened the Darvill upgrade in July 2023. They were photographed hoisting beakers in a toast – if not actually chugging back – the sparkling SA National Standards 241: 2015 potable stuff. It was a moment to savour for uMngeni-uThukela Water staff. They surmounted formidable difficulties and delays bringing the upgraded wastewater works and the 2-megalitres a day reuse project on stream.

Why this was so and how the plant's technical and contractual hurdles were cleared is the subject of a Water Research Commission publication (**WRC Report No. TT 942/24**). The report, ***A demonstration of treatment technologies for direct potable reuse*** considers the pros and cons of the various processes at the plant. It assesses their effectiveness at removing different microorganisms and chemical nasties from wastewater. And it includes a focus on contaminants of emerging concern, a category that includes pharmaceuticals, pesticides, personal care products, pathogens, trace metals and tiny plastic particles not dealt with in water treatment regulations and standards, that may pose a risk to human and environmental health.

With refreshing candour, the report spells out developmental failures and fixes that could help others building full-scale plants, outlining the costs and benefits of the project over its lifespan. The report is the work of Presantha Maduray, Samuel Getahun, Bavana Maharaj and Kerisha Nayager. All are staff of uMngeni-uThukela Water, with Getahun also wearing a University of KwaZulu-Natal hat.

Beyond the deep dive into the costs and complications encountered, the authors investigated how the reuse project's processes might be improved, including by optimising chemical doses at different treatment stages and tweaking the order of the treatment train. They offered pointers and plans for potable reuse plant operation and maintenance, including contractual issues; safety; assessing risk; water quality monitoring; and engaging with the public.

Begun in 2017, the reuse project is part of the R1-billion upgrade to Darvill, increasing the wastewater works capacity from 65-megalitres to 120-megalitres a day. But early on, the project slammed into a speedbump when the upgrade's main contractor filed for business rescue in March 2019, miring the project in "lengthy delays and legal procedures".

Reuse project construction stalled for about 18 months. Then Covid-19 struck. Work stalled again, procurement bogged down, and technical troubles compounded in the absence of maintenance as idle machinery rusted, pumps and filters sprang

Flash mixing in the high-pressure wash plant disperses coagulants – aluminium sulphate and a polymeric coagulant – in the feed water. This helps suspended particles to clump together.

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leaks, flooding damaged equipment and thieves stole cables and fittings. Throughout, loadshedding and outages proved an oversized fly in the commissioning ointment.

The report charts a slew of snags – real and potential. And provides recommendations on how these might be fixed or avoided in future projects.

The ***Water Wheel*** visited Darvill on a drizzly February afternoon. It's a few kilometres east of the N3, down a road that skirts a golf course and passes through grassland and bush, close to a municipal landfill site. It's near the Msunduzi, the uMngeni River tributary that gives its name to the canoe race.

Through the main gate you pass close to reactor basins, big circular secondary settling tanks, and the chlorine scrubber, designed to protect staff from emissions of the gas.
To the north sit four giant concrete eggs – anaerobic digesters which are the works' most visually striking feature. Inside the heated eggs, bacteria break down organic waste in the absence of oxygen.

A little to the north-east, the reuse project is a more modest structure with various filters, pumps and tanks, inside and out. Control room staff monitor the different processes for signs that equipment has tripped or sensor signals (say, for turbidity or chlorine levels) are outside the permitted range. A visitors' centre reflects the project's emphasis on public engagement.

Maduray and Maharaj, both chemical engineers, showed us around. Four distinct, but interlinked, advanced treatment processes produce potable water: advanced oxidation, with hydrogen peroxide and ozone; granular activated carbon filtration; ultrafiltration; and onsite electrolytic chlorination.

Wastewater, which has been through the main works, now of final effluent quality standard and on its way to the Duzi River, is drawn into a high-pressure wash plant. This includes conventional processes of coagulation, flocculation, lamella clarification and rapid gravity filtration. Coagulation uses aluminium sulphate, a positively charged aluminium salt, as well as a polymeric coagulant, to draw suspended particles together, to clump and settle. Lamella clarification uses a series of inclined plates to make settling more space efficient. Layers of coarse and fine sand provide rapid gravity filtration.

The advanced treatment sequence is designed to be swapped around – and will be the subject of future research to evaluate results. For now, the treated wastewater is first exposed to advanced oxidation. Strong oxidants, hydrogen peroxide and ozone, oxidise organic and inorganic compounds in the wastewater transforming pollutants into less toxic products. Ozone is generated on site.

Next, the activated carbon process uses a porous, sponge-like form of granular carbon as a filter media through which the contaminated water passes. Thereafter, ultrafiltration forces wastewater through membranes, sieving out successively smaller particles. Onsite electrolysis generates chlorine for disinfecting the final water.

Advanced oxidation can remove more than 95% of antibiotics, hormones and industrial chemicals; 80% of pesticides; and 50-80% of pharmaceuticals and metabolites. Unfortunately, the proprietary, "black box" technology used for this process was out of action at the time of our visit, awaiting repair by the suppliers.

The anaerobic digesters, the Darvill works' most visually striking feature. Inside the heated eggs, bacteria break down organic waste in the absence of oxygen.

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Treated water, the end product of the reuse project, is stored in a 600 000-litre reservoir for supplying process water to Darvill Wastewater Treatment Works.

The granular activated carbon filters absorb organic matter and the ultrafiltration can eliminate several types of contaminants of emerging concern: more than 90% of antibiotics, hormones, pharmaceuticals, metabolites and industrial chemicals; and 80% of pesticides.

The different processes have their pros and cons. Membranes can foul and ultrafiltration requires considerable pressure, meaning bigger electricity bills. Advanced oxidation process chemical reactions also draw power. Maintenance can be complex, requiring specialist outside contractors. The downtime and expense this entails must be weighed when selecting processes. Then there's the costs of the chemicals used in treatment.

Understanding how the different processes cope with different source-water contaminants – which vary from one wastewater works to another – can help with selecting the most suitable process, says the report. The report is clear: Advanced water treatment with its hi-tech equipment and operating costs is "often more expensive than conventional water treatment methods". But Maduray says rands and cents were never the project's main consideration. It's about learning to use the technology – "it's not plug and play" – and honing processes so the utility and others in the sector are sharp, "ready to go" when necessary.

The authors priced the reuse project at R155-million over a 20-year lifecycle. However, their analysis leans heavily on estimates and assumptions. Delays and difficulties during commissioning meant comprehensive operational data, ideally captured over six months to a year, were not available. It was also difficult to nail down the energy costs of the different processes in the absence of dedicated metering for the reuse project. Similarly, putting a monetary value on the environmental and social benefits of the project is hard to do.

Gauging the effectiveness of the project at removing pollutants from wastewater is central to the study. But it demands testing for microbial and chemical water quality beyond what's required for conventional treatment. The authors identified a bottleneck at uMngeni uThukela's own lab, which is already handling testing work for the utility's operations across KwaZulu-Natal as well as for external clients. Therefore, additional laboratory resources must be planned for.

Capacity constraints are still more acute when it comes to testing for contaminants of emerging concern, which requires advanced techniques. Samples had to be sent to Umea University, in Sweden for analysis, resulting in "significant delays". The study focused on 28 compounds commonly detected in South African wastewater, including antiretroviral drugs, antibiotics, antidepressants, antihistamines, antihypertensives, statins, and anti-inflammatory anticonvulsants.

Maduray says an important lesson was that South Africa must invest in its laboratories, universities and training if we are to analyse contaminants of emerging concern. "If we need to go to reuse, we need to develop this. It must be affordable," she said, adding that research showed the presence of pharmaceuticals in reused water was "people's main worry".

Also key, the project aims to involve and educate a sceptical public who strongly favour using direct reuse water for industrial purposes rather than for drinking. "Public perceptions and community acceptance of direct reuse of treated wastewater remains a challenge to direct reuse," says the report, citing a WRC project (**WRC report no. KV 320/13**). Addressing this will be vital if reuse is to gain wider support.

The authors point out that a single incident could compromise the community's health, with a "high probability of causing the plant's closure in extreme or significant financial losses due to lawsuits". This the report covers in a chapter on developing a safety plan. Public engagement gets its own chapter too, including the establishment of a KZN Water Reuse Chapter, of the Water Institute of Southern Africa. The authors share their findings on forums and at conferences, while the project collaborates with researchers from several universities, "nurturing the next generation of experts".

These engagements help reassure the public about perceived health risk of direct potable reuse, but the report warns that municipalities must first get the basics right. "It is fruitless for local authorities to consider implementing wastewater reuse when existing service levels are low."

The authors plan to present water quality results once sampling and analysis lets them "draw more robust conclusions". "However, based on the available data, the findings thus far are promising," says the report.

Although the ozone generator is offline awaiting repair, the project as a whole is working. The combined processes form a multi-barrier system with "demonstrated effectiveness".

Once through the final process of chlorination, the now-clean water is pumped into a 600 000-litre holding-tank, ready to be used as service water. Your correspondent didn't sneak a sip, nonetheless, we are confident the water has been purged of harmful substances. Indeed, it looked clear and colourless with no odour and there's no reason to doubt it's palatable.

Surely, it tastes like wot it or'ah.

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ECOLOGICAL INFRASTRUCTURE

Water factories: The intrinsic value of a critical resource in water-scarce cities

The effective functioning of ecological infrastructure (EI) is essential for providing a wide range of ecosystem services crucial to human well-being, optimal environmental functioning and economic development. These services offer both direct and indirect benefits, such as water regulation, climate moderation, water purification, biodiversity protection, and soil formation (Rasmussen et al. 2021; Sokolova et al. 2024). Article by Nkosingithandile Sithole.

Riverhorse Valley Business Estate Management Association, 13 June 2018

Cooperative rehabilitation and management of the Riverhorse Valley Wetland involving investment by the public and private sector.

With the rise in climate change impacts and a rapidly expanding population, the significance of water-related EI is anticipated to grow, especially in ensuring the supply of drinking water (Chapagain et al. 2020). Furthermore, the rehabilitation, restoration, and upkeep of EI can boost the resilience of these ecosystems, enhancing their capacity to endure and recover from extreme weather events linked to climate change. Despite the increased awareness of the critical role of EI, water-related ecological systems continue to degrade mainly due to anthropogenically driven activities including inter alia, urbanisation, deforestation, poor farming practices, mining, and pollution (Ziervogel et al. 2022).

With South Africa characterised as a water-scarce country, climate change impacts are expected to increase water demand, both in cities and rural areas. Thus, there is an urgent need to prioritise and increase investment in EI. There are several methods to implement EI interventions, such as restoring or rehabilitating degraded ecosystems that can offer the needed ecosystem services. These actions can help to strengthen the resilience of these ecosystems against human activities and, more significantly, the impacts of climate change (Rebelo et al. 2021). According to the Organisation for Economic Cooperation and Development (OECD) (2022), investment in EI involves maintaining naturally functioning ecosystems by allocating resources like time, funding, or strategic decision-making to protect or restore them.

To encourage investment in EI, it is essential to provide quantifiable, user-friendly information that clearly demonstrates

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the tangible and intangible benefits of EI. These advantages should be presented in an engaging and comprehensive manner and may be tailored to development finance institutions (DFIs) and the private sector. Additionally, the benefits of EI investment should draw on insights and outcomes from existing EI projects.

Showcasing the advantages of EI can play a pivotal role in integrating it into water resource management, and subsequently encourage investment in EI from public and private sector users. However, this lack of information has led to the limited support for EI investment. A new project funded by the Water Research Commission (led by GroundTruth sought to address these challenges by developing a user-friendly EI framework to encourage investment in EI by private sector and DFIs. The framework development process was informed by a range of data collection activities, including, an in-depth literature review, stakeholder engagement, and the evaluation of four South African EI initiatives. The case studies formed the backbone of this research, guiding the literature review, stakeholder engagement, and framework development process.

The review of the four selected EI initiatives was to develop an understanding of the factors driving investment, challenges faced, enabling partnerships and the funding mechanisms in place enabling investment in EI. The evaluation of the four selected EI initiatives aimed to provide evidence-based insights into effective EI initiatives and management in South Africa, highlighting both tangible and intangible benefits of

GroundTruth, June 2019

Concrete butress weir built during phase 1 of Working for Wetlands construction cycle.

R Pienaar

Clearing underway of a riparian zone in the Wolseley area which is infested with Acacia saligna, Acacia mearnsii and other invasive alien plants.

Local temporary farmworkers and a member of the Mountain Club of South Africa involved in hakea clearing in the Klein Swartberg.

EI investment. The diverse nature of these initiatives offered a comprehensive overview of how EI management impacts water users in specific catchments and the mechanisms that spurred investment in these projects. The EI initiatives associated with this study included two sites in the Western Cape namely 1) the Wolseley Water User Association (WWUA) EI Coordinator Initiative, and 2) the Klein Swartberg Initiative; and two sites in KwaZulu-Natal namely 1) the Mpophomeni-uMthinzima (Upper uMngeni) Initiative and 2) the uMhlangane Initiative. These initiatives were selected based on their varied management contexts, intervention types, funding sources, land use settings, and the availability and accessibility of information. This diversity allowed for rich stakeholder engagement, showcasing different forms of EI investment across various catchment areas. These initiatives underscore successful collaborations in addressing the challenges of implementing EI interventions, showcasing the effectiveness of diverse partnerships in achieving sustainable outcomes. The case study analysis was informed by a set of guiding questions which aimed to understand (1) what the quantifiable outcomes (including ecosystem services linked to water security) of the interventions linked to the EI initiatives are (2) the role players and funding mechanisms applied to implement EI investment (3) and how relevant the outcomes of the interventions were to the role players involved. A SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis was also applied to each case study to further distil key lessons from the EI initiatives, and the associated enablers and inhibitors to investment in EI.

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Following this, a brief review of five other EI initiatives in South Africa was conducted. These initiatives include the 1) uMhlathuze Water Stewardship Programme, 2) the Nature Conservancy (TNC) Greater Cape Town Water Fund (GCWF), 3) the Program Skoon Veld-Ceres, 4) the Upland River Conservation, and 5) the Endangered Wildlife Trust Carbon for Conservation Project. Each of these cases demonstrate different EI investment scenarios varying both in scale and partnership complexity. This brief review provided further valuable evidence-based information supporting the framework's development. The nine (9) reviewed EI initiatives are described in more detail below (Table 1)

Table 1: Examples showing the diversity of types, financing arrangements, and scales of EI investment initiatives in South Africa

Factors	uMhlatuze Water Stewardship Programme	The Nature Conservancy (TNC) Greater Cape Town Water Fund (GCTWF)	Program Skoon Veld - Ceres	Upland River Conservation	The Endangered Wildlife Trust Carbon for Conservation Project	Sihlanzimvelo / TRMP (eThekwini)	uMhlangane /Riverhorse Valley	Mpophomeni	Klein Swartberg	Wolseley Water Users Association EI coordinator initiative
Type of investment	This case exemplifies public and private sector collaboration in catchment management. It aims to improve freshwater coastal lakes and surface water dams, promote efficient water use, support agricultural water stewardship, secure ecological infrastructure, and develop community water champions.	This case aims to enhance water security for catchments serving the Greater Cape Town area through EI interventions, such as nature-based solutions and the management and removal of invasive alien plants (IAPs).	Situated in the Western Cape, the Program Skoon Veld-Ceres case is primarily funded by the private sector, with additional support from non-profit organizations. The initiative focuses on controlling invasive species to ensure water supply and biodiversity. Funding comes from local businesses, municipal sources, and WWF's Green Trust.	Funded by the private sector, this initiative targets riparian rehabilitation in the upper uMngeni catchment. The project aims to improve water quality, boost recreational fishing opportunities, and enhance land productivity. Efforts include removing invasive alien plants (IAPs), replanting vegetation, and monitoring water quality.	The Endangered Wildlife Trust's Carbon for Conservation Project showcases private-private partnerships focused on rehabilitating grasslands and wetlands to enhance water quality and quantity in Strategic Water Source Areas (SWSAs). It leverages a sustainable financing mechanism, carbon offsetting, to fund these improvements.	The initiative began with public funding from the municipal Opex budget and later expanded through grants from Development Finance Institutions (DFIs).	Showcases EI investment in an urban environment. It focuses on rehabilitating and managing urban freshwater ecosystems to enhance flood attenuation and water quality. Since the early 2000s, projects like the Riverhorse Wetland Management Initiative, Green Corridors Green Spaces project, Sihlanzimvelo Programme, and eThekwini's Transformative River Management Programme (TRMP) have emerged. These initiatives involve diverse stakeholders, including private businesses, NGOs, civil society, local authorities, and community groups.	Highlights EI investment in urban settings. It aims to rehabilitate and manage freshwater ecosystems to enhance flood control and water quality. Since the early 2000s, projects like the Riverhorse Wetland Management Initiative, Green Corridors Green Spaces project, Sihlanzimvelo Programme, and eThekwini's Transformative River Management Programme (TRMP) have emerged, involving private businesses, NGOs, civil society, local authorities, and community groups.	In Ladismith, Western Cape, a small EI initiative focuses on water security through invasive alien plant (IAP) removal. Local businesses like Ladismith Cheese and Lactalis fund this effort. SAEON's application estimates annual water savings from IAP clearing, providing data to sustain funding. Key supporters include the Mountain Club of South Africa, local farmers, Kannaland Municipality, Cape Nature, and Gourtiz Cluster Biosphere Reserve.	A small-scale initiative in Wolseley, Western Cape, tackles the issue of invasive alien plants (IAPs) threatening water security for the Breede River. Local businesses like Woolworths and Marks & Spencer depend on these water resources. Funded by sources such as Coca-Cola, the Western Cape Government, and others, the project has consistently controlled IAPs. Its success is largely due to Ryno Pienaar, the local EI coordinator since 2017, who manages rehabilitation efforts and multiple funding sources.
Catchment	uMhlatuze Catchment	Multiple catchments supplying the Greater Cape Town area	The catchment supplying Ceres Town	The Upper uMngeni catchment (highland areas), expanded into the broader eastern Drakensberg drainage region	Multiple strategic water source areas	uMhlangane catchment, located in the Lower uMngeni catchment	uMhlangane catchment, located in the Lower uMngeni catchment	uMngeni	Gouritz	Breede

Some of the outcomes from the case studies included the identification of key enablers for the investment in EI, which include:

- **Capitalising on existing partnerships (particularly between funders), can significantly enhance investment in EI**. The WWUA EI coordinator initiative, funded by Woolworths, exemplifies this approach. The EI coordinator-maintained project continuity despite changes in primary funding sources and built trust within the community, encouraging local ownership. Additionally, the coordinator responded to tenders and collaborated on funding proposals. However, appointing an EI coordinator alone doesn't solve all challenges. Certain prerequisites are necessary to ensure their effectiveness.

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- **Leveraging on compliance and regulatory frameworks can enable investment in EI.** Strong environmental legislation and its effective implementation serve as crucial "push factors" that encourage EI investment through development authorisations. For example, developers required to mitigate environmental impacts might invest in EI to comply with regulations. An example of this approach is Mpophomeni-uMthinzima initiative, in which the requirement for upstream wetland rehabilitation as a condition for the environmental authorisation of the wastewater treatment works (WWTW) motivated uMngeni-uThukela Water to support downstream wetland rehabilitation.

- **Articulate the benefits of EI investment and how they align with funders' objectives clearly.** This involves creating a compelling value proposition and business case, supported by scientific data and catchment-specific monitoring. It should also include a systematic evaluation of the expected benefits, costs, and potential risks to the long-term sustainability of the investment.

- **To attract private sector investment in EI, managers need to develop a compelling business case showcasing the socio-economic benefits of the EI intervention**. This business case must be supported by a strong evidence base, which clearly demonstrates the impact on EI and related ecosystem services. Examples of evidence include before and after pictures of project area post interventions, project outcome descriptions, and quantifiable indicators, like the amount of water saved attributed to invasive alien plants (IAPs) clearing.

- **EI managers and funding recipients should seek multiple, diverse funding sources rather than relying on one**. EI initiatives often face short-term private sector funding, which is insufficient for long-term projects that require extended monitoring and evaluation. Multiple funding sources can ensure sustained support over a longer timeframe. The Mpophomeni-uMthinzima initiative is a prime example, with various stakeholders funding different aspects of wetland rehabilitation.

- **Identify opportunities to integrate green and grey infrastructure, which can yield various co-benefits, especially for the private and public sectors.** These benefits include job creation, social equity, specialized expertise for technical EI projects, and increased funding and resources. For instance, in the Mpophomeni-uMthinzima initiative, the restoration of the uMthinzima wetland complex was driven by the importance of the Midmar Dam, a key regional water supply. Additionally, the downstream rehabilitation of the uMthinzima wetland was motivated by uMngeni-uThukela Water (UUW) to meet environmental authorization requirements for the wastewater treatment works (WWTW).

- **To establish effective social processes with key stakeholders—such as funders, implementing agencies, the community, and local authorities—it is crucial to build and maintain strong relationships.** This can be achieved through transparent, upfront, and honest communication about what can realistically be accomplished within the agreed timeframe, including budget constraints, expected outcomes, and potential risks. Additionally, maintaining a good funding relationship is essential for initiatives that have developed organically, like the Klein Swartberg initiative, which evolved through a series of small-scale interventions.

In conclusion, the case study review was instrumental in shaping the framework, offering a comprehensive analysis of how EI management affects water users within specific catchments. It highlighted the mechanisms that facilitated investment in these initiatives and provided valuable insights into the tangible and intangible returns from EI interventions, relevant to both private and public stakeholders. The review also shed light on the factors that hinder EI investment, providing a solid foundation and real-world perspective on EI investment in South Africa.

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REMOTE SENSING

Remote sensing monitoring of soil moisture for South African wetlands

Heidi van Deventer (CSIR and (UP), Laven Naidoo (Gauteng City-Region Observatory & UP), Philani Apleni (UP), Jason le Roux (ARC), Ciara Blaauw (CSIR), Willie Nel (CSIR) and Hebert Tema (CSIR) report on the role of remote sensing in the understanding and conservation of South Africa's wetlands.

Tamsyn Sherwill

Surface soil moisture is an essential climate variable (ECV; https://gcos.wmo.int/en/essential-climate-variables/soil-moisture) which is monitored to inform our understanding of changes in the atmosphere and earth. Soil moisture is also an important indicator, in addition to vegetation and soil types, of the presence of a wetland.

According to the South African National Water Act, Act 36 of 1998 (RSA, 1998:18), wetlands are defined as '***land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil***'. Only the top 50 cm of soil is used for wetland identification and delineation (DWAF, 2005). Therefore, to be able to detect a wetland using soil moisture as an indicator, we should be able to detect and monitor changes in soil moisture up to 50 cm of depth.

In South Africa, wetlands make up < 7% of the extent of the land mass, however, we have not detected all our wetlands yet (Van Deventer et al., 2020). Wetlands were also found to be the most threatened realm both globally (IPCC, 2019) as well as in the two South African National Biodiversity Assessments (NBAs) of 2011 (Nel and Driver, 2012) and 2018 (Van Deventer et al., 2019). Detection and monitoring of a wetland's soil moisture would not only contribute to the improved representation of their extent in the National Wetland Maps of South Africa, but also allow for quantifying changes in extent, health and their hydrological regime (Van Deventer et al., 2021). If these methods can be

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applied also elsewhere in the world, we can monitor these changes for reporting to global targets of freshwater ecosystems in the Kunming-Montreal Global Biodiversity Framework (GBF; CBD, 2022).

What has been done to date, and why do we need to improve it?

Currently, remote sensing is used to globally monitor changes in surface soil moisture up to 5 cm depth (Bauer-Marschallinger et al., 2019). For the world this is measured at a spatial resolution (pixel width) of 12.5 km, and for Europe at 1 km (Soil Water Index | Copernicus Global Land Service). These spatial resolutions are too coarse to detect wetland extent, and monitor their health for reporting to the GBF targets. More particularly, these global products will be insufficient for the detection and monitoring of wetland ecosystem health in South Africa, where most of our systems are shallow, narrow, and covered with vegetation. Remote sensing products with a 30 m spatial resolution, such as the Global Surface Water products (Pekel et al., 2016), has shown an underrepresentation of South Africa's wetlands by 87% (Van Deventer, 2021), in comparison to the latest National Wetland Map version 5 (Van Deventer et al., 2020). This is because only about 11% of the extent of South Africa's wetlands are open water bodies, and since optical and radar sensors can detect and monitor changes to these type of wetlands, if they are more than about 1 m in depth, the global products can detect and monitor only these 11% of our wetlands.

The majority of South Africa's wetlands are, however, ranging from vegetated or palustrine wetlands in the eastern parts of the country, to ephemeral wetlands in the western, arid regions which appear only briefly, and are usually muddy and shallow at times of inundation. Therefore, to improve the detection of wetland extent for palustrine wetlands and wetlands in the arid regions, we need to improve the spatial resolution and accuracy with which we can detect and quantify soil moisture.

The depth at which soil moisture can be detected by the current space-borne satellite sensors, is also limited to 5 cm at the moment (Bauer-Marschallinger et al., 2019). This means that the geographic variation and seasonal changes in soil moisture at depths >5-50 cm below ground, for the detection and monitoring of wetlands, are not detected. If vegetation covers the wetland, it makes it even more difficult for the sensors to detect the soil moisture below the canopy and above-ground biomass.

Radar sensors flown on aerial platforms such as airplanes and drones, however, can improve the depth of sensing compared to the current space-borne sensors. Further work is however, required in South Africa, to test the capabilities of sensors across platforms and assess and develop methods for optimising the predictions.

Colbyn Wetland Nature Reserve as a choice for monitoring teal carbon

The Colbyn Wetland Nature Reserve (CWNR) is a small 70 ha reserve within the City of Tshwane Metropolitan Municipality (CTMM) at about 25°44'21.67"S; 28°15'15.35"E (Gangat et al., 2020; Figure 1). It forms part of the headwaters of the Limpopo River, with the Hartbeesspruit draining through a valley-bottom wetland. The wetland was previously farmed in the 1940s, and a railway line still runs through the reserve. The wetland transitions from grass and sedges in some parts to large macrophytes such as ***Phragmites australis*** (common reed) and ***Typha capensis*** (bulrush) in other places, and areas with terrestrial grassland which occur towards the east.

Riparian trees line the river channel, adding to the challenge of detecting and monitoring changes in soil moisture across the reserve, for two reasons: (i) trees contain a high amount of above-ground biomass that interferes with radar and optical signals, making it challenging to detect soil moisture in these places; and (ii) they cause a significant draw-down in soil moisture, to depths where it is difficult for the sensors to detect soil moisture. CWNR offers an important variation in soil moisture regimes, from a terrestrial to seasonal, and also highly, permanently saturated wetland areas. In addition, a variety of vegetation structures in the wetlands, ranging from marsh vegetation to large macrophytes and trees, offers the diversity of interactions that occurs in the landscape where soil moisture ranges should be quantified and detected. Furthermore, the quantification of the above-ground biomass, enables more advanced radiative transfer modelling to compensate for vegetation in wetlands.

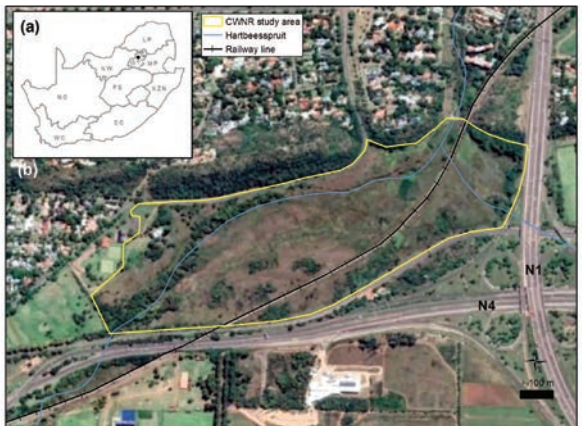

Figure 1: Location of the Colbyn Wetland Nature Reserve (CWNR) in (a) the Gauteng Province of South Africa and (b) relative to the upper reaches of the Hartbeesspruit in Pretoria.

How can we measure soil moisture from satellite images?

Soil moisture is traditionally measured by collecting soil samples in the field, and determining the water content per mass or volume of the soil sample in a laboratory. However, this technique is incredibly time consuming and laborious, thereby constraining continuous soil moisture monitoring. Alternative methods have therefore been developed to continuously measure a soil's water content, which have been predominantly driven by the agricultural sector. In South Africa, DFM capacitance probes (DFM Software Solutions, South Africa) use the dielectric constant (the ratio of the electric permeability of the material to the electric permeability of free space) to measure changes in a soil's water content. DFM capacitance probes are able to monitor water content and temperature at six interval depths, as well as surface temperature. Probes are installed into the soil surface using either a soil auger or a driving pin to create a hole slightly larger than the diameter of the probe. Thereafter the probe is inserted into the ground, and soil slurry applied to remove any air pockets.

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The soil moisture measured by the probes is used to statistically link ground and satellite data using regression (Wang and Qu, 2009). Regression relationships between reflectance or backscatter values extracted from satellite imagery and data collected by soil moisture probes are measured using parametric or nonparametric models (e.g., Gangat et al., 2020). These statistical methods need to be calibrated to achieve consistency between ground and satellite data. Calibration involves the collection of both ground-based measurements and satellite imagery under identical conditions, such as at the same time of day. Regression relationships can quantify soil moisture variation over large areas over time, even in areas where no soil moisture probes are not installed but still within the calibration domain (Bosch et al., 2006).

(a)

(b)

(c)

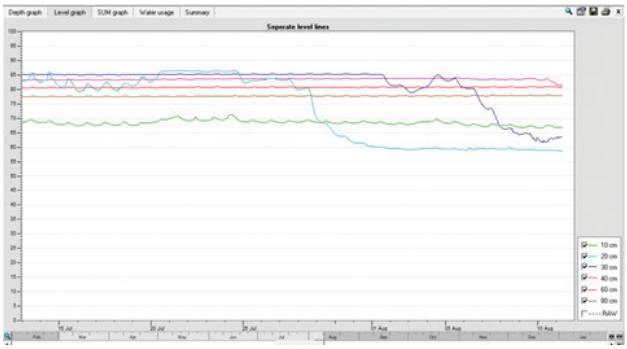

Figure 2: Soil moisture probes are inserted in the ground (a) to measure water content at different depths. (a) Here the DFM company, Mr Lee-Matt Isaks (from DFM Technologies), holds the 80-cm long DFM probe before installation at Colbyn Wetland Nature Reserve (CWNR). Several students volunteered to support the team with installation, including Ms Sisipho Ngebe (on the left), Mr Ayabonga Gangatele and Mr Tlotlisang Nkhase. (b) A photograph of an installed DFM Capacitance probe. Values recorded by these probes will be used to relate to the satellite images, to determine the accuracy to which we can measure soil moisture for different depths at CWNR.

The Gauteng Multi-sensor Campaign (GMC)

In the first semester of 2022, the team working on teal carbon estimation with remote sensing, were able to join the Gauteng Multi-sensor Campaign (GMC). The GMC was a collaborative campaign focused on collecting and generating a large multi-sensor dataset covering various remote sensing application domains and areas of interest. The CSIR captured multi-temporal airborne synthetic aperture radar (SAR) images as part of the campaign. Dual-frequency (C- and L-band) polarimetric SAR data was obtained with a temporal resolution of approximately two weeks over a three-month timeframe between January and May 2022, utilising the CSIR's Department of Science & Innovation's (DSI's) airborne SAR facility. The image below shows an example of a multi-looked C-band SAR image captured over the CWNR. This image was processed to 1-m spatial resolution, without any additional auto focusing.

Figure 3: Side-looking view on the Colbyn Wetland Nature Reserve generated from airborne radar data. The wetland is located north-west of the N1-N4 interchange.

The ARC provided the probes for the monitoring of the soil moisture at the CWNR, while the CSIR funded the initial installation of the probes and batteries, as well as replacement of the batteries in 2024. The outputs of this project will be used in a 'EO4Wetlands' project that the National Research Foundation (NRF) will fund between 2025 and 2027, and a PhD student analysing the potential improvements of soil moisture monitoring for wetlands in the country.

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GREEN SKILLS

Green skills to help nature repair itself – Training more experts in South Africa and Senegal

Africa's population is growing. This means more landscape change and development of supporting infrastructure. Ecosystems are under pressure, made worse by natural disasters induced by climate change. So writes Matthew Weaver, Sinetema Xoxo and Sukhmani Mantel.

In response, governments, scientists and environmentalists are turning their attention to nature-based solutions. These are environmental strategies that aim to address environmental change, including the impact of disasters, climate change, and water and food insecurity. For example, wetlands are a natural resource for humans and create a habitat for wildlife. They filter water and control floods. But they've been degraded all over the world, which threatens biodiversity and human livelihoods. Wetland restoration is a nature-based solution. Other examples are reforestation, and setting up green infrastructure in cities, such as urban forests and roof gardens.

Nature-based solutions are taking off all over the world. In Kenya, about 8 000 mangrove or coastal forests are being restored every year. These shield communities who live on the coast from storms, and absorb large amount of greenhouse gases. The Great Green Wall landscape restoration initiative in Africa's Sahel region is also a nature-based solution. In China, 30 pilot 'sponge cities' have been set up. These contain bioswales (ditches filled with plants that absorb stormwater during heavy rains and prevent floods), and rain gardens made up of plants grown on hillsides that also soak up heavy rains.

However, nature-based solutions are not being established fast enough to decrease global warming. In Africa, particularly, there is a shortage of people who have the green skills needed. Engineering with the skills to design green infrastructure, and environmental scientists who oversee environmental and social impact assessments, are in short supply. Nature-based solutions can't be set up without them.

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Until now, universities have not offered specific degrees in this field. And there are very few professional training courses for ecologists and scientists. The result is a green skills gap. We are a team of ecologists, engineers, sustainability scientists, hydrologists and social scientists who are working on filling this gap. We are revamping curricula at South African and Senegalese universities. Our academic project, 'Nature-based solutions for African resilience', aims to identify the missing green skills in university degrees, and develop nature-based solutions curricula.

If we do not take urgent action to integrate these green skills into education and training, Africa could miss out on opportunities to build a sustainable future.

The green skills education gap

We conducted interviews and surveys with more than 50 experts at South African universities, professionals in consulting firms, and decision-makers in government bodies, to see what kind of training was missing from university degrees and short courses for professionals.

They identified these gaps:

- Design and implementation: There is a shortage of training courses for designers of environmental projects, such as wetland restoration and urban greening.
- Interdisciplinary knowledge: Ecology, hydrology and climate change are mainly taught as part of the environmental sciences. These subjects haven't yet been included in engineering degrees. So there is a shortage of environmental engineers – people with the skills to incorporate natural solutions into engineering projects.
- Community engagement: Nature-based solutions projects are long-term projects designed in partnership with the people of an area. Skills need to be taught in how to set up and run community meetings where everyone has an equal voice.
- Policy and funding: This involves training in fundraising, policy writing and lobbying for support for projects.
- Ethics and engagement: Universities need to teach students how to engage with communities in ways that are ethical. Practitioners therefore need to be trained in how to involve indigenous knowledge systems.

Building green skills

Having identified these gaps, our project decided to set up training and professionals in these areas:

- Nature-based solutions for water management: How to restore city stormwater systems and urban wetlands.
- How to plan for climate change adaptation and conservation
- How to conserve the environment so that it absorbs as much carbon as possible: this needs training in ecosystem preservation such as reforestation and habitat restoration.
- Training people to monitor whether the nature-based solutions are making a difference.

Educational institutions will need to develop specialised courses and integrate this kind of interdisciplinary learning into their curricula:

- Multidisciplinary understanding: Balancing specialised knowledge from different university departments with broader environmental understanding.
- Interdisciplinary modules: For example, courses linking nature-based solutions with water and catchment management.
- Practical learning: Taking students out into the field to analyse successful nature-based solutions,

Why green skills matter for Africa's future

African countries need to act now to set up nature-based solutions to the problems caused by global warming and environmental damage. There is still time to do something. If the continent does not act quickly, the cost will be high. The United Nations Environment Programme has found that developing countries need to adapt to climate change urgently if they want to protect their food, water and agriculture systems.

The International Federations of Red Cross and Red Crescent Societies found that doing nothing to adapt to climate change could result in 200 million people needing humanitarian aid as a result of climate-related disasters by 2050 – up from the 108 million who need it today.

Nature-based solutions can drive sustainable development and create new jobs in climate-change related work. Rhodes University's Nature-based Solutions for African Resilience project is a start. However, this task goes beyond academia. It needs partnerships between universities, business, non-profit agencies, communities and others to develop the skills for society to become resilient to global warming.

- To read more about the Nature-based Solutions for African Resilience project at Rhodes University, visit https://www.ru.ac.za/nbs4afrres/
- This article was first published by The Conversation, https://theconversation.com

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THE WATER WHEEL

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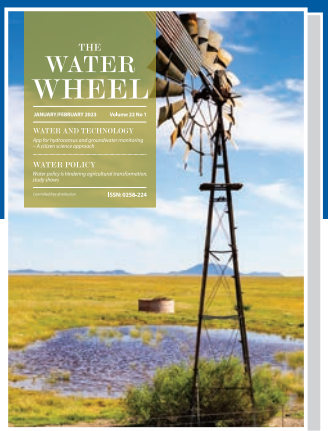

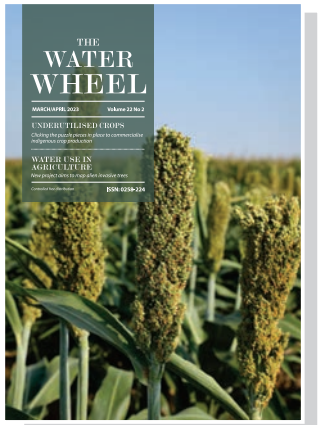

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WATER RESEARCH COMMISSION

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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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