

# THE WATER WHEEL

MAY/JUNE 2024

Volume 23 No 3

## WATER AND MINING

*New atlas gives mine closures more direction*

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## INVASIVE ALIEN SPECIES

*Alien species wreak havoc but select examples show promising solutions*

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ISSN: 0258-224



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# THE WATER RESEARCH COMMISSION (WRC) AND PARTNERS ARE CONVENING A REGIONAL SUMMIT ON ACCELERATING PROGRESS TOWARDS ACHIEVING THE SDGS THROUGH BROADENING THE WATER-ENERGY-FOOD (WEF+) NEXUS

**Theme: Accelerating progress towards sustainability through the WEF Nexus**

**Date: 19-20 August 2024 | Venue: CSIR, Pretoria**

Global challenges such as advancing climate change, rapid population growth, overexploitation of natural resources, and rapid urbanisation exert additional pressure on the rising demand for freshwater, energy, and food, with severe implications for people and the planet. Understanding trade-offs and synergies across water, energy, food, environment, and health is important for sustainable and equitable development under climate change.

The water-energy-food (WEF) nexus approach aims to unite different interests in resource use, manage conflicts, and simultaneously respect the planet's ecological carrying capacity limits. In the broadened context, the WEF+ nexus acknowledges that water, energy, and food security are inextricably linked with each other and environmental and human health/wellbeing. Adopting a WEF Nexus approach is a fundamental shift from pure sectoral approaches to solutions that embrace a cross-sectoral, coherent, and integrated perspective. It challenges existing global, regional, and national structures, policies, and procedures.

Against this background, the Water Research Commission (WRC), in collaboration with the Centre on Climate Change and Planetary Health of the London School of Hygiene and Tropical Medicine, IHE-Delft, the Institute for Natural Resources, the University of KwaZulu-Natal, Nexus Gains, WaterNet, Department of Water and Sanitation, Department of Agriculture, Land Reform and Agriculture and Global Water Partnership Southern Africa, under the auspices of the Global WEF Nexus Community of Practice (CoP), is convening a WEF+ Nexus Regional Summit to deliberate on the WEF+ nexus and its operationalisation for accelerating progress towards achieving the SDGs with a focus on southern Africa.

The summit will address the following questions:

- What challenges and opportunities are related to achieving the SDGs?
- How can operationalising the WEF Nexus assist with accelerating SDGs' implementation?
- What capacity is needed to enhance the operationalisation of the WEF nexus?
- What collaboration, coordination, and partnerships are needed to strengthen the science-policy-practice interface?
- How to share knowledge and best practices on integrated and transformative approaches for accelerating progress towards achieving SDGs?

Regional policymakers, sector experts, researchers/academia (including postgraduates and early career researchers), and civil society actors are invited to attend.

**For more information, contact Prof Sylvester Mpandeli, email: [sylvesterm@wrc.org.za](mailto:sylvesterm@wrc.org.za) or [click here](#)**



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THE WATER WHEEL is a two-monthly magazine on water and water research published by the South African Water Research Commission (WRC), a statutory organisation established in 1971 by Act of Parliament. Subscription is free. Material in this publication does not necessarily reflect the considered opinions of the members of the WRC, and may be copied with acknowledgement of source.

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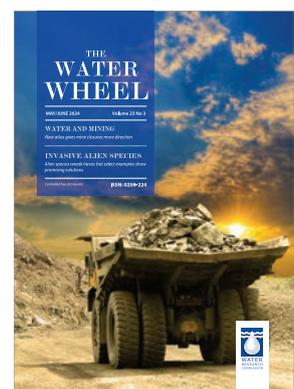
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*A new online tools aim to assist end-of-life mines with more sustainable closure. Article on page 12.*

## NEWS

### Sorghum research collaboration to boost crop's performance



The University of KwaZulu-Natal's (UKZN) African Centre for Crop Improvement (ACCI) is part of a collaborative plant breeding project with the University of the Free State and the Department of Science and Innovation (DSI) company Sorgho, that seeks to improve the yield of sorghum through research into higher-yielding hybrids.

Sorghum, a tropical cereal grass, has been cultivated in South Africa for three

millennia as a local staple for human and animal consumption. It is a highly nutritious, versatile crop that has adapted to growing in harsh climatic conditions that are increasing in a climate-changed world, making it an excellent source of food security.

This latest project, is evaluating exotic germplasm as a precursor to sorghum pre-breeding. This five-year project, which started in 2023, is operating trials at three

sites in the Free State, KwaZulu-Natal and North West provinces. Researchers aim to select breeding lines that will be beneficial for application in the commercial seed industry and future breeding efforts.

The project aims to breed high-performing sorghum hybrids for higher yield, better disease resistance, drought tolerance and better quality in the processing sector.

## Lesotho Highlands Tunnel closure not expected to affect water availability



The planned closure of the Lesotho Highlands Water Tunnel system for six months will not affect water supply to Rand Water. This is according to Water and Sanitation DG, Dr Sean Phillips.

Closure of the tunnels is planned for 1 October 2024 to 31 March 2025 to allow for maintenance work. The tunnel system includes a transfer tunnel, linking Katse Dam with Muela Power Station and Muela Dam, and a delivery tunnel linking Muela Dam with the Ash River Outfall Works between Clarens and Bethlehem.

Work to be undertaken during the shutdown period includes grit-blasting the steel-lined section around the entire circumference and re-applying corrosion protection on the tunnel lining, and other maintenance and repair work identified

during the previous maintenance shutdown in 2019.

The planned maintenance work is being overseen by the Lesotho Highlands Water Commission, a joint governance body between South Africa and Lesotho, and will be jointly undertaken by the Lesotho Highlands Development Agency and the Trans Caledon Tunnel Authority.

Source: SAnews.gov.za

## Workshop tackles management of invasives in protected areas

Ecologists from 17 countries gathered in Stellenbosch earlier this year to share knowledge and best practice approaches to the management of invasive species in protected areas.

The three-day workshop was hosted under the umbrella of the Centre for Invasion Biology Chair in Managing Invasions in Protected Areas, which is hosted within Stellenbosch University's School for Climate Studies.

Prof Tammy Robinson-Smythe, holder of the chair, said in her welcoming address that it was exciting to have specialists from just about every ecosystem – from marine and terrestrial to freshwater ecosystems – together in one room, making this a unique geographically representative gathering. The objective of the workshop was to work towards achieving Target Six of the Kunming-Montreal Global Biodiversity Framework, concerned with, among others, reducing the rates of introduction and

establishment of known or potential invasive alien species by at least 50% by 2030.

A selection of papers delivered at the workshop will be published in a special edition of the journal *Biological Invasions*. In addition, an overarching paper will draw together insights from the workshop, serving as a synthesis of the state of knowledge and identifying gaps in current practices and opportunities for meeting Target 6.

## Largest frog in more than 100 years discovered in Africa

A new species of African bullfrog has been discovered in northeastern Namibia, southern Angola, southwestern Zambia and northwestern Botswana. Named *Pyxicephalus beytelli* It is the largest frog species discovered in more than 100 years.

The largest specimen found is 210 mm long and weighs a kilogram. The discovery was made by Prof Louis du Preez, from North-West University (NWU), and his team of researchers. This is only the fourth species of bullfrog ever identified in Southern Africa.

The species occurs in parts of northeastern Namibia, southern Angola, southwestern Zambia and northwestern Botswana, and is named after the late Ben Beytell, Director of Parks and Wildlife Management in Namibia, who was instrumental in the proclamation of the Khaudum National Park in Namibia, where the species occurs.

The new species is similar to all other species of bullfrogs in its external structure, internal anatomy and general behaviour. However, two of the main distinguishing features of *Pyxicephalus beytelli* are its bright yellow and lime

green colouring, blue spots and a white vertebral line running down its body. Then there are its prominent and somewhat ferocious teeth, which are sloped backwards (recurved), and two large bony protrusions on the lower jaw.

"Their teeth really stand out, and we are excited to learn more about their feeding habits. I can promise you that this frog has a big bite," says Du Preez. Bullfrogs have a varied diet that includes mice, small birds, snakes, insects and even other frogs.

## GLOBAL

## New study adds to knowledge required about malaria and climate change



In tropical and subtropical regions where malaria is prevalent, scientists are concerned that climate warming might increase the risk of malaria transmission in certain areas and contribute to further spread. For a new study, published in *Nature Communication*, researchers from Penn State and Florida universities combined novel experimental data within an innovative modelling framework to examine how temperature might affect transmission risk in different environments in Africa.

"In broad terms, scientists know that temperature affects key traits such as mosquito longevity, the time it takes for a mosquito to become infectious after feeding on an infected host, and the overall ability of the mosquito to transmit the disease," notes Prof Matthew Thomas of the Institute of Food and Agricultural Science at the University of Florida. "But what might seem surprising is that these temperature dependencies have not been properly measured for any of the primary malaria vectors in Africa."

"Our findings provide novel insights into the effects of temperature on the ability of *Anopheles gambiae* mosquitoes – arguably the most important malaria mosquito in Africa – to transmit malaria, says Eunho Suh, joint first author with Isaac Stopard at Imperial College, and assistant research professor at Penn State.

The study supports previous research results in demonstrating that various mosquito and parasite traits exhibit intermittent relationships with

temperature and that under future warming temperatures, transmission potential is likely to increase in some environments but could reduce in others. However, the new data suggest that parasites can develop quicker at cooler temperatures and that the rate of parasite development might be less sensitive to changes in temperature than previously thought. The data also indicate that the successful development of parasites in the mosquito declines at thermal extremes, contributing to the upper and lower environmental bounds for transmission.

Combining these results into a simple transmission model suggests that, contrary to earlier predictions, the anticipated surge in malaria transmission, attributed to climate warming, may be less severe than feared, particularly in cooler regions such as the Kenyan Highlands.

To access the original study, Visit: <https://www.nature.com/articles/s41467-024-47265-w>

## 'Forever chemicals' underestimated in global drinking water sources

Per- and poly-fluoroalkyl substances – commonly known as PFAS – are a group of over 14 000 human-made chemicals that have been popular since the 1950s for their diverse attributes in resisting heat, water, grease and stains.

They have been commonly found in household products such as non-stick frying pans, clothing, cosmetics, insecticides, and food packaging, as well as specialty industry products, like firefighting foam. But despite their broad skillset, the chemicals have a dark side – these 'forever chemicals' once in the environment, don't degrade further.

A new study by the University of New South Wales, published in *Nature Geoscience*, assessed the levels of PFAS contamination in surface and groundwater across the globe. It found that much of our global source water exceeds PFAS safe drinking limits. "We already knew that PFAS is pervasive in the environment, but I was surprised to find out the large fraction of source waters that are above drinking water advisory recommendations," notes senior author of the study, Prof Denis O'Carroll. "We are talking above 5% and it goes over 50% in some cases."

The research team pulled together PFAS

measurements from sources around the world, including government reports, databases, and peer-reviewed literature. Altogether, they collated more than 45 000 data points, which span over roughly 20 years. It is the first study to quantify the environmental burden of PFAS on a global scale.

Prof O'Carroll stresses that these PFAS traces are found in source water, such as dams, and not drinking water itself – drinking water goes through treatment plants, some of which are designed to reduce the amount of chemicals such as PFAS in our water before it comes out of the tap.

## Madagascar drought linked to climate change – researchers



A new study reveals a clear link between human-driven climate change and the years-long drought currently gripping southern Madagascar.

“Using remotely sensed observations and climate models, we could see evidence that climate change is affecting the hydrological cycle in southern Madagascar, and it is likely going to have big implications for the people that live there and how they grow their food,”

notes Angela Rigden, assistant professor of Earth system science at the University of California, Irvine, and the lead author of the study published in the journal, *Climate and Atmospheric Science*. “Their rainy season is getting shorter, with a delayed onset of those seasons.”

A multi-year satellite record of vegetation greenness which shows shifts in southern Madagascar that indicate changes in water availability helped the researchers

make the connection between the drought and climate change. “We’ve taken satellite-based remote sensing data of plants and related it to how much water is available in the soils,” Rigden explains.

The team then compared the shift in the rainy season window to what some climate models report would happen in the absence of human-driven climate change, and is when they noticed the narrowing rainy season window. “That is the fingerprint of climate change, the change in seasonality,” says Rigden.

Another key was the multi-year nature of the satellite record, which stretches back to the early 1980s. Such long observational records, especially for less developed and poverty-stricken places such as Madagascar, are only available from satellites.

If populations know that events like drought are not anomalies but part of a new normal, they can better prepare for the future. “We can come up with strategies to adapt,” Rigden concludes.

To view the original article, Visit: <https://www.nature.com/articles/s41612-024-00583-8>

## Scientists investigate causes of flooding

If rivers overflow their banks, the consequences can be devastating. In order to limit flood damage and optimise flood risk assessment, we need to better understand the factors that can lead to extreme forms of flooding and to what extent.

Using explainable machine learning, researchers at the Helmholtz Centre for Environmental Research (UFZ) have shown that floods are more extreme when several factors are involved in their development. The research was published in *Science Advances*.

There are several factors that play an important role in the development of floods: air temperature, soil moisture, and the daily precipitation in the days

before a flood. To better understand how individual factors contribute to flooding, UFZ researchers examined more than 3 500 river basins worldwide and analysed flood events between 1981 and 2020 for each of them. The result: precipitation was the sole determining factor in only around 25% of the almost 125 000 flood events.

Soil moisture was the decisive factor in just over 10% of cases, and snow melt and air temperature were the sole factors in only around 3% of cases. In contrast, 51.6% of cases were caused by at least two factors. At around 23%, the combination of precipitation and soil moisture occurs most frequently. However, when analysing the data, the UFZ researchers discovered that three – or even all four – factors can be jointly

responsible for a flood event. The more extreme a flood is, the more driving factors there are and the more likely they are to interact in the event generation.

The findings of the UFZ researchers are expected to help predict future flood events.

To view the original article, visit: <https://www.science.org/doi/10.1126/sciadv.adl4005>



# NEW WRC REPORTS

## The establishment of a knowledge hub for contaminants of emerging concern in South African water resources

The present water quality guidelines only cover known contaminants; however, water professionals are already discovering novel pollutants in our water bodies that were previously at levels below detection limits. Categorised as 'emerging' contaminants these substances could have an adverse effect on the environment and human health. Examples include nanomaterials, flame retardants, microplastics, agricultural waste, microbial pollutants, heavy metals, and personal care products. We may significantly improve research efforts by allowing for research collaborations between scientists in the same discipline by collecting research data. This would help uncover knowledge gaps and reduce the likelihood of duplication of research efforts. The creation of an interactive knowledge hub with databases for comprehensive information on growing pollutants of concern in South African surface water sources was the project's primary goal. Additionally, it sought to develop a platform for citizen science that would have fact sheets and brief videos that were supported by scientific evidence. The application developed can be found at <https://www.ceckh.agric.za>.

### WRC report no. 3105/1/23 (Volume 1) and 3105/2/23 (Volume 2)

Links: <https://bit.ly/49UjD4s> (Volume 1) and <https://bit.ly/49UCsVb> (Volume 2)

## Comparative functional metagenome analysis of the Jukskei River system impacted by the urbanisation phenomenon

Urban rivers represent a unique ecosystem in which pollution occurs regularly, leading to significantly altered chemical and biological characteristics of the surface water. However, the impact of urbanisation on the diversity and structure of the river microbial community has not been well documented. The universal problem is the environmental pollution and most important pollutants are the heavy metals in aquatic network because of their toxicity and accumulation. The effects produced by environmental stressors on microbial diversity can be multifaceted, leading to significant changes in community composition and diversity, high spatiotemporal variability, and alteration of community functionality. The aim of this study was to make a comprehensive description of the taxonomic and functional profile of the microbial community, using PICRUSt in the Jukskei River impacted by the urbanisation phenomena with the potential of expressing enzymes that are of industrial relevance.

### WRC report no. 3110/1/23

Link: <https://bit.ly/49VT3la>



## Africa's Living Rivers Programme – Eco-social assessments of aquatic ecosystems

Three decades ago, South Africa began to support an ecosystem approach to water management, long before the term had been coined or the country's law required it. The approach has matured enormously, with several major advances and important consolidation activities funded by the Water Research Commission. Basin-wide modelling of the ecological and social implications of planned water-resource planning and management across Africa and Asia has provided massive, basin-specific DRIFT-Water databases. A much smaller but growing set of data describes the drivers of land-use change and the ecological and social responders (DRIFT-Land). The progress made is mirrored in advances in South Africa's Estuarine Method for calculating Environmental Flows, which has its own array of databases. These databases contain knowledge needed to improve our understating and management of river and estuarine ecosystems. This project was a first step in collating that knowledge into formats that are more readily accessible to managers and decision-makers in the form of generic sets of indicators, response curves and their links driving ecosystem functioning and hence response to human interventions.

### WRC report no. TT 934/1/23 (Volume 1) and TT 934/2/23 (Volume 2)

Link: <https://bit.ly/4cvgDgC> (Volume 1) and <https://bit.ly/43jnUfh> (Volume 2)

## Economic management of conjunctive use of irrigation water and root-accessible water tables

In South Africa, irrigated agriculture contributes significantly to the nation's field crop and horticultural production while exerting immense pressure on the country's water resources. Irrigated agriculture consumes approximately 64% of the available surface water in a country where water scarcity is prevalent. Integrated bio-economic models that include enough detail to provide decision support to improve conjunctive use management of surface water and root-accessible water tables do not exist in South Africa, which hampers the conjunctive management of surface water and root-accessible water tables. The project's general objective was to develop and apply a bio-economic model to improve the conjunctive use and management of surface and shallow groundwater economically.

### WRC report no. 3118/1/23

Link: <https://bit.ly/43IAjiB>

### Quantifying the extent and rate of changes in wetland types of the Maputaland Coastal Plain with remote sensing

Earth observation or remote sensing (RS) are considered Fourth Industrial Revolution (4IR) technologies that can contribute greatly to the monitoring of changes in wetlands and different types of wetlands. While open water (lacustrine) wetlands are currently well monitored with RS, the extent of different palustrine (vegetated) wetland types at a landscape scale is lacking. The Maputaland Coastal Plain (MCP) presents a variety of forested, grass, sedge, and open water wetland cover types that have been surveyed by botanists and earth observation specialists at local scales. The wetlands transition from freshwater to estuarine systems in this sandy, coastal, aquifer-dependent ecosystem. The aim of this research project was to quantify the rate of change of different wetland types on the MCP using remote sensing. In addition, a subcomponent of the work also aimed to understand the social context of these changes, by enabling stakeholder engagement and communication through sharing the remote sensing product output with these stakeholders.

**WRC report no. 3133/1/24**

Link: <https://bit.ly/3Wqnd27>

### Water-energy-food (WEF) nexus for the Crocodile River Catchment

The Water-Energy-Food (WEF) nexus is a particular approach to address the linkages and dependencies between the three sectors. Much of the previous work has been at a national and regional scale, as the parameters are more easily available for whole countries or regions from various reporting mechanisms. This project provided a new approach by integrating Participatory Scenario Development and application of WEF tools at the Crocodile River Catchment level in Mpumalanga Province. The project used mixed methods, both qualitative and quantitative approaches to address the objectives for the Crocodile River Catchment. The relevant literature was reviewed to establish the current state of research on the WEF tools and frameworks as well as the participatory type of engagements with stakeholders. The pertinent WEF indicators were identified from the Analytical Livelihoods Framework (ALF) and Sustainability Performance Indicators (SPIs) together with the Water Footprint and Life Cycle Assessment (LCA) approaches. Indicators were calculated for the Mpumalanga Province across the Crocodile River Catchment and the City of Mbombela Local Municipality.

**WRC report no. 3113/1/23**

Link: <https://bit.ly/3WwjYGu>

### Geospatial modelling of rangelands productivity in water-limited environments of South Africa

Grasslands are renowned for their socioeconomic, ecological and environmental functions, yet they remain the most contested biome that is also extensively impacted by climate change. Specifically, grasslands provide several ecosystem services, which include providing fodder for livestock while regulating elements of the hydrological cycle at various scales. The focus of this project was on assessing the utility of geospatial data and techniques in providing spatially explicit information on grassland productivity suitable for reinforcing the decision-making process for sustainable utilisation of grasslands. In the long run, this could assist farmers in planning activities such as grazing rotation, fodder management, thereby sustainably utilising this natural capital resource with preparedness in the light of climate change.

**WRC report no. 3126/1/24**

Link: <https://bit.ly/3wbsuQl>

### Sustainable application of water footprint in black tea and botanical extract production system

This study was carried out with the aim to contribute to the sustainable tea production system through an application of water footprint in black tea and botanical extracts. The specific objectives were to: evaluate the green, blue, and greywater footprint of tea industrial crop and its botanical extracts; assess the level of vulnerability in the tea production system (black, green, and its botanical extracts) to climate extremes and variability; determine the sustainable trade-offs in the use of linked natural resources water-and environment for the competitiveness of tea; assess the water footprint of the tea crop in the context of future climate change scenarios in Limpopo and identify and prioritize strategic intervention points in the tea production value chain for future sustainability.

**WRC report no. 3128/1/24**

Link: <https://bit.ly/4a4L3nj>

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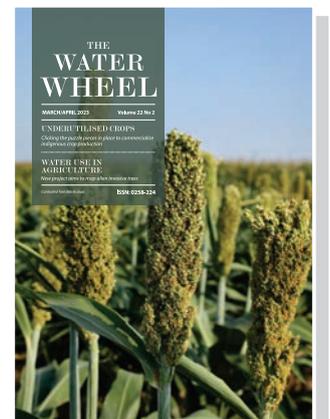
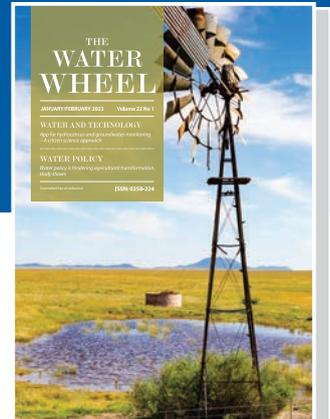
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## RESEARCH AT A GLANCE

### Mapping project sheds new light on alien invasion of SA catchments



A three-year project funded by the Water Research Commission (WRC) has reached an important milestone, releasing invasive alien tree maps for four key catchments in South Africa.

The Mapping Woody Invasive Alien Plant Species (MapWAPS) project is a trailblazing initiative dedicated to mapping alien trees in critical strategic water source areas. Running from 2022 to 2025, the project uses freely available satellite imagery and cloud computing to map alien trees in some of South Africa's strategic water source areas that do not have updated information on biological invasions and their impact.

It is expected that these maps will be a crucial tool for water resource managers, conservationists and policymakers to make informed decision in protecting South Africa's precious water sources. Invasive alien trees have the potential to outcompete native vegetation, alter natural habitats, and disrupt ecosystems. By mapping their distribution, extent, and impact, we gain valuable insights into the areas under threat, enabling proactive conservation measures.

The project team is led by Dr Alanna Rebelo of the Water Science Unit at the Agricultural Research Council – Natural Resources and Engineering, and includes PhD student Liam Cogill, MSc student Thandeka Skosana, and Prof Karen Esler of the Conservation Ecology and Entomology Department, Stellenbosch University.

"These maps serve as indispensable tools for environmental management, allowing stakeholders to identify high-risk zones, prioritise intervention efforts, and implement targeted control strategies," notes Dr Rebelo. "Additionally, mapping invasive alien trees is essential for safeguarding water sources, as these species often consume excessive water, posing a significant threat to the delicate balance of water ecosystems."

The data generated through mapping empower decision-makers, conservationists, and community members to collaboratively address the challenges posed by invasive alien trees and work towards preserving the integrity of our natural landscapes. For example, mapping different wattle taxa in the uMzimvubu catchment can inform local communities as to the feasibility of biochar programmes. For example, Black Wattle (*Acacia mearnsii*) is a higher value wood product compared to Silver Wattle (*Acacia dealbata*).

The project team is focused on four study sites, namely the Luvuvhu catchment (Limpopo), the Sabie-Crocodile catchments (Mpumalanga), the Tugela catchment (KwaZulu-Natal) and the uMzimvubu catchment (Eastern Cape). Typically, the mapping focuses on woody invasive alien taxa, such as pines, wattles, gums, poplars as well as a few other shrubby taxa such as Bugweed (*Solanum mauritianum*). The taxa mapped in each catchment depend on what the key issues in those catchments are, as advised by key stakeholders.

The overall accuracy is high, with 95%, 90%, 88% and 87% for the Tugela, Luvuvhu, Sabie-Crocodile and uMzimvubu catchments, respectively. Similarly, the accuracy for the key invasive alien plant taxa alone is high, with 98%, 97%, 96% and 96% for the Tugela, uMzimvubu, Luvuvhu and Sabie-Crocodile catchments respectively. The Sabie-Crocodile has the highest cover of alien vegetation at 22% of the catchment, which accounts for both invasions and plantation forestry. The uMzimvubu, Luvuvhu and Tugela catchments have a total invaded area of 7%, 6% and 2% respectively.

To access the invasive alien tree maps and delve deeper into the innovative methodologies employed by the project, Visit: <https://sites.google.com/view/alanna-rebelo/mapwaps>

# WATER AND MINING

## New atlas gives mine closures more direction

*Mining can bring a host of ills, not least to our water sources. And when the pit gear grinds to a final halt, things frequently get worse. The good news is that new risk assessment tools and an online atlas should improve closure planning. Matthew Hattingh reports.*



Early one Sunday nearly 60 years ago, a certain Mr Brits of Blyvooruitzicht, a mining town on the West Rand, was up and about, restless. It was 2 am and he was looking for a pill to help him sleep when what sounded like wagon wheels on a rough road caught his attention. Mr Brits peered from his window, but saw nothing out of the ordinary. Seconds later, the noise returned, only much louder. Then Mr Brits watched in horror as the home of his neighbours, the Oosthuizen, “collapsed like a paper cup”.

A giant sinkhole swallowed the Oosthuizen, man, wife and three children (aged six to 12) along with the family’s domestic servant. Their bodies were never found. In the ensuing panic, 170 families were evacuated.

In time, a monument was erected on a hill overlooking where the Oosthuizen once lived. A simple plaque commemorates the disaster and its victims, ending with the inscription, “*God het hulle te aarde bestel*” – “God laid them to rest”. No doubt providence played its part, but man likely had a hand in it too.

Much of the West Rand rests on dolomite, a soluble sedimentary carbonate rock particularly susceptible to sinkholes when water is pumped or otherwise extracted from nearby mines.

To this day residents of towns and townships near Blyvooruitzicht, like Westonaria, and Khutsong, which owe their establishment to deep-level gold mining, are at risk of sinkholes, road collapses, flooding and polluted waters.

Further afield, a similar sinking feeling (or worse) afflicts many residents of the Witbank coalfields, who must reckon with declining water quality and soil fertility. And in the Platinum Belt, shack-dwellers bemoan the around-the-clock noise from nearby shafts. Sadly, mining's environmental ills don't disappear when the pit gear grinds to a final halt. Jobs inevitably disappear along with the basic services and infrastructure that mining companies provide to many communities.

This triple-whammy of environmental, social, and economic ills – and efforts to find a more systematic way to soften the blow – are the focus of a new Water Research Commission report.

*Developing mine closure risk ratings and a post-closure opportunity framework for South Africa (WRC Report No. TT 930/23)* works to put the problem in context. It reviews the literature, draws on cases studies, and interviews experts and community support groups to see what lessons might be learnt.

It also provides several tools to help assess the likelihood of closures and the associated risks. A risk-rating system was developed and translated into an interactive atlas. The atlas – officially launched on 12 March – aims to help the mining industry, professionals, policymakers and communities near

mines, better plan for closures. A framework was developed with step-by-step procedures for understanding local conditions, weighing up influencing factors and exploring post-mining land use options. The process emphasised the need for a shared vision and for fostering community participation to support 'just economic transitions away from mining.'

Mining, once the bedrock of the South African economy, has declined from its peak, at 21% of GDP in 1980, to 7.5% in 2022. Mine closures are widespread, even as attention has shifted away from the demise of gold mining in the Witwatersrand basin to the troubled thermal-coal mines of Mpumalanga. Reserves and resources become depleted, or uneconomical to extract. Meanwhile, the world switches to renewable energy sources. Nevertheless, mining remains vital to South Africa, with over 230 mines operating at present, extracting 22 commodities. The mines are located in a quarter of the country's local municipalities – home to 6.2-million people.

The report, by Megan Cole and University of Cape Town colleagues, Tapiwa Chimbanga, Murad Esau, Amber Abrams and Jennifer Broadhurst, reminds us that badly managed closures are a worldwide problem. Mining disruptions of the natural flow of surface and groundwaters are often difficult to



*Mining remains vital to South Africa, with over 230 mines operating at present, extracting 22 commodities.*

remedy. Active discharge, seepage, run-off and dust emissions from abandoned or ineffectively rehabilitated mine workings harmed “surrounding water sources and land for decades and even centuries”.

Especially worrying was acid mine drainage, in many hard rock ores and coal deposits. “Unless contained, [it] can continue to be dispersed into the surrounding environment. . . with the acidity, salts and metals impacting the quality of water sources and soils, the growth of local vegetation, and the health of living organisms, such as fish.”

Historically, mines close with little regard for the future. Cole reckons South Africa counts anywhere between 4 000 and 6 000 derelict or ownerless mine features – including quarries, waste dumps, heaps and adits. Rehabilitating these represents a R30-billion-plus headache for the state. There’s change for the better though, with the first legislative requirements for rehabilitation introduced in 1956, and numerous new laws and regulations governing closures coming on stream from the 1990s.

A broader understanding of the risks of mining closure has emerged too. Drawing on lessons from the fading Free State goldfields, the authors noted that while the environmental consequences of living near old or abandoned mines were well known, the socio-economic consequences have lately come to be recognised as the “most critical risk facing the sector”. Closures could have “very negative effects on communities and local municipalities, particularly those with poor governance”, the report said, observing that some towns and villages near mines were among the most deprived in the country, with 55% of their populations living below the poverty line.

Closures hurt, but why are some communities hurt more than others? The authors cite several scholars and retired mining boss and national planning commissioner Bobby Godsell, who note that small, isolated mining towns, “whose social, political and economic life are completely dominated by the mine” feel the pain of closure most acutely.

South Africa’s National Water Act, National Environmental Management Act and Mineral and Petroleum Resources Development Act and amendments were intended to prevent or remedy a host of ills, or at least prod the different players in the right direction. However, “The land use objectives are not adequately integrated across the different legislations and plans,” the report said, noting a “disconnect” which meant “successful mine closure remains elusive”.

It needn’t be so. Post-mining land-use planning in a developing country like South Africa “presents an opportunity to use mine closure as a catalyst for sustainable development” and with economic diversification around the world, former mining land has been put to good use. The report cites examples from the literature mentioning everything from agricultural and forestry projects in Australia and Honduras, to wind turbines and museums in Germany’s Ruhr coalfields, and tourism at places like Kimberley’s Big Hole.

Picking among alternatives isn’t straightforward. Alongside legislation, various guidelines have been drafted (and revised) by regional authorities in the mature mining countries of Canada

and Australia, as well as by the World Bank and mining houses like Anglo American. But the report found little consensus among these guidelines on which criteria and indicators should be used, making it hard to assess “successful closure”.

To better understand this, the authors considered four post-mining land use case studies: the Impact Catalyst, focusing on the Mogalakwena platinum mines in Limpopo; the Green Engine initiative, in the Witbank coalfields; the Resilient Futures Community of Practice in the West Witwatersrand goldfields; and Bokamoso Ba Rona, also on the West Rand. The studies covered a wide spread of areas, commodities, mining methods, stages in the life of a mine, urban and rural contexts, water and land resources and demands from residents.

We are limited by space to a brief look at the Resilient Futures Community of Practice study. This happens to include the Blyvooruitzicht mine, near where the Oosthuizen met their fate all those years ago. That mine closed in 2013 amid industrial action, a falling gold price and increasing costs. Nearby, mining continues but ownership and operations have been



*Proper closure and rehabilitation of mines are essential to prevent the pollution of environmental resources.*

consolidated, with some shafts and operations shut or put under care and maintenance.

The Community of Practice study lists mines still operating and their expected remaining lifespan (varying from two to 84 years); describes the local geography (much of it urban); and surveys the population, its living conditions and workforce (58% of miners are unskilled so would struggle to find other jobs). The study shows the region's 22 mine villages remain male-dominated (73%) and that almost 12% of the Far West Rand population live in informal settlements. Widely varying conditions among these communities are a legacy of "apartheid and the inability of the current government to create enough jobs and housing".

Much of the land is arable and "presents an excellent opportunity for post-closure land use if the soil is not contaminated by mining activities", the report noted.

***"Post-mining land-use planning presents an opportunity to use mine closure as a catalyst for sustainable development"***

What about water? Dolomitic land in Khutsong and Carletonville is prone to fissures and sinkholes which "impacts on water infrastructure, causing shutdowns and decommissioning of reservoirs". Mine flooding is another problem. At Kusasaletu, a deep-level gold mine near Carletonville, 1.5-million litres of fissure water must be pumped out of the mine a day. But when mines close and pumping stops, flood waters flow to the surface, raising the risks of acid mine drainage.

What land-use opportunities did the study identify? There was a strong focus on using crops to clean up contaminated soil, air and water and to feed downstream industries. Various fibre crops have been trialled as part of an Anglo Gold Ashanti initiative now in the hands of new owners, Harmony. Non-invasive *Bambusa Balcooa* bamboo found favour with the researchers, due to high yield and end-uses including poles, wood products and fibre for paper and more.

The potential of such fibre crops "make them an attractive opportunity for regenerative agricultural systems" and warrants larger-scale pilot projects. Several other development and land-use initiatives reviewed included the Blyvoor Gold company's local economic development initiatives. These focused on services, including refurbishing the Ekuphakameni Wastewater Treatment Works and maintaining the waste management service in Blyvoor Village.

The other case studies' land use suggestions included large-scale regenerative agriculture, agro-processing, water treatment and game farming. In a presentation at the atlas launch, Cole noted an overall lack of integration in social development initiatives, rehabilitation, and post-mining development and red-flagged "uncertainty on the continuity of projects" accompanying the sale of mines and other assets.

The case studies, along with expert reviews, helped the authors test their mine closure risk rating system, which seeks to gauge the likelihood of a closure, and the accompanying social and environmental risks. Identifying influencing factors and risk categories, they developed indicators and weighting systems for data sets. Likelihood of closure considered ore reserves, commodity markets and operating costs.

Social risk factors and indicators included population size, number of mining jobs, distance from cities and local government capacity.

Evidently the most deprived areas, typically villages in the former Homelands, with large mine workforces were at highest risk, "most notably chrome and platinum mines in Limpopo and North West".

Environmental risk rating considered factors and indicators like duration of mining, mine water threat and distance from protected areas, and threat to biodiversity. "Gold and coal mining have the greatest risk due to acid mine drainage and their location on good arable land," said Cole.

Drawing on more than 65 spatial data sets, the atlas includes a host of functions, letting users zoom in on an area and assess opportunities and risk and to make comparisons. With the option to turn different filters or layers on and off, it helps users understand conditions at a particular mine in a visual way. Maps may be generated that, for example, provide a picture of water resources, transport links, socio-economic profiles and even bird life surrounding a mine.

At the launch guests welcomed the atlas and the other tools developed alongside it.

Dr Ravi Vadapalli, of the Council for Geoscience, called it an "excellent piece of work" which complemented efforts to develop a national mine closure strategy, and wondered if the atlas might in future include closed and abandoned mines.

Others present called for the inclusion of sand mining and quarrying, and details on post-closure projects to help users "see what the neighbours were doing". This would foster partnerships and ultimately help protect water resources.

The atlas is available at <https://www.wrc.org.za/programmes/mine-closure-risk-and-opportunity-atlas/>

To view the final report, *Developing mine closure risk ratings and a post-closure opportunity framework for South Africa (WRC Report No. TT 930/23)*, visit: <https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/TT%20930%20final%20web.pdf>

# WETLANDS

## Sirkelsvlei - Taking a stroll through Cape Point's largest permanent waterbody

*Sue Matthews visits Sirkelsvlei, Cape Point's freshwater gem.*

Sue Matthews



A narrow path of white sand snaked before us as we hiked through the fynbos, pausing to watch five browsing eland before continuing on in our quest. Surely we should have reached it by now... had I taken a wrong turn and led my friends astray? Moments later, a surge of relief and excitement as I glimpsed a flash of blue through the rocks ahead.

We had come to see Sirkelsvlei, the largest permanent waterbody in the Table Mountain National Park's Cape of Good Hope section, more commonly referred to as simply Cape Point, after the iconic tourist site at the tip of the Cape Peninsula. Having hiked and cycled in Cape Point on a number of occasions over the years, I had not been to Sirkelsvlei for more than two decades. My visit then had been discouraging – after a long trudge from the Cape Point gate in particularly blustery and overcast weather, the windswept vlei had appeared grey and unwelcoming.

What a difference a day makes! Today, under an unbroken blue sky and with only the gentlest of breezes, the vlei was a jewel in a setting of brown and green, offset by a spectacular

mountain backdrop. Contrary to its name, Sirkelsvlei is not round but elongated, although each end curves gently along a soft, marshy shoreline, contrasting sharply with the rugged, rocky sides. As we soaked up the view, three bontebok ambled along to the north-west end and lay down on the grass – evidently a favourite spot, judging by the scattering of dung. A splash in the water reminded me that Cape terrapins occur here, but it was only a pair of Egyptian geese, having a bath. Otherwise, the only obvious fauna was a grey heron that flew off shortly after we arrived.

Later, after returning home, I looked up Tony Gardiner's PhD thesis, 'A study on the water chemistry and plankton in blackwater lakelets of the south-western Cape', awarded by the University of Cape Town (UCT) in 1988. Sirkelsvlei was one of six vleis investigated by Gardiner, three of them in Cape Point. For a 15-month period between February 1981 and April 1982, he conducted monthly monitoring and sampling at each of the vleis, with 17 sites in total, amounting to an enormous laboratory and microscopy workload. The research was an extension of Gardiner's Honours thesis in 1980, and after eight years he was

evidently ready for a radical change. Upon completing his PhD, he did an MBA and then entered the business consulting world, never to return to science.

Nonetheless, thanks to Gardiner we know that Sirkelsvlei has a relatively high pH for a blackwater system, as he recorded a mean pH of 6.55 but a maximum of 6.9 in late summer to autumn. This can be attributed to buffering due to Sirkelsvlei's high salinity, which was an order of magnitude greater than the other five vleis studied. Its ion composition closely matches that of seawater, which is a clue to the cause for the high salinity. Sirkelsvlei is only 2.5 km from the sea, as the crow flies, and Cape Point is officially the windiest place in South Africa. The marine salts are simply picked up as aerosols from the sea surface and deposited inland. The wind and the vlei's large surface area to depth ratio then concentrate these salts through evaporation. The highest conductivity recorded by Gardiner was approximately 25% that of seawater, but this was in March 1982, when the major ions were at a peak due to elevated evaporation and lack of dilution. Gardiner notes that Cape Point received 2.7 times less rainfall in the summer of 1981/1982 than in the same five months in 1980/1981, but a look at historical rainfall records reveals that his entire sampling period coincided with a drought. Indeed, his shallowest site in Sirkelsvlei had no water to sample by April 1982, and his deepest – recorded as 1.4 m in September 1981 – had dropped to 45 cm.

By the end of 1982, the vlei had dried up, as it is prone to do during droughts. While terrapins are able to burrow down into the mud and aestivate at such times, fish cannot survive without water. Fortunately, the only fish in Sirkelsvlei were alien species of bass and tilapia that had been introduced over the past three decades – not even the hardy indigenous Cape galaxias has ever been found here, although it does occur elsewhere in Cape Point. Gardiner states that the vlei had also dried up in 1969 and 1973, and on the former occasion the conservation staff had removed truckloads of ammunition casings that had been lying there since the Second World War, when Sirkelsvlei had been used as a strafing range for aircraft.

Sirkelsvlei had a considerably greater phytoplankton biomass than the other Cape Point vleis studied, with high chlorophyll *c:a* ratios indicating a large proportion of diatoms. Zooplankton were abundant, the community being dominated by the



Sue Matthews

*Bontebok would not have occurred naturally in the Greater Cape Town area, but were introduced to Cape Point in 1946 as part of the effort to save the subspecies from extinction*

calanoid copepod *Metadiaptomus capensis*, which has only been recorded from a few other high-salinity vleis and rock pools.

Such a brief summary does not do justice to Gardiner's thesis, which remains the most detailed scientific work on Sirkelsvlei. However, a more accessible account of Cape Point's freshwater systems in general can be found in a chapter of the coffee table book *Between Two Shores: Flora and Fauna of the Cape of Good Hope*, written by Michael Fraser and illustrated by his partner, Liz McMahon. The Scottish couple arrived in South Africa in 1984 and spent their first two years living in Cape Point while Fraser conducted research for his MSc degree on the ecology of fynbos birds. Two years after the book's publication, by David Philip in 1994, they returned to Scotland and haven't returned since, but Fraser tells me that Cape Point remains his favourite place on the planet.

Over the past few years, he has published species accounts of its birds (2016), mammals (2022), and reptiles and amphibians (2023) in the open-access journal *Biological Observations*, which was initiated by the Animal Demography Unit at UCT as a platform for both scientists and citizen scientists to publish biodiversity-related contributions as quickly as possible. Fraser originally compiled the species accounts in the 1990s and has tried to update them with input from local birders and naturalists, but since the journal is not peer-reviewed, there may be some inaccuracies where the latest scientific knowledge has not been incorporated. Furthermore, the title of these three publications all refer to the Cape of Good Hope Nature Reserve, as it was known in Fraser's time there. The reserve was proclaimed in 1939 by the Divisional Council of the Cape, but incorporated into the TMNP when it was established in 1998.

Fraser gives a fascinating overview of the management history in his *Biological Observations* publication on mammals. In the past, there was pressure from some quarters to make Cape Point a game reserve, so a variety of large antelope, as well as zebra, were introduced between the 1940s and 1990s, even though it became increasingly evident that the nutrient-poor, unpalatable fynbos there could not support them. Some, such as wildebeest (both blue and black), were subsequently removed, and supplementary feeding with hay and lucerne was carried out for many years. In the 1970s the bontebok were in terrible condition, and found to be not only infested with parasites, but suffering from osteoporosis and cardiac problems due to copper deficiency. To remedy this, some of the ponds that had been constructed as waterholes for the game animals (and in a few cases the cattle before them) were dosed with copper sulphate.

Sirkelsvlei is in fact the only fresh waterbody in Cape Point that is considered both natural and permanent. It is essentially a giant rock pool between two sandstone ridges, and is replenished primarily by subsurface flow. During winter, scores of ephemeral or seasonal pans are filled by rain, run-off, seepage and inundation from the high water table, since much of the land has a flat profile and the shallow soils overlie hard quartzitic sandstone. These pans dry up in summer, as do most of the streams, at least on the surface. The largest, the Krom River, discharges on the west coast, in a part of Cape Point that is closed to the public. Although it sometimes flows over the beach into the sea, it more typically empties into a lagoon that is



Seine-netting of artificial ponds containing hybrids of common and Cape platannas was conducted for many years to control the number of common platannas.

periodically flooded with seawater during high seas and spring tides. The lagoon is popular with seabirds as a roosting and bathing spot, according to Fraser, who also confirms Gardiner's ascertain that Sirkelsvlei is not attractive to birds.

As for amphibians, Fraser's species account indicates that more than a dozen species of frogs and toads have been reported to occur at Cape Point, but no mention is made of Sirkelsvlei specifically. Other sources reveal that the clicking stream frog, *Strongylopus grayii*, has been heard, if not seen, in the vicinity, and the African clawed frog, *Xenopus laevis*, has been reported from the vlei itself. This little beastie is amusingly described by Fraser in his *Between Two Shores* book as having "all the grace and poise of a Sumo wrestler in battle dress."

Many South Africans know the species as the common platanna, and may have heard that it has become invasive in other parts of the world after originally being introduced as a laboratory animal for pregnancy tests (the female frog lays eggs within a day of being injected with the urine of a pregnant woman). Starting in the 1930s, thousands of frogs were exported from South Africa to medical labs, which soon established their own breeding programmes. The species proved so easy to keep in captivity that a flourishing pet trade developed in the 1950s and '60s. By then, new technologies for pregnancy diagnosis had been developed, so some labs simply released their frogs, but many

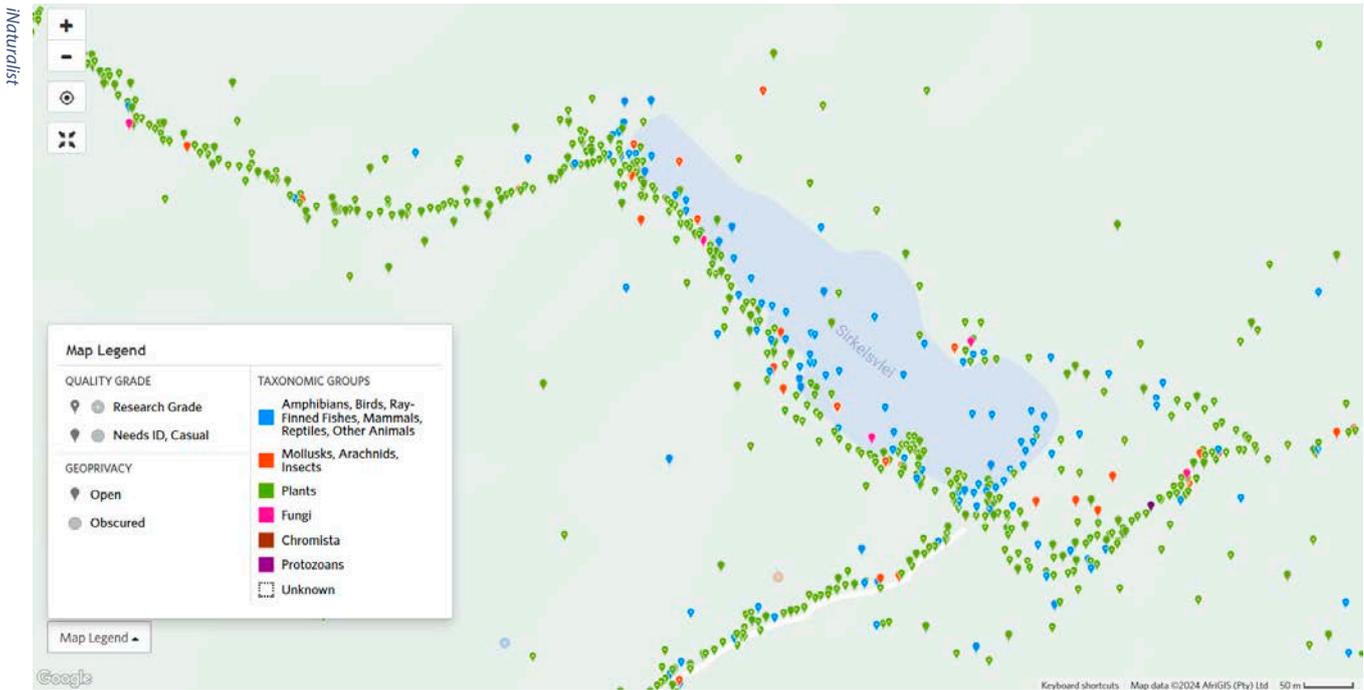
more were already using the species for other biological research and analytical testing. Since the frog is a highly opportunistic species with a wide salinity and temperature tolerance, released animals and escapees from labs, breeding facilities and homes have established invasive populations in the wild over the years, negatively impacting indigenous biota through competition and predation.

In the south-western Cape – and Cape Point in particular – the chief concern has been its threat to the smaller Cape platanna, *Xenopus gilli*. Also called the Cape clawed frog, this species is endemic to the winter rainfall region of the Western Cape, and is classified as endangered in *The IUCN Red List of Threatened Species*, based on the most recent assessment in August 2016. The rationale for this listing was the known area of occupancy of only 60 km<sup>2</sup>, the population being severely fragmented into four disjunct areas between the Cape Peninsula and the Agulhas Plain, and the continuing decline in the quality of its habitat and the number of mature individuals.

Cape Point was considered the stronghold of the species, but fears for it grew from the 1980s when Mike Picker's PhD research revealed that *X. laevis*-*X. gilli* hybrids occurred in half of the reserve's permanent waterbodies (but never in Sirkelsvlei). In 1985 a programme to remove *X. laevis* from the ponds was instituted, with seining and bait-trapping taking place annually



*Cape Point was once considered the stronghold of the endangered Cape platanna, *Xenopus gilli*, but populations further afield have been found in recent decades. The species does not occur in Sirkelsvlei, preferring more acidic, seasonal pools.*



Observations posted on iNaturalist reveal that Sirkelsvlei is a popular destination for hikers, nature lovers and fynbos fundis. The area is a plant hotspot with a number of threatened species, and was listed as a target in the Great Southern Bioblitz 2022.

until 2000, when it ceased following the change in management authority. In 2010, Dr John Measey of Stellenbosch University's Centre for Invasion Biology revived the control programme with his MSc student, André de Villiers, and within five years they had caught and euthanased more than 2 000 *X. laevis*. Monitoring results, detailed in a paper in *Conservation Evidence* (2016), showed a marked increase in young *X. gilli* over the five-year period, suggesting that *X. laevis* has a negative impact on *X. gilli* through predation and/or competition.

Measey continued with the monitoring and control programme for a few years with visiting students from the Organisation of Tropical Studies, a nonprofit consortium of about 50 universities, colleges, and research institutions worldwide. Regular removal of *X. laevis* was also included in SANParks' Annual Plan of Operations for Cape Point, but apparently this work has not been done because of capacity constraints.

Fortunately, *X. gilli* has been discovered in additional locations in the past few years, and hybridisation is no longer considered a major concern. Measey explains that the better genetic techniques that are available now have found no evidence of gene flow, or introgression, between the two species, despite them sharing a habitat for so long. While laboratory studies have shown that hybrid females are capable of backcrossing – producing viable offspring after mating with either parent species – they don't appear to do this in the wild.

Measey says that one way of protecting *X. gilli* from *X. laevis* at Cape Point would be to fill in the artificial ponds where the hybrids occur, since game animals do not use them as waterholes anyway. He explains that under natural conditions *X. gilli* normally breeds in seasonal and ephemeral pans that get inundated in rainy periods. Historically, it was probably the dominant of the two species in much of its range, with *X. laevis*

confined to slow-moving rivers. On the Cape Flats, for example, even large waterbodies like Zeekoevlei and Rondevlei would have been seasonal rather than permanent. And while both species can burrow down into wet mud to aestivate when water dries up, *X. gilli* is adapted to seasonal wetlands by having tadpoles that develop quickly when water is present.

"The tadpoles of *X. laevis* can't develop as quickly, so where the wetlands are seasonal the *X. laevis* don't go through to metamorphosis, and that controls their numbers," he says. "In my opinion, if Sirkelsvlei was the only permanent waterbody left in Cape Point, *X. laevis* wouldn't be so much of a problem."



Sue Matthews

The vlei rat *Otomys irroratus* likely lives in the marshes at each end of the vlei, where it feeds on grasses and other plant material.

# WATER LAW

## Call for more practical legal training to tackle SA water management failures

*New research has drawn attention to several shortfalls in the country's water law education and training programmes – and made recommendations on how to improve the situation. Article by Tony Carnie.*



Unsplash

It's one thing to have great water laws. Quite another to enforce and implement them. South Africa's post democracy water law reform process was hailed internationally, yet that praise has been tempered more recently with the steady collapse of municipal tap water supplies and the increasing level of sewage pollution in rivers across the country.

A new research report commissioned by the Water Research Commission (WRC) notes that the National Water Act of

1998 and the Water Services Act of 1997 cannot be seen in isolation as these laws have since evolved to include more than 120 regulations. These laws are further influenced by many other pieces of environmental, municipal and public finance legislation, along with high levels of scientific and technical complexity.

Surprisingly, however, the researchers reported that none of the water law courses offered currently by local universities



*Sewage effluent from the Northern Wastewater Treatment Works festers along the banks of Durban's uMngeni River.*

specifically incorporate “water-related scientific content”. And though many water sector professionals and state officials have received legal training at university, a significant number of respondents in the WRC study had never received any formal water-specific law training – relying instead upon “on the job” training or self-study.

The project team (led by Prof Tracy-Lynn Field of the University of the Witwatersrand and researchers Basetsana Koitsioe and Kgosi Thage from the Centre for Applied Legal Studies) suggests that there is “an urgent need for investments in capacity-building to interpret, understand, and enforce water law effectively”.

One suggestion emerging from their research is the establishment of a new, multi-disciplinary training institute for water. Alternatively, universities and other sectors could collaborate to offer a new online learning course on water law. These recommendations flow from a recent series of questionnaire responses and interviews conducted with water sector stakeholders, many of who emphasized the need to make water law training “more real, practical and accessible”.

“There was a strong convergence of opinion that water law training should be more practical, such as case studies, simulations, hands-on exercises, real-world examples, problem-solving exercises, and interactive learning methods,” according to the new research report entitled *Water law reform: Themes, gaps and opportunities (WRC report no. 3115/1/23)*. It was based on feedback from a broad range of water specialists and officials in academia, government, water law administration, the legal fraternity, consultancies or social justice groups.

“A significant majority of respondents to the questionnaire (70%) had not received any formal water law training,” the report states. Other respondents also drew attention to the multifaceted nature of water law, as well as its integration with various hard sciences such as ecology, chemistry, and engineering. And yet, the researchers conclude: “None of the water law courses in legal academia teach any water-related science.”

As an example, they noted the University of Cape Town course on Environmental Law for Non-Lawyers provided a space for multidisciplinary engagement with law – but to the best of their knowledge, there was no equivalent “Water Science for

Non-Scientists course'. Former or current employees of the Department of Water and Sanitation also highlighted several "challenges", including limited staff, frequently shifting regulatory priorities, or a lack of appreciation for the importance of water law.

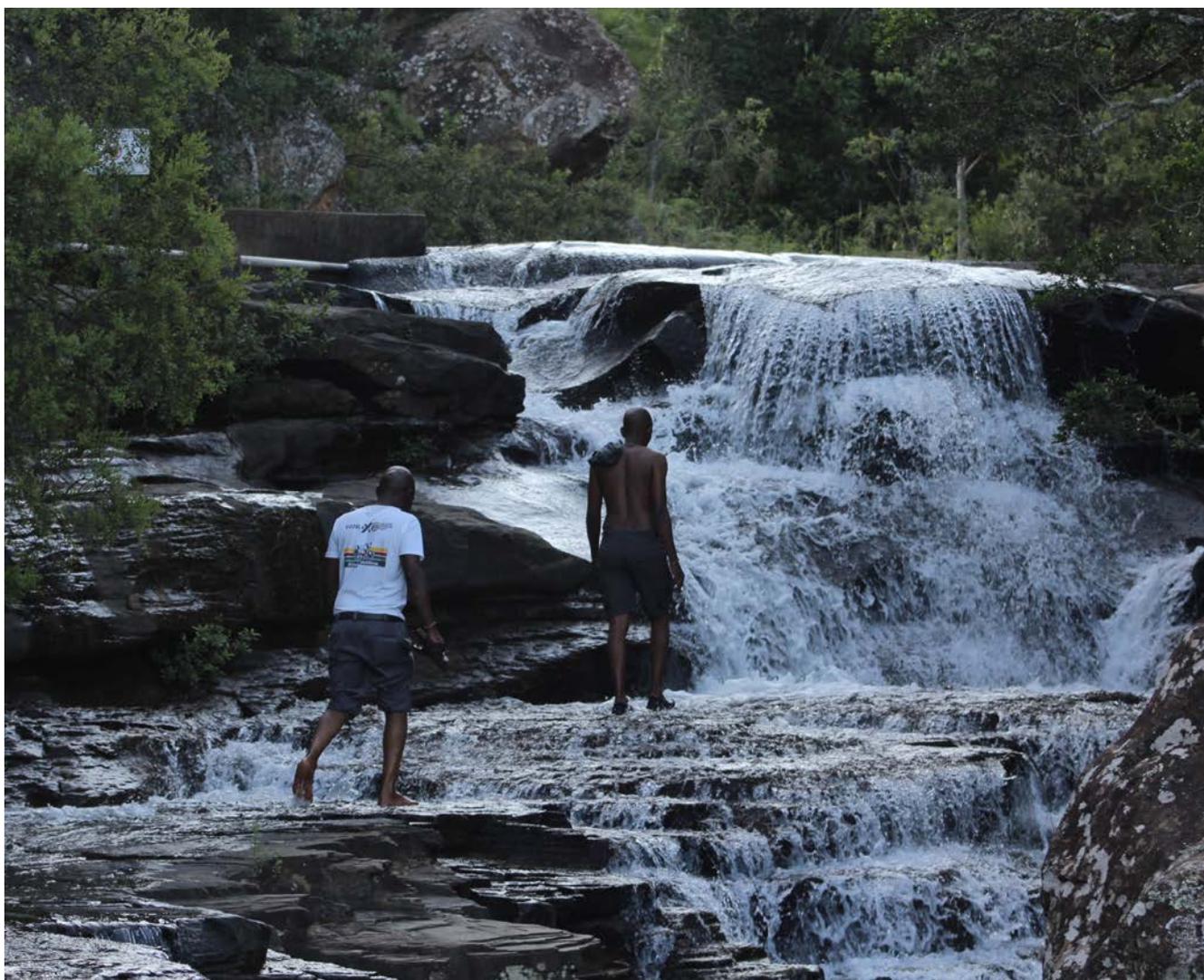
One official who took part in the research emphasised the importance of multi-disciplinary knowledge, noting that in addition to his LLB degree, he was also a registered professional engineer. At least one water department insider also raised concerns about leadership instability and low staff morale.

"So, our department has been controversial. Each and every five years we get something new," he told the researchers, "For me personally ... I wish we were in the Environmental Affairs (department). They have ministers for long, so why are we ... five years and then we change and then another person comes in - new outlook, new everything. I think if you talk to anyone on the ground, the morale is very low because this forever changes."

Another respondent noted that in terms of the National Water

Act, the Minister of Water Affairs was designated as the ultimate custodian of the nation's water resources "but actually has limited powers to intervene in water services delivery at local government level. And so we clearly ... have a huge crisis". A further complication was the degree of autonomy given to local government by the Constitution, creating legal confusion as to whether the provincial or national government should intervene in the event of failures at local government level. Another official voiced similar frustration, stating that there was often uncertainty about legal procedures to halt illegal sewage discharges from municipal wastewater treatment works.

Commenting on the quality and relevance of current academic training for future water sector stakeholders, the respondents reported mixed experiences about the state of water law training. "Some criticised university lecturers for lacking practical experience and scientific knowledge, but this criticism should be weighed against the argument that water law courses are not necessarily designed with the needs of all water law communities in mind."



Tony Carnie

*Visitors explore a stretch of clear water rapids in the Royal Natal National Park. Despite the increasing complexity of water law, a WRC study suggests that there are currently only two public universities that offer a specific water law course at a Master's level.*



*The Amphitheatre section of the uKhahlamba-Drakensberg World Heritage site is a strategic water source – areas of high rainfall that make up just 10% of the land area of South Africa but supply nearly 50% of the surface water.*

"I think that it is very hard to leave training purely to the academics," one of the respondents remarked. "Academics are incredibly important because they're thinking about these issues ... but I think it's really important to also get people in practise to contribute to training. ... So I think it's useful to have a mix because people in practise are often also quite focused and stretched and aren't necessarily thinking about the philosophical problems"

On a positive note, at least two academic programmes were singled out for praise – one a bridging law programme for scientists by former University of Cape Town Prof Loretta Feris as well as the LLM programme led by Prof Michael Kidd of the University of KwaZulu-Natal.

But there was less enthusiasm for some of the training courses provided in the government sector. "I wish there can be training more often," she said. "It is not just for the young ones that come in, but for us that's been there for some time. It does not mean we know everything. And I think this is why we also lose (court or enforcement) cases these days," suggested one official.

Several training courses for State officials were criticised as being too short or too infrequent. "You're cramming all the things when you come out there. You know you're just studying for that certificate because ... your supervisor wants that certificate. So you cannot ... have five-day courses. No, it doesn't work" lamented another official. "And really you don't always have

time to sit still with your team. ... There's always something happening. ... You don't have time to sit with new financial leads, new targets, you must move ... And I think it's the capacity issues in my section or in the department is really hampering us to understand matters because now you are tired, you must come home and you must read on this matter but you're tired, you have kids at home."

The WRC research authors acknowledge that water law expertise cannot be developed overnight, but is rather dependent on a combination of foundational training, workplace experience, further education, and informal learning. Nevertheless, they emphasise the need for more sophisticated training programmes for senior departmental officials and Environmental Management Inspectors (EMIs) to address their specific requirements.

One of the officials interviewed suggested that staff shortages, rather than inadequate training, was a major shortfall. Comparing his role to that of a firefighter, he said: "I go where it's burning."

He also lamented the fact that EMIs did not have time to follow-up on the enforcement action they initiated. "Why? Because I know we are few on the ground. So we don't have that time to follow up. ... I was glad that we could show that we have issued (directives). But where was the follow up? Why was it never escalated? ... I'm telling you, I feel like I'm just a firefighter".

EMIs and other enforcement officers faced further frustration when laying criminal charges at police stations or during subsequent legal proceedings. "The general sense across the board was that actors in the legal services community of practice (SA Police Services, prosecutors, lawyers and advocates) do not know enough about water law."

One of the WRC study respondents expressed frustration that when EMIs tried to open a docket at a police station: "They're going to tell us about crime, rape and stuff. They dunno what I'm talking about. [W]hen we had to go take the docket there, no they don't know what we're talking about."

Another respondent observed that specialist prosecutors had been "sort of riding on the wave of plea bargains and guilty pleas", with the result that when prosecutors were asked to actually present evidence in a trial where an accused does not plead guilty "they have a ton of problems".

Contrary to sentiments about becoming a water specialist through self-study and experience, others believe there is a clear need for more water-specific legal training at a foundation level. "Actually, we don't train water lawyers, we train lawyers and then somewhere down the line they learn to become water lawyers, which for me is ... maybe what's missing is actually a master's degree in water law or something of that nature - a specialisation in water law," a respondent suggested.

In response to this feedback, Field and her colleagues recommended that the Department of Water and Sanitation,

Department of Cooperative Governance and Traditional Affairs South African Local Government Association should collaborate on appointing a service provider to develop an inter-disciplinary, inclusive water services law offering for local government officials. They should also investigate and support the establishment of a multi-disciplinary training institute for water and explore the possibility of a collaborative online water law offering.

The report notes that there are currently two major private water law courses: The first offered by Carin Bosman Sustainable Solutions (CBSS) in co-operation with the Water Institute of Southern Africa (WISA), and the second presented under the auspices of the South African Institution of Civil Engineers.

Overall, however, the current water law training landscape in South Africa was characterized by limited offerings. "There are only two public academic institutions and two private providers that offer specific (master's) courses in water law."

"Opinions varied regarding the need for water law training within the legal services community, with a specific emphasis on training for prosecutors in criminal procedure and evidence rules. For water law administrators, the issue was seen as more related to political will and ethics than knowledge."

To download the WRC report, visit: <https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/3115%20final.pdf>



Tony Carnie

*A hiker takes a break near the base of the Tugela Falls in the Royal Natal National Park. To help protect the water emanating from these areas, WRC researchers have suggested the need for a new, multi-disciplinary training institute for water-related issues.*

## INVASIVE ALIEN SPECIES

### Alien species wreak havoc but select examples show promising solutions

Report paints a sobering picture of the extent and impact of invasive species in South Africa, but highlights examples of how we can gain ground. Article by Petro Kotzé.



Hartbeespoort Dam, or Harties, as it's known locally, is a dam that's become as famous for its triumphs as its troubles. The 2063-hectare reservoir bears the brunt of upstream pollution but, a solution to one of the most vexing consequences was recently highlighted as an example to others in *The Third National Status of Biological Invasives and their Management in South Africa* report, released this March.

The Hartbeespoort Dam, located in today's North West Province, was completed in the 1920s for irrigation purposes and is one of South Africa's largest man-made lakes. It lies in a poort in the Magaliesberg Range through which the Crocodile River cuts its course. Over the past century, Harties has fed irrigation, towns

and settlements and a lively tourism scene that includes plentiful watersports and golf courses plied along its waterline.

Sometime in the early 1900s, while the Union of South Africa was established, the country's involvement in the First World War momentarily waylaid the dam's construction, land was expropriated for the building site and communities relocated, another comparatively insignificant event took place. Water hyacinth (*Eichhornia crassipes*), a plant native to South America, entered South African shores. It was first [discovered in KwaZulu-Natal in 1910](#) and was then dispersed by gardeners, aquarium owners and boaters throughout the country's rivers, lakes, impoundments and wetlands. Beyond the grasp of its natural

predators, the plant flourished and eventually invaded South Africa's water sources far beyond the point of control.

Harties, in the meantime, became [part of a complex system](#) that integrates the activities in the catchment upstream, including urban areas, industries mining and agriculture. The dam is extremely polluted and, due to high levels of phosphates and nitrates, highly eutrophicated. It became fertile ground for the water hyacinth, which feed on the excess nutrients in the water. The alien plant was reported there in the [mid-sixties](#) and by 2017, regardless of various attempts at mitigation, nearly 60% of the dam was impacted by the dense impenetrable mats of the plants, affecting boating, fishing, watersport activities and aquatic biodiversity.

The 'super invasive species' is the world's worst aquatic weed, says Prof Julie Coetzee, Deputy Director of the Centre for Biological Control at Rhodes University. And, she adds, one that's very difficult to control.

However, it's only one of many invasive species that settled in South Africa.

### The state of biological invasives in South Africa

Speaking at the launch of the mentioned report, Minister of Forestry, Fisheries and the Environment, Barbara Creecy, said the findings paint a "sobering" picture. A multitude of invasive species have taken root in South Africa's ecosystems, altering native habitats, outcompeting indigenous species, and disrupting essential ecological processes to wreak havoc on our fragile ecosystems.

According to the report, there has been significant progress in collating a list of alien species in the country, with information, where available, on their distributions, impacts and management. To date, the list includes records of over 3 500 alien species present outside of captivity or cultivation in South Africa, at least a third of which are recorded as invasive.

They are increasing every year. The research reported that new alien species continue to arrive through several different pathways. Over the last decade (2013–2022), 32 new alien species were either illegally or accidentally introduced, a rate of approximately three introductions per year. This is slightly lower than the numbers seen for 2010 to 2019 which were an average of about four new species introduced per year.

These species have been introduced in various ways including as contaminants of nursery material, for horticulture, and through a tightly regulated process for classical biological control.

The invasive species are distributed across the country, with most broad-scale administrative units and biogeographical regions invaded by a variety of taxa. Most alien species are found in the Western Cape, Eastern Cape, and KwaZulu-Natal, and around major urban centres. This is likely because some species are commensal with humans, most were first introduced to urban centres, and because of greater sampling around urban areas (in particular, there has been a rapid, recent increase in observations from citizen scientist platforms such as [iNaturalist](#)). Robust and reliable monitoring systems that consistently track

the distribution and abundance of alien species across the country are, however, lacking. This means that the extent of invasions and the effectiveness of interventions cannot be assessed with a high degree of certainty.

Creecy pointed out the far-reaching consequences on South Africa's economy, agriculture, water resources and public health. Invasive species can devastate agricultural lands, leading to reduced crop yields and increased production costs. Additionally, some invasive species pose risks to human health by acting as carriers of diseases or causing allergic reactions. Eleven tree or shrub species, five fish species, two grass species and one invertebrate species have been assessed to cause 'major' or 'massive' negative impacts at a national level.

The adverse impact of invasive trees and freshwater fishes is particularly significant. Invasive trees reduce our water resources, degrade pasturelands, and exacerbate wildfires. Some alien plant species such as pine trees, for example, are highly flammable, whilst other species clog up our estuaries and watercourses that act as natural mitigation against flooding and cyclones. They can impair water quality and impact our ability to access clean drinking water. Alien freshwater fish reduce the diversity of our native fishes and other aquatic organisms.

### Soldiering on in the fights against invasive species

The Minister also pointed out that South Africa is recognised as a global leader in invasion science, with research as the foundation pillar of our work against biological invasions. We are one of a few countries to have an institute dedicated to researching, monitoring, and reporting on issues relating to the conservation and sustainable use of our biodiversity.

This pillar is led by SANBI, with key partners including the Department of Science and Innovation's National Research Foundation's Centre of Excellence for Invasion Biology at Stellenbosch University, as well as the Centre for Biological Control at Rhodes University (RU), which DFFE's Environmental Programmes Branch funds.

She also announced that the South African government invested over R 1.5 billion to address biological invasions between



Julie Coetzee

*The Hartbeespoort Dam in 2010. The dam is heavily polluted and impacted by cyanobacteria.*



The water hyacinth planthopper (*Megamelus scutellaris*) is the most recent agent to be released on water hyacinth invasions in South Africa.

2020–2022; targeting priority areas such as strategic water source areas, protected areas and biodiversity hotspots. It is, however, not enough.

One successful model that the report mentions can be replicated in other catchments and priority areas is the Greater Cape Town Water Fund. The fund is coordinated by the Nature Conservancy and is a partnership between national, provincial, and local government departments, corporate sponsors and NGOs. It raised over R180 million from the private sector to fund the control of invasive freshwater fishes and alien plants in the water catchments around Cape Town. The fund was based on research that found that clearing Cape Town's priority water catchments by removing invasive trees could generate annual water gains of 50 billion litres within five years (one-sixth of the city's current supply needs). These gains could double to 100 billion litres annually within 30 years. This approach was estimated to be significantly more cost-effective than other water augmentation solutions.

Another successful intervention highlighted is biological control, also reported as the most cost-effective and sustainable method for gaining control of alien plant invasions.

The report states that investment in biological control of invasive species has resulted in at least 17 species being brought under permanent control and the reduction of many other invasions. During 2020–2022, 48 biological control agents (released to control alien plants) were actively managed to increase their abundance or extent, either through mass rearing, re-release or distribution to new areas.

Six new biological control agents were released against five

invasive plant species during 2020–2022. This brings the total of biological control agents released against invasive plant species to 142, with 92 biological control agents established in the field on 66 invasive plant species.

One example is the weevil *Cyrtobagous salviniae*, a biocontrol agent that targets the alien aquatic plant *Salvinia molesta* (Kariba weed). It facilitated the [recovery of epilithic algae and aquatic macroinvertebrate communities](#).

Another is the release of the biological control agent *Megamelus scutellaris* at Hartbeespoort Dam. The tiny bug has resulted in a reduction in the cover of water hyacinth from over 37% to less than 6% over two consecutive years.

Authorities have over the years tried various measures, including biocontrol and herbicides, at Harties, but nothing could stave off the advance of water hyacinth over time. When the Department of Forestry, Fisheries and the Environment (DFFE) approached the Centre for Biological Control with a plea to improve the state of the dam in 2018, they decided on a different approach than before, Coetzee says.

### Getting to the heart of water hyacinth at Harties

The Hartbeespoort Dam is a difficult site to manage with biocontrol, Coetzee explains. In a classical case, the agents would be released at the site once, or maybe twice, which would usually clear the infestation. This approach works especially well in the tropics, she says, but at Harties, during the cold Highveld winters, the plants die back, as do the agents that they feed on them.

However, water hyacinth generates a huge seed bank that rests

A handful of influential historical studies have indicated the severe impacts of invasions on water resources, rangeland productivity and biodiversity. These studies showed that invasive trees use 3–5% of South Africa's surface water runoff each year. Invasive plants reduce the value of livestock production from natural rangelands by R 340 million per year and biological invasions are responsible for 25% of all biodiversity loss, placing them as the largest impact to South Africa's biodiversity after cultivation and land degradation. These negative impacts have not recently been reassessed, the report states, and workflows are required to improve the applicability and repeatability of the methods.

in the sediment, and each flower produces thousands of seeds every year. In spring, when the biocontrol agents have died off after the cold winter, the seeds germinate and start a new infestation.

This time, they decided to try an agent not released at Harties before. The water hyacinth planthopper (*Megamelus scutellaris*) is the most recent agent to be released on water hyacinth in South Africa. Adults are about 3 mm long, and they suck the sap out of hyacinth leaves and petioles, killing the plants. They live for up to 80 days, and the females lay many eggs in a lifetime.

The plan was to inundate the dam with them. Tens of thousands of insects were raised at the RU's Makhanda facilities and released as frequently as possible throughout 2019.

But by January 2020, residents phoned them to say that



*Biocontrol and hyacinth follow a seasonal cycle at Hartbeespoort Dam. During the cold Highveld winters, the plants die back, as do the agents that feed on them. In spring, when the biocontrol agents have died off, the seeds germinate and start a new infestation. By the end of March 2020, less than 5% of the water surface was impacted by hyacinth but the cycle of winter die-offs and spring regeneration continued. Researchers have since started releasing the agent in spring.*

somebody had illegally sprayed the dam with herbicide, potentially killing all the bugs. When they arrived to see the damage, they realised it was, however, the planthoppers at work. "Every single plant on the dam was brown and dying," Coetzee says. She says they not only saw huge patches of dying water hyacinth but also other healthy plants, that would usually be found there, growing from underneath. "Then we knew it was working."

By the end of March 2020, less than 5% of the water surface was impacted by hyacinth but the cycle of winter die-offs and spring regeneration continued. "Come springtime, the seeds regenerated, and the cycle repeated," Coetzee says.

They have since started releasing the agents in spring, as soon as the plants are seen to germinate. However, the RU does not have to go at it alone, anymore. Communities of people around the dam are now rearing and releasing insects. Funding to keep going is also privately raised. Coetzee explains that people even stay in touch via a WhatsApp group, for bugs to be released as soon as possible where necessary.

At the beginning of March, the percentage of the dam affected by hyacinth was down to 10% and, at the time of the interview three quarters through the month, Coetzee says it was at about 2.5%, going into winter.

They are hoping to launch a research project on changes to the hyacinth seed bank, soon. "We are hoping that the biocontrol agents are 'mopping up' the seeds because the plants are prevented from flowering," Coetzee says.

However, she adds that the biocontrol is merely a bandaid on the wound. To permanently get rid of the problem, the pollutions that enter the dam need to be improved.

This was echoed by Creecy. Addressing the challenges posed by biological invasions, she said, requires a coordinated and collaborative effort. "No single entity can tackle this issue alone." Governments, academics, civil society organisations and communities must come together, pooling their knowledge, resources, and expertise to develop effective prevention, early detection and control strategies.

To download *The Third National Status of Biological Invasives and their Management in South Africa*, Visit: <https://www.sanbi.org/wp-content/uploads/2024/03/Biological-invasions-Report-in-South-Africa-in-2022.pdf>

## OPINION

### What might the future hold for the water sector? (Spoiler: Climate change will likely turn the sector on its head)

*What does the future hold for the global water sector? Daily distractions can easily cause one to not reflect much on what may be coming over the horizon. So writes Dawid Bosman of the Trans-Caledon Tunnel Authority (TCTA).*



Hardly any sector or industry remains unchanged in the long run. The energy sector is in the midst of a widespread renewal due to the shift towards renewables, along with much greater private sector involvement, and a move towards decentralised generation. Abroad, we are seeing similar shifts in the water sector, with the adoption of non-conventional water resources. The expectation is that, soon, this will gain momentum locally as well. But there are credible indications that the water sector, globally and locally, will need to adapt and grow capacity to meet an even greater challenge in the medium term; a disruptive period for water is waiting in the wings.

Looking into the future is daunting, and not an exact science; usually, we must accept that nearly all forecasts will be wrong. A business school professor once said about forecasts: "Only

forecast if you must. But then, never give a date. If you are urged to give a date, then never give a number. And if you end up giving both a date and a number, make sure you never go back there." But forecast we must, or we could not plan. We can improve our forecasts by making better assumptions and following recognised trends, not fads or whims; so, we can hope to be less wrong than a complete thumb-suck, and with luck we may even anticipate some parts of what may come. With this in mind, let us venture a glimpse into the future of the water sector.

#### *Two challenges*

Two major challenges seem to stand out; the first is well-known and has been grappled with for at least two decades, mostly by multinational institutions: The world is running out of freshwater. The second challenge emerged more recently and has not been

debated as widely as the first, but holds every promise to turn the sector on its head: The large burden of adaptation to climate change that will fall to the water sector – and its limited ability to respond adequately.

### **Freshwater is running out**

Considering the first challenge: Global water scarcity was the subject of a comprehensive study in 2009 by the 2030 Water Resources Group, published as *Charting our water future*. It found that if global water productivity were to improve only at historical rates, and not accelerate, or new water be produced, then a 24% freshwater deficit would arise by 2030. Alas, current World Bank data shows that improvement in global water productivity, an indicator of economic production per quantum of freshwater drawn, has not shifted from its historical trajectory. The world is in a freshwater deficit, and this deficit is growing.

This aligns with more recent findings; in 2019 the UN Global Water Practice asserted that more than two thirds of the world's population already suffer severe water scarcity for at least one month of the year; nearly half of this population live in India and China. Earlier this year, on 20 March 2024, the United Nations (UN's) *World Water Development Report* was published, indicating that nearly half the global population does not have access to hygienic sanitation, and 2.2 billion people do not have a reliable supply of drinking water. These deficits have increased significantly over the past two decades, despite being targeted as one of the UN's sustainable development goals for 2030. Commenting on this, *The Guardian* wrote: "Little progress has been made on water issues in recent years as the climate crisis, pollution and overuse of freshwater resources in some areas have put further stress on water."

The global water sector remains compromised by widespread inefficiency in water management, largely the result of weak institutions and sub-economic pricing; this is exacerbated on the demand-side by too slow progress in improving water use efficiency in agriculture, industry and homes. We are of course not running out of planetary water, but we do have eight billion people surviving on a small fraction of one percent of planetary water that is accessible freshwater; this is now reaching its limits, and hence the need arises to make better use of what we have, and to inject additional freshwater, sourced from the sea and desalted.

Locally, the 2018 National Water and Sanitation Master Plan indicates that South Africa has been in a water deficit for some time, even though we are in a better position than most nations. Sensibly, the Master Plan proposes closing the gap mainly by using less (i.e., demand management), wasting less (improved conservation), and tapping into 'new' water (non-conventional water, such as desalination and reuse). This approach of addressing both the demand and supply side, and of diversifying the water resource portfolio, is seen in other countries as well.

There is comfort in the knowledge that, where and when it becomes necessary, the technology and know-how exist to produce any amount of freshwater anywhere on the planet, at a predictable price; one need only look to a city like Riyadh in Saudi Arabia to see it being done.

Addressing the scarcity challenge will require stronger institutions, the widespread adoption of economic pricing and new business models, a much greater role for the private sector, and managing water within a new paradigm. There is anticipation of a landmark report by the Global Commission on the Economics of Water, due in September 2024, to guide on these issues. The growing freshwater shortage is bringing the longstanding shortcomings of the sector into renewed focus, but real reform appears to be slow. However, the second great challenge may well create the necessary conditions and urgency to mobilise such reform.

### **Dealing with climate change**

The second challenge relates to how the water sector will need to deal with a changing climate.

There are of course two broad areas for climate change action: First, **mitigation** of the causal effects behind climate change, which involves mainly the reduction of Greenhouse Gas (GHG) emissions in all human activity, and the preservation of carbon sinks, such as the tropical rain forests, in an effort to contain the effects of climate change. Then there is also **adaptation** to climate change, whereby all of humanity will be compelled to adapt how we live and where we live, according to the demands of a changing climate.

It is generally agreed that there is only a limited scope for the global water sector to **mitigate** climate change; Global Water Intelligence (GWI) estimates that only around 2% of global GHG emissions stem from the pumping and treatment of water, and the management of run-off and sludge. Much of this will be mitigated in any event when the energy sector transitions to renewable energy.

However, climate change mitigation across all other economic sectors is not happening fast enough. Despite the efforts by some 200 countries to decarbonise their economies, it now seems that the target set by the Potsdam Institute, of limiting global average temperature increase to no more than 1.5 °C relative to the pre-industrial level, is slipping out of reach. The European Union's (EU's) Copernicus Climate Change Service reports that 2023 was the hottest year on record, at 1.48 degrees warmer than the pre-industrial level. Mitigation of climate change is proving to be a very hard thing to do.

An implication of warming beyond this threshold is that the effects of climate change will likely be much worse than previously expected. Speaking of his impressions emanating from the May 2023 Global Water Summit in Berlin, where Christiana Figueres (negotiator of the Paris Accord on climate change) and Johan Rockström of the Potsdam Institute shared their research on post-1.5°C impacts, the GWI publisher Christopher Gasson says: "Together, they took us to the edge of the known world of international emissions agreements, and gave us a glimpse of the abject terror that lies beyond. It is a world in which the unpredictability of the water cycle comes to dominate our lives".

Already, we are seeing how climate change is leaving its harrowing mark on a planetary scale. With increasing regularity, newsfeeds report of climate-related disasters; even well-resourced countries with modern infrastructure are not spared

the trauma of lethal wildfires, cyclones and heatwaves. What happened in California, Hawaii, Chile, East Africa, Europe, Mexico, Ghana, Argentina, India, Libya, Canada, Myanmar and many others, all in 2023, is surely exceptional. The human and economic toll is grim: Reliefweb estimates that in 2023, at least 12 000 people died in floods, wildfires, cyclones, storms, and landslides, which is 30% more than in 2022. This excludes the much larger number of deaths caused by climate change-related droughts and heatwaves, which is more difficult to attribute and capture.

Floods are particularly dramatic and costly. In his 2021 biography on water, Giulio Boccaletti describes how “atmospheric rivers” are created to convey vast amounts of moisture from the tropics to the midlatitudes. These are tracked by microwave satellites and can be hundreds of kilometres wide and thousands of kilometres long and carry the same amount of water as a major river. The moisture released from these ‘rivers’ can be devastating, overwhelming even highly engineered catchment areas; where there is little flood protection, the impact is usually much worse.

There is now broad agreement that global warming is associated with more frequent and more severe weather anomalies. This

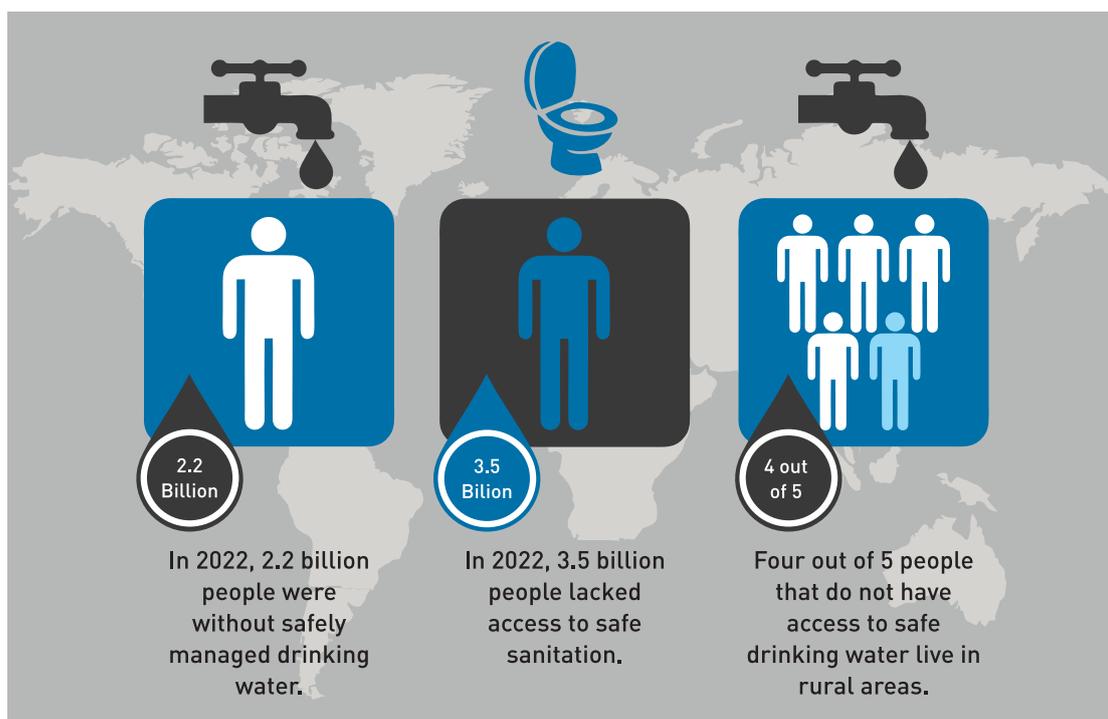
will require adaptation to minimise its impact on lives and livelihoods, which could be in the form of coastal barriers, flood protection through grey and green infrastructure, climate resilient water and sanitation systems, dedicated water infrastructure to combat wildfires, and much more. A recent white paper by GWI, *Investing in a water-secure future*, indicates that 70 to 80% of climate adaptation spending could go towards water management.

“Whatever the cost of climate change mitigation, the cost of climate change adaptation will be at least ten times more, and 70% of it will fall on the water cycle. Our industry is simply not ready to carry that kind of burden,” says Gasson. He also anticipates that vast capital flows will come into the water sector from climate funding. This will rapidly reverse the traditional dynamic in water investment, of demand exceeding supply and late-cycle expenditure, as vast amounts of climate change funding start pursuing water projects, in a quest to improve resilience.

However, the water sectors in most countries are far from ready to be absorbing such a step up in investment, and generally has a limited capacity for converting funding into meaningful and



*It is estimated that at least 12 000 people died in floods, wildfires, cyclones, storms, and landslides in 2023, 30% more than in 2022.*



productive projects. Long suffering from under-investment, the water sector might well be traumatised by what it had been yearning for.

#### Reflection

There are also some grounds for optimism, though. Gasson reminds us that climate comes in the form of wind, heat and water; in excess or scarcity, each has the potential to unsettle our fragile existence. Whereas human ingenuity has yet to find scalable solutions for managing wind and heat (notwithstanding the small-scale cooling of our homes and offices), we have mastered the ability to produce virtually unlimited amounts of water from the sea, and we now have the energy sources to do this with minimal environmental impact. A vast supply of water will enable us to do at least two important things in adaptation

to climate change; there may be many more.

One, would be to secure both our water supply and livelihoods against droughts and floods; this would require a fundamental rethink of how we manage catchment areas and water security, with a much greater reliance on non-conventional water resources. Quite likely, surface water infrastructure would increasingly have a role to contain floods. And two, would be to create more green infrastructure, combat desertification and increase the planetary biomass, which would also serve as a carbon sink.

But for now, at least, our mastery of the production of water is perhaps our best tool in the adaptation to an increasingly hostile climate.

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# THE LESOTHO HIGHLANDS WATER PROJECT TUNNELS



*Water flowing from the Ash River outfall near Clarens, in the Free State.*

TCTA



*Inside the transfer tunnel system.*

The Lesotho Highlands Water Project tunnels have been in the spotlight recently due to the maintenance work due to take place on the tunnel.

The tunnel system is to be shut from 1 October to 31 March next year. This has been prompted by the need for extensive maintenance and repair works in the tunnels to ensure optimal water supply. The tunnels form part of the Lesotho Highlands Water Project, the largest water transfer infrastructure in Africa.

Originally constructed between 1988 and 1996, the 45-km long transfer tunnel takes water from Katse Dam, through the Maluti mountains, to the Muela hydropower station. A delivery tunnel then takes the water from the tailrace of the power station north into South Africa. The 4.5 m diameter delivery tunnel is



*One of four tunnel boring machines used to excavate the tunnels.*

Wikipedia Commons

38 km long in total, the southern section in Lesotho being 16 km (known as Delivery Tunnel south) and the northern section in South Africa being 22 km (known as Delivery Tunnel north).

The route of the water transfer tunnel passes through basaltic flows of volcanic rock. The area also includes some blocky conditions along faults and within doleritic dykes. The south delivery tunnel passes through sedimentary rock, including the Clarens formation. This formation consists of horizontally layered siltstone and sandstone with occasional doleritic dykes and layers of claystone. The full length of the transfer tunnel is lined with 300 mm-thick concrete. The transfer tunnel intake is located a kilometre upstream of the Malibatso Bridge, some 80 km north of the Katse Dam wall.

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