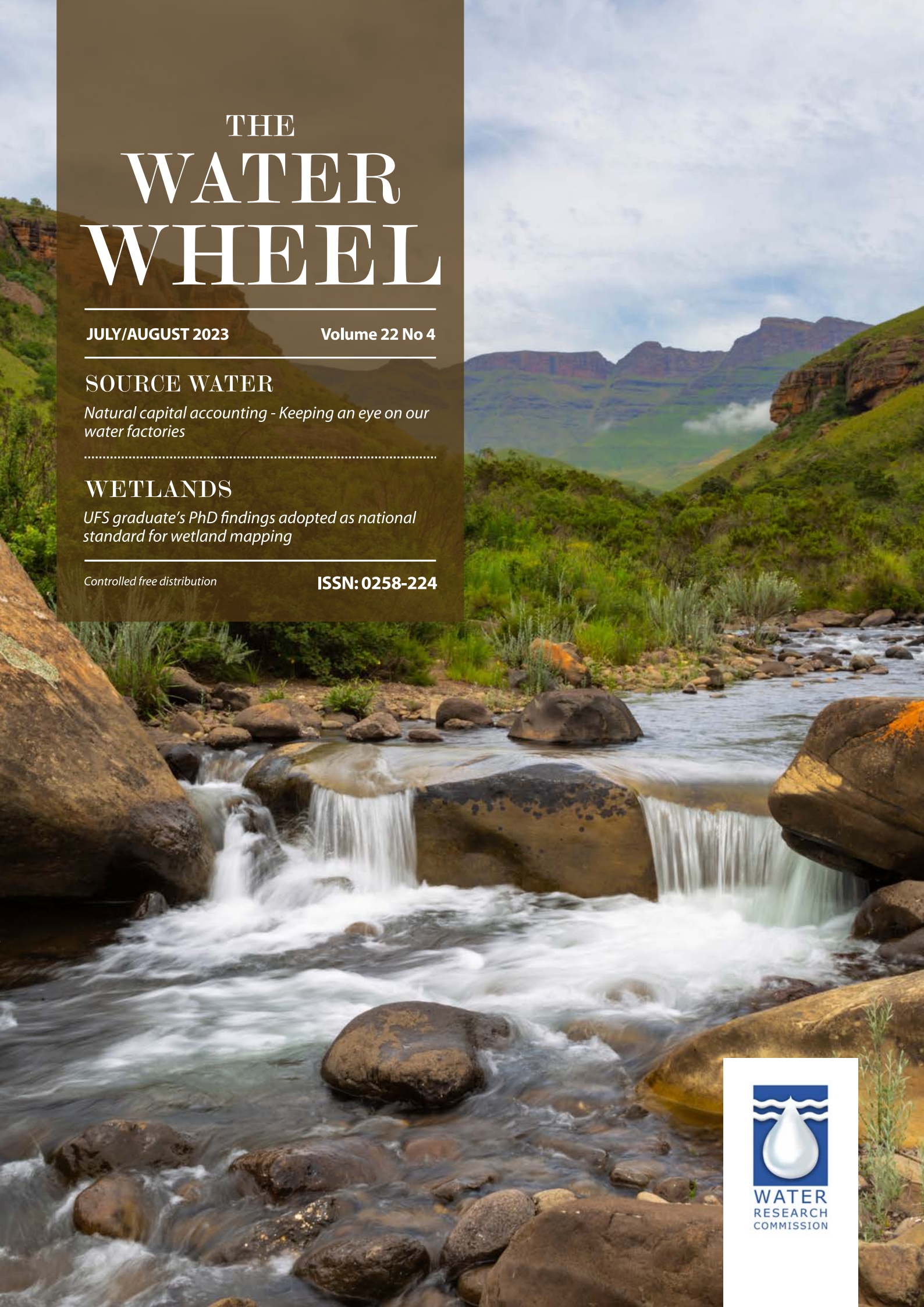

THE WATER WHEEL

JULY/AUGUST 2023 Volume 22 No 4

SOURCE WATER

Natural capital accounting - Keeping an eye on our water factories

WETLANDS

UFS graduate's PhD findings adopted as national standard for wetland mapping

Controlled free distribution

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WATER RESEARCH COMMISSION

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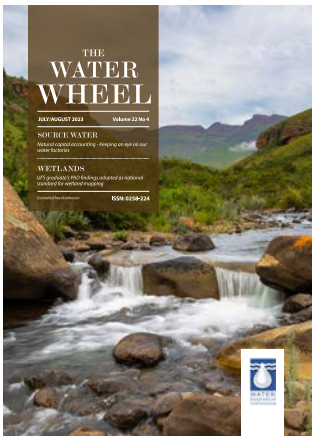

The Water Wheel reports on the outcomes of a recently published natural capital accounting report on South Africa's water source areas. *See article on page 10.*

NEWS

Two KZN water boards merging

KwaZulu-Natal's two water boards, Umgeni and Mhlatuze Water have merged to form one water entity. According to the Department of Water and Sanitation, this is to accelerate the provision of bulk water in the province.

Mhlathuze Water was disestablished on 30 June 2023 and was merged with Umgeni Water, with all its staff, assets and liabilities to be transferred to Umgeni, by 1 July 2023, in terms of Section 46 of the Water Services Act, 1997 (Act No. 108 of 1997). The new water entity is known as uMngeni – uThukela Water.

An advert has since been published with an aim of getting public nominations for members who will be appointed to serve on the uMngeni – uThukela Water Board for a period of four years. The Board members will be mandated to provide an oversight role as non-executive members of the uMngeni – uThukela Water Board and to support the executive management to deliver value-added services and business confidence in discharging their roles and responsibilities commensurable to a leading bulk water services utility in South Africa. An interim Board of Umgeni Water will oversee the governance of uMngeni – uThukela Water until a new Board is appointed.

Mhlathuze Water was established in 1980 and predominantly operated in the uMkhanyakude, King Cetshwayo and Zululand District Municipalities. The reconfiguration comes amid plans by the DWS to have a single water entity operating in each province.

Minister Senzo Mchunu has wished the outgoing Mhlathuze interim Board well and looks forward to working with the new Board members who will be appointed. "Our expectations are quite high. We are looking for people who will want to contribute their knowledge and expertise in the sector, and not just want to improve their pockets. I will not hesitate to shut anyone out who has no intention of working to improve the provision of water in the province, and ultimately, the whole country," he said.

SU marine biologists scoop top awards at aquatic science conference

Two Stellenbosch University (SU) students walked away with the best oral presentation and the best poster awards at the recent annual congress of the Southern African Society for Aquatic Scientists (SASAqS).

PhD student Katie Watson's presentation on the restoration of seagrass meadows at Langebaan earned her the best presentation award, while Bianca Boshoff's poster on the role of seagrass meadows in the accumulation of microplastics in the Knysna Estuary earned her the best poster award. Both are postgraduate students in the research group of Prof Sophie von der Heyden in the Department of Botany and Zoology at SU. And both are conducting their research as part of Project SeaStore, a multidisciplinary effort to potentially restore degraded and endangered seagrass meadows along South Africa's coastline.

Watson's research explores the restoration potential of the seagrass species ***Zostera capensis***, using seagrass meadows in Langebaan Lagoon as a starting point. Preliminary results indicate that differences in the subsites had a more significant impact on the survival and persistence of the transplanted seagrass than planting arrangement or transplant material. Her findings have important implications for our understanding of the colonisation potential of ***Z. capensis*** and will help to optimise transplantation efforts.

For her postgraduate studies, Boshoff wants to determine whether seagrass meadows serve as filters of microplastics from the surrounding environment, as well as potential reservoirs or sinks of microplastics. She has already co-authored a research article based on results from her BSc Honours project, titled 'The role of seagrass meadows in the accumulation of microplastics: insights from a South African estuary' published in the journal ***Marine Pollution Bulletin***, and is now in the final year of her MSc studies.

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Innovative hydroponic solution offers more crops with less resources

A locally developed hydroponic solution is going a long way to increase the productivity of South African farmers while overcoming challenges such as loadshedding.

The system is the brainchild of mechanical engineers, Mogale Maleka and Tumelo Pule (both 30 years old), through their company, AB Farms, which was established in 2017. The pair and their hydroponic system are already making waves and earning accolades. The go-getters clinched the runners-up spot in the Innovation Hub's Gauteng Accelerator Programme awards earlier this year.

Hydroponics involves growing plants without soil. Unlike other hydroponic systems the AB Farms system does not require a continuous flow of water. The system allows plants to have uninterrupted access to nutrient rich water even in times of loadshedding or pump failure. The system can produce a variety of leafy green crops such as lettuce, Swiss chard, strawberries and herbs. Since it is modular the system can be scaled to service households, emerging farmers and commercial farmers.

"The system enables farmers to increase crop production while using up to ten times less land, up to 50% less electricity and up to 90% less water," note the duo.

During the early stages of prototyping AB Farms was assisted by the Water Research Commission (WRC) through its Water Technologies Demonstration Programme (WADER), which assisted with the setting up of a demonstration site at the Westonaria Agri-park. The Gauteng Department of Agriculture, Rural Development and Environment has since come on board to support the development of the innovation through the provision of land, water, electricity and farming inputs, among others. A hydroponic research project is also being funded in Gauteng with the assistance of the WRC Water Utilisation in Agriculture business unit and the Agricultural Research Council.

The company has also installed systems in KwaZulu-Natal and the Western Cape. A household system was also installed in Botswana. Earlier this year AB Farms installed its biggest hydroponic system of 6 000 units in Giyani, in Limpopo, as part of the Giyani Local Scale Climate Change Resilience Programme, an initiative of the WRC and the Government of Flanders.

AB Farms founders Mogale Maleka and Tumelo Pule.

The hydroponic solution enables farmers to increase crop production while saving land, electricity and water.

WATER DIARY

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

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

Ecological restoration
26-30 September
The 10th World Conference on Ecological Restoration will be held in Darwin, Australia. It is expected that the conference will focus on the important, and often neglected, connection between culture and nature, including the role of restoration in enhancing and rebuilding that connection.
Visit: https://ser2023.org

Non-sewered sanitation
10-15 October
The first IWA Non-sewered Sanitation (NSS) conference will be held in Johannesburg. The event, which is being held in partnership with the Water Research Commission, aims to provide stimulus for research an innovation for NSS and off-grid sanitation solutions including faecal sludge management, build the technical and scientific base for NSS and to contribute to scientific knowledge and good practice learnings.
Visit: https://iwa-network.org/events/the-1st-iwa-non-sewered-sanitation/

Wetlands
23-26 October
The annual National Wetlands Indaba will be held in the North-West Province. The theme for this year's indaba is 'It's time for wetland restoration'.
Visit: https://nwi26.org

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GLOBAL

Women and girls still bear brunt of water and sanitation crisis – report

Women and girls are responsible for fetching water in 7 out of 10 households without house or yard connections, according to first in-depth analysis of gender inequalities in drinking water, sanitation, and hygiene (WASH) in households.

Globally, women are most likely to be responsible for fetching water for households, while girls are nearly twice as likely as boys to bear the responsibility, and spend more time doing it each day, according to a new report released in July by UNICEF and WHO. The report, ***Progress on household drinking water, sanitation and hygiene (WASH) 2000-2022: Special focus on gende***r – which provides the first in-depth analysis of gender inequalities in WASH – also notes that women and girls are more likely to feel unsafe using a toilet outside of the home and disproportionately feel the impact of lack of hygiene.

"Every step a girl takes to collect water is a step away from learning, play, and safety," said Cecilia Sharp, UNICEF Director of WASH and CEED. "Unsafe water, toilets, and handwashing at home robs girls of their potential, compromises their well-being, and perpetuates cycles of poverty. Responding to girls' needs in the design and implementation of WASH programmes is critical to reaching universal access to water and sanitation and achieving gender equality and empowerment."

According to the report, globally, 1.8 billion people live in households without water supplies on the premises. The report also shows that more than half a billion people still share sanitation facilities with other households, compromising women's and girls' privacy, dignity, and safety. For example, recent surveys from 22 countries show that among households with shared toilets, women and girls are more likely than men and boys to feel unsafe walking alone at night and face sexual harassment and other safety risks.

Furthermore, inadequate WASH services increase health risks for women and girls and limit their ability to safely and privately manage their periods. Among 51 countries with available data, women and adolescent girls in the poorest households and those with disabilities are the most likely to lack a private place to wash and change.

"The latest data from WHO shows a stark reality: 1.4 million lives are lost each year due to inadequate water, sanitation and hygiene," said Dr Maria Neira, WHO Director, Environment, Climate Change and Health Department. "Women and girls not only face WASH-related infectious diseases, like diarrhoea and acute respiratory infections, they face additional health risks because they are vulnerable to harassment, violence, and injury when they have to go outside the home to haul water or just to use the toilet."

The report notes some progress towards achieving universal access to WASH. Between 2015 and 2022, household access to safely managed drinking water increased from 69 to 73%; safely managed sanitation increased from 49 to 57%; and basic hygiene services increased from 67 to 75%.

But achieving the Sustainable Development Goal target for universal access to safely managed drinking water, sanitation, and basic hygiene services by 2030 will require a six-fold increase in current rates of progress for safely managed drinking water, a five-fold increase for safely managed sanitation, and a three-fold increase for basic hygiene services.

Further efforts are needed to ensure that progress on WASH contributes towards gender equality, including integrated gender considerations in WASH programmes and policies and disaggregated data collection and analysis, to inform targeted interventions that address the specific needs of women and girls and other vulnerable groups.

To access the report
Visit: https://bit.ly/43qfCQV

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World Meteorological Organization declares onset of El Niño conditions

El Niño conditions have developed in the tropical Pacific for the first time in seven years, setting the stage for a likely surge in global temperatures and disruptive weather and climate patterns.

The World Meteorological Organization (WMO) forecasts that there is a 90% probability of the El Niño event continuing during the second half of 2023. It is expected to be at least of moderate strength. The WMO Update combines forecasts and expert guidance from around the world.

"The onset of El Niño will greatly increase the likelihood of breaking temperature records and triggering more extreme heat in many parts of the world and in the ocean," said WMO Secretary-General Prof Petteri Taalas.

"The declaration of an El Niño by WMO is the signal to governments around the world to mobilise preparations to limit the impacts on our health, our ecosystems and our economies," he said. "Early warnings and anticipatory action of extreme weather events associated with this major climate phenomenon are vital to save lives and livelihoods."

El Niño occurs, on average, every two to seven years, and episodes typically last nine to 12 months. It is a naturally occurring climate pattern associated with warming of the ocean surface temperatures in the central and eastern tropical Pacific Ocean. But it takes place in the context of a climate changed by human activities. In anticipation of the El Niño event, a WMO report released in May predicted that there is a 98% likelihood that at least one of next five years, and the five-year period as a whole, will be warmest on record, beating the record set in 2016 when there was an exceptionally strong El Niño.

Improving WASH access can save 1.4 million lives, says WHO

Half of the world's population still does not have adequate access to safe drinking water, sanitation and hygiene (WASH) which could have prevented at least 1.4 million deaths and 74 million disability-adjusted life years in 2019, according to the latest report by the World Health Organization (WHO) and an accompanying article published in ***The Lancet***.

"With growing WASH-related health risks seen already today through conflicts, the emergence of antimicrobial resistance, the re-emergence of cholera hotspots, and the long-term threats from climate change, the imperative to invest is stronger than ever" said Dr Maria Neira, Director, WHO Department of Environment, Climate Change and Health. "We have seen improvements in WASH service levels over the last 10 years, but progress is uneven and insufficient."

The report, ***Burden of disease attributable to unsafe drinking water, sanitation, and hygiene: 2019 update***, presents estimates of the burden of disease attributable to unsafe drinking water, sanitation and hygiene for 183 WHO Member States disaggregated by region, age and sex for the year 2019. The estimates are based on four health outcomes – diarrhoea, acute respiratory infections, undernutrition, and soil-transmitted helminthiases. Diarrhoeal disease accounted for most of the attributable burden, with over one million deaths and 55 million DALYs. The second largest contributor was acute respiratory infections frominadequate hand hygiene, which was linked to 356 000 deaths and 17 million DALYs. (The disability-adjusted life year or DALY is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death).

Among children under five, unsafe WASH was responsible for 395 000 deaths and 37 million DALYs, representing 7.6% of all deaths and 7.5% of all DALYs in this age group. This included 273 000 deaths from diarrhoea and 112 000 deaths from acute respiratory infections. These diseases are the top two infectious causes of death for children under five globally.

Important disparities were noted between regions and income groups. More than three-quarters of all WASH-attributable deaths occurred in the WHO African and South-East Asia regions, while 89% of attributable deaths were from low- and lower-middle income countries. However, even high-income countries are at risk, as 18% of their diarrhoeal disease burden could be prevented through improved hand hygiene practices.

To access the report,
Visit: https://bit.ly/3PTSjfk

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NEW WRC REPORTS

[Sustainable urban drainage systems]

Guidelines for permeable interlocking concrete pavements (PICP) in South Africa

Rapid urbanisation since the beginning of industrialisation has resulted in substantial increases in the proportion of impervious land cover. This, in turn, has increased urban stormwater runoff flow rates and volumes whilst, simultaneously, reducing the groundwater recharge and water quality. Most stormwater systems in South Africa were designed to rapidly convey runoff to the nearest surface water bodies through concrete channels and pipes. This approach is increasingly degrading the state of the water bodies by erosion of natural channels and pollution of downstream receiving waters, while increasing the risk of downstream property damage. Since 1990, there has been a shift towards the use of Sustainable Drainage Systems (SuDS). Permeable Pavement Systems (PPS) are SuDS source control options that manage onsite runoff. They are designed and constructed with permeable surfaces laid on top of open-graded or single-sized aggregate sublayers that infiltrate and temporarily store the water before releasing it for groundwater recharge and/or attenuated downstream flow peaks. They can even be potentially used for rainwater harvesting. However, installations of PICP at South African sites have reported that many were clogged or nearly clogged. The aim of this Water Research Commission (WRC)-funded study was to provide evidence-based data to determine how PICP clogs and consequently what might be done about it. Volume one looks at clogging in PICP while Volume 2 provides guidelines for the design, construction and maintenance of PICP in South Africa.

Link for Volume 1 (WRC Report no. TT 913/1/23): https://bit.ly/44kjkgj
Link for Volume 2 (WRC Report no. TT 913/2/23): https://bit.ly/3pBJDjc

[Water governance]

Sustainable management of water use and water resources: The impact of approaches to restore trust in the government (EnTruGo)

The possibilities for governments to design and implement sustainable water systems is largely dependent on whether government institutions are viewed as trusted and legitimate by affected stakeholders and the wider public. In recent decades, trust in government has declined, with public mistrust provoked by failures of governments to enact their duty towards citizens, lack of transparency and accountability of state institutions, and proliferation of knowledge controversies among competing stakeholders. In several countries, the current situation results in dissatisfaction towards the functioning of governments which, in turn, affects the government's ability to innovate and deliver on sustainability goals for water management. This research formed part of a larger Joint Programming Initiative (Water)-funded research project that brought together researchers from several countries to explore the role of trust in water governance. More specifically, the project set out to enrich the theoretical understanding of public trust and how it relates to interpersonal trust that can be promoted through participatory innovations in different governance contexts. This report synthesises the key findings from the research that was undertaken in South Africa which was funded by the Water Research Commission.

WRC Report no. 3073/1/23
Web link: https://bit.ly/3XPrx9R

[Water quality]

Investigation of the occurrence and risk of infection of pathogenic and antibiotic resistant Campylobacter species in selected source waters within the Kowie catchment, Eastern Cape, South Africa

Locally in South Africa, the annual prevalence of Campylobacter has remained steady since 2010 without declining. In fact, it has been suspected that Campylobacter infection could be endemic in the region. Despite these, the disease has not received much research attention compared to other gastroenteritis infections, such as Shigella and Salmonella. But worldwide, Campylobacter species are increasingly being recognised as leading agents of gastroenteritis that needs to be monitored. Surface water is continually implicated in the spreading of the bacteria in humans, including the antibiotic resistant ones. Direct contact and consumption of faecal contaminated water are principal risk factors for Campylobacteriosis. South Africa is a water-scarce country that relies heavily on surface water resources for irrigation, domestic, recreational and industrial purposes. One continuing problem is an incapacity to precisely predict and identify potential for an outbreak and identify source of spread. This study explores this surveillance gap using both culture-dependent and culture-independent approaches (molecular-based approaches). The result from this study suggests the level of occurrence of Campylobacter and presence of antibiotic resistance genes in the river system presents public health concern. Livestock grazing around the river are the most bacterial pollution contributor to the Bloukrans River. The outcome of this study suggests that potential transmission of pathogenic strains from the river to humans may occur through direct or indirect contact. Relying on culture-based approaches for surveillance may underestimate Campylobacter prevalence. A metagenomic approach to evaluating water samples is more efficient and can be useful for source tracking and the surveillance of pathogens such as Campylobacter spp, as well as for monitoring virulence factors and antibiotic resistance genes. Therefore, this approach should be pursued.

WRC report no. 2886/1/23
Web link: https://bit.ly/43ihKKM

[Climate change]

Climate change and water security: Developmental perspectives for water-linked sectors in a future climate for Africa

The changes in climatic variables such as precipitation and temperature and their associated extremes due to increased global warming from anthropogenic greenhouse gases emission

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are anticipated to increase in frequency, duration, severity and intensity. Characteristics such as heavy storms, prolonged heat waves as well as the rising sea level will have significant impacts on the natural environment and human-made infrastructure, particularly in most parts of Africa, due to low adaptive capacity, among other factors. The impacts are likely to add pressure on the already stressed water resources for agriculture, industry and households, consequently, resulting in a significant impact on local populations, as well as exacerbating individual- and community-level hardship. This project was jointly contracted to the South African Weather Service (SAWS) and the Kenya Water Institute (KEWI), in collaboration with other South African institution that includes the Central University of Technology (CUT) and Kenyan institutions that include Kenya Meteorological Department, Kenya Water Institute and Maasai Mara University. The project aimed to conduct a comparative analysis of climate change impacts on future development and economic growth for priority water-linked sectors in the Limpopo River Basin (LRB), South Africa, and the Mau Forest Catchment Basin (MFCB), Kenya. In addition, the project aimed to develop a framework that will guide developmental perspectives for water-linked sectors in South Africa and Kenya under a changing climate.

WRC report no. 3068/1/23
Web link: https://bit.ly/44h4Q0X

[Policy brief]

Operationalising hybrid water law for historical justice

Promoting equitable access to water and redressing the results of past discrimination are key considerations of the 1998 National Water Act (NWA), in line with South Africa's Constitution. However, despite the legislation containing the necessary legal tools to achieve these stated goals, it has not yet made a substantial impact in delivering redress for past injustices in the allocation of water resources. A study funded by the WRC explored the legal tools available to implement the hierarchy of water allocation priorities in the National Water Resource Strategy to redress past injustices in access to water resources.

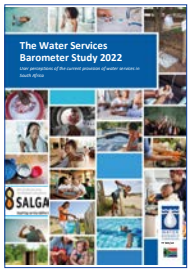
Link to policy brief: https://bit.ly/3NOwyuG
Link to WRC report no. 3040/1/22: https://bit.ly/3Cy6SNT

[Industrial effluent]

The pulp and paper wastewater biorefinery – Potential for concomitant value recovery and wastewater treatment

The need to utilise the world's natural resources more efficiently is increasingly recognised as critical for enhanced sustainability and ability to function within the envelop of the earth's resources. Resource efficiency requires the maximum use of available resources for products of social and economic value whilst minimising un-used resources, undesirable by-products, and waste, and thereby the associated environmental burden requiring assimilation. A key feature of this resource and product orientation in water-scarce South Africa includes the minimising of the water footprint and maximising of its repurposing, including water recycle, reuse and return to the environment at appropriate quality, as well as beneficiation of the contaminants carried in wastewater. This project evaluated the wastewater biorefinery (developed in previous WRC-funded projects) as a vehicle to convert wastewater streams in the pulp and paper sector into resources of organic carbon, nitrogen, phosphorous, energy and water, thereby enhancing resource recovery and reducing waste assimilation burden, while ensuring maximum potential for re-purposing of fit-for-purpose water.

WRC report no. TT 897/22
Web link: https://bit.ly/46Calc5



[Drinking water]

The water services barometer study 2022 – User perceptions of the current provision of water services in South Africa

In 2011 and 2015, the WRC, in collaboration with the South African Local Government Association (SALGA), undertook national surveys to establish users' perceptions of the current provision of water services in South African municipalities. After a gap of seven years, the 2022 study was initiated. It afforded the opportunity to track consumer perceptions as they developed over the ten years since 2011. In addition, it gained insights from questions about service quality. Lastly, it established a national baseline for customer satisfaction with water and sanitation services and the tariffs that municipalities charge for these services. The 2022 perception study confirmed the 2015 finding that consumers' area of residence and living standard (according to the Living Standard Measure [LSM]) have the biggest impact on consumer perceptions of water and sanitation services:

1. Consumers living in Metros are more satisfied with their municipality's water and sanitation services than consumers in other urban areas.
2. Consumers living in Metros perceive they get safer tap water, less interruptions and better water and sanitation services than consumers in other urban areas.
3. Consumers living in Metros also have more confidence than consumers in other urban areas in the effectiveness of their municipalities to manage Free Basic Water, and deal with a water crisis, non-payers, illegal connections, and corruption.

WRC report no. TT 909/22
Web link: https://bit.ly/3O8bZuA

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hendrickm@wrc.org.za or visit: www.wrc.org.za

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SOURCE WATER

Natural capital accounting – Keeping an eye on our water factories

South Africa's strategic water source areas recently came under the spotlight in a natural capital accounting report. The Water Wheel summarises some of the findings.
Article by Jorisna Bonthuys.

Angus Burns/WWF-SA

South Africa, a semi-arid country with limited water sources, is experiencing increased water stress due to factors such as rising demand, pollution, climate change, and inadequate maintenance and investment in water and sanitation infrastructure. Measures must be taken to address these and other issues related to our strategic water source areas to ensure future access to clean and safe water, says Aimee Ginsburg, an ecologist and the natural capital accounting project manager at the South African National Biodiversity Institute (SANBI).

"It is crucial to recognise that what happens in our strategic water source areas significantly impacts the water quality and quantity downstream," Ginsburg says.

Given the climate crisis and the risk of an El Niño event this coming summer, these water source areas are of considerable value, especially those that are still functioning optimally and have not been modified by intensive land use or unsustainable practices. (El Niño is associated with increased temperatures and low rainfall in southern Africa.)

"These areas are national ecological infrastructure assets that must be protected, maintained, and restored," Ginsburg says. (This type of infrastructure comprises naturally functioning ecosystems that provide valuable services and benefits to man.)

Strategic water source areas for surface water make up 10% of the total land area of South Africa. Lesotho and Eswatini and provide 50% of the combined mean annual run-off of these three countries. They cover only about 8% of South Africa's national area. As with built infrastructure, proper management and maintenance are key to preventing the degradation of the ecological infrastructure in these areas.

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Reporting on natural capital

Ginsburg and five of her co-workers spent the last 18 months compiling an account of the status and value of South Africa's strategic water source areas. In this regard, they worked closely with colleagues at Statistics South Africa (Stats SA). The resulting report, published by Stats SA, sheds light on land use patterns and the protection levels of strategically important water assets in South Africa over the past three decades. The report, titled ***Accounts for Strategic Water Source Areas, 1990 to 2020,*** was published in March. The document forms part of Stats SA's Natural Capital series.

This 314-page document presents the results of the country's first set of natural capital accounts for strategic water source areas. This type of accounting for assets such as land, water, and ecosystem services provides valuable insight into the state of these water source areas, particularly in the context of land cover management and the legal protection of land. The report documents the changes in each of the 22 strategic water source areas for surface water in Southern Africa over the last three decades, both on an individual and collective level.

The publication was produced as part of the Ecological Infrastructure for Water Security (EI4WS) project, which started in 2018 and will run until 2025. The EI4WS project is being funded by the Global Environment Facility and implemented by the Development Bank of Southern Africa, with help from the Department of Forestry, Fisheries and the Environment, SANBI, the Department of Water and Sanitation, the Water Research Commission, and other institutions.

The primary goal of the EI4WS project is to enhance water security by integrating biodiversity and ecosystem services into the water value chain. (Ecosystem services such as water purification and natural flood control are provided by nature for the benefit of humans, for free.) As part of this project, Stats SA is partnering with SANBI to develop natural capital accounts for water-related ecological infrastructure.

Previously, Ginsburg and Nokuthula Mahlangu were involved in two sets of national capital accounts, one focused on land and terrestrial ecosystems and the other on protected areas in South Africa since 1900. More recently, they zoomed in on strategic water source areas with the help of three interns: Mookho Makanyane, Luvuyo Kani, and Phumlani Zuma.

The new accounts deal only with strategic source areas for surface water. Strategic source areas for groundwater still need to be mapped at a sufficiently detailed spatial scale to enable the compilation of similar accounts for such areas. Also, in the case of the seven transboundary strategic water source areas shared with Lesotho and Eswatini, the accounts deal only with the portions of these areas situated within South Africa.

Natural capital accounts strengthen the evidence base for government planning and action, helping to ensure that it is grounded in the best available science and data. "This is accounting in biophysical terms," Ginsburg says. "In our recent work, these accounts are concerned with what's happening in land cover classes and protected areas within strategic water source areas.

"We were able to align time-series data on changes in land cover and protected areas in strategic water source areas with other socioeconomic information, such as population census data. The accounts enable us to see where there's an increasing trend in intensive land use and what the protection levels there are like.

"Each strategic water source area has its own story to tell, with different planning and management implications," Mahlangu says. "The results of our accounts provide key insights into which role-players in intensive land use we should be engaging with to protect these areas."

Angus Burns/WWF-SA

Lions River in the Northern Drakensberg. Strategic water source areas for surface water make up 10% of the total land area of South Africa.

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Angus Burns/WWF-SA

In 2020, the size of the protected area estate across all strategic water source areas was 1,89 million hectares (18,9% of the total extent of strategic water source areas).

Land cover affects water security

South Africa has 22 strategic water source areas spread across five provinces (the Western Cape, Eastern Cape, KwaZulu-Natal, Mpumalanga, and Limpopo). From here, water is distributed across the landscape and into our taps via rivers, dams, and pipelines. Collectively, our strategic water source areas support half of the nation's population, two-thirds of economic activity, 70% of irrigated agriculture, and more than 90% of urban consumers.

The health of these areas has far-reaching implications. What happens in the Maloti-Drakensberg strategic water source area in KwaZulu-Natal, for instance, affects millions of people downstream, far removed from the source.

The SANBI researchers tracked changes in intensive land use within these areas, including those related to timber plantations, commercial field crops, mining, and urban settlements. All types of intensive land use combined made up 29% of the total area of strategic water source areas in 2020. The team found that the degree of intensively modified land cover differed drastically between areas. Strategic water source areas in which there were net increases of greater than 20 000 ha in intensively modified land cover (for all intensively modified land cover classes combined) between 1990 and 2020 were: Southern Drakensberg (56 011 hectares), Enkangala Grassland (51 186 hectares), Eastern Cape Drakensberg (42 042 hectares), Upper Usutu (21 544 hectares) and Northern Drakensberg (21 384 hectares).

The areas with a net percentage increase of greater than 10,0% in intensively modified land cover (for all intensively modified land cover classes combined) between 1990 and 2020 were: Kouga (123,8%, from a low base of 21 hectares), Enkangala Grassland (35,7%), Northern Drakensberg (19,1%), Eastern Cape Drakensberg (16,1%), Upper Vaal (14,2%) and Mfolozi Headwaters (10,6%).

The greater the proportion of land cover that has been modified, the higher the likelihood of ecological functioning being compromised. This can hold serious implications for the ability of highly modified areas to support water security, the researchers highlight.

Ginsburg says these and other findings underscore the importance of monitoring and managing land cover changes in order to protect natural resources and promote sustainable development.

Ecological integrity at risk

As a rule of thumb, ecological functioning may begin to deteriorate when natural land cover drops to constituting less than 60% of a landscape or catchment. Ecosystems begin to take strain as natural land cover declines, usually due to conversion to intensive land uses such as cultivation and urbanisation. Taking these factors into consideration when monitoring land use and economic activities in strategic water source areas is crucial to protecting our valuable water resources for future generations. In three of the strategic water source areas, natural or semi-natural land cover comprised less than 60,0% of their total land area in 2020: the Upper Usutu (40,9%), Table Mountain (50,4%), and Mpumalanga Drakensberg (51,3%) areas. In addition, five strategic water source areas were at or close to the threshold of 60% natural or semi-natural land cover: the Upper Vaal (60,1%), Southern Drakensberg (60,4%), Wolkberg (63,4%), Soutpansberg

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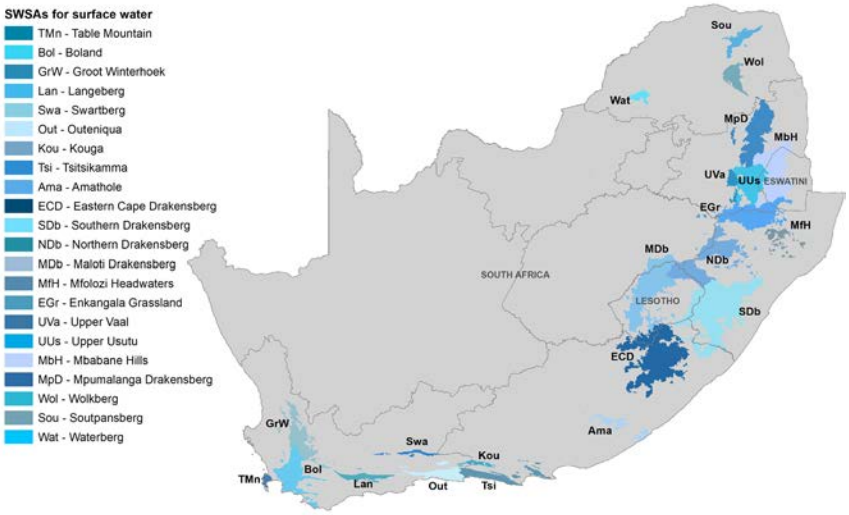

Spatial distribution of SWSAs for surface water in South Africa, Lesotho and Eswatini.

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(63,4%), and Mbabane Hills (64,8%) areas.

"Some of our strategic water source areas have high proportions of intensively modified land cover and low levels of protection," Ginsburg says. "It is crucial that we focus our attention on such areas in order to limit the impacts on water supply and security."

In Upper Usutu, timber plantations were the largest intensively modified land cover class in 2020, covering 40% of this strategic water source area. "To enhance water security from this area, we will, for instance, have to work closely with the local forestry sector," Ginsburg points out.

The strategic water source areas with the highest proportion of natural or semi-natural land cover in 2020 were the Kouga (99,1%), Swartberg (98,5%), Waterberg (92,7%), Groot Winterhoek (87,1%), and Northern Drakensberg (81,7%).

While the published accounts do indicate where natural or semi-natural areas have been intensively modified, they do not provide information about the ecological condition of the remaining natural or semi-natural areas. For ecosystem condition accounts to be compiled, sufficiently systematic spatial data on these pressures will first need to be collected.

Securing vital areas

South Africa's strategic water source areas have already been recognised in several national government policies and plans, including the National Water Resource Strategy II (2013) and the Water and Sanitation Master Plan. Although nearly a fifth of these areas in South Africa enjoy formal protection, some of them have much lower levels of protection.

In 2020, the size of the protected area estate across all strategic water source areas was 1,89 million hectares (18,9% of the total extent of strategic water source areas). Compared to 1,39 million hectares or 13,9% in 1990, this represents an increase of 502 818 hectares (36,1%). The proportion of South Africa's total land area that was formally protected in 1990 was 6,3%, and 9,2% in 2020. This means that, in both years, the proportion of land protected in strategic water source areas was more than double the proportion protected in South Africa as a whole. However, the proportion of protected land varies significantly across the 22 strategic water source areas, from a mere 1,1% in the Eastern Cape Drakensberg area to 76,5% in the Swartberg area.

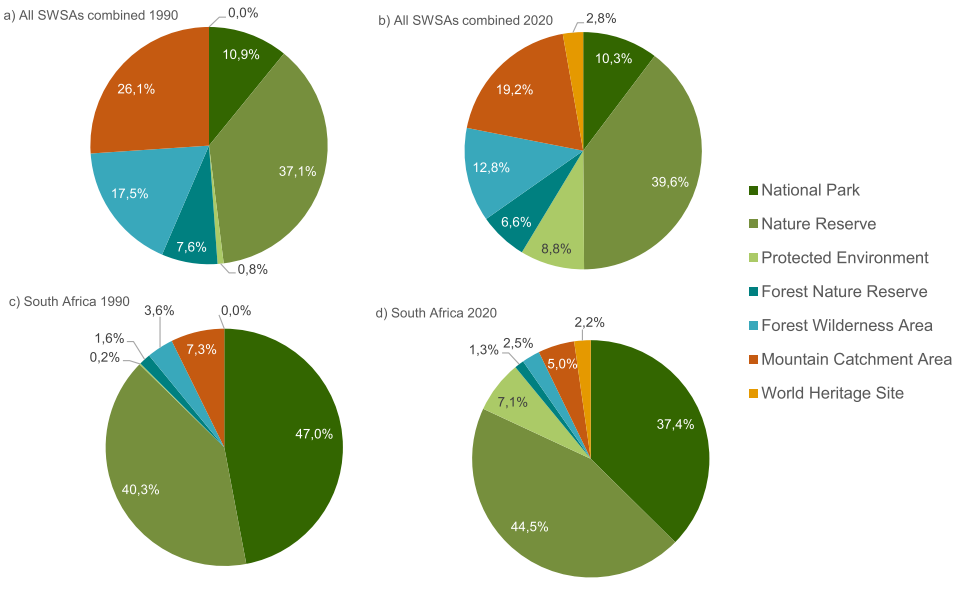
Ginsburg says focused efforts to expand protection in those key areas that currently enjoy very little protection can help secure water quantity and quality for the future. Such efforts include putting in place biodiversity stewardship contracts that involve both landowners and land users in these areas. "The data we collected enables us to make informed decisions towards the protection, management, and restoration of strategic water source areas. There are opportunities to ensure their sound management, including the involvement of role-players in high-intensity land use."

Efforts are, for instance, underway to enhance stewardship and other conservation agreements in these areas, to secure their legal protection, and to ensure their consideration in municipal planning and spatial development frameworks. Identifying strategic water source areas and their links downstream offers an opportunity for achieving synergy in spatial planning across diverse policy sectors, and enables new patterns of collaboration between government, business, and civil society. "Sustaining the ecological integrity of our strategic water sources will help us meet our water needs," Mahlangu adds. "This is the area we should be focusing on."

For further reading:

- **Key findings** and the **data story** from Stats SA about the *Accounts for Strategic Water Source Areas, 1990 to 2020*
- **Main publication** page for *Accounts for Strategic Water Source Areas, 1990 to 2020* D0401.3

Composition of the protected area estate in all SWSAs combined in 1990 (a) and 2020 (b) and for South Africa's mainland in 1990 (c) and 2020 (d)



Accounts for Strategic Water Source Areas, 1990 to 2020, Discussion document D0401.3 (March 2023)

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GROUNDWATER

Emergency drill – Project counts the risk of indiscriminate groundwater use in times of drought

Groundwater is an increasingly important resource, which is why turning to it at times of crisis brings its own troubles. A new Water Research Commission report delves deeper. Matthew Hattingh reports.

Nomthandazo Gumede put the crisis confronting Walmer High School in stark terms: "If there isn't water, we find with our learners, we cannot go on with the teaching." The school's deputy principal, Gumede was speaking to journalists on Nelson Mandela Day last year. It was at the official opening of a borehole, sunk in the ground of the school, a beacon of hope and excellence in the oldest township in Gqeberha (formerly Port Elizabeth).

"Now things are going to change. School is going to be normal… toilets… everything. For us this is life," Gumede told ***TimesLive*** while water from the new well gushed, almost at her feet. At the time, it was the thirteenth borehole opened in the Nelson Mandela Bay Metropolitan Municipality (which includes Gqeberha) by Gift of the Givers, the humanitarian relief agency.

More than seven years of below-average rainfall in the Eastern Cape, crumbling infrastructure, and, according to not a few critics, governance failures, had brought matters to a head. Schools, hospitals, old age homes and thousands of residents across the metro were running dry. Even the police K9 unit wasn't sure where to find water for their dogs. Gift of the Givers were rightly praised for their swift action. But while the boreholes they sank (or in some cases, reopened) helped stave off disaster, tapping subterranean water can potentially have unintended consequences. Unless done right, drilling risks over-depleting the resource, pollution and other ills.

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These concerns were at the heart of a new Water Research Commission (WRC) report, which warns that, "Exploiting groundwater during crisis as an urgent and reactive measure, gives rise to poorly coordinated regulation of increasing users and usage, and fragmented management of aquifers." The report, ***Governing groundwater in city regions: water metabolism and actor networks in the cases of Cape Town and Nelson Mandela Bay*** (**WRC Report No. 3066/1/23**), takes a detailed look at how – and by whom – groundwater is used and managed in the two metros.

We've already touched on Nelson Mandela Bay, Cape Town, of course, emerged from its own crisis in 2018. Day. The three-year 'Day Zero' drought, shocked the Mother City into action, refocusing attention on how it manages water, including groundwater. And not a moment too soon.

The report's authors, Drs Anna Taylor, Ffion Atkins and Christopher Jack, of the University of Cape Town, argue the old ways no longer cut ice. "Traditional forms of governing by command and control are proving ineffective," they write, and quote an earlier WRC report (**WRC Report No. 2741/1/19**) which found the Department of Water and Sanitation has "neither capacity nor the cooperative governance mechanisms" to carry out the country's various national strategies and tactical plans. Similarly, even implementing their water bylaws exceeded the means of the two metros.

The authors called for a consultative and cooperative approach which recognised cities as "system(s) of interdependent actors and flows of water" and which sought to bring together organisations and entities so that groundwater might be better understood, used and protected. They hoped this would influence how water was used, enhancing "stormwater infiltration and increasing the reuse of treated wastewater for non-potable uses and managed aquifer recharge".

To this end, and as part of a WRC-backed capacity-building project (the subject of their report), the authors did interviews, reviewed official documents and organised a series of "learning laboratories". Lab participants included academics, sustainability and groundwater fundis, hydrologists, national, provincial and local government officials and consultants from a number of disciplines. Together, they worked to map the "network of organisations involved in groundwater-related decisions in cities".

To help the participants better grasp how groundwater links to other water flows, the labs sought to quantify the main components of "urban water metabolism". They also considered a number of scenarios that might play out over the next 20 to 40 years as climate change was expected to hit home and as more farmlands in the metros were paved-over – increasing runoff that would previously have soaked into the groundwater.

We will look at a few of the findings and return to the metabolism concept shortly, but first it's worth asking: What's so special about groundwater anyway? Here the report traversed familiar terrain: Water, it noted, was increasingly scarce in South Africa. Looming changes to rainfall levels and patterns were likely to make matters worse, even as the thirst for water grows from competing quarters. Delays dogged the roll-out of new infrastructure, while vital maintenance to the pipes, pumps, transfer canals and treatment plants was more honoured in the breach than the observance.

This is why we are increasingly pinning our hopes on groundwater to plug a growing gap between supply and demand. The trouble is, as the report observed, groundwater is a "distributed resource". This means "widespread mechanisms, capacities and incentives" are needed to monitor it, yet "governance of groundwater remains weak with insufficient monitoring, reporting and enforcement of regulations".

It's not working; what's to be done? Groundwater needs to be managed as part of a wider and inter-connected urban water cycle if it's to serve future generations. We must intervene and innovate, said the authors. But this required us to build a "shared understanding and strengthen capacity for participation in decision-making".

Back to the learning labs. Two were held in each of the metros, from November 2021 to December 2022. A fifth lab was convened online in June this year, bringing together participants from both metros, to mull over what they'd learnt. Taylor shared a slide with the meeting that contrasted the metros by size, population and budgets. She spoke too about the extent to which water systems were integrated (much less so in Nelson Mandela Bay) and how politics differed, with consequences for water management.

"Groundwater needs to be managed as part of a wider and inter-connected urban water cycle if it's to serve future generations."

"One of the things that comes through strongly is the stability in some regards of Cape Town's political leadership and what that has allowed in terms of bedding down of plans. Whereas in Nelson Mandela Bay there has been transition and strong contestation between the two dominant parties."

Taylor was referring to the fractious coalition politics that have emerged since 2016, with neither the African National Congress (ANC) nor the Democratic Alliance (DA) able to command a majority, and how unstable government had hobbled operations in the Eastern Cape metro. She paid tribute, however, to municipal officials for what they had managed to do despite "headwinds".

She noted groundwater played a small part in the overall supply mix – roughly 1% in both metros. But this was changing, with plans in both cities to increase this figure to about 9% over the next decade. The "big unknown", and one of the motivators for the study, said Taylor, was the uncertainty about the private sector, which made it hard to estimate total groundwater abstraction. "Basically, we have very little handle on how many private boreholes exist," she said, explaining that official databases and registers greatly under-represented the reality on the ground.

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Anna Taylor

Participants at the first of the Nelson Mandela Bay learning labs use coloured markers and concentric rings to plot the various actors involved in protecting or conserving aquifers or their recharge. The rings indicate level of influence – from high to none.

Anna Taylor

The group at the second Cape Town learning lab deliberate on the strength of ties between actors using or managing groundwater in the Cape Flats aquifer on a scale of 0 to 3, from no interaction to frequent interaction, defined as more regularly than once a month.

She added that the labs sought to chart who was making decisions about groundwater use and protection with the bigger aim of figuring out the degree to which decision-making was collective and coordinated. "Because we know joined-up decision-making is essential to systems resilience."

"Resilience", an oft-recurring theme (along with "sustainability" and "integration") in the urban planning and environmental disciplines, was about building the capacity of systems and cities to withstand and recover from shocks. Here, climate change is very much in mind.

Taylor's co-author, Atkins, spoke about how urban water management was evolving internationally, with a move to a systems approach. This shifted focus from worrying about securing supply or dealing with drought or floods, to bringing together a variety of problems and solutions and building resilience. She said the study used the "urban water metabolism" conceptual framework to analyse natural and manmade water flows into and out of a city and to link this to decision-making processes. Natural flows from precipitation included run-off, groundwater and evapotranspiration.

Evapotranspiration is a combination of evaporation and transpiration – water lost through photosynthesis – and is markedly higher in Nelson Mandela Bay. Man-made flows included those in the wastewater and potable systems, dams and desalination plants.

Data was collected or estimated for the flows in the two metros. These were collated and used to produce a mass balance, essentially a table of all inputs and outputs. "It helps us understand how well the city is doing against what it says it's going to be doing – its management objectives. Is it water-use efficient? Have we reduced our outputs and external inputs?" said Atkins.

The authors explored different scenarios in the two cities, including decreases to rainfall and increases to evapotranspiration and land-cover. It let them and the labs study the effects of shifts in policy and interventions, such as changes to the water supply mix, recycling and managed aquifer recharging schemes.

How useful was this? Atkins conceded some lab participants saw little value in it for their day-to-day work and criticised it as too academic or for failing to address "social aspects". On the other hand, the metabolism framework helped people from diverse fields share a common understanding and discuss water management. "Its greatest value was seen in the strategic and scenario planning level," she said.

Returning to governance, Taylor said the report divided groundwater decision-making into four broad functions: understanding; operating; regulating; and capacitating. Operating included installing and maintaining infrastructure, groundwater treatment, schemes to recharge aquifers, and the links between these and how surface water was managed.

As an aside, Taylor touched on unregulated sand-mining, which was increasing, especially in Nelson Mandela Bay. "We need to know more about the implications for sustainably managing groundwater."

On the regulating function, she said bylaws in both metros were being updated to include lessons from the droughts, but enforcement remained a weakness. This was also true of water use licensing, which was the responsibility of the Department of Water and Sanitation. Borehole registration and monitoring weren't "happening comprehensively" and needed "a lot more work".

Taylor noted the quality of groundwater was an area of growing interest, with both metros turning to spatial planning to protect sources from pollution risks.

The labs worked to map the state, private, civic and non-government organisations or actors operating in the four functional areas. This included establishing which actors had a formal mandate to make decisions or provide oversight, and which of these, in fact, had the capacity to carry out their mandates. "I would say we are far from having complete

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answers," Taylor said, explaining it was difficult to get robust data on arrangements in flux. She felt the lab findings were useful for providing relative assessments of capacity rather than for establishing any absolute benchmarks.

She spoke about the innovative approaches to governance being pioneered by some of the aquifer monitoring committees keeping tabs on Cape Town's new wellfields and wondered if other similar groups and partnerships might be used to: "Bring multiple groundwater users together to report on their usage and collectively monitor the state of the aquifers and then start to develop more collective rules to manage usage in relation to changes in supply and demand."

"We need much more nimble institutional arrangements… the question is how do we build this," said Taylor.

Yazeed van Wyk, WRC research manager for groundwater hydrology, agreed that there was a pressing need for collaboration in the face of an unprecedented demand for water, compounded by a host of difficulties, including drought and climate change. He mentioned too, the recent fatal cholera outbreak in Hammanskraal where the polluted groundwater has been found unfit for human consumption.

Van Wyk, who was the WRC's project manager for the study and who made the closing remarks at the June lab, wondered how organisations with vested interests might be encouraged to adapt and transform – to move to more sustainable ways of managing water. "How do we get old dogs to perform new tricks?" he asked, suggesting the work of Taylor and her colleagues helped point the way. "Perhaps to use this new approach, as a tool to apply in arrears where implementation should ideally be taking place."

There appears to be little handle on how many private boreholes exist.

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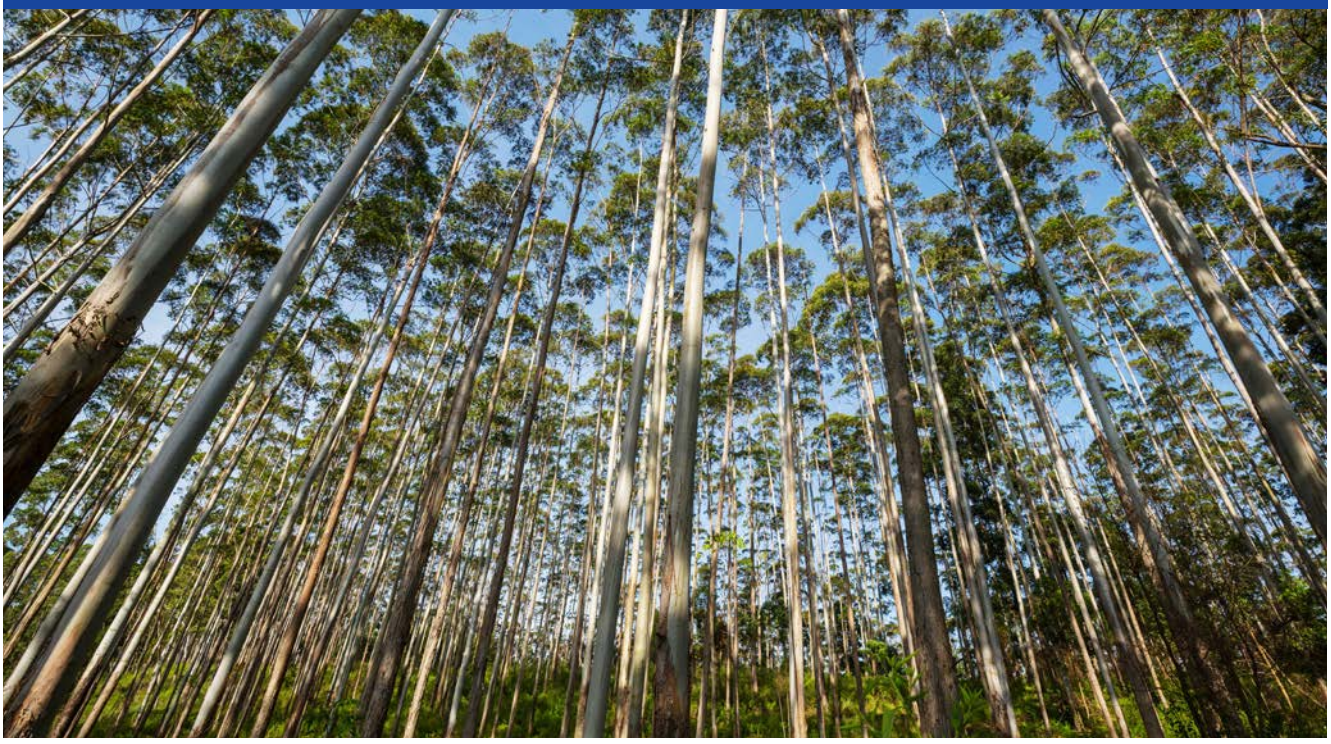
FORESTRY

Forestry and streamflow reduction – making progress in accurate assessment

Insight gained from a Water Research Commission (WRC) funded project has done much to expand knowledge about water use of different commercial forestry species and hybrids. Article by Sue Matthews.



When draft regulations on afforestation genus exchanges were published for comment in October 2015, it set the cat amongst the pigeons. The 'Genus Exchange Regulations' proposed that afforestation water users would have to apply to the responsible authority – the Department of Water and Sanitation (DWS) or relevant catchment management agency – if they planned to exchange the genus of a plantation. And should the new genus be a heavier water user than the one to be replaced, the original authorisation would be amended to reduce the number of hectares planted so that the property's water use would not increase.

Forestry companies are not that different from farmers who want to be able to change the crops they grow according to market demand and prevailing conditions, or simply to spread their risk by diversifying. The South African industry relies mainly on pines and eucalypts, and wattles to a lesser extent, but a variety of species and clonal hybrids within these three genera – ***Pinus***, ***Eucalyptus*** and ***Acacia*** – are currently in use or have been phased out over time, particularly within the past 30 years. Since 2010, there has also been widespread conversion of pine and wattle plantations to eucalypts, although pines still have a slight edge in terms of total area under production countrywide.

Pines are softwoods, used to produce high-value veneers and sawlogs, as well as coarse-fibre pulp needed to make packaging and newsprint. Eucalypts are hardwoods, grown for poles and lower-value sawlogs, but mainly for fine, short-fibre pulp. This

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is in great demand for making high-quality paper and various cellulose products used in everything from textiles and cigarette filters to cosmetics and plastics. Eucalypts also have the benefit of fast growth, with a rotation time of 6–15 years compared to 15–28 years for pines.

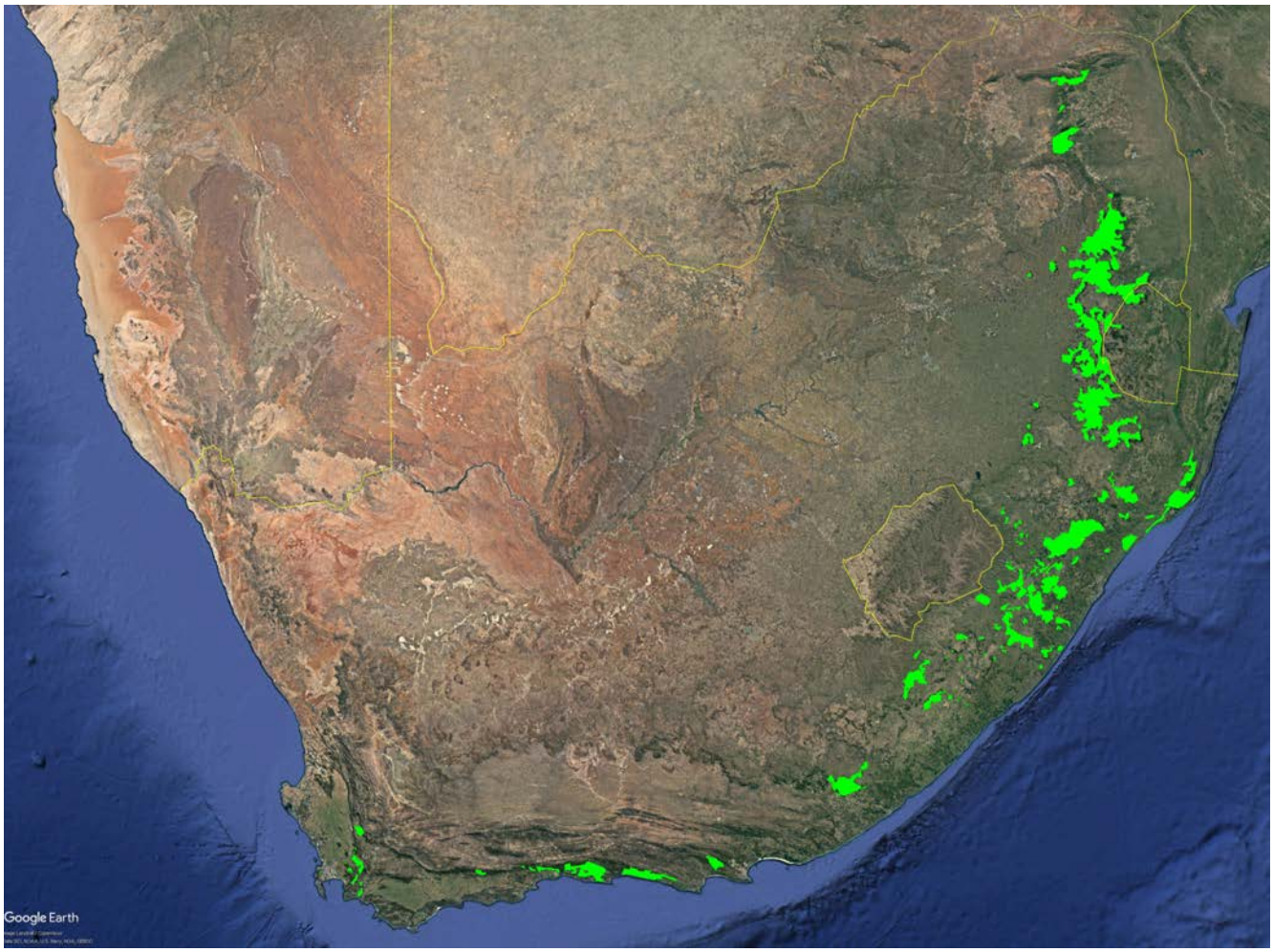
Of course, forestry trees use more water than the indigenous grasses and low shrubs they often replace, largely because they are tall and evergreen but also because – in the case of pines and eucalypts at least – they have deep root systems, able to tap into groundwater reserves. Owing to the potential impact of tree plantations on water resources, commercial forestry was declared a 'streamflow reduction activity' (SFRA) in the National Water Act of 1998, and a water use licensing system was introduced to replace the afforestation permit system.

The licensing system includes an assessment of the likely reduction in streamflow using a procedure that was developed in WRC-funded projects by Gush et al. (2002) and Jewitt et al. (2009) – more on these later – but is based on water use estimates for only one species in each genus, namely ***Eucalyptus grandis***, ***Pinus patula*** and ***Acacia mearnsii***. The available information suggested that ***E. grandis*** had higher water use than ***P. patula***, but the growing conditions during some of the early experimental studies were not reflective of forestry practices.

Besides, what about all the other species and clonal hybrids in commercial plantations? Might a eucalypt hybrid developed for its resistance to drought use less water over its lifetime than a pine species or hybrid? Or could a pine species with particularly fast growth prove to be as 'thirsty' as ***E. grandis***, which has in any case been overtaken by ***E. dunnii*** in terms of hectares planted. And how does water use compare over two or three decades, given the different rotation cycles of pines and eucalypts?

It was recognised that better information was required, so DWS put the Genus Exchange Regulations on hold and subsequently commissioned the WRC project by Clulow et al. (2023), 'The expansion of knowledge on evapotranspiration and streamflow reduction of different clones/hybrids to improve the water use estimation of SFRA species (i.e. ***Pinus***, ***Eucalyptus*** and wattle species)'.

In November 2019, however, Forestry South Africa (FSA) lodged a court application on behalf of its members around the interpretation of the National Water Act's 'existing lawful water use', as well as the definitions of 'streamflow reduction activity' and 'water use' in relation to genus exchange. The Judgment delivered in August 2021 went in favour of FSA on the genus exchange issue but not on the existing lawful water use matter. Since FSA appealed the latter and DWS the former, the case is set



All photographs supplied

Commercial forestry occupies almost 1.2 million hectares of South Africa's land area, with plantations being concentrated in KwaZulu-Natal and Mpumalanga.

A satellite view of three of the project's study sites, situated about 70 km north-east of Pietermaritzburg. The middle site is the Two Streams Research Catchment, where the impact of the Eucalyptus dunni plantation on groundwater and streamflow was monitored using four boreholes (B) and a streamflow recorder (SFR). Instrumentation on a tower (T) within the plantation allowed for energy flux and total evaporation measurements, while an automatic weather station (AWS) provided data on climatological variables. The other two sites, 4 km apart, were plantations of Pinus elliottii and the eucalypt hybrid E. grandis x E. nitens.

to be heard by a panel of five judges at the Supreme Court of Appeal on 24 August 2023. Until then, an exchange of genus or species does not constitute a water use as envisaged in section 21 of the Act, exchanges may take place without the need for authorisation, and the responsible authority is not entitled to insist that the area of land planted be reduced.

Main findings of the project

Regardless of the outcome of the appeal, the WRC project has done much to expand knowledge about water use of different species and hybrids. The project report is split into two volumes, the first of which, 'Improved water use estimation of SFRA species', focuses on field-based studies. These studies were mainly conducted in and around the Two Streams Research Catchment, in the Seven Oaks area some 70 km north-east of Pietermaritzburg. The catchment has been used for a number of hydrological studies since 1999, but it has always been planted to ***A. mearnsii***. In March 2018, following the harvesting of the wattle rotation, a genus exchange was undertaken by planting ***E. dunnii*** in its place. Once the crop was 18 months old, measurements of hydrological processes began, and were continued for two years. The findings were compared with those from a two-year-old ***A. mearnsii*** crop and a mature, six-year-old ***A. mearnsii*** crop, using historical data from the earlier studies at the site. This showed that total water use for the young ***E. dunnii*** was much the same as that of ***A. mearnsii*** of the same age, but about 12% more than for the mature ***A. mearnsii***.

Higher water use by young crops suggests that rotation time needs to be taken into account when considering the implications for stream flow reduction. The project team therefore recommends that measurements continue for the full ***E. dunnii*** rotation to allow for comparison with the historical ***A. mearnsii*** rotation, but they point out that both species could have a negative impact on stream flow and groundwater reserves. "These findings were supported by a reduction in stream flow when the catchment was afforested by either ***E. dunnii*** or ***A. mearnsii***, while the stream flow increased when the catchment was cleared," they note.

Two other plantations adjacent to the Two Streams catchment presented the opportunity to compare ***P. elliottii*** – the second most planted pine species in South Africa – with the eucalypt hybrid ***E. grandis x E. nitens (GN)***. The pine plantation was 20 years old and the eucalypt one eight years old, but the two were at a similar stage of development given the species' different growth and rotation rates, and both were planted at a spacing of 2 x 3 m. Although the sites lacked the boreholes and stream flow gauge of the Two Streams catchment, transpiration by four trees at each site was measured over two years and evapotranspiration estimated to compare the species' water use. Surprisingly, ***P. elliottii*** outstripped ***GN*** in this regard during the first year of the study, using significantly more water, but the difference levelled out over the second year. The lower-than-expected water use by ***GN*** was attributed to water stress, because although the two plantations were only 4 km apart, their soils had different textures and those at the ***GN*** site were generally drier.

The genus exchange ratio between ***GN*** and ***P. elliottii*** averaged 0.92 over the two years, but the project team recommends that the same measurements be conducted at several forestry sites to include different soil and climatic conditions. "Based on these results, a conclusion was drawn that conversion from ***P. elliottii*** to ***GN*** in water-stressed sites and where groundwater resources are too deep for access by trees may not affect groundwater resources," they report. "However, during the wet season, trees may deplete the recharged soil profile soil water content, which may lead to stream flow reduction in the long term."

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A fourth study site was identified at KwaMbonambi in northern Zululand. It was planted with nine-year-old ***E. grandis*** x ***E. urophylla*** (***GU***), the dominant commercial forestry tree in this humid, subtropical region. Transpiration measurements on four trees for a two-year period revealed that water use was in the same range determined by previous studies on ***E. grandis*** and ***E. urophylla*** within the region and at other subtropical sites internationally. The project team notes that despite the very low soil water content and paucity of rainfall during the study period, the trees showed no sign of water stress, suggesting that they were able to access deeper groundwater reserves. This implies that ***GU*** plantations would likely cause a reduction in stream flow, especially during low-flow conditions during the dry season.

As much as these field-studies have provided water-use information for a few species and hybrids that was not previously available, it would clearly be impractical to conduct similar studies on all the other species and hybrids planted by the forestry industry countrywide. Yet some means of taking this tree diversity into account in the water use licensing system would be beneficial, particularly if the Genus Exchange Regulations become legally binding. The second volume of the research report, titled 'SFRA Assessment Utility', provides a method to do so.

The SFRA Assessment Utility is the software tool developed by Jewitt et al. in 2009, although it has been modified and improved over the years. Like the 2002 'Gush Tables' containing estimates of stream flow reduction resulting from afforestation, it is based on outputs from the ACRU hydrological model. But while the Gush Tables were for quaternary catchments, the SFRA Assessment Utility made use of a database on the soils and climate of quinary catchments for the modelling, allowing for estimates of stream flow reduction at a finer scale. Both systems relied on the Acocks Veld Types for the indigenous vegetation that would have existed in the catchment under natural conditions, with simulations of stream flow under this reference land-cover providing baselines against which reductions could be assessed.

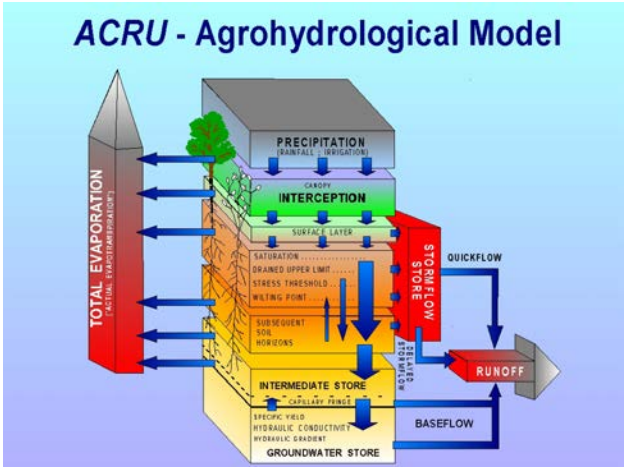
Acocks mapped South Africa's vegetation according to its grazing potential, identifying 70 different 'veld types' in the 1950s. Today, the National Vegetation Map and accompanying database developed by the South African National Biodiversity Institute (SANBI) is the accepted reference land-cover. It has been updated a few times since the first iteration in 2006, and now contains more than 450 different vegetation types. A recent WRC-funded project by Toucher et al. (2020) grouped them on the basis of their hydrological similarity to produce 128 CWRR clusters – so-named because the project was conducted by the Centre for Water Resources Research at the University of KwaZulu-Natal. The vegetation and water use parameters required by the ACRU model were then derived for each cluster in order to develop a new hydrological baseline.

This was used in the current project as the baseline against which the impacts of commercial afforestation could be assessed. Improvements to the climate and soils databases for the quinary catchments were also incorporated into the ACRU model runs. Evapotranspiration is a key variable in the model, estimated using the Food and Agricultural Organization (FAO) method of multiplying the reference evapotranspiration by the crop coefficient (K_c), which is the ratio of actual crop evapotranspiration to reference crop evapotranspiration. One way of obtaining the K_c values for different crops is to derive them from the Leaf Area Index (LAI), a canopy parameter defined as the total single-sided leaf area per unit ground area.

Although LAI can be determined from field-based measurements, it's not without its challenges, as the project team quickly discovered. Their plant canopy analyser needed just the right light conditions – diffuse early morning or late afternoon light with no cloud cover – for accurate measurements, and the weather invariably didn't play along on scheduled field trips. So they turned instead to remotely sensed LAI estimates, and after testing a few satellite products and methodologies settled on the MODIS LAI product. Using data from daily evapotranspiration measurements conducted on ***A. mearnsii*** and ***E. dunnii*** at the Two Streams Research Catchment, the team derived a monthly time-series of K_c and then developed a generic K_c-LAI model, which made it possible to obtain K_c estimates from MODIS LAI values at other sites with different tree species.

Accordingly, 15 sites in KwaZulu-Natal and Mpumalanga containing the major commercial forestry tree species and hybrids were identified, and the monthly averaged K_c values derived. They are for four pine and seven eucalypt species and hybrids as well as ***A. mearnsii***, but for ***P. patula***, ***E. grandis*** and ***E. grandis*** x ***E. nitens*** the K_c value was derived for two different climate zones.

With these K_c values and other required input parameters, the ACRU model was used to simulate mean monthly and annual runoff response for each of the species and hybrids (assuming that the entire quinary catchment was a plantation), as well as the baseline conditions. If the difference in mean annual runoff under forestry was more than 10% of the baseline, the catchment



The ACRU model, used for assessments of streamflow reduction, has its origins in research conducted in the 1970s by Roland Schulze, who developed it further and produced an accompanying handbook as part of a WRC-funded project completed in 1995. Since then, it has been improved and revised to incorporate new information. The model simulates the components and processes of the hydrological cycle affecting the daily soil water budget. More detail can be found at https://cwrr.ukzn.ac.za/resources/acru/.

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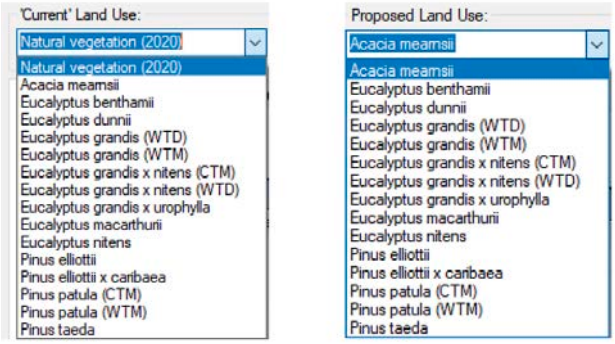
was flagged as a potential candidate for a stream flow reduction assessment. Mapping the results showed that all the pine and eucalypt species and hybrids were estimated to reduce mean annual runoff by more than 10% in KwaZulu-Natal, Mpumalanga and Limpopo – the provinces where they are mainly grown – while ***A. mearnsii*** resulted in the lowest proportion of flagged catchments.

The outputs of the ACRU model runs are contained in the updated SFRA Assessment Utility, now referred to as the Genus Assessment Utility. This allows users to select the current and proposed land use (forestry species or hybrid), followed by the desired output variable (such as runoff simulated by the ACRU model), the quinary sub-catchment to be assessed, and the start month of the hydrological year. The Utility then displays monthly time series in the form of data tables and graphs for the current and proposed land uses, as well as the calculated difference and accompanying statistics.

The project team gives a few suggestions in the report to improve the accuracy of modelled results, as well as more general recommendations. They point out, for example, that it's not ideal that the development and validation of the model for determining K_c values from LAI relied on evapotranspiration measurements from only two species grown at the same site, but the method is documented and repeatable, so water use parameters can be refined as more data becomes available. They add that greater access to the commercial forestry industry's compartment database would be helpful in expanding the sites for which LAI records are obtained. It remains to be seen whether the industry will be willing, once judgement is handed down in the upcoming appeal.

To download the two volumes of ***The expansion of knowledge on evapotranspiration and streamflow reduction of different clones/hybrids to improve the water use estimation of SFRA species*** (i.e. ***Pinus***, ***Eucalyptus*** and wattle species) Visit: https://bit.ly/3JHj9mn (Volume 1) and https://bit.ly/3JJyRxi (Volume 2)



The Genus Assessment Utility is a software tool that allows users to view, extract and make comparisons of different ACRU model simulations for a range of species and hybrids. WTD = Warm temperate dry, WTM = warm temperate moist, CTM = cool temperate moist.

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THE WATER WHEEL

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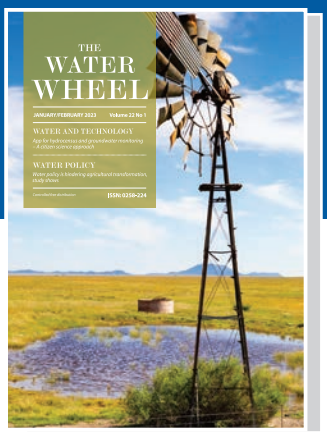

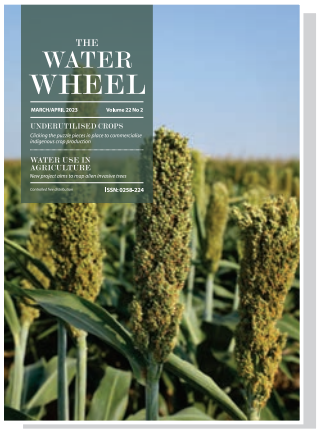

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WETLANDS

UFS graduate's PhD findings adopted as national standard for wetland mapping

An alternative approach for large-scale wetland mapping in South Africa was developed as part of a recent PhD study which will be considered for use by the national institute responsible for wetland data in the country. Jorisna Bonthuys reports.

Lani van Vuuren

Dr Nacelle Collins, a wetland ecologist from the Free State, used a multi-criteria decision-making approach as part of his PhD study to develop an alternative method for wetland mapping in South Africa. The results of his study will be considered by the South African National Biodiversity Institute (SANBI) as an option for wetland mapping in South Africa. SANBI is the data custodian for the national wetland mapping base data. The institute maintains, manages, integrates, uses, and disseminates wetland information.

Collins, a wetland ecologist in the Department of Economic, Small Business Development, Tourism and Environmental Affairs, oversees conservation and management strategies for the Free State's wetlands. Collins, who is also a research fellow at the University of the Free State's Centre for Environmental Management, believes that wetland protection, rehabilitation, and wise use will become increasingly important given the impact of climate change and continued pressure on our water resources. "It's crucial to understand the significance of wetlands in the landscape," he says. "Wetlands play an essential role in addressing many of the challenges that humanity faces today. Wetlands are, for instance, crucial for ensuring water security, mitigating climate change, and providing a safe environment for many aquatic species. The importance of wetlands in sustaining life cannot be overstated, and we need to make every effort to protect them."

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According to Collins, accurate maps are essential for biodiversity assessments, wetland conservation and management decisions. He says the most recent wetland map of South Africa (National Wetland Map 5) is considered to be of too low accuracy to be used with confidence at the national level. "The most recent wetland map showed a low confidence rating for representing the extent of wetlands. It is characterised by an estimated omission error of 50%."

While this map did improve on its predecessor, the NWM4, accuracy assessments showed that 30%, 70%, and 90% of wetlands in the Vaal River, the Olifants River, and the Free State study areas are not represented in the most recent wetlands map when compared to reference datasets. In his study, Collins explored alternative mapping approaches, hoping for comparable or better results to the multispectral approach that has been the most commonly used approach for large-scale wetland mapping.

An alternative approach

In April, Collins received his PhD in the Department of Geography at the University of the Free State. He was the first recipient of the PhD in geography, majoring in geoinformatics at the university. In this discipline, scientists use advanced technologies, such as remote sensing, to interpret and apply geographic data. Collins' dissertation titled ***An alternative approach for large-scale wetland mapping in South Africa*** explored the potential for an alternative method to multispectral imagery for mapping wetlands.

He aimed to find a solution that could quickly and accurately map wetland extent over large regions, using the least amount of available data and funds while requiring minimal technical skills. With this in mind, Collins created a conceptual framework that integrated the best features of both on-screen and digital elevation model-based valley-bottom extraction approaches. This framework consists of a spatial and data structure that paved the way for a more efficient and effective mapping approach.

The results of his study will also inform a wetland management system that can be applied in the Free State and potentially elsewhere. "To manage wetlands, we must be able to assess and prioritise them for a range of different objectives and values. Achieving this goal requires many data inputs, of which my study addresses only one."

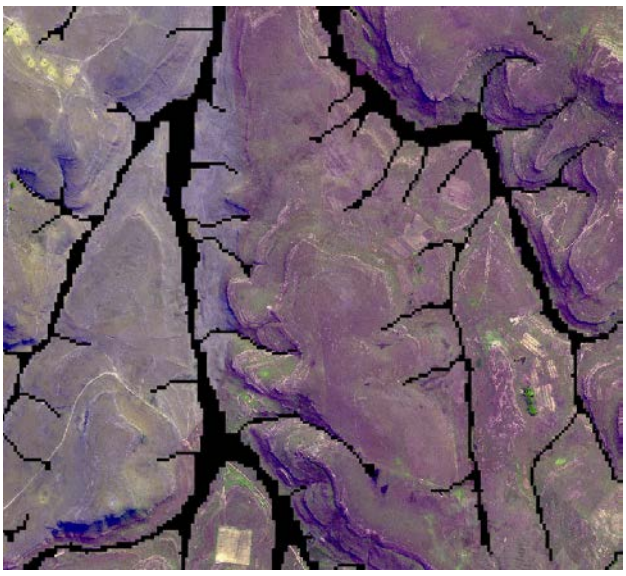
Collins' framework allows for wetlands to be mapped and described using existing data. This means traditional approaches, such as multispectral image analysis, can also be incorporated into the topographic mapping approach. With his framework, users can create improved maps that reflect the most up-to-date information. In addition to providing the technical requirements for the new mapping framework, SANBI also tested tool operations and robustness during their development, while guiding implementation rationale.

Comparing mapping approaches

Collins employed topographic mapping to different reference sites and tracked the time spent on mapping tasks. The first approach involved rapid topographic mapping, while the second approach focused on topographic mapping with increased mapping effort. The third approach included on-screen mapping, which was used to supplement the results of the second approach.

"A key advantage of this alternative framework is that it does not require any training or reference data."

In addition, Collins compared the accuracy of the existing national wetland map (NMW5) to the same reference data. He did this to determine how the topographic mapping approaches using variable mapping effort compared with the reference sites and NMW5.



Above and top: An example of improved wetland mapping that can be obtained using a topographic mapping approach. The blue polygons (top image) are wetland areas in the latest national wetland map (National Wetland Map 5). In terms of topographic mapping, the black areas (bottom image) are potential wetland areas.

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Lani van Vuuren

The new approach is flexible enough to accommodate different scales and levels of accuracy, making it suitable for anyone who wants to map wetlands

Collins assessed mapping accuracy and performance at two sites, one in the Northern Cape and the other in KwaZulu-Natal. He says the mapping accuracies of the three approaches can, at best, be described as moderate to good. "Wetland maps that are created [with these approaches] may not be completely accurate, but they are still an improvement to the national wetland map," he says. "If the priority is efficiency, the first approach [rapid topographic mapping with minimal mapping effort] should be used. However, if accuracy is the main concern, the third approach [topographic mapping supplemented with on-screen mapping] should be pursued.

"The difference between the reported accuracies of multispectral image mapping and the international state of wetland inventorying is striking," he remarks. Collins says that no mapping approach by itself can create a comprehensive wetland map for South Africa. He considers the best solution one that incorporates multiple mapping approaches.

"One of the major challenges when mapping using multispectral images is the need for specialised knowledge and resources," he says. "Unfortunately, this expertise is not commonly found within government institutions in South Africa. As a result, previous attempts at mapping wetlands have been unsuccessful in creating an accurate inventory that can be used confidently at a national level."

Multispectral imaging is a collection of a few image layers of the same scene, each acquired at a particular wavelength band. "These images are created by detecting frequencies, including and other than what our eyes can see. It is a complex and expensive process requiring much technical know-how."

It is also important to note that multispectral wetland mapping has limitations. "One of the major challenges is that it cannot detect and map transformed wetlands," he says. "As a result, their omission from the national wetland map undermines its accuracy. Therefore, we must continue to develop new methods for mapping wetlands to ensure a more comprehensive understanding of these important ecosystems."

Collins says that multispectral image analysis alone still needs to successfully create a comprehensive wetland mapping for South Africa and that the best solution is one that incorporates multiple mapping approaches. "Instead, it might be better for South Africa to explore alternative mapping methods more suitable for its needs. In our context, it would make sense to apply an approach which requires minimal expertise, skill, and funds, with the ability to track change over time."

"Given the past poor accuracies when using multispectral imagery analysis to detect wetland vegetation for large-scale wetland mapping in South Africa, the topographic position is considered the only other viable alternative for large-scale and cost-effective mapping.

According to him, both multispectral and topographic mapping approaches are by themselves unsuitable for wetland mapping, and especially the smaller and narrower wetlands. Both approaches are inaccurate at mapping wetland boundaries. Instead, he says on-screen mapping is the preferred method to achieve more precise results.

With minimal data, Collins' approach can map existing and historic wetland extent over large regions more accurately

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than what has been achieved thus far. Furthermore, it requires minimal to no data preparation and basic geographic information system skills.

Framework offers flexibility

Collins' framework allows for flexibility that integrates other mapping technologies and approaches.

Collins says an ideal mapping approach for South Africa is one where those technologies and approaches most capable of satisfying mapping requirements can integrate available information into a single mapping structure. He achieved this by developing a conceptual mapping framework, which can combine the use and abilities of on-screen, multi-resolution topographic mapping, and other mapping approaches, which, except for monitoring, can collectively satisfy wetland mapping requirements.

He says the achieved accuracies are better than those of the national wetland maps, which along with the improved mapping extent, represents "a meaningful improvement". "This is especially the case when considering that these improvements were achieved at a fraction of the cost and time spent during the more than 20 years of national wetland mapping," he points out.

"A key advantage of this alternative framework is that it does not require any training or reference data. However, in the absence of reference data, and especially when mapping an unfamiliar area, it may be necessary to first relate the imagery to actual wetland occurrence through in-field or other forms of verification."

Although not part of Collins' study objectives, mapping the spatial extent of wetlands while simultaneously accounting for and including existing descriptive data is an additional benefit of his approach not offered by other approaches where attribute data has to be dealt with as a post-mapping exercise.

While Collins concluded that the proposed mapping framework offers a practical solution for large-scale wetland mapping in South Africa, he acknowledges that his approach also has some limitations. His approach has a different consistency and repeatability than other more automated approaches. Inconsistent results can be expected when the same area is mapped by different persons or by the same person using different imagery. Accuracy is also influenced by terrain topography and climatic factors such as mean annual precipitation and evaporation.

On the plus side, the ability of his alternative approach to map existing and historic wetlands has the potential for improved estimates of wetland loss by determining the difference between the wetland potential map and a map of transformed land cover. Such information is essential for monitoring purposes.

One major advantage of the low technical requirements for mapping wetlands is that it allows individuals who are not GIS or remote-sensing experts to participate in the mapping process.

Unlike other mapping models that incorporate different earth observation technologies and approaches at the onset, the open structure of the proposed mapping framework allows for any earth observation technology or other mapping approaches to be added at any time of the mapping process. This can be achieved without the technical skills that are usually required to edit and adapt such modelled approaches.

"With this approach, anyone can easily create maps of wetlands in any area, incorporating both spatial and descriptive data," he says. "The best part is that it is flexible enough to accommodate different scales and levels of accuracy, making it suitable for anyone who wants to map wetlands."

Collins found that this mapping framework can be implemented in incremental steps as it doesn't require data collection, model development, or complex data preparation. This flexibility also means that certain areas, like strategic water source areas, can be prioritised for a greater mapping effort within the same mapping project. Other approaches, such as predictive modelling, do not allow for this kind of prioritisation for large-scale mapping, as the training data are applied equally to the entire area being modelled.

"The results demonstrate that mapping technologies and approaches other than what has been used thus far to create the South African national wetland map can produce wetland maps with improved accuracy and representation, and at significantly reduced time and cost," he says. "Even though the accuracies achieved are considered modest and unsuitable for detailed wetland assessment such as is required for environmental impact assessments, they are considered suitable for large-scale management and conservation planning purposes."

While the proposed alternative mapping approach and conceptual framework for wetland mapping may not represent or include the most current technologies and methods, Collins considers it better suited for developing countries.

Even though the accuracies achieved during this study may not satisfy what can be considered to be the minimum mapping accuracy required for national wetland mapping and inventorying, Collins says they still represent "a marked improvement" to the existing national wetland map. "There is no silver bullet option for mapping wetlands in South Africa," he says. "The differences in accuracies and efficiencies achieved for the different reference sites suggest that what will be the most accurate mapping approach in one area will not necessarily be the most accurate in another. The ability of the mapping framework to incorporate such different mapping approaches that are suitable for different areas makes it suitable for mapping large and heterogeneous areas.

"To manage wetlands effectively and efficiently, we must be able to assess and prioritise them for a range of different objectives and values. Achieving this aim requires many data inputs, of which my study addresses only one."

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OPINION

Where have all the experts gone? – adequate resources required to manage SA's complex systems

If we hope to improve water and food security while becoming climate resilient, then we must insist on adequate resources to manage and develop local groundwater systems. So writes Shafick Adams, Executive Manager at the Water Research Commission.

IGRAC/Flickr

It is estimated that groundwater constitutes 13% of South Africa's water supply. This seems like a relatively small amount compared to the supply from surface water resources. However, this 'mere' 13% provides water to 56% of the population, either as a sole source or combined with surface water. That is just over 34 million people within 23 746 settlements (78.5% of all settlements in the country). Groundwater is a strategic water resource to meet the water security needs for more than half the South African population. On average, groundwater is underutilised in South Africa with considerable opportunity for expansion. Expanding the use of groundwater can help communities and the State build resilience to the impacts of climate change and other drivers of water demand, such as urbanisation, population growth, industrialisation, and agricultural expansion.

In South Africa, groundwater is mainly found in complex geological formations and is typically a local resource. Hydrogeologists play a vital role in the exploration and sustainable management of groundwater resources. These geoscientists specialise in studying groundwater, including its properties, distribution, and movement through rocks and sediments beneath the Earth's surface. In addition, they design and manage wellfields, develop, and implement operating rules to ensure that these systems are operated and maintained as efficiently as possible. South Africa has a competent core of hydrogeologists across the public and private sectors – except where it matters the most. One would think that with the strategic nature of this resource for meeting water security needs and the complexity of our aquifer systems that most water service providers and municipalities would have in their employ

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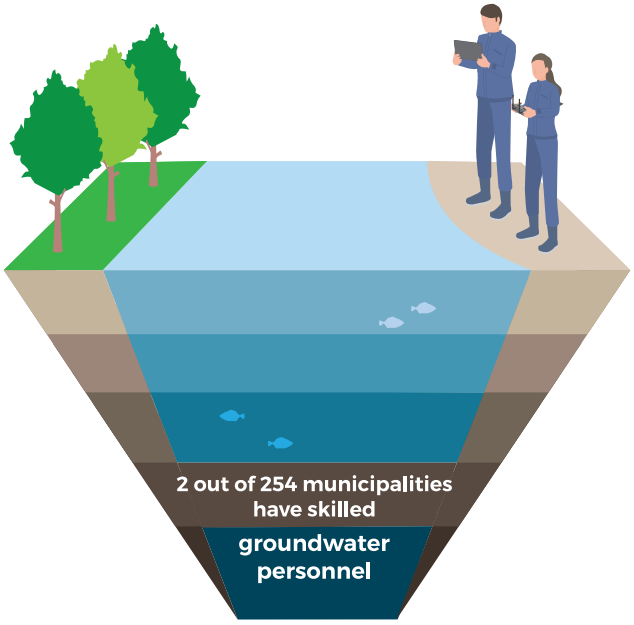
hydrogeologists. Unfortunately, as far as we can establish, only one Metro employs 3 hydrogeologists and 1 in a single District Municipality, 2 out of the 254 municipalities have in their employ skilled groundwater personnel. It is thus no surprise that groundwater is being labelled "unreliable" and "dirty" by decision-makers that do not ensure that these strategic water supply schemes are adequately resourced.

Groundwater is the invisible resource on which many people rely, across the world, for water and food security. It is the resources preferred where no bulk pipeline can and will reach. Competent management of groundwater schemes is essential to ensure that they provide safe and reliable water supplies, protect the environment, and promote sustainable use of groundwater resources. This is especially true for the complex fractured aquifers that characterise the South African landscape. Our understanding, development and management of these complex systems are well supported by excellent research products. These aquifer systems, because of the fractured characteristics, require systematic exploration and development at the wellfield or borehole scale. This is an intense activity, but done right, can provide sustainable water supplies.

Let's take a quick detour. Water stored in surface reservoirs is easy to visualise and understand. As an example, a dam that is at 100% of full storage capacity is easy to visualise (a full bucket). Now try to visualise a body of rock with complex porosity systems (fractures and/or pore spaces). If we saturate these with water, the complexity of determining (or visualising) how full it is, is much more difficult. To unravel this complexity, hydrogeologists use various indirect and direct methods to determine the volume of water within these systems, including the flow through these bodies of rock. It is not something that anyone can do. Once these aquifers (an aquifer is an underground layer of permeable rock, soil, or sediment that contains and transmits water) are explored and developed, it needs more direct and indirect measurements to maintain reliable and clean supplies. Incompetent management of groundwater schemes can lead to inefficiencies, increased costs, and reduced performance. Competent management, on the other hand, can help optimise operation and maintenance costs, ensure efficient use of resources, and maximise the lifespan of groundwater schemes.

If we hope to improve water and food security while becoming climate resilient, then we must insist on adequate resources to manage and develop local groundwater systems. It requires suitable permanent skills at municipalities that use groundwater as a sole or conjunctive resource. In some municipalities, there is a glimmer of hope as they explore alternative ways to improve the development and management of their groundwater resources. In a few instances, there are excellent champions for groundwater – the institutional entrepreneurs. Institutional entrepreneurs are characterised by their ability to identify and exploit opportunities for change, challenge existing practices and norms, and mobilise support for their initiatives. They achieve this through proper planning and budgeting for help. This help comes from the private sector. National and Provincial Water and Sanitation hydrogeologists assist where they can. Locally and globally, hydrogeological experience has moved away from the public sector into the private sector. In the South African context, as interest in groundwater waned, many of these soughtafter experts simply left the country. Hydrogeologists trained on these complex aquifer settings are indeed sought after internationally and generally neglected locally. In September, South Africa will host a global groundwater congress where the latest developments will be discussed and showcased. Unfortunately, at the time of writing, no municipal official has registered for this event.



The role of hydrogeologists is essential for ensuring the sustainable management of groundwater resources, which are critical for human survival and economic development. If we are indeed serious about making communities resilient while continuing to adapt to a hotter and drier climate, we need to correct this mismanagement of groundwater, especially the municipal arena. The strategies, plans, tools, and expertise exist to do this.

The International Association of Hydrogeologists will hold its 50th Congress in Cape Town from 18-24 September. Visit: https://iah2023.org.za/

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