THE WATER WHEEL

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WEATHER AND CLIMATE

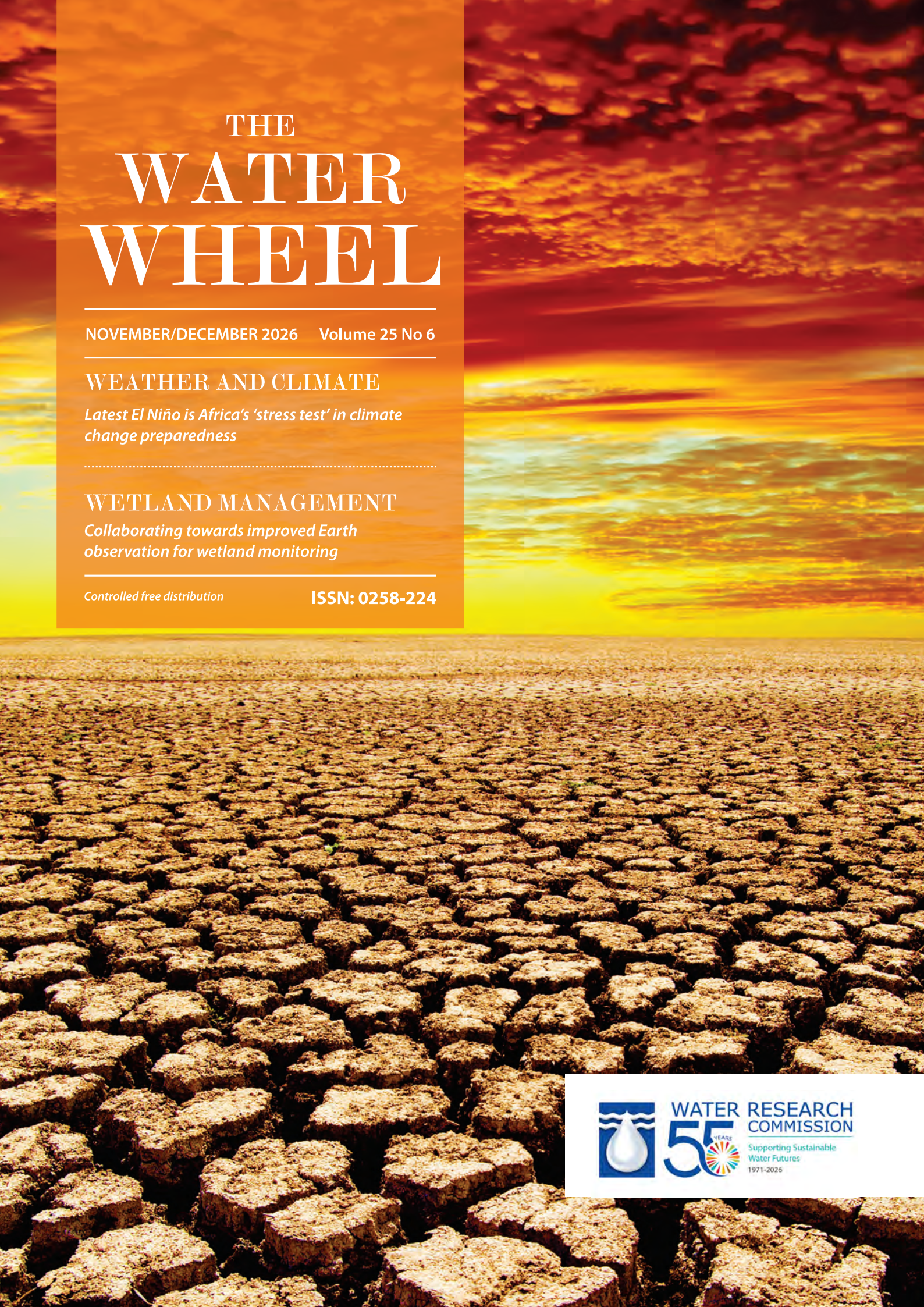
Latest El Niño is Africa's 'stress test' in climate change preparedness

WETLAND MANAGEMENT

Collaborating towards improved Earth observation for wetland monitoring

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Supporting Sustainable Water Futures
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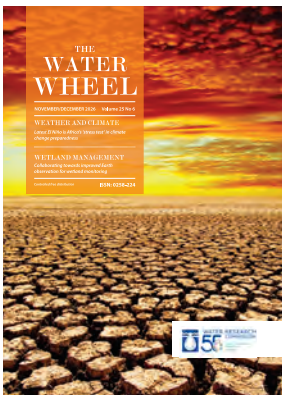
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The Water Wheel *unpacks some of the potential risks around the super El Niño, and what the subcontinent can expect. See the article on page 10.*

NEWS

Looking beyond the borehole: Aquifer recharge systems for urban water resilience



Hydrogeological experts gathered in Stellenbosch from 14 to 16 September 2026 to explore practical pathways for managed aquifer recharge, a practice in which water is purposefully introduced into underground aquifers to store, treat and secure water resources for future use or environmental benefit.

Hosted by the CSIR, the gathering highlighted the importance of adopting a forward-looking approach to the sustainable management of South Africa's groundwater resources. The engagement focused on managed aquifer recharge systems in southern Africa, with discussions covering aquifer recharge, geophysics, groundwater monitoring and nature-based solutions for water resource management.

Setting the stage for looking beyond the borehole, CSIR chief researcher Prof Vhahangwele Masindi remarked that managed aquifer recharge systems have gained prominence in recent decades and outlined the CSIR's innovative capabilities in support of water sustainability initiatives across South Africa. Dr Ricky Murray of Groundwater Africa, who developed South Africa's 2009 artificial aquifer recharge potential map, presented on the 10 success criteria used to evaluate different types of managed aquifer recharge schemes and ensure sustainable artificial groundwater replenishment. He also provided insights into the effectiveness of these criteria in evaluating a range of recharge schemes.

Managed aquifer recharge schemes require a multifaceted approach that combines hydrogeological exploration, numerical modelling, engineering design, environmental assessment and regulatory approval, supported by field trials and ongoing monitoring. "Implementation practice is showing that there are several factors that determine the outcome of a managed aquifer recharge scheme's success or failure and I think one of the most important developments was the 2007 Managed Aquifer Recharge Strategy, which summarises those success criteria," says CSIR senior researcher Dr Nicolette Vermaak.

Currently, there are more than 52 operational managed aquifer recharge schemes in southern Africa that have undergone some form of assessment or feasibility study using the foundational work laid by the managed aquifer recharge 10 success criteria and implementation checklist developed by Murray. "We are receiving specialist-driven guidance from Dr Murray in applying the 10 success criteria of these schemes in a project that the CSIR is managing for the Water Research Commission," says Vermaak.

International bank signs $200 million loan with government to support water infrastructure

The New Development Bank (NDB) and the government have signed a US$200 million loan agreement to support infrastructure for a bulk water supply scheme in Limpopo.

"By expanding access to reliable water supplies, the project is expected to strengthen water security and support economic activity in the region," the National Treasury said in a statement. This initiative will be implemented through Stage 1 of the Olifants Management Model Program (OMMP), which will help address bulk water supply needs in Mogalakwena Local Municipality, Limpopo. It will implement a bulk water supply scheme that abstracts water from Flag Boshielo Dam on the Olifants River. The scheme will supply bulk raw water to industrial users and feed water treatment works that will provide potable water to communities in the municipality.

The OMMP is a public-private partnership funded by government and private-sector industrial users, represented by the Badirammogo Water User Association. "The sovereign loan from the NDB to the Government of South Africa, represented by National Treasury, will finance the public-sector contribution to Stage 1. The loan will support sustainable water infrastructure at local-government level on favourable financing terms," National Treasury added.

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Water mega-project delays put spotlight on infrastructure delivery



Delays affecting South Africa's strategic water infrastructure projects have come under scrutiny, with the Portfolio Committee on Water and Sanitation calling for stronger accountability and closer monitoring of implementation.

The Department of Water and Sanitation (DWS) briefed the Committee earlier this year on progress with major projects, including the Lesotho Highlands Water Project Phase II, raising of the Clanwilliam and Tzaneen dams, the Mzimvubu Water Project, the Mokolo and Crocodile River (West) Water Augmentation Project Phase 2A and the Olifants Management Model Programme.

DWS attributed delays to procurement challenges, poor contractor performance, community disruptions, environmental authorisation appeals, electricity connection delays and funding constraints. The department is engaging National Treasury for additional funding while using available reserves to maintain implementation.

Committee members raised concerns about the impact of prolonged delays on communities without reliable water supplies and questioned discrepancies between planned and actual construction dates. They also sought greater clarity on contractor accountability, local business participation, employment opportunities for women and community engagement.

DWS said procurement reforms, stronger project management and improved community engagement were helping stalled projects move forward.

The Committee agreed that quarterly infrastructure progress updates would be incorporated into its programme, allowing members to track projects against milestones and strengthen oversight of delivery.

New register to track action against water polluters

South Africans are now able to see which municipalities, companies and other entities have faced formal enforcement action for polluting the country's water resources.

The Department of Water and Sanitation (DWS) launched its National Pollution Register on 1 October 2026, which gives the public access to information on entities that have been issued with directives, convicted of pollution-related offences, or ordered by courts to pay damages arising from water pollution. Deputy Minister of Water and Sanitation, Dr Jack Bloom, visited two sites ahead of the launch to demonstrate how pollution upstream can have consequences for the water available to communities downstream.

The first stop was the Hartebeestfontein Wastewater Treatment Works, which was issued a DWS directive in August 2025 in relation to pollution. Wastewater from the area ultimately flows downstream towards Rietvlei Dam.

The delegation then visited the Rietvlei Water Treatment Plant. Rietvlei Dam is a source of raw water for the plant, but deteriorating raw-water quality has affected Tshwane's ability to use the dam as a drinking-water source, according to the DWS.

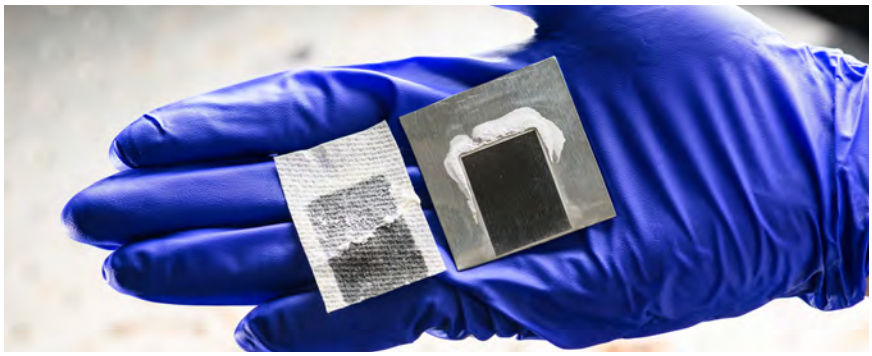
To access the National Pollution Register, visit: https://ws.dws.gov.za/ecms/reports/natpol.aspx#!



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GLOBAL

New desalination method turns ocean water into drinking water without waste



University of Rochester

The United Nations estimates that 2,2 billion people lack safely managed drinking water, and communities from California to the Middle East rely on desalination plants to convert ocean water to fresh water.

Common desalination techniques, such as reverse osmosis and thermal distillation, are energy-intensive, require pre- and post-water treatment, and leave behind a concentrated saltwater byproduct called brine. The brine byproduct has a significantly negative impact on sea life when it's deposited back into the ocean by raising the salt level and lowering oxygen in the water.

But a novel approach developed at the University of Rochester offers a way to overcome these drawbacks. Researchers at the university's Institute of Optics developed a new solar-thermal desalination process to produce fresh water in an energy-efficient way that does not leave behind brine and requires no chemical additives to pre-treat the water. A team led by Chunlei Guo, a professor of optics and of physics and a senior scientist at URochester's Laboratory for Laser Energetics, describes their method in a paper published in Light: Science & Applications.

The technology uses solar panels made of black metal etched with femtosecond lasers to make the surface super light-absorbing and superwicking – or extremely attractive to water. The panels have a laser-treated active region that pulls a thin layer of water across the surface, absorbs nearly all solar radiation, distils the water, and deposits the leftover salts and minerals into the panel's untreated sides or 'passive' region so that the salt does not clog the active region and disrupt continuous desalination.

To keep their solar panel surface from gumming up, Guo's team precisely etched the black metal's grooves so the various salts and minerals in ocean water would simply slough off. They also leveraged a physical phenomenon that has plagued clumsy javaphiles for centuries: the coffee ring effect. "If you drop coffee on a surface, eventually the water evaporates, and there's a ring left at the outer edge that is the concentrated coffee particles," says Guo. "We use that same principle to advance the salts to the passive region."

Testing their solar-thermal desalination technique using samples of water from the Pacific, Atlantic, and Indian Oceans, Guo and his team were able to make the surface self-cleaning.

• To read the original paper, visit: https://bit.ly/3Wcgif5

El Niño events intensify as global temperatures rise

El Niño events have become nearly 40% stronger over the past 40 years compared with those recorded during the pre-industrial era, according to new research published in ***Science***.

Researchers from the University of California, Santa Barbara and others analysed modern and ancient coral samples from the Galápagos Islands to reconstruct El Niño activity over the past 1 000 years. The findings show that El Niño events in the past four decades were stronger than any recorded before about 1850, when human-driven greenhouse gas emissions began significantly altering the climate.

Corals grow in annual layers, with their chemical composition providing a record of historical seawater temperatures. Researchers analysed 13 coral samples, including living colonies and ancient coral boulders, to track temperature changes associated with El Niño. Climate modelling also found no evidence that natural factors such as volcanic eruptions or changes in solar activity could explain the recent increase in intensity.

The researchers warn that global warming may be amplifying El Niño, potentially increasing the frequency and severity of climate extremes, including droughts, floods, wildfires and food insecurity They also caution that current climate models may not fully capture how El Niño responds to global warming, highlighting the need for improved climate predictions and preparedness.

To access the original article, visit: https://bit.ly/4sslBTA

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Bugs could help detect 'forever chemical' contamination



Researchers have discovered that neurons in a locust's brain can distinguish among multiple PFAS compounds, including PFOS, one of the world's most common 'forever chemicals,' at environmentally relevant concentrations.

PFAS, or per- and polyfluoroalkyl substances, are used in products ranging from nonstick cookware and waterproof fabrics to firefighting foams. Because they break down very slowly, they persist in water, soil, and living organisms, making contamination difficult to monitor and clean up. "PFAS are extremely difficult to detect," says Debajit Saha, associate professor in Michigan State University's College of Engineering and Institute for Quantitative Health Science and Engineering. "There is a tremendous need for technologies that can identify them at very low concentrations."

Despite decades of engineering, scientists still struggle to build artificial chemical sensors that rival the sensitivity of living organisms. To test whether insects could detect PFAS, researchers recorded neural activity from the portion of a locust's brain that processes odours. The insects were exposed to gases containing several PFAS compounds, including PFOS, one of the most common and heavily regulated PFAS chemicals found in the environment.

The researchers found that each PFAS compound produced a distinct pattern of neural activity – an 'odour fingerprint' that allowed the insects to distinguish between different chemicals. The team also demonstrated that locusts could detect PFOS at concentrations similar to those found in contaminated environmental samples.

This finding bewildered the researchers because PFAS are entirely human-made chemicals. Unlike the natural odours insects have evolved to recognise, PFAS have existed only for decades, making it unclear why the locust's sensory system responds so strongly to them.

The study is a proof of concept. Next, the team is testing environmental water samples collected in Michigan to determine whether the approach can detect PFAS contamination outside the laboratory. Ultimately, the researchers hope to miniaturise the technology into portable biological sensors capable of rapidly screening multiple PFAS compounds in the field.

The research appears in the ***Journal of Hazardous Materials Advances***.

Biology may offer a completely different way to detect PFAS," Saha says. "If living sensory systems can recognise these chemicals, we may be able to build faster, more versatile tools for monitoring contamination."

The team is now working with environmental samples collected in Michigan to determine whether the approach can identify PFAS contamination outside the laboratory.

• To access the original study, visit: https://bit.ly/4yLD9vy

Africa's digital growth must factor in water security, study warns

Africa's growing digital economy must balance the expansion of data centres with the need to protect scarce water resources, as new research highlights the risks posed by water stress to the infrastructure powering the digital world.

A study published in ***Environmental Science & Technology*** found that one-quarter of the world's 9 347 identified data centres were located in areas experiencing water shortages for at least one month a year under historical climate conditions. This proportion could rise to 33% under a scenario of 3°C global warming.

Although Africa accounts for just 2% of the data centres included in the study, the continent's relatively small share should not obscure the importance of planning for water sustainability as digital infrastructure expands.

Data centres require water to cool computer servers, while the electricity needed to operate them can also have an indirect water footprint. Their demand for reliable, continuous operation may place additional pressure on local water resources already needed by households, agriculture, industry and ecosystems.

The study highlights the importance of considering local water availability when deciding where to build new facilities. It also points to potential solutions, including wastewater reuse, more water-efficient cooling technologies and locating infrastructure in areas with adequate water supplies.

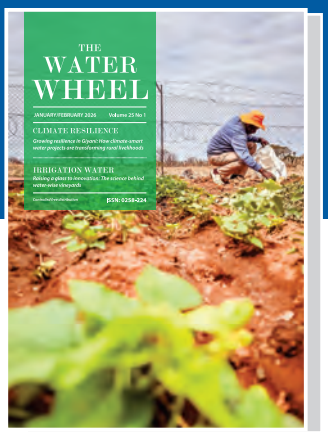
For African countries pursuing digital transformation, the findings underline the need to integrate water security into infrastructure planning from the outset. Sustainable digital growth will depend not only on computing capacity, but also on responsible water management and informed decisions about where new facilities are established.

• To read the original study, visit: https://bit.ly/4imOk7P

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SOUTH AFRICA EARNS FIVE INTERNATIONAL AWARDS FOR ITS RICH IRRIGATION HERITAGE

Recognition at global congress places South African water infrastructure and engineering history in the international spotlight.

South Africa has received five international recognition awards at the 26th International Commission on Irrigation and Drainage (ICID) International Congress, held in Marseille, France, from 12-17 October 2026. The awards recognise the country's historic irrigation infrastructure and its outstanding contribution to international irrigation and drainage activities.

Led by Prof Sylvester Mpandeli, Chairperson of the South African National Committee on Irrigation and Drainage (SANCID), and former ICID Vice President, the South African delegation secured four World Heritage Irrigation Structures (WHIS) awards and the ICID's 8th Best Performing National Committee Award.

The four historic structures recognised are the Vaal Barrage System in Gauteng, Bulshoek Dam in the Western Cape, and Upper van Staden's and Nqweba dams in the Eastern Cape.

The WHIS programme recognises irrigation and drainage structures that are more than 100 years old and have made a lasting contribution to agriculture. These structures must demonstrate historical, cultural or technical significance, marking important developments in irrigation history and offering lessons for sustainable water management. The awards highlight the importance of preserving South Africa's water infrastructure heritage while showcasing the engineering achievements that have supported agricultural development over generations.

South Africa's fifth award, the 8th Best Performing National Committee Award, recognises SANCID's overall performance in advancing the objectives and activities of the ICID. All five nominations were coordinated by SANCID, with Prof Mpandeli and his team preparing the submissions that led to the international recognition.

Putting South Africa on the global map

Speaking from Marseille, Prof Mpandeli said the SANCID leadership had made it a priority to raise South Africa's international profile in irrigation and drainage. "As SANCID leadership, it has been our goal to put South Africa on the global map," he said.

South Africa's latest achievements build on a growing record of international recognition. The country received its first WHIS award in Sydney, Australia, in 2024, followed by four awards in Kuala Lumpur, Malaysia, in 2025. At the 2026 congress in Marseille, South Africa received a further four WHIS awards alongside the national committee accolade.

According to SANCID, South Africa has now secured nine WHIS awards in total, with all nine recognised structures included in the ICID Register of World Heritage Structures. The latest awards reinforce the country's position as a leading African nation in the recognition of historic irrigation infrastructure.

South Africa has held the top position on the African continent for WHIS awards since 2025, surpassing countries such as Egypt and Morocco, which had each received two awards. The country is also now among the world's six leading recipients of WHIS recognition.

Preserving the legacy of water infrastructure

Established in 2012, the WHIS initiative celebrates irrigation and drainage structures that reflect the ingenuity, technical knowledge and agricultural practices of earlier generations. Beyond their historical value, these structures provide insights into how communities have managed water resources and developed agricultural systems over time.

For South Africa, the recognition underscores the richness of its irrigation and drainage history and the value of bringing this heritage to international attention.

SANCID plans to continue identifying and showcasing the country's historic irrigation and drainage infrastructure, including canals, barrages and dams that are more than a century old, through ICID platforms.

The latest awards celebrate not only the country's engineering legacy, but also the continuing importance of irrigation and effective water management in supporting agriculture and water security.



Representatives of the SANCID committee posing with the ICID awards and ICID President, Dr Marco Arcieri, at the recent conference in Marseilles, France.

WEATHER AND CLIMATE

Latest El Niño is Africa's 'stress test' in climate change preparedness

As this year's powerful El Niño raises the prospect of drought, floods, and extreme heat, Africa faces a 'stress test' of resilience this summer. Jorisna Bonthuys reports.



From water-related disease outbreaks to people living in extreme heat in informal settlements, links between extreme weather, water security, and public health are becoming impossible to ignore.

This year's El Niño has already broken many records. In the Northern Hemisphere, summer brought high temperatures and unprecedented heatwaves. Heat stress caused 35 000 excess deaths in Europe. In Dakota, an informal settlement south of Durban, the climate crisis already takes shape beneath a metal roof. Heat builds inside rooms where residents cook, sleep, and care for children. After sunset, temperatures remain high, denying exhausted bodies a chance to recover before another hot day.

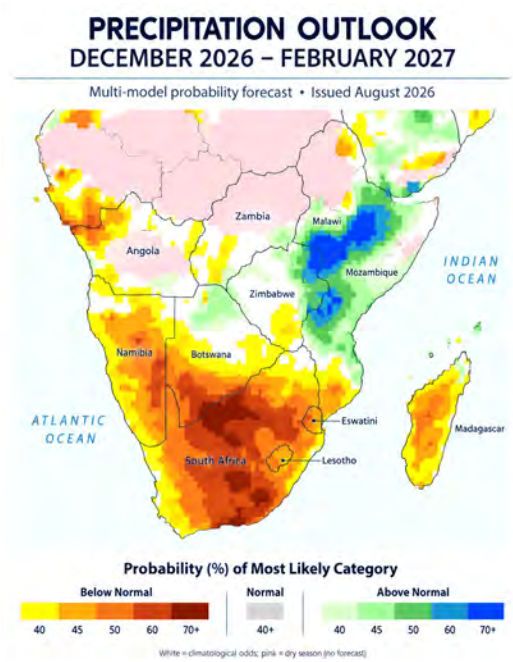
These experiences bring warnings about a warmer world into sharp local focus. When extreme weather arrives, will people have water, and will the health services meant to protect them still function?

For Prof Francois Engelbrecht, a leading climatologist and director of the Global Change Institute at the University of the Witwatersrand, these questions lie at the heart of how communities and decision-makers deal with this year's El Niño event. Prof Helen Rees, executive director of the Wits Reproductive Health and HIV Institute (Wits RHI), focuses on how climate change shifts the landscape of emerging infectious diseases, including the evolving Ebola outbreak and malaria.

Both experts served as panellists in the African Academy of

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CCSR/IRI Multimodel probability forecast for precipitation for December-February 2027



SA Precipitation Outlook 2026 caption – The super El Niño may lead to severe drought in southern Africa, with unprecedented heatwaves and record-breaking temperatures. A key risk is high water demand, which, in combination with water infrastructure and electricity provision issues, may result in frequent water shortages/outages.

Sciences' recent presidential lecture series, which focused on the continent's health system preparedness amid climate-change-linked disease shifts.

Prof Rees said that climate change is altering the "rhythm, reach and range" of infectious diseases on the continent and elsewhere. Both shared concerns about Africa's readiness for climate-related changes and El Niño-related challenges.

This year's event offers a "stress test in climate change preparedness", Prof Engelbrecht said. It could temporarily expose societies to extremes they will increasingly have to manage as the planet warms.

"If [this year's] El Niño brings the usual signal of below-normal rainfall to southern Africa, this summer will likely be the warmest on record."

The practical question is not simply whether Africa can get through one difficult El Niño summer. It is whether this season's El Niño response measures will remain effective when such pressures recur, intensify, or persist. For example, can authorities maintain reliable water supplies when heat-driven demand and reduced inflows occur simultaneously?

Prof Engelbrecht's research highlights the longer-term danger of severe, multi-year drought affecting Gauteng's water system – not a prediction that this single season will cause a 'Day Zero' crisis.

The 2023/24 El Niño offers a warning about how far water stress can travel through society, he pointed out.

During this event, Zambia and Zimbabwe documented maize crop losses of more than 70%. As a result, approximately 27 million people needed food assistance, while Southern African Development Community countries appealed for $5.5 billion for lifesaving support, recovery and longer-term resilience.

Water shortages also affected energy production in the region. Prof Engelbrecht mentioned depleted water supplies at Lake Kariba and major electricity outages in Zambia during this event. Closer to home, the Vaal Dam's water level dropped by 40% in one year.

Food insecurity, disrupted livelihoods and strained services also affected health systems. For subsistence farmers, repeated harvest failures threaten more than one season's income: how many devastating summers can a household endure before farming no longer sustains it?

Why this El Niño is concerning

El Niño begins thousands of kilometres from Africa, with unusually warm surface waters in the central and eastern equatorial Pacific. Events occur roughly every two to seven years and typically last nine to twelve months. Changes in atmospheric circulation can shift rainfall patterns and increase the likelihood of extreme temperatures far away.

In its latest seasonal outlook released in October, the World Meteorological Organization (WMO) reported that this El Niño was firmly established and almost certain to persist through February 2027. The WMO said the event could be unprecedented in strength across four decades of monitoring, with tropical Pacific sea surface temperatures potentially reaching 3.8°C above average from November to January.

However, an event's strength does not determine the severity of its impacts everywhere. The powerful 1982/83 and 2015/16 events brought major droughts in southern Africa; the 1997/98 event did not produce the same response.

Southern Africa generally receives less summer rainfall during El Niño, while East Africa often experiences above-normal rainfall, sometimes with flooding. Prof Engelbrecht warned that dry conditions combined with accumulated global warming could produce exceptional heatwaves across southern Africa and southern West Africa.

"If [this year's] El Niño brings the usual signal of below-normal rainfall to southern Africa, this summer will likely be the warmest on record," he said. "Zambia, Malawi, Angola, Namibia, Botswana, Zimbabwe, Mozambique, and South Africa are all vulnerable to drought during El Niño."

The South African Weather Service's latest seasonal outlook forecasts widespread dry conditions across the interior and north-eastern regions, with above-normal minimum and maximum temperatures in most areas. The warming background adds urgency. Evidence indicates that strong and very strong El Niño events will become more frequent in a warmer world.

The 2023/24 event, combined with climate change, helped push 2024 to become the planet's hottest year on record. The current event could make 2027 the hottest.

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Zayan Vota/Flickr



Zambia and Zimbabwe documented maize crop losses of more than 70% during the 2023/24 El Niño.

Masixole Feni /Groundup



Vulnerable groups, including children and the elderly, are especially susceptible during extended periods of high temperatures.

Africa does not face a uniform impact, but uncertainty does not justify waiting, Prof Engelbrecht emphasised. It requires different preparations and adaptations: protecting supplies where drought threatens, and safeguarding water quality, sanitation and communities where floods may follow.

Prof Engelbrecht highlighted several major risks related to regional tipping points and extreme- event risks. More frequent, intense multi-year droughts, heatwaves and fires threaten rainfed crops and cattle production. Considering biophysical heat stress alone, sectoral tipping points are estimated at about 3°C of global warming; socioeconomic pressures could bring collapse earlier.

A multi-year drought could threaten Gauteng's water supply, he pointed out. An intense tropical cyclone could potentially reach Maputo or Richards Bay, or move into the Limpopo River valley. Durban also faces future mega-floods without a landfalling cyclone.

In addition, infectious diseases could expand their range in warmer and, in some places, more humid conditions.

Vulnerability at home

The Academy of Science of South Africa's recent regional assessment links extreme heat to mounting pressure on water, energy and health systems, disproportionately affecting those least able to protect themselves. Prof Engelbrecht identified older people, pregnant women and people with existing medical conditions as particularly vulnerable, especially in informal housing.

Research in Dakota shows how regional heat can become more dangerous indoors. During the summer of 2024–2025, researchers from the University of Cape Town, the University of Exeter and Project Empower recorded indoor temperatures frequently above 35°C and sometimes exceeding 40°C. Some readings were up to 10°C higher than those at nearby official weather stations.

Residents reported headaches, dizziness, rashes, breathing difficulties and disrupted sleep. Women doing housework and caring for others were exposed for much of the day.

The central finding is unsettling: outdoor measurements do not necessarily reflect heat risks inside homes. Dakota's heat-stress exposure creates an overlooked public-health emergency.

Forecasts offer protection only when they prompt action. Heatwaves can be predicted about a week ahead, Prof Engelbrecht said, providing time to plan water provisioning and other services.

How climate hazards change disease risk

Prof Rees explained that changing rainfall, rising temperatures, and extreme weather events alter vector habitats and stress local water and sanitation systems, compounding risks for diseases like Ebola and cholera.

Understanding these risks requires looking beyond individual pathogens to ecosystems, animal hosts, human movement, humanitarian crises and political conditions. Many African countries face overlapping climate hazards, instability and epidemic risks. Integrating meteorological and environmental data into public-health planning can help authorities anticipate outbreaks.

She pointed out that climate change and infectious diseases interact in crucial ways. Many African countries are vulnerable to climate hazards, geopolitically unstable, and prone to epidemic diseases.

In recent decades, climate change has contributed to several epidemics. For example, climate events linked the 1993 hantavirus outbreak in the USA and the 1997 Rift Valley fever outbreak in East Africa. (The hantavirus outbreak followed increased rainfall during the 1992–1993 El Niño. The Rift Valley fever outbreak was driven by an extreme 1997–1998 El Niño/ Southern Oscillation event that caused heavy rainfall, flooding and a surge in mosquito populations.)

"In the 21st century, we are now really understanding that climate change and biodiversity loss and ecosystem disruption are influencing disease emergence," she said. While direct links between climate change and initial wildlife-to-human Ebola spillover are complex, environmental degradation and habitat shifts increase human-animal interactions.

Prof Rees identified four linked pathways through which climate hazards can alter infectious-disease risk on the continent. First, hazards can bring pathogens closer to people. Floods may contaminate water, and environmental changes can alter the distribution of disease-carrying mosquitoes and other vectors.

Second, hazards can bring people into closer contact with

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pathogens. Displacement, changing livelihoods, and crowded temporary accommodation can create unfamiliar exposures. Third, environmental conditions can favour pathogen survival or transmission. Temperature influences mosquito survival, biting and the replication of viruses they carry; warmer aquatic environments can favour certain bacteria.

Fourth, disruption can weaken human defences. She pointed out that malnutrition, physiological stress, unsafe water and interrupted healthcare make infections more dangerous. A single flood can activate several pathways by damaging sanitation, contaminating supplies, displacing families and interrupting treatment.

Prof Rees described the recent Ebola outbreak in the Democratic Republic of the Congo as a "perfect storm": deforestation, mining, weak health services, poor surveillance and conflict combined to accelerate transmission. Climate pressures compound the social, political and economic conditions that allow epidemics to grow.

Climate-related hazards aggravate diseases

Climate change influences disease by altering interactions among pathogens, hosts, vectors, and the environment. Prof Rees cited research showing that one or more climate-related hazards have aggravated 58% of known human pathogenic diseases.

"In the future, we will face an extraordinary mix of warming, precipitation, floods, storms, and changes in ecosystems and ocean temperatures," she said. "This will directly affect vector-borne, waterborne, and airborne diseases."

The rise in global temperatures enables climate-sensitive disease vectors like mosquitoes and ticks to expand their ranges and reproduce faster, increasing their capacity to transmit diseases.

Prof Rees said mosquito-borne diseases are among those affected, as warmer conditions allow disease-carrying insects to move into new areas. Mosquitoes are the primary vectors for dengue, yellow fever, chikungunya, and Zika. Dengue fever has spread significantly in recent years, with nearly half the world population at risk. This expansion is driven by climate change, globalisation, population growth, and the spread of the ***Aedes*** mosquito.

Malaria transmission is shifting, increasing in areas where it was previously uncommon, including Europe, and declining where temperatures exceed optimal conditions. "Overall, we see a higher likelihood of outbreaks when favourable climate conditions coincide with urbanisation, travel, and weak vector control," she said.

"In Africa, we are seeing a new urban malaria mosquito-borne disease. ***Anopheles stephensi***, originally from South Asia and the Arabian Peninsula, has spread and is rapidly expanding across the Horn of Africa and into African cities." Researchers first detected it in Djibouti in 2012, and it has spread to six other countries.

Unlike many malaria vectors, it thrives in urban environments, breeding in water-storage containers and other artificial habitats. "We saw a similar pattern with the spread of Zika in Latin America, where urban environments and storage containers served as mosquito sources," Prof Rees said.

The mosquito transmits both ***Plasmodium falciparum*** and ***Plasmodium vivax***, adding another challenge to malaria control. She also highlighted rising insecticide resistance and diagnostic difficulties as rapid tests become unsuitable for some malaria infections being recorded.

Flooding creates a different but connected threat. Contaminated water can increase cholera and other diarrhoeal diseases, with particularly severe consequences for children under five. Cholera prevention is inseparable from reliable water and sanitation infrastructure.

Prof Rees noted a sevenfold increase in cholera cases in southern and eastern Africa in early 2026 compared with 2025. Thirteen African countries reported outbreaks, including Mozambique following catastrophic flooding. Floodwaters can simultaneously damage infrastructure and expose families to contaminated water.

The challenge is to connect surveillance and prevention across services that often respond separately: weather forecasting, water provision, sanitation, housing and healthcare. Their failures can reinforce one another, just as effective protection in one area can reduce pressure on another.

Preparing for more than one extreme summer

Major shifts in global health funding and mounting debt pressures threaten countries' ability to respond, Prof Rees warned. Many African countries spend more on loan interest than on health or education, limiting investment in services and pathogen surveillance.

Vaccines remain important, but large outbreaks create sudden demand. Reliable supplies, functioning sanitation and resilient infrastructure help prevent infections before emergency responses become necessary.

Roughly half the region's urban population lives in slums or informal settlements, where extreme heat, unsafe water and crowded conditions overlap. In these settings, preparedness must reach beyond issuing warnings.

This makes the quality of the response as important as the forecast. A week's warning of a heatwave creates an opportunity to organise supplies and services; it does not itself reduce exposure. Similarly, information about changing disease risks must translate into surveillance, prevention and access to care.

The season's El Niño lessons will include whether authorities identify the most exposed communities, keep essential services operating and act before hazards become health emergencies.

For households, the test is immediate: can they stay safe through another hot day, obtain clean water and reach healthcare when needed? For decision-makers, it is also cumulative: can systems withstand repeated shocks without leaving communities progressively less able to recover?

This year's El Niño is temporary, but its consequences may outlast the event. Failed harvests, damaged infrastructure and interrupted care can leave households and services less able to withstand the next shock.

The stress test will reveal whether warnings lead to protection, water keeps flowing, sanitation holds and healthcare reaches people in time – and where investment is needed before the next extreme event.

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IRRIGATION AND FOOD SAFETY

Dishing the dirt: the long road to food safety in South Africa edges forward

Pollution in rivers doesn't stay confined to the waterway. Its influence can ripple outward and into everyday life. Bacteria carried in the water may end up in leafy greens that we bring home and serve at the table. So writes Petro Kotzé.



For more than a decade, the Water Research Commission (WRC) has funded researchers to follow that journey from the river to the farm to the market stall, each study building on the next and filling gaps in current knowledge. One of the latest recent studies, led by the University of Pretoria (UP) and the University of KwaZulu-Natal (UKZN), looked more closely at the circumstances on smallholder farms and in informal markets, and how the risks can be mitigated.

The report, ***Fit-for-purpose guidelines for managing microbiological water quality risks in smallholder farms and informal fresh produce supply chains*** (**WRC Report No. 3268/1/26**), is another piece of the puzzle that grows more complex as we learn what we eat and how interconnected the elements that influence it are.

A trail of questions

The first broad sweep was an investigation into the quality of water used to irrigate our food, published in 2012 under Prof Trevor Britz, who led the Department of Food Science at Stellenbosch University at the time. His team monitored major irrigation rivers and found exceptionally high microbial and pathogenic loads. Their report uncovered the bleak state of our rivers, and the concomitant risk to those that depend on them. "The potential of pathogenic organisms being transferred from irrigation water to the surface of fresh produce plus their ability to survive in these unfavourable conditions presents the scenario where consumers unknowingly face a high risk of being infected with harmful organisms when consuming fresh produce," they wrote (**WRC Report No. 1773/1/12**).

Senior Researcher at the UP's Department of Plant and Soil Sciences, Dr Erika du Plessis, working within Prof Lise Korsten's team, continued the work in 2015 (**WRC Report No. 1875/2/15**). The project followed microbial contamination from the farm to the market and showed early signs of antibiotic-resistant

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Shushan Yemane



An ongoing WRC-funded study is surveilling the Apies River for antimicrobial resistance, testing 14 sites (like this one) along the river.

E. coli, with crops eaten raw of particular concern. Then, in 2017, a revision of the national irrigation water guidelines was being developed by Meiring du Plessis et al., which introduced a risk-based Decision Support System (DSS) that allowed far greater site specificity than the generic 1996 guidelines.

In 2021, du Plessis, with Dr Stacey Duvenage and Prof Lise Korsten of UP, compared formal and informal supply chains in the Cape Town and Tshwane metros (**WRC Report No. 2706/1/21**). They flagged leafy greens as the highest-risk crop and found multidrug-resistant bacteria in the mix. Still, they also remarked that little was known about the informal sector, despite its economic importance. They pointed out that guidance written for commercial growers was not achievable for smallholders.

"There was nothing fit for purpose specifically for smallholder farmers," says Dr Loandi Richter-Mouton, researcher in the same fresh produce and water safety group at the Department of Plant and Soil Sciences. "If that is the only water that they have available to use for irrigation, and there is ***E. coli*** in the water, you can't tell the farmers not to irrigate their crop with [this]," she says. "You must think of alternative methods to try and help them with their available resources." Following the retirement of Dr du Plessis, Dr Richter-Mouton led the next study in the Korsten team, which aimed to address this.

Filling the gap

Dr Richter-Mouton is not new to the question, having completed her Honours on the 2015 project led by Dr du Plessis and Prof Korsten. The existing guidelines, she explains, were not designed for smallholders whose only water source could be contaminated. In the recent project, the team looked for practical ways smallholder farmers could improve their water quality, even though they can't necessarily reduce inputs at the source of contamination.

For this project, the UP team was joined by microbiologist Prof Stefan Schmidt of UKZN. They tested everything from water chemistry to the full genetic code of individual bacteria and looked for traditional foodborne pathogens, as well as a broader range of bacteria and the genes that make them resistant to antibiotics or harmful to people.

The researchers sampled nine smallholder farms and one river, arranged in three case studies. They selected farms that included different farming methods and water sources.

The first case study covered six farms in Gauteng, North West and Limpopo that used varied water sources, irrigation methods, crop types and systems. Their water came from boreholes, a river, a dam and the municipal supply, and the farmers used overhead and drip irrigation and a hosepipe. Between them, they grew leafy greens, roots, and fruits, using aquaculture, integrated livestock, and organic and conventional farming methods.

On one farm, for example, the farmer grows tilapia and vegetables together. Borehole water runs through the fish tanks, picks up nutrients from the fish waste, and settles in a dam before the top water irrigates lettuce, kale, tomatoes, okra and spinach. On another, Chinese spinach, rape and kale grow beside pigs and chickens, and the manure goes straight onto the fields.

The second case study examined three small farms that combine vegetables and pigs, using pig waste to fertilise the crops. Each kept 20 to 25 pigs and used the same borehole water to irrigate spinach and to supply water for the pigs to drink. Workers cleaned the pens daily; one farmer said he occasionally applied pig manure to the fields, and on one farm the pigs roamed freely in the enclosure.

The third case study moved to Sobantu township in KwaZulu-Natal, where small-scale farmers irrigate from the uMsunduzi River. Failing wastewater infrastructure often pollutes the

Michelle Adams



The impact of polluted rivers that are used for irrigation in South Africa has been under investigation for years. The photo shows the Apies River, which is heavily polluted and the subject of a current study.

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Lindiwe Mbau



Panellists at the recent farmer engagement, as part of the ongoing WRC-funded study. (From left) Dr Eunice Ubomba-Jaswa (WRC); Dr Vashnee Govender (UP Faculty of Veterinary Sciences); Prof Lise Korsten (UP Faculty of Natural and Agricultural Sciences); Dr Mahlane Godfrey Kgatle (Gauteng Department of Agriculture Land Reform and Rural Development); and, Dr Loandi Richter-Mouton (UP Faculty of Naturla and Agricultural Sciences).

river. Here the team sampled the river itself and tested leafy vegetables from street vendors in town.

What they found

Across three case studies and more than 200 samples, the team did not detect any classical foodborne pathogens on fresh produce, and only one Salmonella isolate was recovered from a single baby carrot sample. "The big wow of this study," Richter-Mouton says, "is probably that we didn't get any pathogenic ***E. coli*** in our fresh produce." She reads it as a sign that farmers who are not regulated are already doing some things right: "We didn't actually find foodborne pathogens even in environments where it looks likely, which tells me that the farmers do have some sort of best practices that they are implementing at some level."

Their results come with a caveat: they visited each farm only once, and they could not trace the vegetables at the informal market back to their farms of origin. Without repeat sampling, the team cannot yet say whether the same organisms and genes persist or shift with the seasons. Nor does it mean the water carries no risk. The river showed the problem most starkly. On all 37 sampling occasions, the uMsunduzi exceeded the recommended limits for faecal bacteria in water used to irrigate produce that may be eaten raw. An earlier study of the same river had recorded a highest ***E. coli*** count of 7 900 most probable number (MPN) per 100 ml. This time it reached 170 000 MPN/100ml. Salmonella was confirmed in the river on seven occasions. Across the study, irrigation water emerged as the primary driver of contamination.

The more complex issue, Dr Richter-Mouton says, is antimicrobial resistance (AMR). All ***E. coli*** isolates from the farm case studies were multidrug-resistant (resistant to three or more classes of antibiotics). Sequencing found clinically significant resistance genes, and near-identical DNA fingerprint and resistance profiles in a farm's irrigation water and its harvested crops, which the report treats as confirmation of direct water-to-produce transmission.

In the KZN river, most ***E. coli*** isolates were susceptible to the antibiotics tested. However, more than a fifth were resistant to ampicillin, and one strain belonged to a lineage linked to urinary tract and bloodstream infections elsewhere in the world.

The leafy greens from the market carried no ***E. coli*** above the detection limit but did carry antibiotic-resistant opportunistic bacteria. "If you become sick, treatment options become difficult if the pathogens are resistant to the specific antibiotics," Dr Richter-Mouton explains. AMR is "a much bigger, much more complex problem worldwide." It is also why the team went beyond counting bacteria to reading their genes. The same species can be harmless or not, depending on what it carries. In the case of Enterobacter, the same organism can be harmful or helpful depending on its genes. With one set, it causes diseases; with another, it acts as a biocontrol agent that naturally destroys harmful organisms.

Resistance reaches food from various places. When resistant organisms from hospitals enter the waterways through effluent or wastewater, she explains, their resistance genes can be

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transferred to the bacteria already in the environment, "and now you get expanded resistance in your normal natural flora that's on your products." She points to faulty wastewater treatment works pumping raw sewage into the rivers as one of the current biggest influences. "It's very difficult to remove once the system is compromised," adding that, though they are careful to avoid the politics, it's also important to show what's going on.

Water first

The aim, she stresses, is awareness, not blame. "If you think about your food, you also need to think about the environment it was grown in... What is upstream of your water, what is downstream of your water?"

The project outcomes included two ten-page guides approved by the WRC, in plain language, one for farmers and one for informal vendors. For vendors, a three-step routine of test, treat and wash is recommended. For farmers, they propose simplified risk tiers linked to water source, crop and irrigation method, with stricter limits for raw-eaten leafy greens and surface water than for borehole or municipal water.

Decision trees, low-cost testing, and basic treatments such as sand filtration are meant to help farmers assess risk without a laboratory. Where water cannot be cleaned up, the report points to multiple barriers, such as drip irrigation where feasible, safe composting and washing produce in clean water.

Further along the trail

The research team is already busy with the follow-up study. The current WRC-funded study (C2024/2025-01602) focuses on longitudinal antimicrobial resistance (AMR) surveillance along river systems. They are sampling at 14 sites along the Apies River, from its origin to its convergence with the Pienaars River, Dr Richter-Mouton explains, on a bi-monthly basis for a year, starting in July 2025. Again, collaborating with UKZN, three sites along the uMsunduzi river are also being sampled.

Their analysis grows clinically significant bacteria from the water in the lab and also reads the DNA directly from the water to map the full set of resistance genes it carries, known as the resistome. They aim to determine whether the same organisms and genes appear over time and across seasons, working towards a proper risk assessment, with the results going into an open-access dashboard.

To mark their mid-project findings, they held a meeting with local farmers to share their findings and learn what they would like the study to address further based on the results. But Dr Richter-Mouton says the discussion rapidly shifted away from antimicrobial resistance and focused instead on the immediate, day-to-day challenges farmers face along the highly polluted Apies River.

They spoke of clear, cumulative losses on the Apies, including crops failing, lucerne yields far below normal, polluted farm dams (including sludge from a 2025 Rooiwal wastewater treatment works failure), sharp drops in labour, land values down ~50%, and water-truck deliveries stopped in early 2023. They also described years of meetings with no repair and pollution from both sewage and industrial sources, with the river damaged by the authority meant to protect it.

For Dr Richter-Mouton, their feedback clarified that while researchers may pursue a defined question and objective, effective science communication requires prioritising the broader needs and realities of the farmers themselves. Addressing the foundational pollution problem is a necessary first step, she says, adding that it is almost unfair to expect farmers to engage with antimicrobial resistance in the water when the scale of the underlying contamination remains so extensive.

The work continues, and results will leave more questions for future research projects to answer. Some of those, already raised at the meeting, include facilitating shared, cross-departmental action, stronger biosecurity, the participation of farmers in industry and animal-safety forums and, in the long term, ranking rivers according to how safe they are to use, and more proof to support One Health (the idea that human, animal and environmental health are tied together) impacts.

For enquiries, contact Dr Loandi Richter-Mouton at loandi.richter@up.ac.za

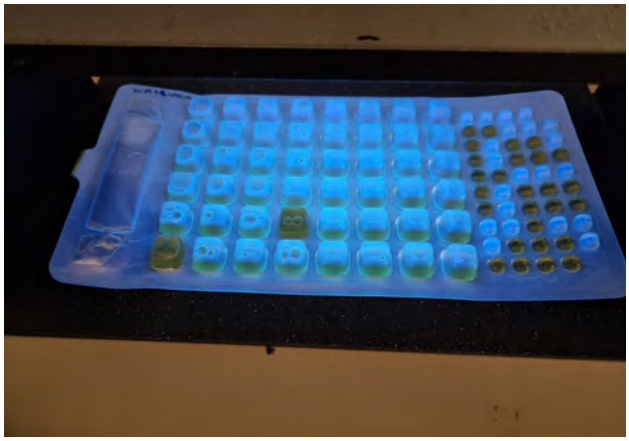


Photo supplied

E. coli *fluorescence of Colilert enumeration – a standardised laboratory method used to detect and quantify total coliforms and Escherichia coli (E. coli) in water samples.*



Loandi Richter-Mouton

The site of clear wastewater input into the Apies River, which is used for, among other uses, irrigation and agriculture.

WETLAND MANAGEMENT

Collaborating towards improved Earth observation for wetland monitoring

From satellite technology that enables Earth observation (EO) to muddy boots on the ground, South African scientists are joining forces with collaborators to improve the monitoring of South Africa's threatened wetlands. Through the National Research Foundation-funded EO4Wetlands project, researchers from different disciplines and institutions are combining cutting-edge monitoring technology with hands-on fieldwork to improve wetland monitoring with EO. Article by Dr Heidi van Deventer, Charl Broekman, Abri Broere, Thabiso Choshi, Jonathan Diederiks; Dr Piet-Louis Grundling; Dr Christel Hansen, Nancy Job, Eulalia Jordaan, Marijke Koopmans; Dr Jason le Roux, Hannes Marais, Joshua Meyer, Elijah Mogakabe, Rethabile Mothae; Dr Laven Naidoo, Luther Nthangeni, Regina Mabokachaba, Dr Grace Maponya, Dr Juan Scheun, Collin Silima, Prof Ed Stam, Tshifhiwa Thenga, Stanley Tshitwamulomoni, Natalie Vos, Michele Walters, and Scout Yatt.

We often hear that wetlands are highly threatened and poorly protected; however, few people have had the privilege of walking through the wetlands located in the metropolitan area of the City of Tshwane, South Africa. Realising their beauty and that they are highly functional and provide valuable ecosystem services builds an appreciation of their resilience to the onslaught of anthropogenic and climate change impacts. Accessing these wetlands with a diverse range of people who share a similar passion and keen interest, who exchange and share knowledge and information to optimise understanding, helps to sharpen the persistence and focus towards refined wetland monitoring, and ultimately greatly enhances this experience.

The National Research Foundation (NRF) funded a three-year project, 'Earth Observation for Wetlands' (EO4Wetlands), as part of its Earth Systems Science Research Programme (ESSRP) (project code ESS240507217738). The programme pursued collaboration among various institutions to ensure that science and research are shared, understood, and interactively developed, breaking down silos and the separation of people across institutions and disciplines.

The EO4Wetlands project enabled collaboration between geoinformation and environmental management scientists who focused on ecosystem mapping and monitoring, soil scientists and species experts, as well as local and traditional authorities, to improve the exchange of wetland monitoring in selected study areas. These included six study areas across three provinces: Colbyn Wetland and Rietvlei Dam nature reserves in Gauteng, De Berg and Verloren Vallei nature reserves in Mpumalanga, and Lake Fundudzi and the Mutale wetlands in Limpopo.

So much water emerging in a watershed?

What is fascinating about Rietvlei Dam Nature Reserve is that its southern boundary is about 13,6 km downstream from a major watershed between primary catchments. The main catchment feeding the reserve (known in technical terms as catchment A21A) is drained by two rivers, namely the 20 km-long Grootvlei River in the east and the 25 km-long Rietvlei River in the south. Both flow northwards into the 32 km-long Sesmylspruit, where Rietvlei Dam is located.

Groundwater from this catchment historically contributed up to 16% to the water supply for the City of Tshwane. These rivers converge with the Kaalspruit-Olifantspruit, 2,6 km downstream of the dam, to form the Hennops River, then the Crocodile River, which joins the Limpopo River, a cross-border river between South Africa and its neighbouring countries.

A variety of wetland types are evident so high up in this watershed catchment, of which many are permanently saturated (see Figure 1). Interesting to also note the 'pans' or depression wetlands right on the watershed, and springs emerging at such a high elevation. The contribution of interflow from aquifers

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is therefore evident but has not yet been studied to assess its proportion of the contribution to surface wetlands and their ecosystem services. Not only do the wetlands provide habitat for plant and animal species, but they also slow water flow to reduce flooding and erosion, while promoting filtration and infiltration.

This article provides an overview of the collaborators and some of the trips undertaken to date at the Rietvlei Dam Nature Reserve and highlights the value of in-field exchange in complementing workplace and workshop discussions.

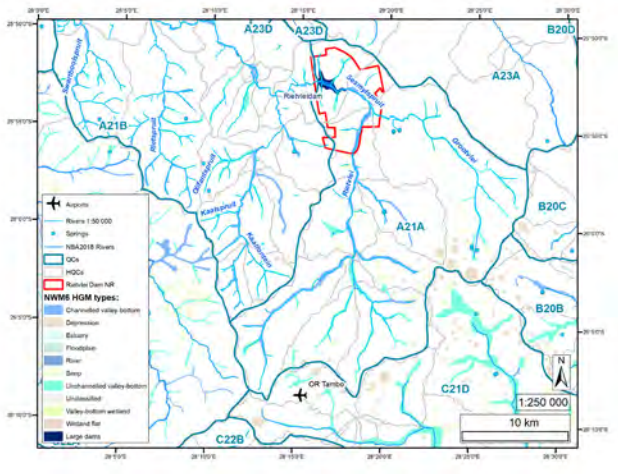


Figure 1: The location of the Rietvlei Dam Nature Reserve (NR) relative to the Hydrological Quinary Catchments (HQC; 5th level; Clark et al., 2024), with many springs and wetlands so high up on a watershed. NWM6 = National Wetland Map version 6 (SANBI, 2024); HGM = Hydrogeomorphic (types).

Beautiful nature in a metropole: Get your feet wet, up close and personal

While many visitors drive through Rietvlei Dam Nature Reserve, kayak on the dam, take a guided hike or have braai opportunities, very few people have had the chance to walk through these wetlands. What appears to many as just 'veld' in South African colloquial language, in fact, is marshland or 'vlei', with different species of sedges (mostly with edges) (see Figure 2).

On a closer walk-through, the differences in depth and species are evident. For example, one of the depressions is only 10 cm deep, as measured with a soil auger, compared to the upper parts of a valley-bottom wetland, reaching depths of 60 cm. The 32 km-long stretch of the Sesmylspruit is a channelled valley-bottom wetland, with patches of ***Phragmites australis*** reeds and homogeneous areas of ***Carex*** spp., likely the lesser pond sedge, which is about 1.5 m high.

Peat soil was historically extracted here, in the southern part of the wetland, before the reserve was declared. Subsequently, Working for Wetlands was officially launched in 2002 and did some of the first restoration along the spruit already in 2000, and vegetation has evidently re-established.

The beauty of the wetlands can be better appreciated when you get your feet wet, and by being able to walk to the ***Kniphofia*** (red-hot pokers or torch lilies) flowers, and to see orchids, and get the names of the species through the iNaturalist app, including flowers, orchids and dragonflies (Figure 3).



Figure 2: Palustrine marshlands at the Rietvlei Dam Nature Reserve between 2025 and 2026 show the variation in plant species ranging from sedges to reeds.



Figure 3: Species observed at Rietvlei Dam Nature Reserve in and close to wetlands: (a) Eulophia welwitschia *(banana orchid); (b)* Palpopleura jucunda *(Yellow-veined Widow) and c)* Habenaria epipactidea *(Epipactis-Like Habenaria or the Lightning Ghost Orchid.*

Collaboration and exchange optimise understanding and sharpen focus towards solutions

The NRF project has facilitated the exchange of information about possible EO methods for monitoring wetlands, with the

Rietvlei Dam Nature Reserve serving as a hub for interaction among people with diverse backgrounds, skills, knowledge, and contributions. In January 2025, participants of the NRF ESSRP EO4Wetlands project were joined by experts from the Department of Forestry, Fisheries and the Environment (DFFE), the Agricultural Research Council (ARC) and UNISA to scout for sites and plan complementarity of projects (Figure 4a).

Subsequently, even students from UNISA in wildlife management joined the outing, where the feasibility of soil moisture probes at sites was investigated based on Charl Broekman's PhD (Figure 4b). The installation of soil moisture probes (also formally called 'continuous logging soil moisture probes' or 'DFM capacitance probes') was facilitated by DFM Technologies in 2026, including Lawrence van der Westhuizen, Jeromeo Mento and Ndiyafhi Muthuhadini (Figure 4c).











Figure 4 - Outings to Rietvlei Dam Nature Reserve since January 2025:

a. Dr Christel Hansen (UP), Dr Michael van der Laan (ARC), Dr Piet-Louis Grundling (DFFE); Ms Michelle Hartslief (WeatherSA. UNISA); Dr Anna de Jager (UNISA), Dr Heidi van Deventer (CSIR, UP), Ms Renée Grundling (UP), and Dr Jason le Roux (ARC).

b. Charl Broekman (UP), Albert Durand (AIE), Dr Heidi van Deventer (CSIR, UP), Luther Nthangeni (CTMM), Ntokozo Shongwe (student at UNISA, Nature Conservation), and Nombuso Nkambule (student at UNISA, Nature Conservation).

c. Ndiyafhi Muthuhadini and Ditshego Maleka (DFM Technologies) installing moisture probes.

d. Charl Broekman illustrating the challenges of the chlorophyll and Leaf Area Index (LAI) meters to record physical values in the palustrine wetlands that are grazed and have little above-ground biomass of vegetation.

e. Ms Rethabile Mothae (TUT), Prof Ed Stam (UNIVEN), Mr Thabiso Choshi (UNIVEN), Ms Tsholofetso Seipone (VUT), Mr Luther Nthangeni (CTMM), Ms Lebohang Borole (VUT), DFM staff Mr, Mr Lesley Rambau (CTMM), Mr Jonathan Diederiks (NRF), Mr Lawrence van der Westhuizen (DFM Technologies).

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To our knowledge, this is the first time that these probes are used in wetlands in the temperate climatic region and Grasslands Biome of the country, and the first time for establishing error estimation of various satellites for monitoring soil moisture in wetlands. These probes will play an important role in refining the extent and duration of the hydrological regime cycles, which are very poorly represented and monitored in global datasets.

Most of the collaborators and some of the stakeholders gathered on 21 August 2026, for the last installation of one of the soil moisture probes at the Rietvlei Dam Nature Reserve (Figure 4d). This site visit enabled everyone to share what they are working on and to show in the field the opportunities, challenges, and limitations. All collaborators and the stakeholders could then engage. This enriching experience enabled everyone to ensure cross-pollination of understanding, identify gaps for follow-up, and consider opportunities for improvement.

In addition, Dr Le Roux from the ARC is leading work to refine the classification and assessment of soil types in the wetlands of the study areas. Several students are also contributing to the refinement of EO monitoring of wetlands and rivers (UP team and students), wetlands in the Limpopo Province, which are montane and subtropical (UNIVEN team and students) and associations with faunal species such as Lepidoptera, macroinvertebrates, and amphibians in palustrine wetlands (TUT team and students).

The EO4Wetlands project demonstrates that monitoring and protecting South Africa's wetlands requires more than scientific knowledge and advanced technology; it requires people working together across disciplines, institutions and geographical boundaries. By combining satellite observations, soil moisture monitoring, ecological research and hands-on fieldwork, researchers are building a clearer picture of how wetlands function towards improved protection.

Please see the full list of collaboration participants and stakeholders in Table 1, and their contributions to the overall project aim.

Table 1: List of authors, contributors and stakeholders related to the NRF ESSRP project EO4Wetlands

Name	Position	Department, Organisation	NRF project relation
Dr Heidi van Deventer	Principal Researcher	Sustainable Ecosystems, Council for Scientific & Industrial Research (CSIR)	Project lead and supervisor to geomatics students
Mr Charl Broekman	PhD Student	University of Pretoria (UP); Department of Geography, Geoinformatics and Meteorology	PhD in Geoinformatics; 'Refining earth observation methods for the monitoring of soil moisture of palustrine wetland
Mr Abri Broere	Master's student	BioPulse Research Group; Department of Nature Conservation; Tshwane University of Technology (TUT)	Master of Applied Science in Nature Conservation; Macroinvertebrate wetland associations
Mr Thabiso Choshi	PhD Student	University of Venda (UNIVEN): Department of Geography and Environmental Science	PhD in Environmental Sciences; 'Quantifying Vegetation Dynamics and Hydrological Functionality of the Mutale Wetland Using Multispectral and Hyperspectral Datasets'
Mr Jonathan Diederiks	Director: Strategic Science Missions (SSM), Thematic Research Support and Advancement	National Research Foundation (NRF)	Funding organisation
Dr Piet-Louis Grundling	Scientific support staff and Research Associate.	Department of Forestry, Fisheries and the Environment (DFFE) Centre for Environmental Management, University of the Free State	Collaborator
Dr Christel Hansen	Senior lecturer	UP	Collaborator, supervisor of geomatics students
Ms Nancy Job	Lead: Freshwater Biodiversity Programme	South African National Biodiversity Institute (SANBI)	National stakeholder
Ms Eulalia Jordaan	Ecological Technician	Mpumalanga Tourism and Parks Association (MTPA): Scientific Services, Ecological Systems	Provincial stakeholder
Ms Marijke Koopmans	Master's student	BioPulse Research Group; Department of Nature Conservation; Tshwane University of Technology (TUT)	Master of Applied Science in Nature Conservation; Lepidoptera communities across habitat types and altitudinal and seasonal gradients in a high-altitude ecosystem at De Berg Nature Reserve Mpumalanga, South Africa.

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Name	Position	Department, Organisation	NRF project relation
Dr Jason le Roux	Researcher	Agricultural Research Council - Natural Resources and Engineering (ARC)	Soil calibration and interpretations, co-supervisor to Mr Broekman's PhD
Mr Hannes Marais	Wetland Ecologist	MTPA (retired)	Provincial collaborator
Mr Joshua Meyer	Honour's student	UP: Department of Geography, Geoinformatics and Meteorology	BSc Hons Geography and Environmental Science; An Assessment of DFM soil-moisture probe accuracy across contrasting soil types in Colbyn wetland, South Africa
Mr Elijah Mogakabe	Scientific Manager and Programme Manager	Department of Water and Sanitation (DWS)	National stakeholder
Ms Rethabile Mothae	Master's student	BioPulse Research Group; Department of Nature Conservation; Tshwane University of Technology (TUT)	Master of Applied Science in Nature Conservation; Environmental and seasonal patterns of amphibian communities in a pristine Ramsar wetland.
Dr Laven Naidoo	Senior Researcher	Gauteng City-Region Observatory (GCRO), a Partnership of the University of Johannesburg, the University of the Witwatersrand, Johannesburg, the Gauteng Provincial Government and Organised Local Government in Gauteng (SALGA), Johannesburg, South Africa.	Co-supervisor of Mr Broekman's PhD study and Ms Mabokachaba's MSc.
Mr Luther Nthangeni	Ecologist	City of Tshwane Metropolitan Municipality (CTMM)	Provincial stakeholder
Ms Regina Mabokachaba	Master's student	UP: Department of Geography, Geoinformatics and Meteorology	MSc Geoinformatics. Title: 'Comparing object-based and pixel-based approaches to quantify changes in palustrine wetlands for the Colbyn Wetland Nature Reserve'
Dr Grace Maponya	Lecturer	UNIVEN: Department of Geography and Environmental Science	Collaborator, Supervision of students working on remote sensing applications for wetland monitoring.
Dr Juan Scheun	Lecturer	BioPulse Research Group; Department of Nature Conservation; Tshwane University of Technology (TUT)	Collaborator, Supervision of students working on wetland faunal associations
Ms Collin Silima	ASD - Provincial Coordinator - Limpopo Assistant Director: Environmental Programmes Non-Infrastructure	DFFE	National stakeholder
Prof. Ed Stam	Associate Professor	UNIVEN: Department of Geography and Environmental Science	Collaborator, EO4Wetlands coordination and supervision of Mr Choshi
Mr Tshifhiwa Thenga	Functional Head: Nature Conservation Operations	CTMM	Provincial stakeholder
Mr Stanley Tshitwamolomoni	Director: Water Sources and Wetlands Conservation	DFFE	National stakeholder
Ms Natalie Vos	Functional Head Nature Conservation Operations | Rietvlei Nature Reserve	CTMM	Provincial stakeholder
Ms Michele Walters	Lecturer	BioPulse Research Group; Department of Nature Conservation; Tshwane University of Technology (TUT)	Collaborator, TUT EO4Wetlands coordination and supervision of students working on wetland faunal associations
Ms Scout Yatt	Honours Student	UP: Department of Geography, Geoinformatics and Meteorology	BscHons Geoinformatics. Title: 'Geomorphic characterisation of waterfalls in southern Africa using available geospatial datasets'

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WATER POLLUTION

Tyre wear particles and (water) pollution: A complex environmental issue

Against the background of the strong decline in rail transport and the simultaneous increase in light- and heavy-vehicle traffic on the South African road transport system, questions arise such as: What impact does tyre wear have on the environment? Do released tyre particles form part of microplastic pollution? Do tyre particles occur in water resources and soil samples? What health risks arise from this form of environmental pollution? Do climatic differences play a role in the intensity of tyre-wear pollution? What research methodologies are used to investigate the process, incidence and effects of tyre wear experimentally? How can the polluters responsible for this form of environmental pollution be held financially accountable? What role does the consumer, for example, driver's behaviour, play in the process? Handré Brand discusses some of these questions.



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South African researchers Krüger, Snyman and Odendaal (2019) point out that a large proportion of anthropogenic metal emissions originates from vehicle traffic and enters all three environmental domains (air, water and soil), creating a pollution dilemma that is complex and problematic. In addition, chemicals such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals present in crumbed (recycled) rubber have been identified as harmful to human health and the environment by a South African group of chemists (Sibeko, Adeniji, Okoh and Hlangothi 2020).

Further, according to Kang et al. (2025), tyre wear particles represent a very large share of traffic-related microplastic emissions and may be a significant source of microplastics in aquatic systems. In Europe, approximately 1.3 million metric tonnes of particles are released annually, while more than 6 million metric tonnes are estimated to enter agricultural soils worldwide each year. Particles suspended in the air are inhaled and may be associated with physical health risks, such as respiratory and cardiovascular diseases.

Kundel et al. (2025) analysed soil samples collected along the Swiss road network. As expected, samples taken directly alongside road surfaces contained high concentrations of tyre wear particles, averaging approximately 111 000 particles per kilogram of dry soil, with up to 615 000 particles per kilogram measured at some locations. Concentrations declined significantly with increasing distance from the road surface. 10 metres from the road, concentrations were approximately ten times lower than at 1 metre. The particles were generally microscopic and elongated, with an average Feret diameter of approximately 63 micrometres (one thousandth of a millimetre).

Zhang et al. (2023) point out that, because of stricter exhaust-emission standards and the increasing use of electric vehicles, non-exhaust emissions (particularly tyre particles) are gradually beginning to exceed tailpipe emissions. Because electric vehicles are, in many cases, heavier than comparable internal-combustion vehicles, greater vehicle mass, together with factors such as torque and driving style, may contribute to increased tyre wear.

The authors also emphasise that, up to 2023, no standardised international regulatory framework existed to limit tyre-particle emissions, nor was there a universally applicable technology capable of eliminating tyre wear completely. This observation should, however, be viewed in context, because international and European regulatory initiatives concerning tyre wear are now being introduced. Regulation of TWP emissions remains at a developmental stage, with important gaps in testing, standardisation and coverage of different vehicle and tyre categories.

Measurement techniques and methods, for example, laboratory experiments versus real-road tests, are not uniform, which makes comparison of data between studies difficult. This highlights the need for standardised testing and measurement procedures in this important field of research (Zhang et al. 2023).

Tyre wear therefore appears to be an increasingly relevant global issue, but the question remains whether it receives sufficient attention in relation to the scale of the problem.

Direct costs

Because vehicle tyre wear, in addition to presenting a pollution dilemma, theoretically represents a direct cost factor, the principles of logistics management (Pienaar and Vogt 2025) are directly relevant. Logistics management may be defined as an aspect of supply-chain management concerned with planning, implementing and controlling the effective forward and reverse flow of goods between the point of origin and the consumer (Pienaar and Vogt 2025:29). A wide range of activities is associated with the flow of goods, including packaging, inventory management, customer service and the transport of goods.

In transport, tyre wear is a typical "running-cost item" (Pienaar 1985:100), because it is directly associated with vehicle movement. It can also be quantified objectively in physical units, for example, grams per kilometre. On an open tar road with relatively less traffic than in an urban environment, and taking factors such as driving style and tyre type into account, tyre wear increases as vehicle speed increases. Between 90 and 100 kilometres per hour, wear reaches a peak and then begins to decline after 100 kilometres per hour (Pienaar 1985:117).

Tread wear is caused in several ways (Pienaar 1986:205), including rolling-resistance friction, friction where the tyre meets the road surface, and the effects of braking forces when vehicle speed is reduced. Forces between the tyre and road surface arise from deformation and friction effects. These effects result directly from relative speed between the tyre structure and road surface, for example during braking or steering. Frictional forces and relative speed generate heat, causing temperature changes in both the tyre structure and tread (Schubert, Ketan, Schabauer, Lex and Hausberger 2026).

In a case study using a four-axle combination truck operated by Alpha Carriers as an illustration, total tyre-use cost in 2024 was given as 155 cents per kilometre for that vehicle (Pienaar and Vogt 2025).

Pollution resulting from tyre wear is regarded as an unpriced negative externality because particles released through tyre wear may cause substantial environmental and public-health damage, while the cost of damage is not included in the purchase price of tyres or in transport costs. Vehicle tyre wear therefore represents both a direct expenditure for companies in the form of tyre-use costs and an additional indirect, unpriced environmental cost.

Polluter pays principle

The polluter pays principle is the generally accepted practice according to which those who cause pollution should bear the costs of managing it (that is, prevention, control and rehabilitation) in order to prevent damage to human health or the environment (Ward and Hicks 2022). For example, a factory that produces a potentially toxic substance as a by-product of its operations is normally held responsible for the safe disposal of such by-products. The polluter pays principle forms part of a broader set of principles intended to promote sustainable development worldwide and is formally reflected in the 1992 Rio Declaration (Ward and Hicks 2022).

The National Environmental Management Act of 1998 (NEMA)

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is South Africa's primary legislative framework for environmental management (Savannah Environmental 2026). It sets out fundamental principles for environmental management and establishes mandatory requirements for environmental impact assessments. NEMA applies across economic sectors and requires potential environmental consequences of listed or specified activities to be considered, investigated, assessed and reported to the competent authority in accordance with the Act and applicable regulations.

The extent to which NEMA and the polluter pays principle are applied consistently and successfully in practice and through South African case studies falls outside the scope of this article. Ridl and Couzens (2010:112) state in this regard: "It appears that we might be entering into a crucial phase in the development of South African environmental law – it is going to require extreme vigilance (even activism) from environmental lawyers if, out of the current maelstrom of case law, statute law, politics and policy, a proper balance amongst economic growth, social development and environmental protection is to emerge."

Tyre wear particles and soil quality

According to Kang et al. (2025), the structure and quality of agricultural soil decline significantly when tyre wear particles are present. Their global literature review reports reductions of up to 25% in soil porosity, 20–35% in the decomposition of organic material, and 40–60% in the presence of nitrogen-fixing bacteria in originally high-quality agricultural soils. Laboratory findings further indicate the presence of toxic substances and heavy metals such as zinc, copper and PAHs in soil samples. Risks include physical blockage of plant roots, zinc-induced oxidative stress, reduced photosynthesis and growth retardation. These processes also create risks of bioaccumulation in the food chain.

Kundel et al. (2025) similarly found that the carcinogenic substance benzo[a]pyrene, which also occurs in exhaust emissions, was present in Swiss soil samples, particularly those collected near highways. Sixty-three per cent of the samples



Tread wear is caused in several ways, including rolling-resistance friction, friction where the tyre meets the road surface, and the effects of braking forces when vehicle speed is reduced.

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Vehicle tyre wear represents both a direct expenditure for companies in the form of tyre-use costs and an additional indirect, unpriced environmental cost.

analysed exceeded the Swiss soil threshold value for this substance. These chemical and tyre wear particles therefore appear to be two sides of the same pollution issue, without implying any causal relationship.

Bouredji, Lumière, Lakhmi, Muresan-Paslaru, Pourchez and Forest (2025) conclude that the toxicity of tyre wear particles in soil can be attributed to two main sources: the intrinsic toxic properties of tyre and road-surface particles, and exogenous contaminants that these particles accumulate from the local environment. It is therefore important to investigate the combined toxic effects of tyre wear particles and substances such as benzo[a]pyrene in soil samples.

Water systems: the central pollution pathway

Hapich, Van Emmerik, Waldschläger, Maurer, Yang and Gray (2026) investigated how tyre wear particles are transported during rainfall in urban areas. They used a rainfall-runoff simulator to determine the effects of factors such as surface roughness, rainfall intensity and terrain slope. Cryo-milled tyre-tread material supplied by the United States Tire Manufacturers Association was used in the experiment. The particles consisted of a composite mixture of tyre material from passenger cars (41%), light trucks (14%) and heavy-duty/commercial trucks (45%). These proportions were representative of tyre particles normally found in natural environments in the United States.

Low surface roughness, high rainfall intensity and low slopes resulted in the fastest particle wash-off, with rainfall intensity being the most important factor. Relatively large particles (>1 000 micrometres), once mobilised, moved faster than smaller particles (<125 micrometres). This contrasts with the movement patterns normally observed for mineral sediments. Flow depth was more important than flow velocity or shear stress. The particles were therefore transported more frequently as surface load than as bed load. This also differs fundamentally from sediment transport, possibly because of the hydrophobic properties of the particles and the possibility that air bubbles

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adhere to them (Hapich et al. 2026).

The full implications of these findings remain an open question because existing urban stormwater systems are designed mainly to deal with sedimentation. The transport of tyre wear particles by water nevertheless differs fundamentally from sediment transport. Consequently, conventional preventative measures may not be sufficiently effective to intercept these particles before they reach natural watercourses.

The concentrations of vehicle tyre particles found in aquatic environments vary substantially according to the water source, sampling method and analytical method. Sun, Wang, Ouyang, Liu and Zhang (2025) report concentrations ranging from 0.03 to 179 milligrams per litre. The particles accumulate mainly in sediments because of their high particle density (Song, Lin, Oh, Grossart and Yang 2025), although water chemistry, turbulence, and particle shape and size also play a role.

The constituents of tyre particles can release toxic leachates, including heavy metals – especially zinc – and organic compounds such as 6-PPD. 6-PPD refers to chemical additives with useful industrial functions, such as protecting rubber against oxidative degradation, but they may pose unintended and serious risks to ecosystems when transformed into other chemical compounds and thereby enter aquatic environments. These releases can cause oxidative stress, DNA damage, altered immune responses and disturbed feeding behaviour in aquatic organisms. Effects vary according to species and exposure concentration (Song et al. 2025).

Taken together, the water-related evidence in the literature cited here points to an important pathway by which tyre wear particles can move from roads into stormwater, rivers and other aquatic environments. The problem is not limited to the physical presence of particles in water: the particles can also act as carriers or sources of chemical substances that are released into the aquatic environment.

Possible solutions

Kang et al. (2025) propose a three-level remediation approach: greater emphasis on source reduction by developing advanced technical tyre compositions designed to reduce wear substantially; environmental interception through effective bio-designed filtration systems and membranes; and chemical management of contaminants through the development of new bio-remediation techniques.

Kumar, Biswas, Mulla, Singh, Shukla, Ahanger, Shekhawat, Verma, Siddiqui and Seth (2024) focus on the management of micro- and nanoplastic pollution, which also includes vehicle tyre wear particles. For identification and monitoring, they recommend advanced analytical techniques such as spectroscopy, microscopy and spectrofluorometry.

No single, simple solution exists for pollution caused by vehicle tyre particles (Sivalingam, Gayathri, Boopathy, Choi and Sangeetha-Selvan 2026). In addition to Kang et al. (2025), this Indian and Korean research group proposes a multi-level approach: preventing pollution at the tyre itself as the primary source of the problem; early capture and removal of harmful chemicals before they reach water resources such as rivers and oceans; chemical degradation or neutralisation of pollutants; and ultimately the replacement or elimination of harmful chemicals, such as 6-PPD, associated with tyre wear.

Conclusion

This literature review emphasises that tyre wear should not be regarded merely as an unavoidable by-product of road transport, but as a significant and complex form of environmental pollution deserving increasing scientific attention.

Although effective road-transport systems are essential to any modern economy, the environmental costs associated with tyre wear can no longer be placed entirely outside the transport system. Tyre pollution is a systemic problem in which vehicle mass, tyre design, driving style, road surface, rainfall, stormwater management and regulation are closely interconnected. The central challenge for the future is therefore to develop reliable, standardised measurement methods; quantify the actual ecological and health risks; and allocate responsibility and costs among the relevant stakeholders in a fair and scientifically defensible manner.

Based on the literature considered, tyre wear is clearly an increasing environmental issue. Greater uncertainty remains about whether science, industry and policymakers are responding rapidly enough to the impacts and consequences of this difficult challenge. It also illustrates the principle that, when technical-industrial problems are solved innovatively, related problems of a different nature may often be created.

- This is a translated and edited version of the original LitNet article in Afrikaans, published on 29 September 2026.

Notes

The sources referred to in this article were used selectively, which may be regarded as a limitation. By-products of vehicle tyre wear also contribute to atmospheric pollution, and this factor, together with possible health implications, has received relatively little attention. The main purpose of the article is to raise awareness of the environmental implications of the release of tyre wear and tyre particles, rather than to constitute a comprehensive academic article or make a scientific contribution.

Wessel Pienaar and Leon Loxton are thanked for their willingness to check and edit the section under the heading "Direct costs" for factual correctness before publication, as well as Johann le Roux for his input concerning NEMA.

For the purposes of this article, AI was used mainly for translation, basic linguistic editing and paraphrasing. Google Scholar and the Stellenbosch University Library databases were used to identify relevant publications for consideration and selection.

MUNICIPAL WATER SUPPLY

Groundwater: A strategic asset for municipal water security

While groundwater makes up a relatively small share of major bulk water supply in South Africa, it is an indispensable water source for hundreds of small towns and rural settlements, with even large metropolitan areas depending on it to some extent. K Pietersen, E Masemola, S Clarke, T Kanyerere, B Wilschut and T Hlatywayo emphasise the importance of recognising groundwater as a strategic municipal asset and provide some pointers to local authorities to improve its governance.



Despite the important role of this water source, there is still a general reluctance to recognise groundwater as a strategic municipal asset and to make the governance, funding and risk-management decisions needed to protect it. Groundwater should not be treated only as an emergency supply during droughts or service disruptions. It should be incorporated into the municipal water supply strategy alongside surface water, reuse, demand management, storage and climate-resilience measures, with clear responsibilities, lifecycle funding and routine risk oversight.

Strategic value of groundwater

Groundwater strengthens municipal water security because it is locally available in many areas, naturally stored in aquifers, less exposed to evaporation than surface storage, and able to buffer drought and seasonal variability when managed correctly. It supports rural settlements, small towns, agriculture, schools, clinics, ecosystems and, in some areas, urban supply systems.

Groundwater's strategic value lies not only in the volume of water available, but also in its ability to diversify supply, reduce dependence on distant bulk schemes, support phased infrastructure development and improve resilience during climate extremes.

The strategic value of groundwater therefore depends on how deliberately municipalities govern it. Once groundwater is recognised in planning and performance systems, council and senior management must assign responsibilities, fund the necessary institutional capacity and ensure that technical decisions are linked to executive oversight.

Decisions about borehole development, abstraction rates, water quality, sanitation, stormwater, land use and industrial activity all

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affect aquifer sustainability, so groundwater requires the same level of strategic attention as other water sources and municipal infrastructure assets.

Figure 1 illustrates groundwater as one component of a diversified municipal water supply portfolio. It shows why groundwater should be planned and managed alongside surface water, reuse, demand management, storage and climate-resilience measures rather than treated as a separate emergency source. This portfolio approach reduces dependence on any single source, supports drought preparedness and strengthens long-term water security when each component is governed, funded, monitored and operated as part of an integrated municipal system.

Governance responsibilities

Municipal councils and senior management should provide clear political and administrative leadership for groundwater. Council should approve the policy direction, bylaws, budgets and performance expectations needed to protect aquifers and secure reliable services. The municipal manager should ensure that groundwater responsibilities are allocated across water services, engineering, planning, environment, finance, disaster management and performance-management functions. Groundwater cannot be left only to technical staff or consultants; it requires institutional ownership and routine executive oversight.

Water services authorities (WSAs) and water services providers (WSPs) should ensure that groundwater schemes are properly investigated, authorised where required, operated within sustainable yield, monitored for water levels and quality, maintained through planned operation and maintenance (O&M) programmes, and protected from contamination and vandalism.

Municipal planning and environmental functions should identify recharge areas, wellfields and vulnerable aquifers in spatial plans and development-control systems. Finance officials should ensure that capital and operating budgets reflect the full lifecycle costs of groundwater schemes, including monitoring, treatment, security, energy, rehabilitation and professional support.

National government remains responsible for overall water-resource regulation and custodianship, while municipalities are responsible for water-services planning, delivery and local controls. This division of responsibilities means municipalities must work closely with the Department of Water and Sanitation (DWS), catchment management agencies (CMAs), neighbouring municipalities, water boards, private users, farmers, industries and communities. Shared aquifers require shared data, coordinated abstraction management and clear arrangements for pollution prevention, compliance and emergency response.

Funding requirements

Groundwater schemes often fail when funding focuses on drilling and equipping boreholes while ignoring the investigation, testing, monitoring, treatment, security, energy, operator training, data management, operation and maintenance required to keep them working. Municipal budgets should therefore treat groundwater as an asset class with full lifecycle cost requirements.

Capital expenditure should cover professional hydrogeological assessment, borehole siting, drilling, testing, infrastructure design, treatment where needed, telemetry or monitoring equipment and secure headworks. Operating expenditure should cover electricity or alternative energy, pump maintenance, sampling, laboratory analysis, data management, rehabilitation, security, spare parts and ongoing technical support.

Municipalities should create dedicated groundwater budget lines in the Medium-Term Revenue and Expenditure Framework (MTREF) and link them to measurable outputs in the Service Delivery and Budget Implementation Plan (SDBIP). Funding applications and infrastructure programmes should require evidence that groundwater projects are based on sound aquifer assessment, sustainable yield estimates, water-quality testing, O&M planning and long-term monitoring. Where grants or emergency funds are used to develop groundwater, municipalities should ensure that future operating costs are budgeted before schemes are commissioned.

Funding should also support preventative action. Protecting recharge zones, repairing leaking sewers, improving sanitation, securing wellfields and maintaining monitoring networks are usually cheaper and more effective than responding to aquifer contamination, borehole failure or emergency water shortages. Council should therefore regard groundwater protection and monitoring as risk-reduction investments, not optional technical expenses.

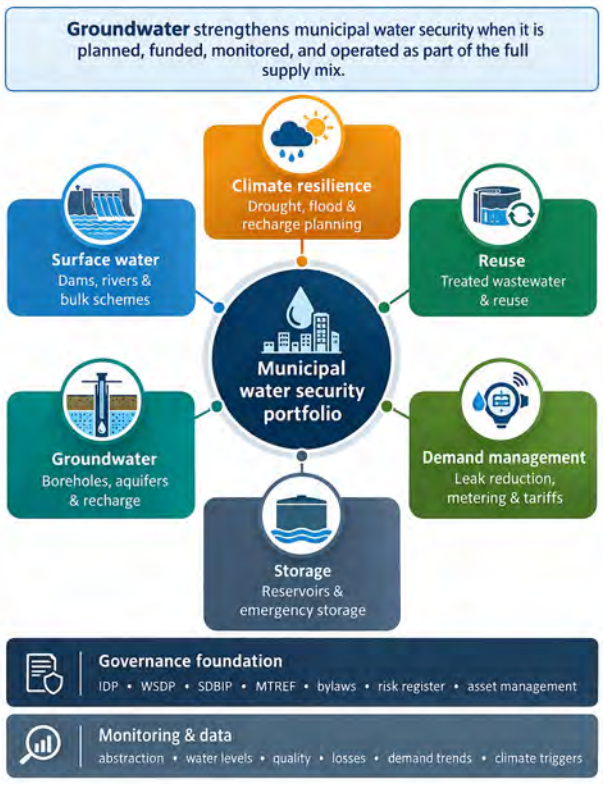
Figure 2 presents groundwater as a lifecycle investment that requires funding beyond initial drilling and equipment. It shows the full cost chain from hydrogeological assessment, borehole siting, drilling, testing and commissioning through to operation, monitoring, treatment, security, maintenance, data management and eventual rehabilitation or replacement. By linking these costs to the MTREF, SDBIP, asset management, procurement and risk-management systems, the figure shows how sound funding decisions reduce the likelihood of scheme failure, unsafe water and avoidable emergency expenditure.

Risk management priorities

Groundwater risk management should be incorporated into municipal risk registers, drought plans, water safety planning, asset management and internal audit systems. Key risks include overabstraction, declining yields, contamination, saline intrusion in coastal areas, drought stress, weak monitoring, inadequate technical capacity, unregistered private boreholes, vandalism, pump and power failure, poor water quality, insufficient treatment, fragmented mandates and funding gaps. Each material risk should have an assigned owner, a monitoring indicator, a response threshold, a budget requirement and a reporting route to senior management and council structures.

Groundwater monitoring is the foundation of risk management. Municipalities should monitor abstraction volumes, water levels, pump performance, water quality, energy use, infrastructure condition and user impacts. Monitoring data should be stored in a municipal system, reviewed regularly by competent technical staff, and used to trigger operational responses such as reducing abstraction, rotating boreholes, repairing infrastructure, increasing treatment, investigating contamination or communicating restrictions to users.

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Groundwater should be viewed as one managed component of an integrated municipal water supply portfolio, working alongside surface water, reuse, demand management, storage and climate-resilience measures, and supported by governance, funding, monitoring and risk-management systems.

The most important governance message is that groundwater reliability is managed, not assumed. Municipalities that plan early, allocate responsibility, fund lifecycle costs, protect aquifers, monitor continuously and respond to warning signs can use groundwater to improve long-term water security. Municipalities that treat groundwater as an emergency fallback risk borehole failure, public-health impacts, rising costs, service interruption and loss of community trust.

Figure 3 illustrates the groundwater risk pathway and response cycle that municipalities should use to move from early warning signs to accountable action. It shows how groundwater risks are identified, monitored through agreed indicators, assigned to responsible officials, escalated to senior management when thresholds are exceeded, linked to funding and corrective actions, and reported to council for oversight. The figure reinforces the principle that groundwater risk management is a continuous governance process that connects technical monitoring, administrative accountability, budget decisions and political oversight.

Recommended actions for government management

To turn these governance, funding and risk-management principles into practice, municipalities should adopt a deliberate groundwater management programme that converts policy commitments into routine planning, budgeting, monitoring and reporting. The following recommendations provide a practical agenda for councillors, municipal managers and senior officials responsible for water security, infrastructure investment and service-delivery accountability.

1. **Recognise groundwater as a strategic municipal asset**. Council should formally recognise groundwater in the IDP, WSDP, MSDF, drought plan, infrastructure plans and municipal risk register, with clear policy statements on its role in long-term water security and climate resilience.
2. **Assign accountability at senior level.** The municipal manager should allocate groundwater responsibilities across water services, infrastructure, planning, environment, finance, disaster management and performance-management functions, with a designated senior official responsible for coordination and reporting.
3. **Secure competent hydrogeological support.** Municipalities should appoint, contract or share qualified hydrogeological expertise to guide borehole siting, testing, sustainable yield assessment, monitoring network design, abstraction rules, water-quality interpretation and scheme rehabilitation.
4. **Create and maintain a groundwater asset register.** All municipal boreholes, springs, wellfields, pumps, meters, treatment units, reservoirs, telemetry equipment and monitoring points should be recorded in an asset register that includes location, condition, yield, water quality, ownership, operating status and maintenance history.
5. **Fund the full lifecycle cost of groundwater schemes.** MTREF and SDBIP allocations should provide for investigation, drilling, testing, equipping, monitoring, treatment, security, energy, maintenance, operator training, data management and rehabilitation, not only for initial infrastructure installation.
6. **Monitor water levels, abstraction and quality routinely.** Municipalities should establish minimum



Figure 2. Groundwater lifecycle funding model – the full cost chain from hydrogeological assessment and drilling through commissioning, operation, monitoring, treatment, security, maintenance, data management and rehabilitation, supported by municipal budgeting, asset management, procurement, risk management and council oversight.

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monitoring schedules for groundwater levels, abstraction volumes, pump performance, water quality, infrastructure condition and energy use, with results reviewed regularly and reported to management.

7. **Operate within sustainable yield and defined rules.** Abstraction should be based on tested aquifer and borehole performance, with operating rules for pumping hours, borehole rotation, drought restrictions, recovery periods, emergency use and response thresholds when water levels or water quality deteriorate.
8. **Protect recharge areas, wellfields and vulnerable aquifers.** Groundwater protection zones should be reflected in spatial planning, land-use decisions, development approvals, sanitation planning, stormwater management, waste management and environmental controls.
9. **Strengthen bylaws and local controls.** Municipal bylaws should address borehole registration, source protection, pollution prevention, drilling standards, private borehole information, land-use controls near sensitive aquifers and enforcement mechanisms where local activities threaten groundwater.
10. **Integrate groundwater into drought and climate-resilience planning.** Manage groundwater conjunctively with surface water, reuse, demand management, and storage, with clear rules for when and how groundwater is used under normal, dry, and emergency conditions.
11. **Build operational capacity.** Operators and technicians should be trained in pump operation, basic hydrogeological monitoring, water-quality sampling, meter reading, fault detection, maintenance procedures, security checks and escalation protocols.
12. **Use data for decision-making and public accountability.** Groundwater information should be stored in an accessible municipal system, reviewed by competent staff, used to trigger management actions and summarised in reports to council, senior management and relevant oversight structures.
13. **Groundwater can make a significant contribution to municipal water security** when it is treated as a managed public asset rather than an emergency fallback. Its strategic value lies in its ability to diversify supply, strengthen drought resilience, support local service delivery and reduce pressure on over-stretched surface-water systems. These benefits, however, depend on deliberate governance, adequate funding, routine monitoring and disciplined risk management.

For councillors and senior managers, the central policy task is to make groundwater visible in municipal planning, budgeting and accountability systems. This means assigning clear responsibilities, funding lifecycle costs, protecting recharge areas and wellfields, monitoring abstraction and water quality, responding to early warning signs and reporting performance and risks through established municipal oversight structures. Groundwater management should therefore be embedded in the IDP, WSDP, MTREF, SDBIP, asset register, risk register, drought plan and water safety planning processes.

The conclusion for municipalities is clear: groundwater reliability is achieved through governance choices made before a crisis occurs. Municipalities that plan, budget, monitor and protect



Figure 3. Groundwater risk pathway and response cycle — risks are identified, monitored, assigned to responsible officials, escalated to management, funded through municipal planning and budgeting systems, and reported to council for oversight and corrective decisions.

groundwater can build a more resilient and flexible water supply portfolio. Municipalities that neglect these responsibilities risk infrastructure failure, unsafe water, rising costs, reduced public trust and greater vulnerability to drought and climate variability. Groundwater should therefore be managed as a long-term strategic asset that supports reliable, equitable and climate-resilient municipal water services.



Unlocking the power of groundwater: A practical guide for municipalities

Groundwater is a lifeline for many South African communities, but managing it sustainably requires the right knowledge and tools. The Water Research Commission's new Groundwater Management Handbook (**WRC report no. TT 973/26**) provides municipalities with practical guidance to unlock and protect this valuable resource. From borehole maintenance and water quality monitoring to pollution prevention, sustainable abstraction and long-term planning, the handbook offers solutions to common groundwater challenges. Packed with practical checklists, management tools and real-world case studies, this essential resource helps municipalities prevent costly infrastructure failures, strengthen drought resilience and improve water security. A must-have guide for municipalities committed to reliable, sustainable water services.

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NON-REVENUE WATER

Every drop counts – Municipalities answer the call on water losses

South Africa is losing nearly half its treated water to leaks, illegal connections and billing failures, costing the country billions of rand every year. Now, a pioneering Water Research Commission (WRC) initiative is equipping municipal officials with the skills to turn the tide on water losses. With an overwhelming response from municipalities nationwide, the Every Drop Counts programme is demonstrating the power of knowledge and collaboration to tackle one of South Africa's most pressing water challenges. Article by Sarah Slabbert, Nadja Green, Ronnie Mckenzie and Shanna Nienaber.



Leaking pipes, illegal connections, faulty meters and billing failures add up to what the sector calls non-revenue water (NRW) – and the bill runs into billions of rand a year in wasted infrastructure investment and lost municipal income. Speaking in a parliamentary Question and Answer session in June, Water and Sanitation Minister, Pemmy Majodina, put a number on that bill: the national NRW average stood at 47.3%, equivalent to more than 2.1 billion kilolitres of water a year (2 100 million m^3/year). "The average cost of supplying water per kl in South Africa is R12.41/kl and the Rand value of NRW is approximately R26 billion," she said (***BusinessTech***, 18 June 2026).

The tools to fix this are not new, and none of this is rocket science. The methods are well documented and the software already exists. The Water Research Commission (WRC) has spent the past three decades promoting the burst and background water loss methodology first developed by the UK water industry in the late 1980s and building a suite of software models and associated documentation: SANFLOW, BENCHLEAK, PRESSMAC, ECONOLEAK. The WRC's Municipal Water Demand Management Scorecard supports the No Drop programme developed by the Department of Water and Sanitation (DWS) to track municipal performance in water loss management and non-revenue water. What has been missing is not knowledge, but the capacity inside municipalities to put that knowledge to work.

That is the gap the WRC set out to close in July with the launch of a national NRW training and performance challenge for

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The course has delivered some impressive results in a short time span.

municipal teams. Developed by the WRC and hosted, for the pilot phase, on the Water Institute of Southern Africa (WISA) learning platform, "Every Drop Counts" is a self-paced, CPD-accredited online course built directly around the WRC's own NRW tools. Officials work through eight modules and five practical assignments covering the IWA water balance, leakage detection, pressure management and demand-side interventions, earning a Certificate of Completion and 3 CPD points recognised by WISA, the South African Council for Natural Scientific Professions (SACNASP) and the Engineering Council of South Africa (ECSA).

The programme launched officially on 22 July at the WISA conference in Cape Town, where WRC leadership, DWS and the South African Local Government Association (SALGA) set out its ambition: a pilot target of 100 municipalities by the end of 2026, and a longer-term goal, called NRW 2030 and launched jointly by the WRC and DWS, of reaching 30 000 water sector professionals by the end of the decade. WISA is supporting 100 subsidised places for the pilot phase – the first 50 free, the next 50 at R1 150 per person.

A fast start

Ten days after registration opened, the numbers told a story the project team had not expected. The campaign drew 601 verified registrations from every one of South Africa's nine provinces, reaching officials in 82 of the country's 144 water services authorities – 55% of the country's municipal water providers, in ten days. Just over half the registrants were municipal officials themselves; the rest came from water boards, consulting engineers, universities and other parts of the sector, evidence that the appeal reached well beyond the original target list.

The shape of the response is itself telling. In some municipalities (eThekwini Metropolitan Municipality alone produced 66 registrations) the message clearly travelled from desk to desk once it landed. In 44 other authorities, a single official signed up, often in small or rural municipalities that national campaigns rarely reach at all. Both patterns matter: one shows depth, the other shows reach.

Engagement has not stopped at registration. A WhatsApp community now links learners across the country, with a weekly update, a provincial leaderboard, and a live Q&A with NRW-expert Ronnie McKenzie, turning what could have been a solitary online course into a functioning community of practice.

What's still to do

Sixty-two water services authorities have not yet registered, and the campaign's next phase is aimed squarely at them. Three provinces, the Northern Cape, Western Cape and Free State, account for nearly three-quarters of that gap. The Northern Cape is the priority: it has the largest number of outstanding authorities and, on the DWS's own No Drop risk assessment, the weakest water conservation and demand management planning in the country.

Reaching it will take direct engagement through SALGA and DWS provincial offices rather than another general campaign; the project team has learned that this audience responds to a direct, personal prompt rather than to sustained general awareness campaigns.

Registering is the easy part

A completed course and a certificate are a start, not an endpoint. The real measure of the programme's success will be whether a technical official in a small Northern Cape municipality, or a plant supervisor in a district municipality with a fraction of a metro's resources, can take what is learned in an online module and apply it to their own metered areas, their own infrastructure challenges, with all the local complications that no generic course can anticipate.

That is where the rest of the water sector has a role to play that goes beyond funding a pilot. If competence in managing non-revenue water is to become normal practice rather than a skill demonstrated once on a certificate, DWS, SALGA, MISA, National Treasury and the Department of Cooperative Governance and Traditional Affairs (CoGTA) need to do two things that municipalities cannot do for themselves.

First, they need to demand it: build NRW competence: a functioning water balance, a credible leakage reduction plan, evidence that a municipality can act on its own No Drop findings, into the conditions attached to No Drop reporting, infrastructure grants, water services authorisations and support arrangements.

Second, they need to reward it: give municipalities and officials who do the work public recognition and preferential access to support, so that the incentives facing a municipal manager point in the same direction as good practice. A leaderboard changes behaviour inside a single course; a policy incentive supported by a clear funding formula changes behaviour across a sector.

Alongside that, the WRC and its partners are exploring what could follow the online modules: some additional courses or modules providing implementation support that will help alumni apply what they have learned systematically and sustainably in their own municipality, rather than leaving them to translate theory into practice alone.

The bigger picture

In ten days, a training campaign reached more than half the country's water services authorities and put officials from South Africa's largest metros and its smallest rural councils into the same online classroom. That is a genuine achievement for a sector not always known for moving fast. Whether it becomes a turning point for South Africa's water losses depends on what happens next, and on whether the institutions with the power to demand and reward competence choose to use it.

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WATER USE EFFICIENCY

University introduces smarter way to manage agricultural water in arid regions through new app

As droughts intensify and pressure on South Africa's scarce water resources grows, smarter irrigation has never been more important. A new satellite-based water use efficiency (WUE) application developed by Sol Plaatje University's Arid Region Water Research Centre, in partnership with the Water Research Commission, puts powerful scientific insights at users' fingertips. Article by Dr Morena Mapuru and Prof Mohamed AM Abd Elbasit from the Arid Region Water Research Centre (ARWRC) at Sol Plaatje University.

Water scarcity is one of the greatest challenges facing agriculture worldwide, and South Africa is no exception. Increasing temperatures, prolonged droughts and changing rainfall patterns continue to place enormous pressure on the country's limited water resources. As the demand for food increases, farmers must find ways to produce higher yields while using less water. This has made water-use efficiency one of the key priorities for sustainable agriculture and climate change adaptation.

To help address this challenge, the Arid Region Water Research Centre (ARWRC), which was established at Sol Plaatje University in partnership with the Water Research Commission (WRC), has developed an innovative Water Use Efficiency (WUE) and Crop Water Requirement (CWR) application.

Developed using Google Earth Engine, the application combines satellite-derived climate information with scientific modelling to provide rapid estimates of crop water requirements and irrigation performance. Designed as a practical decision-support tool, the application enables users to evaluate water productivity and make informed irrigation decisions using freely available climate data.

Why water use efficiency matters in South Africa

South Africa is one of the world's most water-scarce countries, receiving an average annual rainfall of approximately 465 mm, which is nearly half the global average. Climate change, population growth, expanding agricultural activities and increasing competition among different water users continue to place significant pressure on the country's already limited freshwater resources. Agriculture accounts for approximately 60% of South Africa's freshwater consumption, making efficient irrigation essential for improving water security and ensuring sustainable food production.

Improving water-use efficiency enables farmers to produce more food with less water while reducing production costs and minimising pressure on rivers, dams and groundwater resources. Reliable information on crop water requirements is therefore essential for improving irrigation scheduling, increasing agricultural productivity and strengthening resilience to drought. The WUE application was developed to support these goals by providing users with an accessible, science-based tool to evaluate irrigation performance and promote sustainable water management.

How does the app work?

The WUE application is an interactive decision-support tool that estimates WUE and CWR using satellite-derived climate information and user-supplied agricultural data.

The application calculates how efficiently crops use irrigation water by combining climate variables with crop-specific information. It estimates the amount of water required by a crop, compares the actual water use with benchmark values, and classifies irrigation performance as either Optimal or Below Optimal.

Unlike many conventional irrigation tools that require specialised software or extensive field measurements, this application operates entirely within Google Earth Engine, making advanced geospatial analysis accessible through a simple and user-friendly interface.

How was it developed?

The application was developed using Google Earth Engine, a cloud-based geospatial analysis platform that processes large volumes of Earth observation data efficiently. The application integrates the ERA5-Land Daily Aggregated climate dataset with the internationally recognised FAO-56 Penman–Monteith

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equation to calculate Reference Evapotranspiration (ET_0), the foundation for estimating crop water requirements.

The application automatically retrieves daily climate variables, including air temperature, relative humidity, wind speed, and net solar radiation. Users provide additional information such as crop type, crop coefficient (Kc), cultivated area, irrigation water applied, and crop yield.

- Using these inputs, the application calculates:
- Reference evapotranspiration (ET_0)
- Crop water requirement (CWR)
- Water use efficiency (WUE)
- Benchmark water use efficiency
- Irrigation performance (optimal or below optimal)

The application also generates interactive time-series graphs displaying changes in ET_0, crop water requirement, temperature, humidity, and wind speed throughout the selected period, allowing users to better understand the climatic factors influencing crop water demand.

What is the purpose of the app?
The primary purpose of the application is to improve irrigation water management by providing users with a practical, science-based tool for evaluating water-use efficiency. It enables users to estimate crop water requirements under current climate conditions, calculate WUE in kg/m^3 for different crops, and compare irrigation performance against established benchmark values.

The application also supports improved irrigation scheduling and enhanced water productivity, contributing to climate-smart agriculture and the sustainable management of water resources. By integrating Earth observation and climate data into an easy-to-use platform, it promotes informed decision-making and simplifies complex scientific calculations, effectively bridging the gap between research and practical agricultural management.

Who can use the app?
The application has been designed for a broad range of users involved in agriculture and water resource management, including farmers and irrigation managers, agricultural extension officers, water resource managers, researchers and university students, government departments responsible for agriculture and water resources, agricultural consultants, and non-governmental organisations working in climate adaptation and sustainable agriculture. By using freely available Earth observation and climate datasets, the application can be applied across South Africa and readily adapted for use in other regions experiencing similar water scarcity challenges, making it a versatile tool for improving agricultural water management and supporting sustainable decision-making.

How can one use the app?
The application has been designed to be intuitive and requires only a few simple steps outlined below to execute a task, as set out in Figure 1.

Within seconds, the application automatically calculates and displays:
- WUE (kg/m^3)
- CWR

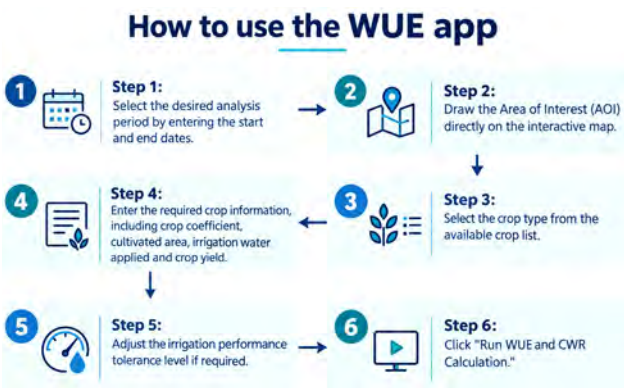


Figure 1. The six steps to follow for the effective use of the application.

- Benchmark WUE
- Irrigation performance assessment
- Mean ET_0 map
- Time-series graphs of ET_0, Crop Water Requirement, Temperature, Relative Humidity, and Wind Speed

These outputs provide valuable information for irrigation planning, water allocation, and improving agricultural productivity.

Benefits of the application
The application offers several practical advantages for improving agricultural water management. It enables the rapid estimation of crop water requirements, supports more effective irrigation planning and scheduling, and helps reduce water wastage while increasing agricultural water productivity.

The application also provides easy access to satellite-derived climate information through a user-friendly interface that requires minimal technical expertise, making it accessible to a wide range of users. By supporting evidence-based decision-making for sustainable agriculture and being freely accessible through Google Earth Engine, the application provides a practical and cost-effective solution for enhancing water-use efficiency.

Looking ahead
Digital technologies are transforming agriculture by making scientific information more accessible to farmers and decision-makers. As climate change continues to intensify water scarcity, tools that combine satellite observations, climate data and cloud computing will play an increasingly important role in improving agricultural resilience.

The Water Use Efficiency application demonstrates how modern Earth observation technologies can be translated into practical solutions that help users optimise irrigation, improve water productivity and strengthen climate resilience. By providing timely and scientifically robust information, the application supports sustainable agricultural development and contributes to more efficient management of South Africa's scarce water resources.

To read more about the ARWRC's activities, visit: https://bit.ly/4ifsofX

To access the app, visit: https://aridregionwaterresearchcentre.users.earthengine.app/view/water-use-efficiency

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DEEPLY ROOTED IN SOUTH AFRICA WATER SOCIETY

www.wrc.org.za

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

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

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

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