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*Water Research Commission – Celebrating South
Africa's outstanding researchers*

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**WATER RESEARCH
COMMISSION**
55 YEARS
Supporting Sustainable
Water Futures
1971-2026





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

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SPECIAL EDITION

Water Research Commission – Celebrating 55 years of water research excellence

South Africa's complex and evolving water landscape has always demanded ingenuity, perseverance and a willingness to look beyond conventional solutions. From a water-scarce country facing growing demands from a developing economy and population, to a nation confronting climate change, environmental pressures, ageing infrastructure and unequal access to water and sanitation, the challenges are considerable.

Meeting them requires more than infrastructure and investment. It requires knowledge, innovation and, above all, people with the vision and determination to turn ideas into solutions.

For 55 years, the Water Research Commission (WRC) has played a pivotal role in building this knowledge base and supporting the people who create it. Established in 1971 in response to South Africa's growing water challenges, the WRC has evolved into a cornerstone of the country's water research, development and innovation landscape. Its mandate has remained centred on identifying the country's water knowledge needs, supporting research that addresses priority challenges, and ensuring that the knowledge generated is shared, applied and translated into impact.

Over more than five decades, WRC-funded research has helped to shape the understanding, policies, technologies, tools and practices that underpin water management in South Africa. It has also helped create opportunities for generations of researchers, scientists, engineers, practitioners and innovators to develop their expertise and make their mark on the sector.

Among these individuals are researchers whose careers have extended far beyond the projects they initially undertook. Through curiosity, perseverance and a commitment to excellence, they have become leaders in their respective fields – some achieving national and international recognition for pioneering research and innovation. Their work has contributed to addressing some of the country's most pressing water challenges, while influencing policy and practice and advancing knowledge well beyond South Africa's borders.

Just as importantly, many of these exceptional researchers have become mentors and champions for those who followed them. Their contribution is therefore measured not only in research papers, technologies, models, policies or awards, but also in the

people they have inspired and the new generations of water professionals they have helped develop. In this way, their legacy is both scientific and human.

The stories captured in this publication offer a glimpse into that legacy.

Many of the researchers featured here began their careers as students or emerging researchers working on WRC-funded projects. What may have started as an opportunity to investigate a specific water challenge became, in many cases, the foundation of a lifelong career dedicated to improving South Africa's water future. Their journeys demonstrate the value of investing in people and creating opportunities for young researchers to engage with real-world challenges.

Their achievements span disciplines, institutions and generations. Some have pioneered new approaches to water treatment, resource management or environmental protection. Others have developed technologies, methodologies and decision-support tools, influenced policy, built research capacity or opened new areas of scientific enquiry. Together, their contributions reflect the breadth and depth of South Africa's water knowledge ecosystem.

As the WRC celebrates its 55th anniversary, this special edition is both a tribute and a record. It recognises a tiny selection of exceptional individuals whose careers have helped shape the water sector and whose association with WRC-funded research has contributed to the Commission's enduring legacy. The list of researchers featured is not nearly as exhaustive as we would have liked it to be; however, there was just not enough time and space to feature all of South Africa's dedicated and ingenious water and sanitation researchers in one volume.

The publication is also an acknowledgement that research is ultimately about more than generating knowledge. It is about applying that knowledge to improve lives, protect the environment, strengthen communities and build a more water-secure future.

The stories that follow are stories of curiosity, resilience, passion and purpose. They remind us that breakthroughs rarely happen in isolation. They are built over years of research, collaboration,

mentorship and persistence – and often begin with a single opportunity.

For 55 years, the WRC has helped create those opportunities. The researchers celebrated in these pages demonstrate what can happen when talented people are given the space, support and resources to pursue important questions and turn knowledge into impact.

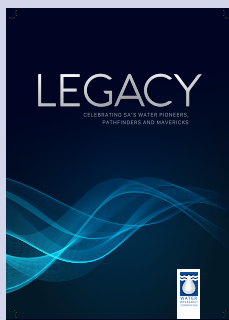
Their stories belong to the history of South African water research. More importantly, they form part of its future.

The Water Wheel team

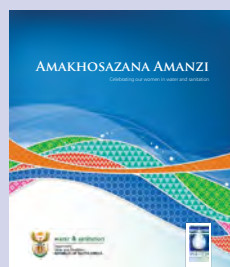
South African water research profiler series

This special edition should not be read in isolation. Rather, it adds to the collection of WRC publications over the years dedicated to South Africa's hardworking researchers and water sector leaders.

Related publications:



Legacy – Celebrating South Africa's water pioneers, pathfinders and mavericks



Amakhosazana Amanzi – Celebrating our women in water and sanitation.



Supplement to the Water Wheel September/October 2011.



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BONGIWE MCATA

Turning lived experience into research for resilient communities

Her journey between township and rural life taught Dr Bongiwe Mcata that agriculture is about far more than production. Today, the University of Fort Hare researcher brings together agricultural economics, food systems and indigenous knowledge to explore how water, food, livelihoods and climate resilience can be addressed as interconnected challenges.

Article by Kim Trollip.

From family gardens to food systems, Mcata's research is rooted in the communities and experiences that shaped her understanding of agriculture, livelihoods and resilience. In Mdantsane, where space was limited, her mother grew spinach in the family garden. In Perksdale Location in the Eastern Cape, where Mcata's rural roots lie, the family cultivated maize, grew vegetables and kept chickens, pigs and goats. Livestock could provide food for the household but could also be sold to generate income.

Agriculture was therefore never simply about growing food. "It is about livelihoods, dignity, resilience, culture, identity and the ability of communities to sustain themselves," she says.

Looking back, Mcata can see that many of the questions she explores as a researcher were already taking shape around her. Why are some communities able to use the resources available to them to create livelihoods and resilience, while others remain vulnerable to food insecurity, climate shocks and limited economic opportunities?

Her university education gave her the theories and analytical tools to understand what she had witnessed growing up. Her research has since taken her beyond the farm and into the bigger systems that determine how people produce, access and consume food, manage resources and build livelihoods.

Learning to ask better questions

Mcata's interest in agricultural economics began at school, when she took economics as a subject and became fascinated by how people make choices when resources are limited, and how economic decisions at household, community and policy levels can shape livelihoods and opportunities.

Her own life had already given her a practical introduction to those questions. Born in Mdantsane and with rural roots in Perksdale Location in the Eastern Cape, she moved between township, village and different schooling environments,

eventually completing her matric in Pretoria. Those experiences exposed her to different cultures, circumstances and ways of understanding education and opportunity.

Agricultural economics appealed to her because it brought together two worlds she already understood: agriculture and economics. She went on to complete a Bachelor of Science in Agriculture, majoring in Agricultural Economics and Economics, followed by Honours, a Master's degree and a PhD in Agricultural Economics.

It was during her undergraduate years at the University of Fort Hare, however, that she began to discover what research could mean to her.

As a Xhosa-speaking student, Mcata assisted lecturers with fieldwork in communities across the Eastern Cape. One of her first research experiences was as an enumerator on a project involving the Zanyokhwe Irrigation Scheme. She also became involved in research on open-pollinated varieties (OPVs), working alongside postgraduate students from Agronomy and assisting with questionnaires.

Those early experiences opened her eyes to research in a different way. She realised that research was more than studying in a classroom, reading articles or writing assignments. It involved travelling to communities, listening to people's experiences, asking questions, collecting information and making sense of what they were telling her.

She also discovered that she genuinely enjoyed the process. "I was already someone who enjoyed learning, writing and socialising, so fieldwork brought these interests together," she says. "I could travel to places I had never been, meet different people, learn from communities and contribute to research."

As a student, she joked that she was able to "travel, learn and get paid for it". But beneath the humour was an early insight into the kind of researcher she wanted to become. Her curiosity went beyond the subject of the research; she was equally interested

in the people, their experiences and the knowledge they could contribute.

That people-centred approach has remained an important part of her career. For Mcata, engaging with communities is not separate from the research itself. It is a way of understanding the problem more fully – and ensuring that the knowledge generated has relevance beyond the university.

Agriculture is bigger than the farm

Today, Mcata sees food systems as a web connecting people, land, water, knowledge, technology, production, markets, institutions, culture and households.

That broader view is important when considering rural communities facing water constraints. A technically effective agricultural intervention may still fail if people cannot afford it, maintain it or incorporate it into their lives. Agricultural economics provides a way of bringing these dimensions together – asking whether an intervention or technology works technically and ensuring it works for the people who will use it.

"Can people afford it? Is it accessible? Does it respond to their realities? Does it create or strengthen livelihood opportunities? Will communities adopt it? And, importantly, can it be sustained over time?"

Those questions are particularly important for smallholder and family farmers in rural communities, where the decision to adopt a new water-saving technology or agricultural practice is rarely about the technology alone. The upfront cost may compete with immediate household needs. Access to finance, markets, infrastructure, extension services and information all matter. Previous experiences with government or development projects can influence people's willingness to try something new, while gender roles, access to land and decision-making power can also shape what is possible.

Climate variability adds another layer of uncertainty.

Photo supplied



Bongive Mcata holds a PhD in Agricultural Economics. Her research interests are focused mainly on inclusive agricultural development, food security, and socio-economic transformation within South African communities.

For Mcata, a sustainable solution should make sense environmentally, economically and socially. "People cannot be expected to protect resources for the future if the proposed solution makes it harder for them to meet their needs today."

Her understanding of these questions is also personal. She grew up between two worlds: the peri-urban environment of Mdantsane and the rural landscape of Perksdale. At the time, she did not have the academic language to describe many of the practices she encountered as indigenous knowledge. She simply knew them as part of life.

In the village, she encountered mud houses and the use of cow dung to maintain floors. Her grandmother valued traditional foods such as *umfino*, including bitter leafy vegetables, and *mleqwa*, traditional free-range chicken.

Trips to collect water from the river could also become opportunities to pick *iziphingo*, a wild fruit that was part of the local environment. Before taps were introduced, the river was a source of water. The family collected rainwater and managed livestock using knowledge passed down through generations.

Only later did Mcata recognise how much knowledge was embedded in these ordinary experiences: knowledge of food, water, livestock, plants and the local environment. It taught her that indigenous knowledge is deeply place-based, practical and intergenerational.

HERS-SA



In 2025, Dr Mcata won the Emerging Young Women Leaders Award (HEWLA) presented by the non-profit organisation Higher Education Resources Services South Africa (HERS-SA). This recognition honours exceptional women who are shaping the future of higher education.

Bringing knowledge together

Mcata says scientific knowledge can provide new technologies, evidence and analytical tools, while indigenous knowledge provides generations of place-based experience and understanding. She sees research as a space where different forms of knowledge can meet.

Communities are not simply recipients of knowledge, she argues. They are knowledge holders.

Researchers therefore need to listen before arriving with predetermined solutions. Local experience can reveal practices, risks and opportunities that may not be visible from an academic perspective, while science can contribute methods for testing, monitoring and adapting those practices.

The aim is co-learning and co-creation: researchers and communities working together to develop solutions that are scientifically credible while remaining grounded in local realities.

That philosophy comes together particularly clearly in one of Mcata's most meaningful projects.

A school becomes a living laboratory

During her five-year tenure at the University of Mpumalanga, Mcata worked on a R2.5 million Water Research Commission and Old Mutual Foundation-funded project. She remains associated with the university as a Research Fellow, allowing her to continue her involvement in research projects, grants and the students she supervises.

Entitled *Demonstrating Climate Resilience in Four Rural Schools with Limited Water Availability by Enhancing Food and Nutrition Security through Innovation and Science Transfer*, the project involved four rural schools in Limpopo, the Eastern Cape, Free State and Mpumalanga.

The project transformed underused school spaces into climate-smart nutrition gardens, using approaches such as rainwater harvesting, drip irrigation, mulching and indigenous crops. The schools became "living laboratories" where learners, educators and communities could explore agriculture, science, environmental stewardship and practical problem-solving. The project also supported three postgraduate students – one PhD

candidate and two female MSc Agriculture bursary recipients.

“One of the project’s most important lessons,” adds Mcata, “Was that innovation does not necessarily mean inventing something completely new. Rainwater harvesting, mulching and indigenous crops are not new ideas. Innovation can lie in bringing existing knowledge, technologies and resources together differently for a particular context.”

Technical success does not automatically equal development success. A solution must be usable, affordable, maintainable and appropriate to the community. Its benefits also need to survive beyond the point when the researchers leave. Mcata believes this is what meaningful research impact looks like: knowledge moving beyond a report or publication and becoming something that people can use.

Learners and educators began engaging with food production, water management and climate resilience. The gardens became places where classroom learning could connect with the realities of the environment around them. “Most meaningful for me was seeing people begin to take ownership – asking how practices could be maintained, adapted and used in their own circumstances,” she adds. “That is an important moment for a researcher because it tells you that the knowledge is no longer yours; it has become something that people can use and make their own.”

Research for a changing rural landscape

Looking ahead, Mcata believes South Africa needs to stop treating water security, food security, rural development and climate change as separate challenges. For rural communities, they are experienced as one interconnected reality. Building climate-resilient, water-smart food systems will require more than infrastructure and technology. It will require water-use efficiency, appropriate technologies, finance, markets, extension support and relevant information – alongside greater recognition of the knowledge already held by communities.

She is particularly passionate about creating opportunities for young people and women in rural areas. Rural development, she argues, should extend beyond agricultural production to include processing, agribusiness, environmental management, technology and entrepreneurship. Young people should be able to see rural areas as places where they can build meaningful futures, rather than simply places they need to leave.

This systems perspective also shapes the kind of researcher she believes the next generation will need to become.

They will have to be comfortable with complexity and uncertainty, and able to work across disciplines. A water challenge might require insights from agriculture, economics, engineering, environmental science, sociology and policy. Technical and digital skills will remain important, but so will the ability to listen, collaborate, communicate and translate complex ideas for different audiences.

Above all, Mcata advocates what she calls a “both-and” mindset: scientific innovation alongside indigenous knowledge; economic

development alongside protection of natural resources; new technology alongside local practices; global thinking grounded in local realities.

And she believes young researchers should remain humble enough to say, “I do not know” – and then learn from someone outside their discipline or from someone whose knowledge comes from lived experience.

Mcata’s commitment to taking learning beyond the classroom has also been recognised nationally. In 2025, she won the Emerging Young Women Leader (Academic) at the 2025 HERS-SA Higher Education Women Leadership Awards and took second place in the EDHE Learning and Teaching Excellence Awards for her work integrating entrepreneurship into the BSc Agriculture curriculum.

The recognition reflects her belief that agricultural education should prepare students not simply to understand the sector, but to identify opportunities within it and contribute to solving real-world problems. At a University of Mpumalanga seminar in 2025, she argued that research should not remain in “library shelves or hard drives”, but should generate income, create jobs and provide solutions for communities.

“If, years after a research project has ended, a learner remembers what they learned, a community continues using a practice, or someone is better equipped to respond to a challenge because of something we contributed, then I know the research has had a life beyond the university.”

The knowledge comes full circle

Perhaps the most personal measure of Mcata’s research impact is the connection she sees between where she came from and what she is now able to contribute. She grew up experiencing many of the realities she now studies: rural livelihoods, agriculture, traditional foods, water challenges and community-based ways of managing resources. She works with communities and students confronting some of those same challenges.

For her, impact can be found in a learner who becomes curious about agriculture or science, an educator who gains a new teaching resource, a household that learns a practical way of producing food, or a community that gains confidence in its own knowledge.

Her ambition is not simply to build a body of publications and

projects. She wants her research to be rigorous enough to contribute to scholarship, but grounded enough to be felt in everyday life. And perhaps that brings her journey back to where it began: with the ordinary things she saw, experienced, and questioned as a child, such as the family garden, the livestock, the river, and the food on the table.

"If, years after a research project has ended, a learner remembers what they learned, a community continues using a practice, or someone is better equipped to respond to a challenge because

of something we contributed," she says, "then I know the research has had a life beyond the university."

Now, through her research and teaching, Mcata hopes to help the next generation recognise the value in those questions – and in the knowledge and experiences they bring with them.



To read about Bongiwe Mcata's research, visit: <https://orcid.org/0000-0002-6066-4007>

Photos supplied



Mcata has worked with schools in Limpopo, the Eastern Cape, Free State and Mpumalanga to transform underused school spaces into climate-smart nutrition gardens.

BONGIWE MCATA - RESEARCH IN FOCUS

Building climate-resilient food systems in water-constrained rural communities

Mcata's research journey has evolved from a focus on agricultural economics and production towards a broader understanding of the systems that shape rural livelihoods. Her work increasingly brings together agriculture, water, food security, climate resilience and indigenous knowledge, reflecting her belief that these challenges cannot be understood in isolation. Her experience of working directly with communities has been central to this evolution.

Selected outputs

- Garden ownership as a solution to food insecurity in urban areas of South Africa: case of food gardens in Alice Town, Eastern Cape province, *Journal of Agribusiness and Rural Development*, 2019, <https://bit.ly/3TSxHZr>
- ICT education and determinants of acceptance amongst smallholder farmers in Mbombela, South Africa, *South African Journal of Agricultural Extension*, 2024, <https://bit.ly/4yiKv9H>
- The determinants of willingness to pay for organic fertilisers: the case of smallholder vegetable farmers in Mpumalanga, South Africa, *Frontiers in Sustainable Food Systems*, 2026, <https://bit.ly/4zzgaVl>

Featured project

Demonstrating Climate Resilience in Four Rural Schools with Limited Water Availability by Enhancing Food and Nutrition Security through Innovation and Science Transfer

Funding: Water Research Commission and Old Mutual Foundation

DAVID IKUMI

Unlocking wastewater: How resource recovery from treatment plants can confront water and sanitation challenges



As South Africa contends with an escalating water and sanitation crisis, Prof David Ikumi promotes innovation through research and academic mentorship. He views wastewater not as something to discard, but as a valuable source of energy, nutrients, and reusable water.

Article by Jorisna Bonthuys.

Ikumi explains, "Wastewater is no longer just something to treat – it is a platform for water security, energy recovery, and nutrient circularity."

To advance this perspective in practice, Ikumi – a full professor in the Department of Civil Engineering at the University of Cape Town (UCT) – provides academic mentorship on wastewater and environmental systems to his students.

Highlighting the real-world impact of this approach, he says, "Wastewater treatment plants represent a great opportunity within the framework of the circular economy." Ikumi's commitment to this belief has, over the years, propelled him from a high school science project on a polluted river to recognition as an expert in bioengineering models for wastewater treatment plants.

A personal journey

Ikumi's journey into the world of water began in Nairobi, Kenya, where he was born and raised. As a high school learner participating in a national science congress, he tackled projects that focused on pollution in the Nairobi River. "This was probably where my water journey started," he recalls.

His older cousin, Myra, who was living in Pretoria, suggested he study in South Africa. Motivated by this idea, Ikumi was eager to explore his education options. He moved to Pretoria to obtain a South African matric certificate. A year later, he was admitted to UCT's civil engineering programme.

Initially, Ikumi's ambition was to become a structural engineer, building bridges, high-rise buildings, and dams. However, during his first year, he met Prof George Ekama, who later became his



David Ikumi is a professor in the Department of Civil Engineering at the University of Cape Town.

supervisor and mentor in wastewater studies. "Prof Ekama was full of energy and incredibly knowledgeable about wastewater in particular," Ikumi recalls. "He reignited my passion for water because of how he taught his classes and by being passionate about the topic."

After graduating, Ikumi worked briefly at a marine engineering firm. Despite this, he kept feeling drawn back to academics. One day, Ikumi showed up unannounced at Ekama's office and expressed his interest in wastewater research, asking whether he could study under the expert. Ekama responded enthusiastically and they discussed his options. This encounter paved the way for Ikumi to start a Master's degree at the start of the next academic year.

"Prof Ekama was part of a very exciting research group which was at the forefront of wastewater-related research," Ikumi says. "At the time, UCT's Water Research Group included experts like Prof Ekama, Prof Mark Wentzel, and Prof Richard Loewenthal.

"They were leading in research about wastewater. For example, the group developed a system to remove nitrogen and phosphorus from wastewater. This process, called the 'UCT process', is now used worldwide, including in South Africa. It is a configuration used to remove organics and nutrients from the wastewater using biological treatment, via growth of mixed cultures of microorganisms in wastewater treatment reactors."

Unfortunately, Ikumi's study plans faced practical hurdles in the department. His mentor, then the department head, couldn't teach one-on-one courses to a single student. "We had to figure out a way for me to gain knowledge and use it to carry out the necessary research," Ikumi says. "Prof Ekama defined my research project to be very comprehensive. My work was very experimental at the time. My first experiment involved the operation and testing of lab-scale systems that replicated three full-scale wastewater treatment plants."

As his research expanded, Ikumi's Master's degree was upgraded to a PhD in civil (wastewater treatment) engineering. The work

demanding a whole host of experiments and further data. This deep immersion in the field only strengthened his fascination, turning his focus on wastewater into what is becoming his life's work.

Ikumi completed his PhD degree and began his postdoctoral fellowship as a research visitor at the Université Laval in Quebec (Canada). He later completed this fellowship at UCT under the Carnegie fellowship that was working to develop a new generation of African academics. Afterwards, he was employed as a senior lecturer in UCT's Department of Civil Engineering.

"Wastewater holds untapped power. We need to unlock it and translate that potential into real systems that improve water security and sustainability."

Modelling the (un)known

Today, Ikumi specialises in bioprocess modelling and creates computer models of treatment plants. These virtual replicas simulate plant responses to changes, such as load spikes from urban growth or industrial wastewater, without real-world risks.

Ikumi's dynamic 'glass-box' models track carbon, nitrogen, and phosphorus across the plant, revealing treatment progress and outcomes. "Virtually replicating conditions in treatment plants is like assembling a puzzle, challenging yet rewarding. We analyse wastewater for key elements, then track them to compare phosphorus removal methods.

"By entering all this information into virtual systems, we can model outcomes," he explains. "We use equations to translate

biological, physical, and chemical processes into models. These are based on recurring behaviour by microorganisms that treat wastewater. The models then help us design ideal systems and optimise their operation."

Modelling also helps find bottlenecks, test scenarios, and optimise sludge retention or aeration. This can reduce capital costs by avoiding oversized facilities and cutting significant electricity costs, he adds.

"The models let us then evaluate treatment strategies and find the best approach. For example, we compare biological and chemical phosphorus removal, or explore options such as energy or nutrient recovery and water reuse. Calibration adjusts predictions to real measurements; validation checks accuracy with past data."

This approach is useful, as each treatment plant has its own challenges. "Input to these model equations includes wastewater characteristics," Ikumi explains. "We match the flow of components through the treatment system to predict treated water quality under different scenarios. The origin of the wastewater can differ, for instance. It might be runoff from vineyards, food scraps, city garbage, household refuse, slaughterhouse waste, factory byproducts, among countless other sources.

By simulating complex biological processes (such as how bacteria remove contaminants in wastewater), these models enable better decisions for design, operation, and upgrades, helping treatment plants avoid costly inefficiencies.

"These scenarios illustrate how using mathematics can help you choose the cheapest option, remove pollutants, and ensure the water meets environmental standards. So, you're using mathematical equations to help guide design choices in water quality work, training, or use.

"This work delivers practical engineering tools for informed decisions – whether designing new systems or optimising

current processes – streamlining expert oversight of wastewater treatment."

For new plants, these models help select cost-effective, compliant designs. For upgrades, the models minimise energy, chemicals, and waste by guiding resource recovery. They also future-proof plants for climate change and urban growth by ensuring compliance and enabling recovery, he points out.

South Africa's ongoing water crisis makes these advances increasingly urgent. Recent 'Green Drop' reports reveal stark failures: only 2% of the country's 995 wastewater plants earned certificates in 2022, with 34% critical. These and other audit reports highlight pollution and water resource waste, underscoring the need for reforms in municipal water and sanitation services.

About 88% of South Africa's wastewater treatment plants are also high risk. They often exceed design capacity, deal with dysfunctional processes and equipment, and experience non-compliance issues.

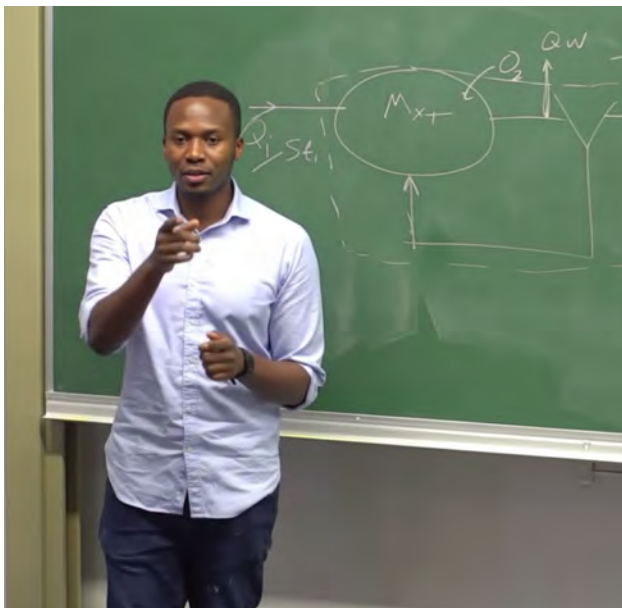
Defining the future of wastewater

Ikumi has worked on many projects that identified real problems in treatment systems that are overwhelmed.

"Our research group focuses on envisioning the ideal future of wastewater treatment systems. We use the glass-box model as a tool to help us adjust our designs to address the specific problems of a wastewater treatment plant. We use bioprocess modelling to define and pursue that vision. This modelling approach informs our exploration of future systems. It makes it very clear how the system's inputs are changed and why they produce different outputs."

No longer mere treatment plants, these facilities can embody 'circularity': a design principle focused on using resources efficiently and minimising waste, such as reclaiming water for reuse, capturing biogas for energy, and recovering nutrients for

Photo supplied



Ikumi's research creates advanced frameworks for designing and optimising water and resource recovery facilities, with the main goal of supporting risk-informed decisions under uncertainty.

agriculture. "For example, sometimes the challenge is building a new plant from scratch to handle a specific type of waste," Ikumi explains. "Some coal-to-fuel processes, for instance, produce waste that is very strong and rich in organic material, requiring specialised handling. There are also many design options to consider."

Expanding knowledge horizons

The Water Research Commission (WRC) has been central to his career. "This support gave me a platform for in-depth, long-term research I couldn't do otherwise," he says. "WRC funding lets us move from understanding processes to shaping infrastructure decisions."

The WRC has funded over ten projects in which he participated – many under his leadership. Ikumi's research includes developing a full-cost recovery model for wastewater infrastructure, digital twins for reclamation and reuse, and models to track micropollutants and pathogens in local treatment plants.

Photo supplied



Prof David Ikumi (second from left) as a panellist during a Water Engagement Day event.

Some of his work combines AI-powered models, real-time sensors, and digital twins – virtual plant replicas that recalibrate and predict in real time. "With mathematical models, recent projects let me integrate artificial intelligence (AI) into my work. I'm interested in models that teach themselves, using AI for solutions to different waste types, and new ways to study and monitor microbes."

He envisions, for example, a Cape Flats or Zandvliet digital twin in Cape Town projecting optimisations as treatment plant conditions shift. "I want to explore how digital technology can help these plants learn and improve, and create a flexible, model-based framework. The next generation of wastewater plants will be digitally enabled learning systems."

"My research is shifting to integrating water and sanitation systems into future smart cities, especially through wastewater treatment plants."

Expanding on this vision, he says, "Real-time sensors and digital models give me a system that knows exactly what is happening in that plant and shows what actions are needed as things change."

Ikumi's research creates advanced frameworks for designing and optimising water and resource recovery facilities, with the main goal of supporting risk-informed decisions under uncertainty.

This work integrates fundamental process understanding with data-driven intelligence to develop adaptive, AI-enabled

platforms that combine mechanistic modelling and probabilistic evaluation.

Transitioning beyond the technical realm, collaborations with social anthropologists and governance experts help him to challenge public perceptions and policy bottlenecks related to wastewater treatment facilities. "Technical solutions fail without buy-in from key roleplayers," he notes. "We need to learn to communicate our results in a clear and accessible manner to decision-makers."

As a lecturer, Ikumi extends this integrated approach by equipping graduates in water quality engineering for bioprocess design and operation. Drawing on chemistry, microbiology, and mathematics, he champions modelling for plant-wide integration: from activated sludge (a process using microbes to break down waste) to sludge digestion (breaking down organic matter into biogas).

Beyond technical outputs, the influence of WRC-funded research is evident through skills development and industry collaboration. Numerous postgraduate students educated through these projects now work in municipalities, consulting firms, and research institutions, driving improved operational methods and accelerating the adoption of innovation. Engagement with water utilities, regulators, and professional associations has also ensured research findings are converted into practical guidance, advancing data-driven policy design and infrastructure strategy.

Photo supplied



Ikumi's research creates advanced frameworks for designing and optimising water and resource recovery facilities, with the main goal of supporting risk-informed decisions under uncertainty.

Future plans

Looking ahead, Ikumi emphasises the need for sustained investment in long-term, system-oriented research programmes. "The water sector faces many challenges: climate change, urbanisation, energy constraints, and emerging contaminants. Integrated solutions must span disciplines and institutional boundaries."

He believes that the next generation of wastewater infrastructure should be adaptive systems. "These systems must learn from data, optimise resource recovery, and support societal goals such as climate mitigation and the development of the circular economy."

Current projects focus on system-wide approaches to alternative water reuse, such as combining acid mine drainage with municipal wastewater for fit-for-purpose reuse and potable water savings.

He also hopes to better understand the microbial interactions that affect treatment performance. Inspired by biological systems, Ikumi examines polyphosphate-driven energy regulation to enhance the resilience of engineered systems.

Ikumi and his team build integrated plant-wide models that connect activated sludge, settling processes, and biofilm-based technologies, accounting for microbial competition, solids separation, and contaminant tracking. Experimental platforms

and virtual laboratory networks are developed to improve data quality, standardisation, and collaboration.

His future focus includes more work on AI-digital twin frameworks, African collaboration on urbanisation and climate resilience, and advancing resource circularity locally.

Ikumi aims to make a tangible difference: connecting universities and businesses, applying data tools in cities, advancing digital systems, and supporting African research. "I want research to be implemented in action on the ground," he says.

"Wastewater holds untapped power," he asserts. "We need to unlock it and translate that potential into real systems that improve water security and sustainability."

"More and more, we are starting to see wastewater and what it contains in a new way, where nothing is wasted. This could make a huge difference for the communities we work with.

"Hopefully, we inspire our students and future researchers and engineers along the way. My ultimate hope is that through innovation, collaboration, and putting our research to work in real communities, we not only envision but deliver a future where everyone has secure, sustainable water. This is the legacy I aim to build."



To read more on David Ikumi's research, visit: <https://orcid.org/0000-0001-9158-2525>

Photo supplied



Part of the team for the ERASE (Evaluation of Resource Recovery Alternatives in South African water Treatment systems) project, funded by a DANIDA grant and coordinated by the Technical University of Denmark alongside the University of Cape Town.

EYOB TESFAMARIAM

From the ground up: a soil scientist dedicated to improving the food production system



Prof Eyob Habte Tesfamariam, an Associate Professor in the Department of Plant and Soil Sciences at the University of Pretoria, has built a career on defining practical guidelines for sludge application in agricultural contexts. Committed to seeing his work applied in practice, he has expanded his scope to systems thinking and influencing the policies that can give his work wings.

Article by Petro Kotzé.

At the core of Prof Tesfamariam's research is the principle that, in natural systems, there is no waste – only underutilised resources, often arising from the absence of integrated, cross-disciplinary approaches to resource use. His work focuses on the recycling of biowastes in agricultural systems, advancing a systems-based perspective that rethinks waste generation by designing for reuse from the outset, and by drawing on the way natural ecosystems function through the integration of floral, faunal, climatic, and edaphic processes.

Tesfamariam is an agricultural systems modeller whose work focuses on understanding how water, nutrients, carbon, gases, and contaminants move through agricultural systems, and how these systems can be designed to enhance resilience in water-scarce environments, particularly under the pressures of climate change. He has, over the past two decades, built a career that has evolved from hands-on fieldwork, digging soil pits and running long-term field trials, to influencing national guidelines and contributing to international research collaborations.

Yet, he maintains that impactful research must be grounded in field realities. Tesfamariam first gained practical experience in the Horn of Africa. After graduating with a degree in Soil and Water Conservation, he worked as a soil surveyor in his birthplace, Eritrea. From 1997 to 2002, he served as head of the Soil and Water Conservation research unit and as acting head of Agricultural Engineering in the Department of Agricultural Research within the country's Ministry of Agriculture. In 2004, however, his career took a decisive turn when he commenced his PhD at the University of Pretoria.

The long road to Sludge Application Rate Advisor

Funded by the Water Research Commission (WRC), Tesfamariam's PhD investigated the safe and sustainable application of wastewater sludge across different crops, soils, and

agro-ecological zones in South Africa. At the time, application rates were largely based on international standards. However, the WRC sought locally relevant scientific evidence to support the development of the first sludge-use guidelines tailored to South African conditions. “We sought to determine the maximum application rates appropriate for agricultural lands,” Tesfamariam explains. The research evaluated a range of cropping systems, including rainfed maize, intensive irrigated maize–oat rotations, rainfed pasture, and turf grass systems.

A key outcome of the PhD was the finding that it is agronomically, economically, and environmentally unsustainable to prescribe a single, uniform application rate across South Africa’s diverse agro-ecological conditions. This raised a critical follow-up question: how should appropriate application rates be determined for specific soil–crop–climate combinations?

Addressing this question marked the beginning of the next phase of Tesfamariam’s long-term collaboration with the WRC, which, he notes, “profoundly shaped my career.” Extensive field trials, controlled laboratory and lysimeter experiments, and multi-site studies across South Africa’s agro-ecological zones were undertaken to quantify nutrient release dynamics, crop responses, and environmental risks, including nitrate leaching and contaminant accumulation. These datasets were systematically collected and validated across all nine provinces. The integration of this work ultimately informed the development of modelling approaches and a decision-support tool, later called the Sludge Application Rate Advisor (SARA) model.

“It took approximately 15 years,” Tesfamariam reflects. The focus then shifted from tool development to technology transfer. Over a period of four to five intensive months, and with the funding support from the WRC, Tesfamariam travelled across all nine provinces, delivering hands-on training to specialists from the Department of Water and Sanitation, agricultural extension officers, and municipal personnel managing wastewater sludge. The aim was to ensure that the tool was not only scientifically

robust but also practically applied in real-world contexts.

The research ultimately informed national guidelines and WRC strategies, contributing to a shift from a purely precautionary approach to a risk-informed framework. This has enabled safer agricultural reuse of biosolids while supporting productivity and safeguarding soil and water resources.

“I began by studying how water and nutrients behave in soils,” he says. “But working closely with the WRC from my PhD onwards shifted my focus toward real-world impact.”

Grounding research in lived experiences

Tesfamariam’s insistence on grounding modelling in lived experiences is rooted in early mentorship. He recalls how his PhD supervisor, the now-retired Prof John Annandale, emphasised that researchers should not hide behind models and software. Prof Annandale, recipient of the WRC Legend Award in 2021, championed an unapologetically applied approach to science. Among his notable contributions is the development of the user-friendly Soil Water Balance (SWB) model, which has been widely used to address water-related challenges within quantitative environmental biophysics research at the University of Pretoria.

The deeply practical philosophy, adopted early in Tesfamariam’s career, continues to define his work. “Most of my work is in the field,” he says, explaining that models are essentially quantitative representations of observed reality. In this sense, the SARA model is not an abstract construct but a numerical distillation of field-based evidence, designed to reflect the behaviour of real agricultural systems and to address questions of direct relevance to farmers, regulators and policy-makers.

Following the risks

After establishing safe sludge application rates, Tesfamariam’s work naturally progressed to examining the long-term consequences of sludge use and other agricultural inputs.

Photo supplied



Prof Eyob Habte Tesfamariam is an agricultural systems modeller and Associate Professor in the Department of Plant and Soil Sciences at the University of Pretoria.



Tesfamariam's work is based on a practical philosophy, and he described his models as quantitative representations of observed reality. Here, he conducts training on using the Sludge Application Rate Advisor (SARA) model in the Free State. The tool was designed to reflect the behaviour of real agricultural systems and to address questions of direct relevance to farmers, regulators and policymakers.

A key question concerned the fate of heavy metals in the soil-plant-water system over time. His first PhD student tracked these metals through the full soil profile and across different crops, assessing potential risks to human health, plant growth, and groundwater quality. The findings were reassuring: where sludge complied with the South African sludge guideline upper limits, heavy metals did not accumulate to harmful levels in the soils, did not pose health risks through crop uptake, and did not significantly leach to groundwater.

Building on this foundation, the research expanded to soil microbial systems, recognising that microbial communities underpin soil health and long-term sustainability. A subsequent PhD study investigated whether repeated sludge applications affected microbial biomass, diversity or activity. For the high-quality municipal sludge evaluated, the results again indicated stability, with no significant shifts in microbial structure or function.

With these core risks addressed, the research moved into one of the most pressing frontiers in environmental science: emerging contaminants. His students investigated pharmaceutical residues and other contemporary pollutants, including their potential role in antimicrobial resistance, as well as metabolites and transformation products that may persist longer in the

environment.

Field-based studies conducted across 18 farms in three districts of Gauteng analysed soils and groundwater, revealing that these contaminants are already present at very low concentrations in areas that received commercial inorganic fertiliser and animal manure. This pointed to broader anthropogenic sources, particularly routine agricultural practices such as the use of fertiliser and manure.

This recognition that modern contaminants are already embedded within agricultural systems now underpins Tesfamariam's latest research on microplastics. A new PhD project is investigating the contribution of sludge-derived microplastics to agricultural soils, including their characteristics, mobility through the soil profile, potential uptake by plants, and possible pathways to groundwater.

Consistent with his systems-based approach, this body of work follows a clear trajectory: comprehensive monitoring of the soil-plant-water continuum, coupled with quantitative analysis to generate evidence that can inform guidelines and policy for the safe management of sludge and other agricultural inputs in an increasingly complex environmental landscape.



Tesfamariam received a WRC Knowledge Tree award in 2017. Here he is flanked by former WRC CEO, Dhesigen Naidoo and WRC Board member, Prof Aldo Stroebel.

Just as his early WRC-funded PhD research provided the first South African evidence to move beyond imported sludge-application standards towards locally grounded guidelines, his current work on emerging contaminants and microplastics addresses a new gap, where global policy frameworks remain underdeveloped, by generating the field-based data needed to define what “safe” means in practice.

From soil to systems thinking

Over time, Tesfamariam’s work has expanded in scope, moving into increasingly broader scientific and collaborative networks. He has collaborated with several national and international research organisations, including the French National Institute of Agricultural Research (INRA) and the Research Council for Agriculture and Analysis of Agricultural Economies of Italy (CREA). These collaborations extend to his work on assessing the impacts of extreme weather events under a changing climate on maize production in South Africa, as well as identifying appropriate adaptation and mitigation strategies.

He has also worked with researchers from a range of European institutions and universities, including the Czestochowa University of Technology, the Norwegian University of Life Sciences, the Warsaw University of Technology, the VSB Technical University of Ostrava, and the Université de Lille, focusing on biodegradable waste management within a circular economy context. In addition, he has collaborated with Rothamsted Research on greenhouse gas emissions from agricultural systems, and with the International Fertilizer Development Centre on optimising fertiliser use for crop production.

Alongside this expanding network, his research has evolved from a predominantly soil-focused perspective to a broader systems approach. “At this stage, I work at the interface of science and policy,” he says. “It took time to get here. First, you must understand the system. Once you can explain it in a way people can understand, you can translate it into policy or guidelines”. This process requires continuous translation, turning complex, process-based science into practical, usable knowledge.

Looking ahead, he sees his role expanding further. “I would like to work more at this higher level of thinking,” he says, “so that the

impact will be greater.” That may involve deeper engagement in policy spaces, where his long-term, field-grounded insights can inform decision-making at scale.

At the same time, he places strong emphasis on developing people. By supervising postgraduate and postdoctoral researchers, Tesfamariam has helped build a network of scientists and practitioners working in related fields. “The investment in me has led to investment in many others,” he reflects.

He has supervised and co-supervised 30 postgraduate students to completion at Master’s and PhD levels, and is currently supervising and co-supervising a further three MSc and seven PhD students. At the undergraduate level, he teaches Soil Water Relations and Irrigation and at the postgraduate level, Advanced Environmental Soil Physics.

Tesfamariam speaks of the immense satisfaction of seeing his students grow and contribute, proudly noting that many of his former students now hold academic and professional positions across South Africa and internationally. Overall, his significant contributions to research, development, and innovation in sustainable agronomy have led to recognition as a National Research Foundation-rated researcher and his promotion to Associate Professor.

A way of seeing

Beyond the technical depth of his work, Tesfamariam is driven by a strong ethical and personal commitment to caring for the Earth in ways that sustain both ecosystems and the people who depend on them. His career is not only about transforming waste into a resource; it is also about designing systems that enable such transformations to be safe, scalable, and sustainable over time.

“If we expect the Earth to continue to provide for us, we must take care of it,” he says. “My role is to contribute to protect this Earth; to guard and nourish it.” Even after many years in research, this sense of purpose continues to drive him. “Knowing that,” he adds, “makes me even more committed to continue.”



To read more on Eyob Tesfamariam’s research visit: <https://orcid.org/0000-0003-0724-9864>



Photo supplied

Tesfamariam conducting research in the field.

JOHAN VAN TOL

From landslides to wetlands: digging into water security



Why a Free State soil scientist digs what he does and how his research is aiding efforts to better manage our scarce water resources.

Matthew Hattingh reports.

What do deadly landslides, ill-conceived tree-planting schemes, and overgrazing have in common? For our purposes, the answer is Dr Johan van Tol, who over the past two decades has been applying his considerable energies to the study of these and an impressive variety of other environmental problems or phenomena, some with the support of the Water Research Commission (WRC).

Van Tol is a youngish soil scientist and a specialist in the youngish discipline of hydropedology. As he put it in his inaugural lecture marking his appointment to full professorship at the University of the Free State last year: "Hydro 'is obviously water, and 'pedo' or 'pedon' – which has nothing to do with 'paedophile' – means soil or ground in Greek."

Speaking to the *Water Wheel*, Van Tol explained that hydropedology bridges the gap between more established fields dealing with surface water and groundwater. It focuses on the relationship between soil and water, examining what happens after the rain hits the ground – whether the water flows overland or sinks down, and the bearing soil properties have on this. Hydropedology took off internationally around the turn of the millennium, and is today important in efforts to understand, protect and manage South Africa's scarce water resources.

Lengthy lobbying of the Department of Water and Sanitation by a handful of soil scientists, Van Tol among them, led to a better appreciation of the significance of soil to water flow. Finally, in 2019, a hydropedological assessment was added to the requirements of the country's water use license application process. These regulations set out the steps to be followed before any significant changes may be made to land use.

Thus, before a mine can be opened, infrastructure built, or a big tract of veld cleared for housing, the mandatory impact assessments must include not only surveys from hydrologists, geohydrologists, and other specialists, but from hydropedologists too.

As Van Tol quipped in his inaugural address, "Pretty cool, not only

did we change or improve the policy, but we also created a lot of opportunities (for ourselves), as well as for other soil scientists.”

In 2023, Van Tol and co-authors Nancy Job, Darren Bouwer, Simone Murugan and Pieter le Roux completed *Hydropedological Assessment Guidelines: Theory and application in a South African wetland management context* (WRC Report No. TT 925/23). The report provides a theory primer, taking practitioners through the ins and outs of doing a survey, and offers suggestions on interpreting the results. The theory part draws on the South African Soil Classification System. The system, revised in 2018 with contributions from Van Tol, describes more than 1 600 soil forms and families and their key characteristics. It's used to identify soils.

Armed with an understanding of soil characteristics and their interplay with topography, climate, and vegetation, consultants can work out the likely path water will follow, and at what rate, be it surface runoff, subsurface lateral flow, or bedrock flow. The report's decision tree can be applied to different land use changes, such as mining, agriculture, forestry, and residential.

Wetlands are a central focus because their protection is crucial to the country's water resources, with hydropedology helping to identify how they are recharged. According to Van Tol, many of the hydrological concepts we use were developed in the Northern Hemisphere. These frequently assumed groundwater and surface water intersect, causing streams to flow. Yet in South Africa, particularly in semi-arid areas and the higher reaches of river systems, where the groundwater was perhaps 60 to 70 metres beneath the surface, this wasn't the case.

Many wetlands (a major source of rivers), besides playing a vital role in regulating flow, preventing erosion and purifying water, were fed not by groundwater or surface water, but by lateral flows within the slope. This has implications. “If you're going to mine through that, then you're cutting off a source of water to the wetlands,” explains Van Tol.

Another scenario he mentioned was forestry in KwaZulu-Natal.

“We've got a policy in forestry to have buffer zones around wetlands. But if your source of water is from the crest, and you've got a recharge area, it drains directly through the soils. And if you're planting the crest with trees, you're going to dry up your wetland.” Which was why it was crucial for wetland protection to understand how the water gets to it, and why Van Tol was excited about hydropedology, the “new science now embedded in the national water policy”.

Apart from informing land use choices and suggesting steps to reduce harm, or perhaps offset it with rehabilitation work elsewhere, hydropedology is being used to map and model pollution pathways, sources and sinks. Landslide prediction is another area where Van Tol has put his expertise to good, potentially life-saving, use. We are speaking here of the shallow movement of soil layers above bedrock, and not of falls, topples and flows, to say nothing of landslides triggered by seismic activity or glaciers unleashing avalanches (as happened in Nepal and Tibet recently).

When we think of flooding in South Africa, we imagine swollen rivers and torrents of water. But we should be thinking of soils too. Consider the calamitous April 2022 floods in the Durban region that claimed more than 440 lives and caused more than R17 billion in damage to infrastructure. Some 12 000 homes were also destroyed – from middle-class dwellings in the hilly, stream-dissected suburbia of Westville, to Clare Estate shanties clinging to steep slopes. Hundreds of localised slope failures, earth slips, and mudslides played a big part in the devastation.

The city and relief agencies were overwhelmed. It didn't help that South Africa lacked a dedicated landside early warning system. Meteorologists issued a series of increasingly severe flood warnings as Subtropical Depression Issa gathered up her skirts and ran rampant over coastal KwaZulu-Natal, dumping a deluge on Durban, with the city's Virginia Airport recording 304 mm over 24 hours on 11-12 April.

But general alerts, even at a regional level, don't cut it. “How do warnings to avoid low-lying bridges prepare you for a mudslide?”

Photo supplied



Johan van Tol is professor and head of Soil Science at the University of the Free State.



Van Tol sampling soils on the Amphitheatre summit in the Drakensberg to quantify carbon stocks in Southern African alpine soils.

said Van Tol. The hydrological factors driving landslides differed from those causing floods. Precipitation is only part of the tale; soil has a story to tell too, to borrow a phrase from Van Tol. The landslides that did so much damage in Durban were a consequence of soil properties and soil conditions. Soil moisture levels before the storm were particularly significant. Topography, geology, and land use were other contributing factors.

"So, if you understand how the water flows through the soils, you should be able to detect or predict where landslides should be expected." Van Tol said this was the approach to a study he and University of the Free State colleagues, Jaco Kotzé and Jay le Roux, pitched to the WRC. This led to a recent project titled ***Towards a landslide early warning system for South Africa*** (Project No. C2023/2024-01184).

In the final report, the Bloemfontein team drew on the literature and case studies in Durban's Pinetown area, and in Port St Johns-Lusikisiki, in the Eastern Cape. They mapped landslide scars with the aid of satellite imagery. Multiple satellite data sources were used to estimate the crucial soil moisture values.

Combined with soil and climatic information, they were able to build a hydrological model. This was coupled with a slope stability model, a mathematical tool used to calculate the likelihood of a slope, or a structure on it, staying put. Their predictive modelling proved a success, improving the accuracy of identifying landslide risk. It marked progress towards a national landslide early warning system, capable of issuing alerts several days before slope failures occur. However, developing and implementing a national system would likely be a long, complex process. The report highlighted the need to incorporate the presence of any hard infrastructure into the model. Considerable stakeholder engagement and capacity building were also needed.

Positive responses to their work include that of the Eastern Cape's Department of Cooperative Governance and Traditional Affairs. They expect to sign a memorandum of understanding with the department in November 2026 to develop and implement a landslide prediction system in the province.

Meanwhile, Van Tol has been busy with research and consultancy

work elsewhere in South Africa and neighbouring countries. In the Lesotho Highlands, he is running a project mapping soils and quantifying soil carbon stocks to aid alpine wetland restoration. The “terrible state” of Lesotho’s wetlands, says Van Tol, the result of overgrazing, poor road drainage, and destructive ice rats, is “probably the most pressing” concern facing South African water scientists. The project is seeking financial support, possibly from the international owners of Lesotho’s diamond mines, in the form of carbon footprint offsets.

Van Tol is also involved in a hydropedological study in the Western Cape. A keen birder and bird photographer, Van Tol used the opportunity to visit the Strandfontein Sewage Works, a mecca for waterbirds. There he was “very excited” to spot a rare Purple gallinule, adding to a Southern Africa life list now exceeding 720 species.

Birds, or rather their absence, featured in a recent [paper](#) Van Tol co-authored on afforestation in Zimbabwe’s Eastern Highlands. It exposes the perverse incentives that can arise from ill-conceived environmental schemes, underlining the importance of proper studies before land use changes.

“Tobacco companies cleared Miyombu veld in the lowlands. And then they felt guilty about it. So, they decided to plant eucalyptus trees in the grasslands of the Highlands... some of the last breeding grounds of the blue swallow. So, the blue swallows are not there anymore. You’ve got eucalyptus that drinks up all the water and the tobacco companies got funding... green funding.”

Still, Van Tol describes himself as an optimist by nature. It’s a quality that buoyed him on a journey starting at undergrad Agriculture studies at the University of the Free State (the *boitjie* from Vanderbijlpark said he warmed to soils when he found it was one of the few subjects where his farmboy classmates didn’t have a head start on him), to completing his PhD in hydropedology under Prof Peter Le Roux at the same university.

Academic positions followed at Fort Hare University before he eventually returned to the University of the Free State, attracted by career prospects as much as a more family-friendly environment. Van Tol, 42, and his wife, Ronel, have three boys, Ivan, Wiham, and Simon. Van Tol was impressed by the quality of post-graduates; however, he had reservations about the effects



Cowan McLean

The soil tells a story. Soil morphology reveals the interactive relationships between soils and water — the focus of hydropedology. A Manguzi soil form in the Mpumalanga Highveld.

of artificial intelligence on students in general and wondered whether it might be blunting their ability to write and reason, and to sift fact from fiction.

Johan van Tol



Combining two passions — birding and soils: A Southern Carmine Bee-eater takes flight from a Dundee soil form along the Kwando River in Namibia.

Johan van Tol



Degradation of peat wetlands in the Lesotho highlands poses a major threat to water resources in southern Africa.

Nevertheless, he values AI as a productivity tool. For example, ChatGTP allowed him to do all the modelling himself for the landslide early warning project, after a budget cut left the team without a programmer. "We are busy with a paper on the risk, potentials and pitfalls of AI in soil science," he notes.

This will join nearly 100 peer-reviewed journal articles Van Tol already has under his belt. Apart from those already mentioned, he's had a hand in WRC projects encompassing efforts to develop a national soil map, mooted damming of the Mzimvubu River, hillside hydrology, a Mokolo River case study, fracking, and pollution from on-site dry sanitation systems. Nevertheless, Van Tol points out there's more to science and a life of service than journal counts and citation numbers, the stuff of publish-or-perish metrics.

He suggests a more useful measure might be whether the work was changing people's lives or improving the environment. "I

love nature, and as a Christian, to me one of the first assignments that God gave us is to look after the Earth, and I think it's embedded in most of us."

He feels that soil (and water, for that matter) scientists are as much mentors and promoters of good citizenship to their students, particularly postgrads. "They see your ethics in terms of science, and they go and replicate that. The postgraduate guys very often go into high positions and then that dribbles, dribbles down."

To the ground, you might say.



To read more on Johan van Tol's research, visit: <https://orcid.org/0000-0002-0222-8119>

Johan van Tol



Landslides — or 'manslides'? Human activities can destabilise slopes and contribute to slope failure. This scene in Umdloti, following the April 2022 KwaZulu-Natal floods, captures the scale of the devastation that prompted Prof Johan van Tol and colleagues to develop a landslide early warning system for South Africa.

MARK GRAHAM

From algae to action: A career transforming water monitoring

History, someone once remarked, does not repeat itself, but it rhymes. GroundTruth founder Mark Graham's career has a certain circular quality too, with its recurring focus on nutrients in the water. He talks about water monitoring tools, citizen science and his consultancy's work with the Water Research Commission (WRC).

Matthew Hattingh reports.

On a bright autumn morning, we spot three AmanziChamps walking up Mandela Drive, Mpophomeni, not far from the wastewater works. Charlene Russell, wetland ecologist and educator with environmental and engineering consultancy GroundTruth, pulls over. We climb from her car, and Russell whistles. Seeing us, the men approach.

Nhlanhla Buthelezi wears a blue uMngeni-uThukela Water shirt and racy gold Aviator-style sunglasses. Colleagues Sphamandla Ncengwa, and Luthabo Xulu, also in the utility's livery, tramp about in gumboots. After greetings, the men tell us they've been collecting samples at Site 3, a wetland on the lower reaches of the Mthinzima stream. Running through Mpophomeni, a fast-growing township in KwaZulu-Natal's Midlands, it feeds Midmar Dam.

Ncengwa is carrying a velocity plank, a see-through yardstick. Put into a stream, broadside to the current, the difference in the water level at the stick, upstream versus downstream, shows water speed. Xulu has a water clarity tube. There's a disc inside the clear plastic tube: you draw it away from yourself. Moving the disc farther away, depending on how murky your sample is, you will cease to see it at some point. The tools are calibrated to give standardised measures of water at a given sampling point.

Xulu also has some tubes he's filled at Site 3; he says these must be kept warm in his pocket for 16 hours. Thanks to a chemical reagent, they change colour if they contain coliforms or *E. coli*. The quicker they change colour, the more *E. coli* there is. A chart tells the user at a glance the level of *E. coli* in the sample, revealing how much sewage was in the watercourse.

Test tubes, clarity tubes and velocity planks. These low-tech, accurate tools let the Champs monitor water quality in and around Mpophomeni. Data captured on a dedicated app is later mapped and analysed.

There's much at stake.



Founder of GroundTruth and co-developer of the internationally acclaimed miniSASS river monitoring tool, Dr Mark Graham is an aquatic ecologist with 30-plus years' experience in terrestrial and aquatic ecosystem functioning and management.

Mpophomeni, east of Howick, across the N3, is home to about 27 000 people. It's served by a R474-million wastewater treatment plant (opened in July 2025), but plenty of the township's sewage doesn't get to the plant, flowing instead out of manholes and elsewhere and finding its way into Midmar Dam, under a kilometre away. It's one of the dams on the uMngeni River supplying water to four million people in greater Durban and Pietermaritzburg.

Twelve Champs are employed by uMngeni-uThukela, part of an initiative established in 2011 by GroundTruth, civil society's Duzi-uMngeni Conservation Trust (DUCT) and the Wildlife and Environment Society of South Africa. Residents of Mpophomeni volunteered to do something about their township and its polluted waters and were initially known as EnviroChamps.

The Champs report blocked or broken sewers, helping reduce the number of overflowing manholes from 700 to about 40 over six years. They also report freshwater leaks and illegal dumping, and help with surveys and community awareness campaigns that educate residents about what not to throw down toilets and drains.

The Champs learned to use a citizen science version of the SA Scoring System (SASS) to assess rivers' environmental health using biomonitoring. Mark Graham, Chris Dickens, and Jim Taylor pioneered this simplified version, called miniSASS.

It averages sensitivity scores assigned to aquatic macroinvertebrates (think dragonflies, mayflies, beetles, crabs and snails), collected during a rapid five-minute sample of a river or stream's habitats. These organisms are identified using a simple field guide and grouped into 13 classes, each with a sensitivity score. Pollution-sensitive taxa such as stoneflies and caddisflies score highest, while true flies, leeches and worms score lowest. Averages above seven indicate near-natural conditions; those below five reflect poor water quality.

MiniSASS is a game-changer, says Graham, aquatic scientist and founding director of GroundTruth.

At GroundTruth's historic Hilton offices, Graham explains how miniSASS was developed in Mpophomeni and how it spurred a whole movement of water citizen scientists, in South Africa and abroad, giving the public a tool to produce credible results to hold local authorities and utilities to account.

Returning to KwaZulu-Natal around 1992 from abroad, he found work with uMngeni-uThukela Water (or uMngeni as it was then known), assisting with a WRC research project. Working on his MSc, he investigated algae proliferation in dams on the uMngeni system caused by eutrophication, or too many nutrients in the water resulting from sewage in the system.

This green water looks, tastes and smells bad. Worse, the algae can excrete "pretty nasty toxins", some linked to liver cancer. "So you have to filter and clean that stuff out before you can sell your water to your customers," he explains.

Algae was entering the pipeline between Nagle Dam and the Durban Heights Water Treatment Works. Turbulence and pressure changes caused the algae to rupture, making it "much more difficult to extract and clean". Graham was fascinated, trying to simulate what was happening with the Nagle water, and understand the algal rupturing process. The utility wanted to avoid similar problems between Inanda Dam (then being built), and the new Wiggins water treatment works.

Another WRC-funded project modelled the relationship between water quality and algal communities in very different dams in the uMngeni system. Researchers wanted to predict when algal levels in particular dams might become problematic, producing nasty compounds, to better plan treatment across the system.

Graham's next WRC project (the basis of his PhD), looked at algal dynamics and water quality and water treatment costs. At uMngeni Water until 2004, Graham did research, some under the WRC banner, and plenty of routine monitoring – water testing and analysis. He also developed biological monitoring and testing techniques based on algae counting and measuring, and very precise toxicity testing that measured the effects of pollutants that would be hard to analyse chemically.

Graham explains his interest in SASS biomonitoring: "The problem is...a biological organism [is] much more variable. How do you convert biological monitoring into a much more rigorous, robust technique that's repeatable?"

Along with some colleagues he found ways to apply the rigour essential to lab work to SASS methodology, producing the SASS version 5 technique and securing its International Standards Organisation accreditation. SASS5 offers several

advantages: Conventional lab analysis of chemical determinants in grab-sampled water provides a snapshot of water quality, at a particular place and point in time. But it tells you little about upstream or downstream water and might miss episodic pollution events. "So if you're an industry in town here," Graham explains, referring to nearby Pietermaritzburg, "You see the guys coming on Tuesday to sample. Then if you were a dodgy character, you would open the taps on Tuesday night, after they've gone and let all your nasty industrial pollution out."

By contrast, SASS testing is like a video, he says, producing "an historical picture of the quality in the preceding couple of weeks".

Macroinvertebrates can't leave the water when it's polluted. Their absence or presence makes SASS an effective indicator of typical water quality and reveals persistent and intermittent pollution, helping locate where water quality suddenly turns bad.

MiniSASS was spurred by a request from a colleague in uMngeni-uThukela's environmental education and outreach arm who wanted to make [SASS] more accessible and community focused. Graham and his co-developers distilled SASS. Drawing on a "huge data set", they optimised the weights attached to different data classes. This collaboration between uMngeni-uThukela's scientists and educators, and the Wildlife and Environment Society of South Africa produced an adapted, mini version, with results "pretty close" to a full SASS.

Graham says miniSASS prompted a water citizen science movement nationally, helping the public collect samples and investigate conditions in rivers, wetlands and other water bodies around them.

In 2004, Graham founded GroundTruth (above the garage at home, and financed from his home loan access bond). With his team – which eventually grew to about 50 water professionals and engineers – he continued developing miniSASS and other citizen tools. These have gained traction and interest in South Africa and abroad, with the United Nations recognising miniSASS as a valuable tool for monitoring its sustainable development goals.

In 2013, the WRC presented GroundTruth with a Community

Empowerment award for its miniSASS work. Subsequently, the WRC supported the consultancy to develop 10 citizen science tools and present the findings in book form. These included miniSASS and a website (<https://minisass.org/>) where the public can upload and share findings; water clarity tubes; velocity planks; and an adapted wetland health tool – miniWET-Health. These allow the public to produce data that suspected polluters, or officials, will struggle to fob off.

The clarity tube, for example, gives a calibrated, non-subjective measure of suspended solids, used to monitor outflows from sewage treatment works and monitor standards. It's much easier for the public to use than chemistry-based single-use tests.

In the early 2000s, DUCT and residents of Shiyabazali informal settlement above Howick Falls used citizen science to challenge declining quality from uMngeni-uThukela Water's Howick wastewater treatment plant. EnviroChamp and resident Zongile Ngubane took daily clarity-tube tests, but officials were sceptical. But when Graham, also a director of DUCT, confirmed the rigour of the tool, a dramatic recovery followed.

Graham says the 2026 Green Drop Report and a GroundTruth paper show wastewater treatment works and systems in catchments countrywide failing. "Water that goes into the rivers is poorly treated, if at all... and lands up in a dam and you've got eutrophication, you must clean this eutrophic algal-rich water," says Graham.

uMngeni-uThukela has a "significant problem with massive algal infestations" and is under pressure over water quality, while "treatment costs have rocketed", he says, costing millions of rands a month. Graham adds that neglected wastewater systems are malfunctioning, with municipal officials not directing sufficient resources at pressing priorities, including maintenance.

Graham feels his work gives the public greater agency to affect change. "You're knocking on the door at the right place to say, 'We see there's a problem. Here's our data, and we can see what it's doing to the system.'" It also addresses the lack of inspectors often given as an excuse for official inaction. "Now you've got the... population doing that, or every school kid in Grade 12 doing a project on this. Suddenly the leverage effect is enormous."



Graham demonstrating the velocity plank at the WaterNet conference in Lesotho 2024.



The AmanziChamps and GroundTruth team after a briefing on the new WRC project under way in Mpophomeni.

Citizen science has a democratising effect. GroundTruth has taught everyone from children to Pam Tshwete, the former Water and Sanitation deputy minister, how to use miniSASS. It helps people connect their actions to their consequences. “Whatever might be happening with that sewer, or that litter. Where is it going? What’s it doing? How is it impacting?”

After meeting the Champs, Russell and I visited sampling Site 3, where the Mthinzima enters a wetland immediately below the R617, the Underberg road, before trickling into Midmar. Years ago, someone, a farmer perhaps, cut a channel to drain the wetland, directing water straight into the dam. Around 2016, GroundTruth’s engineers designed berms and weirs to divert the water to seep slowly through the landscape. The rehabilitation was a success, but the wetland still receives a high nutrient load, notes Russell.

With this in mind, a fresh WRC-GroundTruth project aims to establish a framework for a water quality credit market at a municipal level, by incentivising practices to improve water quality at a household level. “Polluter pays” systems typically involve agriculture and industrial polluters buying credits (for pollutants like nitrogen and phosphates) from farmers already reducing their own nutrient runoff.

Russell explains that learning labs would get Mpophomeni residents to co-create water quality improvement practices – perhaps installing greywater filtering systems at their homes or collecting plastic for recycling. How it would all work, the nature of the credit system, and the size of incentives were still to be co-developed. A pilot of the system is scheduled for next year.

The Champs have been helping with a baseline study to understand residents’ circumstances and confirm locations of pollution hotspots where the project will be focused.

Ultimately, the aim is helping uMngeni-uThukela, and us, the greater public, to protect our investments – the new Mpophomeni wastewater plant, the restored wetland, and the dam below – a major tourism and water supply asset.

Russell notes that the dam is OK for now, but “It’s about preventing Midmar reaching that [tipping] point.”



To read more on Mark Graham’s research, visit: <https://orcid.org/0000-0001-9655-2296>



Zongile Ngubane filling up a clarity tube with discharge water from the Howick wastewater treatment site in Shiyabazali.

NICKY TAYLOR

Making every drop count: the scientist helping South African farmers use water smarter

For Dr Nicky Taylor, understanding how plants use water is as much about getting her hands dirty as it is about sophisticated science. After decades working at the intersection of agriculture, plant physiology and water research, she is equally passionate about the next generation of researchers who will carry the work forward.

Article by Kim Trollip.

Taylor did not set out to become a water researcher. Her route into the field was shaped by a love of plants, a fascination with how things work and, ultimately, a chance encounter with a mentor who changed the direction of her career. If you had asked Taylor in her twenties where she expected to end up, the answer would probably have been plant physiology. Her Master's and PhD research at the University of KwaZulu-Natal focused on avocados and the mechanisms controlling fruit growth. She enjoyed understanding what was happening inside a plant and, importantly, why.

Then came a job advertisement, a trip to Pretoria and a Sunday lunch that changed the course of her career.

A few years ago, Taylor applied for a position at the University of Pretoria and travelled there for the interview. John Annandale, a professor involved in irrigation and water research, needed someone with a plant background for a water project. During the interview process, Annandale and his wife took her to lunch. He subsequently arranged for her to attend a water course in Pietermaritzburg.

Before she quite realised what was happening, Taylor had been drawn into agricultural water research. "It really was chance. And serendipity," she recalls.

She has never regretted it.

Today, Taylor is a Senior Lecturer in the University of Pretoria's Department of Plant and Soil Sciences. Her research focuses on measuring and modelling the water use of fruit trees, using field measurements and plant physiological techniques to understand how trees respond to their environment. Her work has included pecans, macadamias, apples, citrus and avocados.

Agricultural water-use research is a relatively small community,



Dr Nicky Taylor is a senior lecturer in Plant Production and Soil Science at the University of Pretoria.

says Taylor, and that has been one of the things she has enjoyed about the field. Researchers work together, share ideas and challenge one another's thinking.

Over the years, she has been fortunate to work alongside and learn from a number of people who have influenced her own approach. Soil scientist Prof Keith Bristow, who later moved to Australia but remained connected to the department, was an inspiration – highly intelligent, but also someone Taylor admired for his sense of social responsibility. Agricultural scientist and irrigation/water researcher Dr Richard Stirzaker introduced her to practical irrigation tools, while hydrometeorologist Prof Colin Everson remains someone she says she “still can't keep up with”.

She also points to the contribution of women working in the field, including agricultural and climate-change researcher Prof Stephanie Midgley in the Western Cape and agrometeorologist researcher Dr Caren Jarman. Agricultural water research can be physically demanding, particularly when it involves long days of fieldwork, and Taylor has seen the field gradually become more diverse.

A curiosity about how things work

Taylor's interest in plants began long before her career in research. Growing up in Pietermaritzburg, she was surrounded by plants. Her father was an enthusiastic gardener and family holidays were often spent outdoors in the nearby Drakensberg. Her childhood passion, however, was sport.

“I was just sport mad,” she says. “Anything that involved a ball and involved chasing a ball like a small Jack Russell was me.”

At school, science, history and geography captured her attention far more than accounting. A Grade 10 project on plants sparked a particular interest in botany and in the mechanisms behind how plants work.

There were other interests she never had the opportunity to explore. At the all-girls school she attended at the time, practical subjects such as woodwork and electronics were not available.

Instead, she had needlework.

She laughs about it now, but Taylor has always been drawn to figuring things out. “I like the mechanisms,” she explains. “I quite enjoyed being a bit of an electrician.”

Working with sap-flow measurements, evapotranspiration, instruments and data loggers allowed her to investigate plant water use in the field and understand the processes behind the numbers. The transition also taught her the value of a good mentor. Annandale introduced her to projects, networks and opportunities that helped establish her career. Taylor believes young academics can struggle to find their way into research projects and funding while they are still finding their feet.

A good mentor can make all the difference.

“Sometimes as scientists, we think we know best and we really don't,” she says.

“We need to find what they [farmers] need, and how we can then communicate it or adapt what we're doing to make it a little bit more applicable to them.”

From measurements to decisions

At the heart of Taylor's research are deceptively simple questions: how much water does a crop need, how much land can a grower plant with the water available, and how much water should be applied at a particular time?

Answering them requires careful measurement and an

understanding of the many factors affecting a tree's water use. Taylor's work examines transpiration, soil evaporation, canopy size and weather, and uses models to estimate water requirements across orchards.

For growers, the answers have real financial and operational consequences. They are also becoming more important as South Africa faces increasing competition for a limited water resource.

Climate change adds another layer of uncertainty. Taylor is interested in what hotter and drier conditions will mean for crops but cautions against assuming that plant water use simply rises in a straight line as temperatures increase. "The relationship is not linear," she explains. That complexity is precisely why good measurements matter.

Her pecan research illustrates the point. Working across three contrasting production environments, the research team built detailed datasets on orchard water use and tested their approaches under different conditions. The work also challenged the perception that pecans are exceptionally thirsty crops.

"We got really nice water data sets from three slightly contrasting environments," she says. "Our pecans are seen as using so much water, and then to actually have data to say, well, actually, it's not that bad."

For Taylor, the value of research lies partly in being able to replace assumptions with evidence. But producing the evidence is only part of the job.

Taking science into the orchard

For Taylor, research has to reach the people who can use it. She has shared her findings through grower associations, research days, orchard visits and water-management courses. These interactions are also opportunities to listen.

"Sometimes as scientists, we think we know best and we really don't," she says. "We need to find what they [farmers] need, and how we can then communicate it or adapt what we're doing to make it a little bit more applicable to them."

That exchange matters because farmers are making decisions in a much bigger context than irrigation alone. Water has to be managed alongside marketing, spraying, fertilisation, labour, finances, electricity disruptions and rising fuel costs.

Taylor's relationship with the Water Research Commission has been important in supporting this work. She credits the commission's long-standing support, often in partnership with grower associations, with providing reliable funding for research and students.

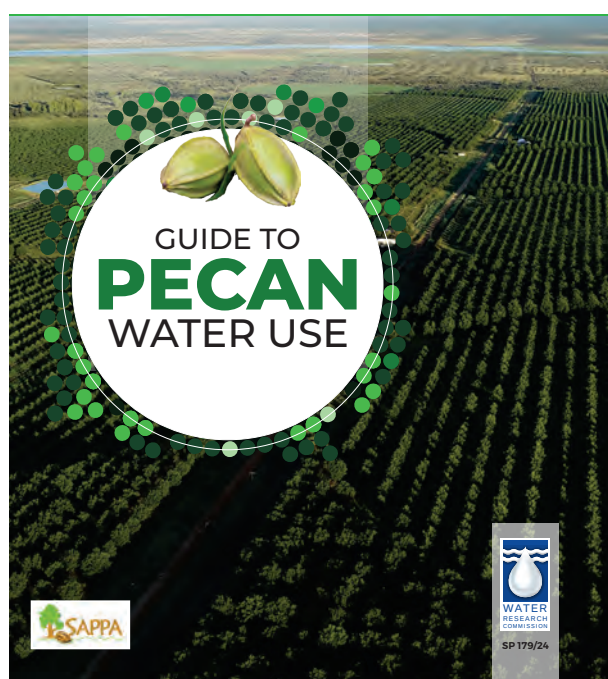
For Taylor, translating research into something useful is an essential part of the work. The same philosophy carries into her teaching. Taylor describes mentoring students as the most rewarding part of her job. She wants young researchers to become excited about agriculture and science and takes seriously the responsibility of giving them the kind of support she received early in her own career.

She also believes in leading from the front. When students are working in the field, Taylor works alongside them. If there is a difficult or unpleasant job to be done, she is prepared to get stuck in. There are long days, mud, troubleshooting, humour and music.

Seeing former students later in their careers, sometimes encountering them again at farmer days, is particularly rewarding. It is a reminder that the impact of research can extend beyond the research itself.

The water questions ahead

Taylor sees considerable challenges ahead for agriculture.



Taylor's research on pecan water use has combined detailed field measurements with modelling to build a better understanding of how much water orchards need, and how those requirements vary between regions and seasons. The work has provided growers with evidence to support irrigation planning and more productive use of water – an increasingly important consideration for an industry largely located in South Africa's semi-arid regions. Her work has resulted in products such as the WRC published Guide to pecan water use, which has become a popular guide among pecan nut growers.



Taylor's work often involves the installation of specialist equipment – potentially dangerous work.

Climate change, a drying climate, population growth and increasing competition for water will place growing pressure on farmers to use water efficiently. Domestic water needs will increasingly compete with agricultural demands, while growers will have to produce food under increasingly uncertain conditions.

Yet she believes South Africa has a strong foundation of irrigation expertise and agricultural water research on which to build.

Technology will increasingly form part of that picture. Satellite and spatial tools can help researchers and growers identify stressed areas within orchards, assess uniformity and even identify potential irrigation problems such as leaks or blocked equipment.

Artificial intelligence has a role too, particularly in programming, analysing information and handling large amounts of material.

But Taylor is wary of allowing technology to replace curiosity and judgement. "You still need to think a lot." It is a characteristically direct observation from someone whose career has been built around asking questions, testing assumptions and figuring out how things work.

For young people considering a career in agriculture, water research or related fields, her advice is equally straightforward: find what excites you. Be curious. Pay attention to detail. Keep learning. Agriculture, she points out, has room for people with many different interests and skills. There are opportunities across fields ranging from genetics and microbiology to water science, and she has seen the sector become more diverse over the course of her career.

Her own path is perhaps the clearest illustration of where

curiosity can lead. A childhood fascination with plants became a career in plant physiology; a chance meeting over Sunday lunch opened a door into water research. And the questions have kept coming. "There's no replacement for water," she says. "So there's always going to be a role for water scientists."

For someone who was always interested in understanding how things work, there is perhaps no better reason to keep looking. There is always another question to ask, another problem to solve, and another generation of researchers to bring along.



To read more on Nicky Taylor's research, visit: <https://orcid.org/0000-0002-2912-4416>



Aerial view of the 18-year-old mixed cultivar pecan orchard on the banks of the Orange River between Groblershoop and Grootdrink, which for a while served as Taylor's study area.

PHILISWA NOMNGONGO

The water that shaped a scientist – From a 2 am water collection to nanotechnology research



For Prof Philiswa Nomngongo, the journey into water research began long before she entered a laboratory. Growing up in rural Pondoland, she knew from childhood that access to clean water could not be taken for granted. Today, a researcher at the University of Johannesburg, she uses analytical chemistry and nanotechnology to investigate pollutants in South Africa's water systems – while helping to develop the next generation of scientists.

Article by Kim Trollip.

Growing up in Pondoland, between Lusikisiki and Flagstaff in the Eastern Cape, a young Philiswa Nomngongo would get up at 2 am to collect water. Getting there early was a matter of necessity. If she wanted water before the cows disturbed the spring, she had to get there first.

“At that time, nothing struck me as, is this water clean? All we wanted was clear water. Years later, when I was studying environmental chemistry and learning that water contains all these different things, I remembered the water in my village and started wondering: what does my water contain?”

Nomngongo developed a love of chemistry at school, thanks largely to her science teacher, Mr Fred Iumba. Despite the lack of proper laboratory facilities, Iumba found ways to make chemistry tangible by demonstrating reactions with familiar household substances and explaining the chemistry behind everyday things.

“He made it so interesting to us,” says Nomngongo. His influence extended beyond the classroom. He encouraged his pupils to apply to university and pursue careers in science, and Nomngongo believes his encouragement helped set many of them on their eventual career paths. “I always say if it wasn't for him, I don't think I'd be a professor today.”

She went on to study chemistry at university, initially considering several possible career paths. In her second year, however, an applied chemistry course brought environmental chemistry into focus. The students went to the rivers, collected water and analysed it for parameters such as pH. For Nomngongo, the experience triggered an unexpected connection. “I remembered my water in my village,” she says. “And when we were being taught that water contains things, I wondered, what does my water contain in my own village?”



Philiswa Nomngongo is a South African professor of analytical chemistry and the South African Research Chair (SARChI) in nanotechnology for water at the University of Johannesburg.

The question stayed with her. Rather than entering the workforce after graduating, she decided to continue studying until she could conduct that kind of analysis herself.

Learning to lead

Nomngongo's development as a researcher was shaped by another important mentor, Prof Jane Ngila, who supervised her Master's and doctoral studies. She remembers learning from her supervisor's discipline, long hours and determination to complete the task at hand. But perhaps more importantly, she learned about supervision.

While still a student, Nomngongo was given responsibility for overseeing laboratory activities as a "lab captain". The laboratory included Master's and doctoral students, and being entrusted with that responsibility gave her an early taste of what it meant to lead others. It planted an ambition. "I thought, I would like to be a supervisor one day," she recalls.

The experience is significant because capacity development has since become one of the most rewarding aspects of her own career. Today, Nomngongo is a professor in the Department of Chemical Sciences at the University of Johannesburg and holds the DSI-NRF SARChI Chair in Nanotechnology for Water. Her research uses analytical chemistry, environmental science and nanotechnology to detect, monitor and ultimately help address pollutants in water systems.

Making the invisible visible

Some of the pollutants that concern Nomngongo are surprisingly ordinary, including pharmaceuticals, personal-care products and other chemicals that are part of everyday life. They can eventually enter water systems, yet many so-called emerging pollutants are not routinely monitored or regulated in the same way as more established contaminants.

Antibiotics, for example, raise concerns about antimicrobial resistance, while substances such as per- and polyfluoroalkyl substances (PFAS), often known as "forever chemicals", and

microplastics are attracting increasing attention.

For Nomngongo, the problem is compounded by knowledge gaps. Research into emerging contaminants in South Africa is often concentrated on particular rivers or locations, leaving large parts of the country without a clear picture of what is present in their water.

"There may be many studies, but that does not mean we have a picture of what is happening across the whole of South Africa. We need to understand what is happening in different places, because the pollutants and the risks are not necessarily the same everywhere."

Her work, therefore, involves developing analytical methods that can identify pollutants, understand how they move through environmental systems and assess their potential implications for people and ecosystems. Nanotechnology has become an important part of this work. For Nomngongo, it is not simply about using an advanced technology because it is fashionable. It can also solve a very practical research problem.

Analytical chemistry can be expensive, particularly when specialised materials are required for extracting and detecting pollutants. Nomngongo and her research team develop their own materials in the laboratory, including nanomaterials that can mimic commercially available products. The approach can reduce costs while allowing researchers to produce and reuse materials rather than repeatedly purchasing expensive commercial products.

Her research consequently sits at an intersection: analytical chemistry provides the tools to identify what is in the water; environmental science helps explain how pollutants move through the system; and public-health considerations help determine what those findings could mean for people and animals.

Returning to the questions of childhood

That intersection has taken Nomngongo back into rural

communities – and, in a sense, back to the questions that first began forming when she was a child.

One WRC-supported project examined water sources in villages in the Eastern Cape where boreholes had been installed almost two decades earlier. Nomngongo wondered whether the boreholes were still functioning and whether they were still sufficient for communities that had grown considerably since the infrastructure was installed. Rather than deciding in advance where the communities obtained their water, the researchers asked residents to show them.

They sampled boreholes, springs and streams and investigated the quality of the water people were using. The research found that a functioning borehole did not necessarily mean that sufficient water was available. In some communities, boreholes operated according to schedules, with different areas receiving access on different days. Elsewhere, residents relied on springs and streams when boreholes were not working.

The findings also highlighted the vulnerability of some water sources. Livestock could contaminate springs, while changes in settlement patterns and sanitation infrastructure could potentially affect groundwater quality.

Yet one of the most valuable lessons for Nomngongo came from listening to the communities.

People already knew which water sources they trusted, which tasted salty, which were hard, and which they avoided. Their knowledge did not necessarily use scientific terminology, but it contained observations that could be tested scientifically. “They may not use the scientific term ‘water hardness,’” she says, “But they understand the practical implications – why they would not use certain water for certain purposes.”

For Nomngongo, this reinforces the importance of approaching

communities without assumptions about what they do or do not know. Scientific measurements can validate and explain observations, while community knowledge can help researchers understand what is happening on the ground. That collaborative approach is increasingly important as her research moves towards examining the impacts of small towns and other activities on nearby rivers.

“There may be many studies, but that does not mean we have a picture of what is happening across the whole of South Africa. We need to understand what is happening in different places, because the pollutants and the risks are not necessarily the same everywhere.”

Many smaller towns are located alongside rivers that remain important sources of water downstream. Waste entering a river in one location can therefore affect communities, agriculture or bulk water users further downstream. Nomngongo wants research to contribute to those conversations rather than ending when the laboratory analysis is complete.

“What is the point of identifying these problems if we are not going back to the communities and sharing what we have found?” she asks.



Nomngongo with some of her students in the lab. She describes capacity building and teaching as some of the most fulfilling aspects of her career.



Nomngongo grew up in Pondoland, between Lusikisiki and Flagstaff in the Eastern Cape.

A changing water landscape

Climate change is adding another layer of uncertainty. Nomngongo has seen changes in rainfall patterns in the Eastern Cape, including sampling periods that were expected to represent dry seasons but instead experienced substantial rainfall. Seasons that once felt predictable are becoming less so.

These changes matter for both water quality and water availability. Heavy rainfall can increase turbidity and wash pollutants and solid waste into water systems, while warmer conditions can affect microbial activity.

The result is greater uncertainty about patterns that researchers might previously have expected to see. For Nomngongo, this strengthens the case for more intensive water-quality monitoring, particularly in areas where formal water systems are limited, and communities remain dependent on local sources.

She is particularly interested in rural areas, where small towns, growing settlements, waste management, agricultural activities and hospitals can all potentially influence water quality. There is also a wider lesson here. Protecting water requires understanding what is happening around it.

Staying curious

For a researcher whose career began with a simple childhood question, curiosity remains central to Nomngongo's advice to young scientists. "Being curious" is what keeps her moving forward, she says, encouraging researchers to ask questions, work hard and focus on problems that matter to society. In addition to being curious, young researchers also need to be adaptable and creative, willing to solve problems in unfamiliar circumstances and, importantly, prepared to learn and sometimes to unlearn too.

Some of the most valuable lessons may come from unexpected sources. "You can learn from a community member who has never been in school," she says.

Collaboration is equally important. Water challenges rarely fit neatly within disciplinary boundaries, and researchers need to work with people who have different expertise – including social scientists and communities themselves. "For me, scientific impact is not necessarily about making a spectacular discovery. I prefer to be in the back seat, watching the people I have trained take the lead. Some of my former students are now working in academia, while others are contributing to the water sector. Seeing them succeed is one of the greatest rewards of my career."

Her ambition as a second-year student was to be part of research that made a difference and to discover something useful. It did

not have to be a Nobel Prize. Sometimes, she says, making a difference means being able to tell people what is happening in their water – and what can be done about it.

For the girl who once woke at 2 am to reach a village spring before the cattle, that curiosity has travelled a remarkably long way.

To read more about Philiswa Nomngongo's research, visit: <https://scholar.google.com/citations?user=GZajrk8AAAAJ&hl=en&oi=ao>



Taking water samples in the field.

SALMINA MOKGEHLE

A plant scientist who is building a resilient future through knowledge, people and practice

From her position as Senior Lecturer at the University of Mpumalanga, agricultural scientist Dr Salmina Mokgehle is growing a community of researchers and farmers who can help unlock the power of underutilised indigenous crops for a sustainable future.

Article by Petro Kotzé.

“Water,” says Dr Salmina Mokgehle, “lies at the centre of agricultural sustainability.” And, for research to matter, she adds, it must generate knowledge that helps communities and decision-makers manage this resource responsibly.

A Senior Lecturer in Horticulture at the University of Mpumalanga, Mokgehle has carefully crafted a career that achieves exactly that. Her work brings together indigenous knowledge, horticultural science, and climate-smart agriculture. Her research, she explains, chips away at one core question: how medicinal plants and underutilised crops can contribute to climate-resilient food systems, biodiversity conservation and rural livelihoods in South Africa.

Just over a decade into her career, she is recognised for her growing contribution to agricultural and environmental research (as reflected in her NRF Y2 rating, awarded in 2024), but the foundations for her journey were laid many years earlier.

A career rooted in childhood knowledge

Mokgehle was born and raised in Overdyk (Ga-Moleele), Bochum, a small rural village outside Polokwane in Limpopo. Growing up, agriculture was a part of everyday life. “My mother has always been cultivating plants,” she recalls. She saw firsthand how agriculture supports families and communities. She also learned about the traditional use of plants for healing and everyday health. “We used them for food, but my mother also used some to treat different ailments,” she says. The local African ginger (*Siphonochilus aethiopicus*), for example, was used to treat the common flu.

These early experiences sparked her curiosity about the relationship between plants, water, and people’s well-being, she says. Consequently, she pursued studies in agricultural science to better understand how plants grow and how natural resources



Dr Salmina Mokgehle is a Senior Lecturer in Horticulture at the University of Mpumalanga. She is an agricultural scientist whose work brings together indigenous knowledge, horticultural science, and climate-smart agriculture.

such as water can be managed responsibly. And when it came to choosing a topic for her PhD, she focused on a plant well known from her childhood. Her thesis, completed in 2017 at the University of KwaZulu-Natal, investigated variations in plant growth, yield, and metabolites in response to different irrigation regimes and nitrogen levels of the African ginger. In essence, she wanted to understand how to commercially produce the plants and develop medicinal products.

African ginger (*Siphonochilus aethiopicus*) is a highly valued medicinal plant that is threatened by overharvesting and habitat loss in South Africa. The plant is widely used in traditional medicine to treat ailments such as respiratory illnesses, pain, and malaria. Wild populations of the endangered species are declining and facing a loss of genetic diversity. Yet, there is limited scientific understanding of how cultivation practices influence its growth and medicinal properties.

To address this gap, Mokgehle's PhD study identified growing conditions that optimise both biomass production and the accumulation of valuable secondary metabolites, including antioxidants and volatile compounds. She found that cultivation can serve as a viable alternative to wild harvesting, supporting both conservation and commercial use.

Today, that early interest continues to shape her research, she explains, as she works to find solutions that balance agricultural production with environmental protection. However, Mokgehle's research has expanded beyond individual crops to consider entire farming systems. Her work now explores how water, soil, plant growth and farming practices interact to support sustainable agriculture.

Underutilised crops remain a key focus of her work, particularly those that are both water-efficient and nutritionally valuable. Still often overlooked in mainstream agriculture, the plants are

well adapted to local conditions and can play a significant role in food security and resilience. Her current work on indigenous and underutilised fruit trees reflects this integrated approach. The research examines both nutritional composition and water use, positioning these crops within broader food and health systems.

A WRC-funded project, led by Mokgehle, is exploring how the milkwood (*Mimusops zeyheri*), an indigenous fruit tree, can improve farmers' and communities' food security and nutritional intake. This tree is naturally suited to local conditions but is often overlooked in farming systems. The project (*Prospect of unlocking the potential and sustainable integration of the underutilized indigenous fruit tree milk wood (Mimusops zeyheri) in the cropping system for combating food and nutritional insecurities*) explores ways to grow and integrate the tree alongside other crops so that it can provide additional food, income, and health benefits. By promoting its use, the project aims to help communities become more food-secure while adopting sustainable farming practices that protect the environment.

In this way, Mokgehle's work sits at the intersection of water management, agriculture and community well-being. It is not only about how to grow the right crops, but about how they can support people's lives in water-constrained environments.

Research rooted in reality

While research forms the foundation of her work, Mokgehle is clear that knowledge must reach those who can use it most.

In her first Water Research Commission (WRC)-funded project, conducted while she was at the Agricultural Research Council (ARC), she worked directly with smallholder farmers in the Vhembe district. The project focused on underutilised crops and water-use practices, combining scientific research with practical,

on-the-ground support. "We were able to provide training to the farmers about cultivating some of these plants," she explains. "We were also able to buy them some resources that make it easier for them to know about water utilisation and water application."

One farmer's story stands out. When the project began, the farmer was producing vegetables on a small scale, with limited access to markets. Through training, support and improved water-use practices, the farmer's production increased significantly. By the end of the project, she was able to take her produce to market and generate income.

"When we did the exit strategy, for me, this outcome was a plus," Mokgehle says. "Initially, she [the farmer] was not producing high amounts of crops, but by the time we were leaving, she was already taking her produce to the market. I was very glad."

For Mokgehle, the value of the project lay not only in the research results but also in the relationships built along the way. For that project, she says, farmer engagement meetings brought together the WRC, local municipalities and traditional leaders, creating a platform for dialogue and support. "We had very fruitful discussions to support the farmers' initiatives," she says.

An ongoing WRC-funded project on Mokgehle's plate focuses on supporting rural communities in Mpumalanga (more specifically, Luphisi and Salubindza in the Mbombela Municipality) to improve their farming practices. The project (*Farmer-led agricultural production interventions through sustainable farming practices for underutilised indigenous crops by rural communities in Mpumalanga*) places farmers at the centre of decision-making. "In these areas, many farmers are interested in growing indigenous crops and medicinal plants, but often lack access to information about how to cultivate them effectively," Mokgehle explains.

To address this, Mokgehle and her team organised training workshops and practical demonstrations for farmers. During these sessions, farmers learned simple cultivation practices that help medicinal plants grow well under local conditions. The training covered topics such as soil preparation, planting methods, crop spacing, watering practices, and natural methods for managing pests and diseases.

Farmers were also introduced to ways to use water more efficiently, protect soil health, and grow crops well-suited to their local environment. The workshops encouraged open discussion, allowing farmers to ask questions, share their own knowledge, and learn from one another.

In addition to workshops, the team conducted field demonstrations where farmers could see the cultivation methods being applied directly in the field. These demonstrations helped farmers understand how small improvements in planting and water management can make a big difference in crop growth and yield.

By encouraging farmers to take the lead in adopting these practices, the project aims to improve food security, increase household income, and make farming more resilient to climate change while making better use of available water resources.



As part of the research taking place under Mokgehle's helm, smallholder farmers in Luphisi are trained in the correct use of an irrigation pump.



Mokgehle's work advocates for agriculture as a connected system in which water, soil, crops and people are interdependent. She works closely with all stakeholders, including community partners, students, and technical experts.

This approach reflects a broader philosophy of her work: research should not be something done **to** communities, but something developed **with** them.

Beyond collaborating with local stakeholders, a central theme running through Mokgehle's work is capacity building. WRC-funded projects have not only supported farmers but also provided opportunities for postgraduate students to train. In one project alone, she supervised three Master's students, including one recruited directly from the local community.

At the University of Mpumalanga, she teaches more than 200 students each semester, combining theoretical knowledge with practical field experience. She encourages students to engage with real-world challenges and to see science as something that connects directly to society.

By supervising postgraduate and honours students, she helps develop the next generation of agricultural scientists, equipping them with both technical skills and an understanding of community-based research.

This deliberate approach to building local expertise is part of a longer-term vision that she is consistently working towards. She says she aims to grow both a community of researchers working on underutilised crops and a network of farmers who can build sustainable enterprises around them.

Throughout, the WRC's support has run like a vein through Mokgehle's career. Her first WRC grant was valued at approximately R800 000, and she explains that it provided her with an opportunity to lead a project, manage public funds and demonstrate impact. For an early-career researcher, this was a significant step.

"I was very excited at that time," she recalls, "because these funds were not only going to add value to me as a researcher, but they were also going to be used to capacitate our smallholder farmers."

Successfully completing this project laid the foundation for future work. "It was easier for me to write the next proposal," she explains, "because the WRC had already seen that I had completed the project, shown impact, and trained students." A subsequent project, after she moved to the University of Mpumalanga, received funding of around R1 million, helping her further work towards her vision.

Today, Mokgehle continues to work with the WRC, with ongoing research projects that build on this foundation. The partnership has supported not only her research but also her broader role in community engagement and institutional development.

Over time, her work has continually evolved towards understanding agriculture as a connected system in which water, soil, crops and people are interdependent. She works closely with agronomists, soil scientists, postgraduate students, and community partners, she says, creating opportunities to share ideas and develop solutions together.

In fact, throughout the conversation about her career, Mokgehle returns to the importance of relationships. Whether working with farmers, students, funders or collaborators, her approach is grounded in trust and long-term engagement. She describes these connections as central to both the success and sustainability of her work.

To achieve that, she emphasises the importance of translating research findings into accessible formats for farmers,



The research team from the University of Mpumalanga that participated in a smallholder farmers' workshop in Salubindza, Mbombela.

communities and other stakeholders. She lists examples, including newsletters written in simple language, as well as media engagement and outreach activities.

This commitment to communication reflects her broader approach to research: knowledge should not remain within academic institutions, but should be shared in ways that are practical and meaningful.

Bridging knowledge for sustainable futures

Building a research career within a developing institution like the University of Mpumalanga, established in 2014, has required resilience and determination, Mokgehle says. But she adds that securing research funding, managing field projects, and responding to the challenges of research proposals have all helped strengthen her focus on what she wants to achieve and her determination to get there.

On that, she is very clear. Her goal is to help position underutilised crops and medicinal plants within sustainable food and health systems. In a country where water scarcity and climate variability increasingly affect farming, understanding how to use water responsibly is essential for both food security and environmental sustainability.

Her progress towards that has been steady. Through her research, teaching, and community engagement, Mokgehle continues to build bridges between science, farming communities, and sustainable development, ensuring that knowledge about medicinal plants and water management benefits both people and the environment, now and into the future.

To read more about Salmina Mokgehle's research, visit: <https://scholar.google.com/citations?user=8tm-LUoAAAAJ&hl=en>



An ongoing WRC-funded project, led by Mokgehle, focuses on supporting rural communities in Mpumalanga and, more specifically, Luphisi and Salubindza in the Mbombela Municipality. The work places farmers at the centre of decision-making – an ongoing trend in Mokgehle's work.

SEBINASI DZIKITI

A life committed to growth through agriculture

*Agrometeorologist
Dr Sebinasi Dzikiti reflects
on an award-winning career
that saw him help improve
water productivity of South
Africa's most valuable crops.*

Article by Petro Kotzé.

Growing up in Zimbabwe, then referred to as the breadbasket of southern Africa, Sebinasi Dzikiti knew one clear path would help him contribute to his country's economy: agriculture. However, as a student of physical sciences, he says he needed to enter this field through a side door.

Though he didn't know it then, his mission would lead to a celebrated career spanning across the borders of his birthplace. And after three decades, he has won international acclaim for his work to help farmers squeeze the most output from high-value commercial crops with the least amount of water – fueling economic growth for both farmers and the countries they operate in.

His road has been one of commitment, passion, and constant work, rewarded with long-term support from funders and mentors. But, in the beginning, it took a serendipitous nudge in the right direction.

Early career in Zimbabwe

Dzikiti graduated with a BSc Honours in Physics from the University of Zimbabwe in 1996. However, after his MSc in Agricultural Meteorology, also at the University of Zimbabwe, the young scientist couldn't find employment. After being hired as a research assistant, he applied for his PhD in Applied Biological Sciences. The decision was partly motivated by funding for the Agricultural Meteorology programme from a consortium of Flemish universities, including Ghent University in Belgium. This also offered the way into agriculture that he was looking for.

Dzikiti tackled the course with fervour. To develop his research topic, he recalls taking a taxi to travel to a citrus farm located almost 40 kilometres outside of Harare, "to see if I could do some work for them..." Zimbabwe, like South Africa, also faces serious water shortages, so he reckoned that a career in agricultural water management would see him play a role in the agricultural sector. At the time, he was interested in testing a new irrigation technique called partial root zone drying (PRD), which had just been developed in Australia, but had not yet been tested in citrus orchards. PRD is a form of deficit irrigation, he explains,

that entails supplying water to part of the plant's root zone while keeping the other part dry. In this way, the plant is tricked into thinking it is stressed by producing root-generated stress hormones from the dry side, which causes partial stomatal closure, thereby reducing plant water use without compromising yield, as the plant still gets sufficient water from the irrigated side.

The farmer was immediately interested and introduced the budding researcher to Citrus Research International (CRI), which supervised, evaluated, and co-funded the study. This set the wheels in motion for Dzikiti's collaboration with CRI staff in the Department of Horticultural Science at Stellenbosch University (SU), while he was registered for his PhD in the Laboratory of Plant Ecology at Ghent University in Belgium.

Continuing the work in South Africa

After completing his PhD in September 2007, Dzikiti moved to the Department of Horticultural Science for a postdoctoral research position in June 2008. The position, which was a collaboration between SU and another Belgian University (Katholieke Universiteit, Leuven), focused on developing advanced plant-water relations monitoring techniques that integrate in situ and hyperspectral remote sensing technologies. In 2010, he moved to the Council for Scientific and Industrial Research (CSIR) as a senior researcher in the Hydro Sciences Research Group, under the mentorship of prominent South African scientist and hydrology expert, Dr Mark Gush, now with the Royal Horticultural Society in the UK.

There, he stepped into research aligned with his original motivation for switching to agriculture, working in areas that contribute to the country's economy.

As in many water-scarce countries, there is increasing competition among sectors of the South African economy for water resources. Irrigated agriculture, in particular, is under pressure to use water efficiently, as the sector is estimated to account for approximately 60% of available surface water. The fruit tree industry is highly dependent on irrigation (about 90%) and must improve water-use efficiency as water stress increases, without compromising fruit quality, size, yield and profits.

Over the years, the WRC, in collaboration with fruit industry

partners, has funded several research projects towards this goal. One Dzikiti stepped into: *The water use of selected fruit tree orchards*, a project led by Gush, introduced him to another career-defining partnership, this time with the WRC.

The start of a journey with the WRC

The project also introduced him to "the WRC way" of doing research. This entails, he explains, a practical approach to research, spending multiple days in the field collecting data – an approach he still practices. It also leans on reference group meetings, cementing his habit of working on projects that bring together sector experts, researchers, and stakeholders to guide, monitor, and evaluate ongoing work.

Already familiar with many quantitative techniques, including water use modelling, Gush now introduced Dzikiti to key ecophysiological and micrometeorological equipment, allowing him to move from estimating water use to actually measuring it.

These include the eddy covariance and surface renewal systems that permit measurement of evapotranspiration at the level of a whole orchard block, and the heat ratio sap flow methods for monitoring tree water use, which work at the level of the individual tree. Dzikiti could now validate and calibrate his models against real measurements rather than literature values and generate the site-specific water use figures that irrigation scheduling, water allocation and licensing decisions require.

For the first WRC project he led (from 2012 to 2014), Dzikiti used it to understand the actual water cost of the alien invasive species *Prosopis*, or mesquite. The tree was brought to the Northern Cape in the 1890s for wood, shade and fodder but, with taproots intruding as much as 70 metres down, it now chokes the region's riparian zones in dense thickets.

The study investigated how *Prosopis* invasions compete with indigenous deep-rooted tree species like the sweet thorn (*Vachelia karoo*), and quantified potential groundwater savings that could be obtained by clearing the invasions. Working in a heavily invaded catchment near Nieuwoudtville, a town that depends entirely on groundwater, the team compared *Prosopis* water use with that of the indigenous sweet thorn.

The difference was stark. Invaded stands transpired around

All photographs supplied



Dr Sebinasi Dzikiti is a senior lecturer in the Horticultural Department of Stellenbosch University.



Dr Sebinasi Dzikiti with former colleague and mentor, Dr Mark Gush, now with the Royal Horticultural Society in the UK.

544 mm a year, against just 91 mm for the native trees. The study also showed that *Prosopis* lifts deep water into shallow soil, suppressing local plants and helping itself spread.

Dzikiti and colleagues recommended clearing sparse stands early, before they thicken into impenetrable, high-consumption thickets. Where invasions were removed, the water table's decline slowed, opening the way for the land to recover.

Back to the orchard

The next WRC project that Dzikiti led (co-funded with Hortgro Science) took him back to the orchards. Running from 2014 to 2018, the project set out to answer how, and if, a water-scarce country could afford its most productive apple orchards. At the time, some farmers were already pulling 120 to 140 tons of apples per hectare, well above the 80 to 90 tons that have long marked a profitable orchard. More fruit, however, meant more water. "Yes, we want high yields," Dzikiti notes, "but what if we didn't have the water for it the following year?" Dzikiti and his collaborators wanted to know where the limit lay.

Leading a team drawn from the CSIR, the Agricultural Research Council, and the universities of Pretoria and Stellenbosch, Dzikiti compared two cultivars: Golden Delicious and Cripps Pink, the latter sold as Pink Lady when it colours well. What surprised him was that crop load mattered far less than canopy size. It is the leaves, not the fruit, that drink the water.

Golden Delicious carries a dense canopy to shield its green fruit from sunburn, and used about a fifth more water than the open-canopied Pink Lady. Pink Lady, kept open so sunlight can trigger its pink pigments, used less water and earned close to double the income per cubic metre of water consumed. It was, on every measure that counted, the more sensible tree to grow.

His third project grew out of the first two. The volume of high-quality data from actual orchard water-use measurements was growing, and Gush wanted to consolidate it and add value. In essence, the idea was to develop a simple yet scientifically credible tool that runs on platforms easily accessible to farmers to help them plan irrigation in real time. They wanted to build a smartphone app to forecast how much water an orchard would need over the coming week. But when Gush left for the UK before the work began, the lead passed to Dzikiti.

The app pulls a weather forecast for the farmer's location and, with simple inputs from the farmer, calculates accurate crop coefficients (a forecast of a tree's actual water needs). "From the palm of your hand, if you click a few buttons," Dzikiti says, "you get a projection of how much water you are going to need between one and two weeks ahead."

Due to its success, the WRC has since funded a follow-up to extend the app to pears, nectarines, peaches, plums and cherries.

Award-winning work

But it was Dzikiti's next project that would become a global landmark. Initiated and funded by the Inkomati-Usuthu Water Management Area (IUWMA) and the WRC, it ran from October 2020 to March 2024. The IUWMA is a major producer of subtropical fruit such as mango, litchi, banana, avocado, macadamia and citrus. With water resources in the catchment almost fully allocated, little to no water is left for new developments. Yet some established growers hold far more water than they use.

"Because of historical imbalances, some farmers have more water than others," Dzikiti says, "so it's very difficult for new players to come on board who also need water." As such, allocation reform and the redistribution of that water, a promise written into the 1998 Water Act, could not take place. For these reforms to happen, the catchment required tools to ensure accurate and equitable redistribution of water. The aim of the resulting study was to develop a tool to estimate water requirements of key irrigated crops in any part of the IUWMA catchment.

The resulting Decision Support System (DSS) for monitoring orchard water use was developed using 50 years of daily climate data (1960 – 2010) in each of the more than 250 quaternary catchments in the IUWMA, together with scientifically validated crop coefficients. A grower clicks their spot on the map, loads their farm boundary, and enters a few plain facts about the orchard. Using the same crop-coefficient method as in earlier work, a reliable estimate of trees' water needs, yield, and efficiency is obtained.

A pioneering piece of work, the DSS won the international Watsave Innovative Water Management Award from the International Commission on Irrigation and Drainage (ICID) in 2025, which Dzikiti describes as a major honour, particularly because it validates the scientific depth of the work and its practical value. And he points out that, though it is a uniquely Inkomati product, it can travel if researchers elsewhere adapt it to their own environment.

The measure of success

The recognition that means most to him, though, is not for a tool. Asked about his most important achievements, Dzikiti immediately reaches for a glass, drop-shaped trophy on his desk. It is a WRC Knowledge Tree Award, bestowed on him in 2021 for his work to build people rather than products, in Dzikiti's case with researchers at universities short of resources, among them the University of the Western Cape, Zululand, and Venda.

"Quite a number of students and staff have benefited from our interactions," he says with clear pride. "It shows I've made a contribution in terms of capacity building here in this country."

The work continues

His most recent WRC project, co-funded by Hortgro, saw the team turn to pears. Investigating the green Packham's Triumph and the blushed Forelle, the team examined how a growing region's climate shapes an orchard's water use and yields. They built a model that splits an orchard's water loss between the trees and the ground, then ran it forward under hotter, drier conditions in the Western Cape. Earlier studies had warned that

orchard water use might climb by as much as 18% by mid-century. His model puts the rise far lower, around 6 or 7%, and only by the end of the century.

The difference comes down to the trees themselves. As the air grows thirstier, they close their pores and hold on to water, a reflex the older forecasts had left out. What drives most of the extra demand is not the trees at all but bare, evaporating soil, exactly the loss a grower can cut with mulch, drip lines and narrower sprinklers.

That a study finished in 2026 could still be sharpening answers first asked of apples a decade earlier owes much to one funder. The WRC, Dzikiti says, gave him something rare in research: the room to follow a thread across many projects rather than dropping it when a contract ended.

"We have been able," he says, "to follow up on ideas that would have otherwise been left hanging out there." Instead, each project grew out of the one before it, staying close to on-the-ground needs from the industry partners and farmers who ultimately use the results.

"It's only through consistency that you achieve significant milestones in life," he says. For him, the real measure of success will be impact. By the time he retires, he says, he hopes to leave behind tools "with my name stamped on it" that farmers and water managers routinely rely on to make better decisions in a waterscarce world. Inspired by the South African stalwarts who developed models like SAPWAT (South African Plant Water) and SWB (Soil Water Balance model) that have become industry standards, Dzikiti's ambition is quietly resolute: to keep doing the science, building the tools, and working with the right people, consistently, until his own contributions are as firmly rooted in the country's orchards and catchments as the trees he has spent his career helping to sustain.

To read more about Sebinasi Dzikiti's research, visit: <https://scholar.google.com/citations?user=Z1B6eV4AAAAJ&hl=en>



In 2025, Dzikiti won the international Watsave Innovative Water Management Award from the International Commission on Irrigation and Drainage (ICID). Handing over the award is ICID President, Dr Marco Arcieri.

BETSIE LE ROUX

Turning problems into possibilities: Putting people at the heart of environmental sustainability

Dr Betsie le Roux's way of scientific enquiry is unusual. Rather than looking for the norm, she looks for the anomaly. The case everyone else writes off as an outlier is, to her, the one worth studying. An ecologist by training, she approaches environmental questions from the standpoint of the people who live inside them.

Article by Petro Kotzé.

"Within ecology, people are always part of the picture; it's always intertwined," notes Le Roux. "If you improve a poor person's quality of life, that's usually also more ecologically sustainable. One can develop solutions that not only improve the quality of life for households living in poverty, but also enhance environmental quality and help resolve ecological problems."

Her fieldwork of late has centred on a case in point: South Africa's Agri-Parks programme, launched in 2015 to revitalise rural economies through integrated farming hubs. The programme targets the country's most deprived rural and peri-urban areas, aiming to uplift emerging farmers, produce food and redress inequality.

One of Le Roux's Water Research Commission (WRC) funded studies of the programme, where she led a small team, produced a finding typical of her work: the Agri-Parks' widely reported failures did not call for more funding, land or training. They called for something more fundamental. Almost every stakeholder's vision for the programme, she found, was misaligned with the farmers' lived reality. "We are setting them up for failure," she told *The Water Wheel*. Rather than propose another novel fix, her recommended a change in how the existing ones were applied.

That habit of asking a different question rather than reaching for a familiar answer runs through the whole of Le Roux's career.

Early life and a way into water

Le Roux grew up in a missionary family, her father and grandfather both missionaries, in a small community outside Polokwane (formerly Pietersburg). She describes her childhood as steeped in environmental consciousness, the creation, the Earth, how one lives within it, and what one does about the problems one sees. "From [the time] I was small, I was convinced this is what my life's work would be."

She trained first in general biological sciences and then in plant

ecology, earning an MSc in Botany in 2007 before joining the engineering consultancy BKS (Pty) Ltd as an environmental scientist in 2008. The role exposed her to water quantity and quality management, wetland delineation and wastewater treatment, but it was the water quality work that held her attention.

Other parts of the job did not sit as well. She found environmental impact assessments an ineffective tool for protecting rare or fragile environments, and the remote fieldwork, often conducted with limited security, felt increasingly unsafe as she thought ahead to starting a family. She also felt her achievements were not meaningful enough.

Her hopes for a next step that would take her toward water arrived as an opportunity to pursue a WRC-funded PhD in Agronomy at the University of Pretoria, focused on the water footprints of vegetable crops. By then, the mother of a four-month-old daughter, she remembers the decision feeling frightening. "But it was everything I wanted," she says, and so she pushed through.

She completed her PhD in 2017, developing a simplified framework to estimate the volume of water used for agriculture in a catchment, using crop water footprints and production data. Her PhD now behind her, Le Roux's supervisor suggested they apply for a further WRC project, this one on the government's Agri-parks initiative.

Finding her way into Agri-parks

Le Roux explains that part of the motivation for applying was that the topic was new, so the team could compete on an equal footing with other applicants. They won, and she became project leader for a team of agricultural specialists. It would become one of the more demanding, and more rewarding, chapters of her career.

The brief was to assess the Agri-park's water balance. The prevailing assumption was that these were large, farmer-run agricultural zones that drew heavily on local water, but this was not what they found. It turned out to be five farmers on three hectares, entirely government-run, she says.

The farmers shared a single borehole pump on a rotating schedule, and each ran it almost non-stop on their turn, because once you had access, you used it for as long as you could. "As I got into it, I realised this wasn't just an agricultural problem; it was a deep social problem," notes Le Roux. "So the kind of solution people usually propose, namely 'let's use water more efficiently', is actually pointless."

Le Roux also realised they weren't the right team for this kind of problem, which she describes as socially complex, beyond the grasp of agricultural technological solutions. She turned to her father, Dr Attie van Niekerk, whose own path had taken him from missionary and theology work into development work focused on poverty alleviation. In 1994, he founded the Nova Institute, a non-governmental organisation (NGO) focused on improving quality of life for poor households. With his input, the project produced results strong enough for the WRC to commission a follow-up study.

The real outcome, she believes, was arriving at a better research question altogether: how does water-use efficiency relate to the market, and to the whole ecosystem and web of relationships between government and the farmers that the Agricultural Hub was meant to serve. "There are so many issues bound up in this that you'd really need a much deeper study," she says.

This one identified a pattern among successful smallholder farmers and led to the Sukuma Transformation Tool, which determines the level at which a farmer is operating, assesses how efficiently they work, and identifies what needs to change before they can proceed to the next level. Le Roux now also works part-time for Nova. What drew her to the NGO, she says, is its focus on implementing ideas that more traditional research projects can only formulate.

A father's wisdom, shared

Much of how Le Roux works traces back to something her father told her early on. "The problem doesn't lie with the people," he said. "It lies in the fact that you're coming from a completely different context. The solution you give them might work fine in your own context, but not in theirs."



Dr Betsie le Roux, photographed here with WRC research manager, Dr Samkelisiwe Hlophe-Ginindza, is a self-employed specialist researcher, with over 15 years of experience in agronomy, botany, water management and project management.



A farmer shows off her crops at Lefatlheng, Hammanskraal. Le Roux believes that working with communities towards solutions, rather than imposing solutions on them, is the secret to successful communities.

The world people actually inhabit sits beyond the reach of purely rational thought, explains Le Roux. People can tell you that something works without being able to say why. They are not always consciously aware of everything an outsider would need to understand to design a solution properly. "So the only way to actually develop something workable is to do it together with them," she says.

That means treating the community as part of the team, something she describes as particularly hard because of a delicate power balance. When you are seen as the expert, you are also expected to know the answer, and often you yourself think that you do. The answer, she believes, lies in talking less. "The first step is not to come in with a fixed idea, but rather to ask and to listen, and try to understand." Whenever someone on her team talked too much, she found the power balance snapping straight back to "everything must come from us."

"I think part of why we get it right is that we work across so many different projects that we're never really the specialists in any one of them. We come in fresh each time, ask questions, try to understand the real problem, and by the end of the conversation, [stakeholders] start to understand the problem themselves, or begin looking for solutions on their own." It is an approach, she admits, which is hard to teach.

A toilet nobody wanted

Career highlights for Le Roux are not papers or policy wins, rather it's when a community wins. To illustrate she recalls a project that involved a specific toilet, despised by the community in which it was installed by the municipality. "The women there said that after using the toilet you'd have to go and change your clothes, otherwise you'd carry the smell with you."

Her team spent months working on-site to solve the problem alongside the community. After many discussions, they decided on a simple urine-diversion trap that directs the liquid into a bottle and lets the solids drop into a small basket lined with

grass. The system produces compost and a comfrey-based liquid fertiliser for vegetable beds. "It's now a really good toilet," Dr Le Roux says. "I use it myself whenever I'm there."

The proof is in how people rated it. The first time Le Roux's team asked, a mother scored her household's toilet a one out of ten. Her daughter gave it zero. Asked again roughly two years later, mother and daughter both said ten.

Nearby, a farmer named Sammy has become one of the project's biggest advocates for the use of treated urine as fertiliser. Once needing to commute to town for a job in a shop, Sammy has expanded his farming operations to around 500 square metres to earn roughly what he used to earn in town. His enthusiasm for the 'new' fertiliser is clear. "Yes, welcome, just bring urine!" he told Le Roux's team enthusiastically when they last enquired if they could visit. Their work in the area now includes continued investigation into the effectiveness of different fertilisers and the safety of urine fertiliser should commercial distribution of the crops be considered.

Le Roux also mentions successfully trial-running the idea to discuss problems in working groups selected by the farmers themselves. It created space for all roleplayers to connect and network, leading to long-term working relationships.

Results like these did not come from arriving with a plan. In focus groups, Le Roux's team never opens with an agenda, but rather names the subject, for example, sanitation or agriculture. Then they sit, listen and take notes. Two hours can pass on agricultural problems for every ten minutes spent on sanitation, which tells her which problem the community is actually trying to solve.

Learning to sit with complexity

That toilet is also small proof of a theory Le Roux started reading about around 2019 and 2020. Complex-systems theory gave her a language for something she already sensed in the field – that a social system is complex, and fixing its separate pieces in isolation rarely helps. "Sanitation isn't something you can fix

on its own," she explains. "You have to look at the whole picture. Everything is integrated."

That belief also shapes how her team avoids being directive. Rather than arriving with a single solution, they offer three or four options. Given a choice, people weigh up what will actually work for them, and often talk themselves into a version suited to their own circumstances. "Once communities start getting it right themselves, they're invested, and they begin working with you properly, incorporating their own ideas," Le Roux notes.

It also means paying close attention to whoever succeeds, rather than averaging across those who do not. Sammy is exactly that kind of case. "Whereas conventional science always looks at the average, we're always looking at the outliers, where cases actually worked. A conventional scientist would say if everyone failed, that one success was just an anomaly, but for us, that's exactly the outcome that matters." Her team studies what that farmer did differently, then tries to replicate it with everyone else.

It is a slow method, and she credits the WRC with being willing to fund it. "You're working for three years with just five to ten households, and the numbers are so small that most funders don't see the value in it," she says. "That's the one thing we've appreciated most: that they're genuinely on board with it."

What success looks like

Le Roux intends to keep doing what she is doing, moving between agriculture, sanitation and water management as new ideas arise, adding whatever she can to the work. "Success, for me would be contributing as much as I possibly can toward better outcomes for households. "For me it's about how much I can do for households living in poverty and for the environment."

It is a view shaped by the foundation laid in her early career. Ecology taught her that people are never separate from the environments researchers study. In her experience, if you improve a poor household's quality of life, you usually improve that household's ecological footprint too, especially if you understand that, from the beginning, the poor quality of life of a specific community and the ecological problems they experience are all part of a larger, complex, socio-ecological system.

"The more I can do in that direction, the happier and more successful I'll feel," she says. "If, by the end of my career, I've managed to scale up one or two really good ideas that have had real impact, I'll be happy. That would be success for me."



To read more about Dr Betsie Le Roux's research visit: <https://orcid.org/0000-0002-2079-5539>

The five tiers of the Sukuma Transformation Tool



The five tiers of the Sukuma Transformation Tool. The tool is an agricultural evaluation framework designed to support the empowerment and commercial scaling of smallholder vegetable farmers. Instead of attempting to immediately push small-scale farmers directly into large-scale commercial farming – a primary reason many agricultural initiatives fail – the tool focuses on gradual, structured growth

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

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

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

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