ISSUE 4

CURIOS.TY

Research . Rethink . Relearn

WATERSHED

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ABOUT *CURIOSITY*

Curiosity is a print and digital magazine that aims to make the research at Wits University accessible to multiple publics. It tells the stories of pioneering research at Wits through the voices of talented researchers, students and academics. First published in April 2017, *Curiosity* is published three times per year. Each issue is thematic and explores research across faculties and disciplines at the University that relate to that theme. This issue is themed WATERSHED and highlights water-related research at Wits that spans engineering, the liberal arts, the earth and social sciences, and healthcare.

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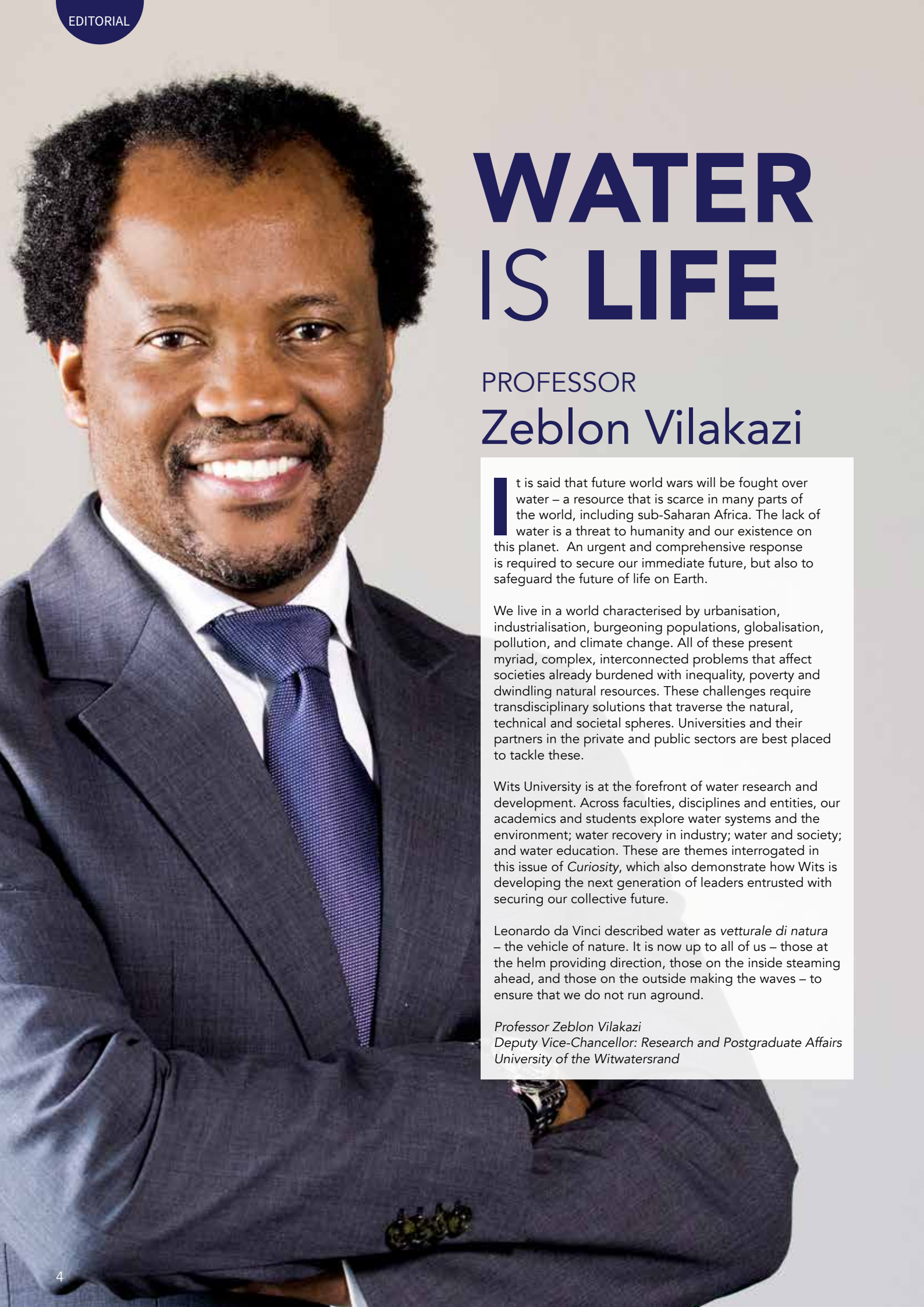

WATER IS LIFE

PROFESSOR Zeblon Vilakazi

It is said that future world wars will be fought over water – a resource that is scarce in many parts of the world, including sub-Saharan Africa. The lack of water is a threat to humanity and our existence on this planet. An urgent and comprehensive response is required to secure our immediate future, but also to safeguard the future of life on Earth.

We live in a world characterised by urbanisation, industrialisation, burgeoning populations, globalisation, pollution, and climate change. All of these present myriad, complex, interconnected problems that affect societies already burdened with inequality, poverty and dwindling natural resources. These challenges require transdisciplinary solutions that traverse the natural, technical and societal spheres. Universities and their partners in the private and public sectors are best placed to tackle these.

Wits University is at the forefront of water research and development. Across faculties, disciplines and entities, our academics and students explore water systems and the environment; water recovery in industry; water and society; and water education. These are themes interrogated in this issue of *Curiosity*, which also demonstrate how Wits is developing the next generation of leaders entrusted with securing our collective future.

Leonardo da Vinci described water as *vetturale di natura* – the vehicle of nature. It is now up to all of us – those at the helm providing direction, those on the inside steaming ahead, and those on the outside making the waves – to ensure that we do not run aground.

Professor Zeblon Vilakazi
Deputy Vice-Chancellor: Research and Postgraduate Affairs
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FEATURED

RESEARCHERS

A number of Wits experts are featured in this edition of *Curiosity*. View the profiles of all the researchers and contributors at: **www.wits.ac.za/curiosity**

1 LUMBWE CHOLA

Dr Lumbwe Chola is a Senior Health Economist and Researcher at PRICELESS SA in the School of Public Health. He holds a BA in Economics from the University of Zambia, an MPhil in Health Systems Research and a PhD in Health Economics from the University of Bergen, Norway. His research interest is priority setting to improve maternal, newborn and child health. He has also researched obesity economics and non-communicable diseases. He published in several peer-reviewed journals.

2 LENORE MANDERSON

Lenore Manderson is a Distinguished Professor of Public Health and Medical Anthropology at Wits and Visiting Distinguished Professor at the Institute at Brown for Environment and Society, Brown University, USA. An NRF A-rated scientist, Manderson's research concerns anthropology, social history and public health. She is a specialist in inequality, social exclusion and marginality, the social determinants of infectious and chronic disease, gender and sexuality, immigration, ethnicity and inequality in Australia, South Africa, Ghana, the Solomon Islands, Southeast and East Asia.

3 GILLIAN MAREE

Gillian Maree is a Senior Researcher at the Gauteng City-Region Observatory. She is an urban planner specialising in sustainability, environmental management and spatial planning, and water and biodiversity specifically. Her research interests are the intersection and interdisciplinarity between science, society, and spatial planning within urban environments.

4 BUSISIWE MASHIANE

Busisiwe Mashiane is a fourth-year student in the School of Chemical and Metallurgical Engineering at Wits. Her research interest in slow sand water filtration systems for domestic use stems from growing up in a disadvantaged water-insecure community in Mpumalanga. Mashiane has since 2014 tutored mathematics in Alexandra through ASSIST where she is now Executive Director. Read her blog at https://learningtobedot.wordpress.com/.

5 KHULISO MASINDI

Khuliso Masindi is a PhD candidate and an Associate Lecturer in the School of Geosciences. His research focuses on modelling water resource responses to natural and anthropogenic activities in the Vaal River Basin. His research interests include numerical groundwater flow modelling, remote sensing applications in water resource management, and the impacts of climate variability on groundwater resources. He has co-published papers on different aspects of groundwater in peer-reviewed journals.

6 MUCHA MUSEMWA

Professor Mucha Musemwa is the Head of the School of Social Sciences at Wits University. He is an environmental historian whose research focuses on the history and politics of water and droughts, and contestation over resources in colonial and post-colonial Zimbabwe. He obtained his PhD from the University of Minnesota-Twin Cities, USA. He is a board member of the International Consortium of Environmental History Organisations and a member of the American Society for Environment History and the International Water History Association.

7 CRAIG SHERIDAN

Craig Sheridan is Associate Professor and Lecturer in the School of Chemical and Metallurgical Engineering, Director of the Centre in Water Research and Development (CiWARD), and co-founder of the Industrial and Mining Water Research Unit (IMWaRU) at Wits. His research interest is in the processing and treatment of agricultural, industrial and mine effluent streams. His research aims to mitigate the impact of people on water resources and contribute towards a sustainable future.

8 COLEEN VOGEL

Coleen Vogel is a Distinguished Professor in the Global Change Institute and previously the BMW Chair of Sustainability at Wits. An NRF A-rated scientist, Vogel co-authored the Africa Chapter of the Intergovernmental Panel on Climate Assessment's Report and the Summary for Policy Makers of the 4th Intergovernmental Panel on Climate Change Report. Her research interests include transformative education for global environment change and sustainability, climate change broadly, and adaptation and disaster risk reduction through the interaction of physical and social dimensions shaping change.

ADDITIONAL CONTRIBUTORS

- **David Andrew**, Associate Professor and Head of the Division of Visual Arts
- **David Block**, Professor in the School of Computer Science and Applied Mathematics
- **Isabel Hofmeyr**, Professor of African Literature leads Oceanic Humanities in the Wits Institute for Social and Economic Research (WiSER)
- **Dyani Jeram**, Master's candidate in the Global Change Institute
- **Mike Muller**, Visiting Adjunct Professor in the Wits School of Governance
- **Vishwas Satgar**, Associate Professor in the Department of International Relations, School of Social Sciences
- **Clive Vinti**, PhD candidate in Environmental Law at the Mandela Institute

OUR PALE BLUE DOT

BY RESHMA LAKHA-SINGH

Molecular hydrogen is the most abundant molecule in the matter between stars in Space, and water helps to cool collapsing clouds and dust during the formation of stars. But is there any way to use this water to save ourselves?

Do we look to the stars to save life as we know it? Will Captain Kirk or the Defenders of the Galaxy beam us up to another planet that is flowing with water? Astronomer, Professor David Block from the Wits School of Computer Science and Applied Mathematics explains why saving the planet by casting our eyes up into the sky is not that simple.

HAVE SCIENTISTS DISCOVERED WATER ON OTHER PLANETS?

The short answer is, yes! But the full answer is not that simple. While we have discovered water on Mars, the question is whether we will ever be able to have access to it. Mars as a destination is difficult for humans to reach and even more difficult to live on. Mars has polar ice caps made of frozen carbon dioxide (dry ice), and despite us having a similar climate to Mars, it is a very hostile environment with dust storms sometimes covering the entire planet. The temperatures dive well into the negatives at night and in winter. Earth's average temperature is 14°C, whilst Mars' is -63°C.

IS THERE ANY WATER ON THE MOON?

Yes, in March 2010, India's lunar probe, *Chandrayaan-1*, discovered more than 40 permanently darkened craters near the moon's north pole that contain about 600 million metric tonnes of water-ice. A metric tonne of water corresponds with water filling a container where each side spans approximately one kilometre. A small bay or lake in South Africa which is 50 metres deep and 3.5 kilometres square would contain that approximate volume of water. It is believed that water-bearing comets, asteroids and meteoroids delivered this to the moon by crashing into it.

HAVE WE SEARCHED ANY OTHER PLANETARY SYSTEMS FOR WATER?

Scientists have discovered exoplanets, which are planets that are outside our planetary system, orbiting other stars. As at February 2018, there are 3 728 confirmed planets in 2 794 systems with 622 systems having more than one planet. This discovery has encouraged the research for extra-terrestrial life with a special interest in planets that orbit a star which is in a habitable zone, where it is possible for liquid water to exist on the

The seven Earth-size planets of TRAPPIST-1, an exoplanet system about 40 light-years away, based on data current as at February 2018. The image shows the planets' relative sizes but does not represent their orbits to scale. The art highlights possibilities for how the surfaces of these intriguing worlds might look based on their newly-calculated properties. *Picture: NASA/JPL*

surface if the atmospheric pressure is like ours.

The exciting news is that astronomers have discovered seven planets, three of which are Earth-sized, orbiting *TRAPPIST-1*, a red dwarf star located just under 40 light years away from the Sun. These three exoplanets orbit within a habitable zone from the dwarf star, making it possible for life to thrive.

NASA has indicated that a closer study of the seven planets suggests that some could have far more water than the oceans of Earth, in the form of atmospheric water vapour for the planets closest to their star, liquid water for others, and ice for those farthest away. This makes *TRAPPIST-1* the most thoroughly known planetary system apart from our own.

CAN WE SOURCE THIS WATER TO SAVE EARTH?

Wearing my futurist hat, yes we can use these planets as a source of water. However, we won't see this in our life-time. Earth is the only planet in our planetary system with easily-reachable water. Hence, let us protect what we have and begin our journey to save our planet. Carl Sagan called Earth the "Pale Blue Dot". We have just the right atmospheric and chemical compositions, water and temperature on the planet for life to be possible. We need to protect what we have. ⊡

David Block is a Professor in the Wits School of Computer Science and Applied Mathematics. At 19, he became a Fellow of the Royal Astronomical Society of London. At 20, the Royal Astronomical Society published his paper on relativistic astrophysics. Block has been a visiting researcher at the Australian National University, the European Southern Observatory, the California Institute of Technology, and Harvard University. The NSTF-BHP Billiton Award acknowledged him as a leading science communicator in SA. He is the only scientist in Africa whose work has twice featured on the cover of *Nature*.

SAND SWEEPS WATER CLEAN AT HOME

Wits scientists are developing technology to purify water with sand and are exploring how the natural environment functions in rural communities in southern Africa.

BY ERNA VAN WYK

The slow sand filter method has been used for centuries to treat water. It's so effective that the World Health Organization has given it its stamp of approval: "Under suitable circumstances, slow sand filtration may be not only the cheapest and simplest but also the most efficient method of water treatment."

However, this method has mostly been used on a large scale and isn't suitable for the thousands of South African households who battle daily to have clean drinking water in their homes.

Busisiwe Mashiane, a fourth year chemical engineering student in the School of Chemical and Metallurgical Engineering at Wits, is researching and developing a slow sand filter to meet the needs of South Africans.

"Many South Africans living in disadvantaged communities across the country not only have difficulties accessing water but also face many health risks due to the lack of access to clean drinking water," explains Mashiane.

"Our aim is to develop a low-cost but highly efficient water treatment system that can treat river water effectively and make it consumable. We want to ensure that, because people in these communities cannot afford elaborate water treatment methods, our system can assist in their basic human right of having access to clean potable water."

HOW IT WORKS

A continuous water flow from a 25 litre tank feeds into a reactor

Pictures by Lauren Mulligan

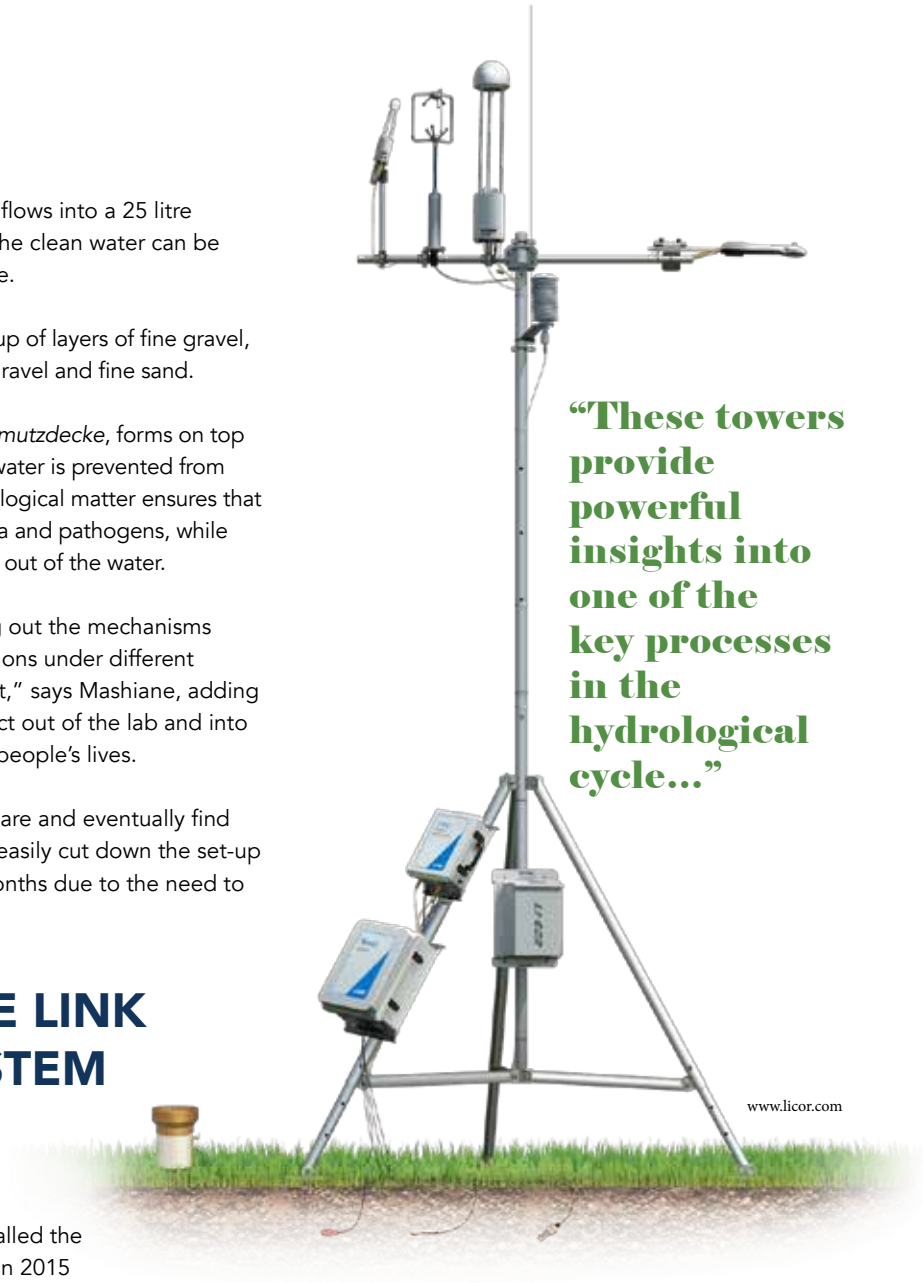
tank (the sand bed). From here the water flows into a 25 litre transparent sterlisation tank, after which the clean water can be dispensed into a storage container for use.

The sand bed in the reactor tank is made up of layers of fine gravel, then activated carbon, and finally coarse gravel and fine sand.

A layer of biological matter, called the *schmutzdecke*, forms on top of the sand and the *schmutzdecke* in the water is prevented from flowing through the sand. This layer of biological matter ensures that the filtered water is free of harmful bacteria and pathogens, while the sand bed strips the physical impurities out of the water.

"Our research project is aimed at figuring out the mechanisms of the slow sand filter, to see how it functions under different conditions, and to find ways to optimise it," says Mashiane, adding that the plan in future is to take the project out of the lab and into homes where it can make a difference in people's lives.

"We want to discover what its limitations are and eventually find the best way to replicate the design and easily cut down the set-up time – currently between three to four months due to the need to wait for the biological layer to form." ⓒ



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"These towers provide powerful insights into one of the key processes in the hydrological cycle..."

RESEARCHING THE LINK BETWEEN ECOSYSTEM AND CLIMATE

A high-tech scientific research installation, called the Eddy Covariance Flux Tower was erected in 2015 in Agincourt, Mpumalanga, which is home to the Medical Research Council/Wits Rural Public Health and Health Transitions Research Unit.

"The Eddy Flux Tower is a piece of equipment which measures the exchange of energy and gases between the land surface and the atmosphere, and does so at landscape scale – over a footprint of about a kilometre. The towers were set up to measure carbon dioxide exchange, but also measure water exchange," says Professor Bob Scholes, world-renowned scientist in systems ecology (regarding African savannahs) in the School of Animal, Plant and Environmental Sciences at Wits.

The Agincourt tower is part of a network of towers in the Skukuza and Malopeni villages in the Lowveld. It was erected by a research consortium that includes Wits University, the Council for Scientific and Industrial Research (CSIR), and various South African and German universities.

The project investigates the coupled carbon and water cycles of natural and disturbed savannah ecosystems in southern Africa. It aims to deepen the knowledge on how the natural environment functions in rural communities in southern Africa. This knowledge is crucial for understanding the link between ecosystems and climate, and how changes in land use may impact the climate in the future.

"These towers provide powerful insights into one of the key processes in the hydrological cycle, which control the amount of water entering aquifers [an underground layer of water-bearing permeable rock] and rivers for human use, and how it might change with a changing climate," says Scholes.

The flux tower houses a range of sophisticated equipment used to measure how much carbon dioxide, water vapour, and energy move between the land surface and the atmosphere. Other measurements, including climate parameters (temperature, humidity, rainfall, atmospheric pressure), are made to get more information about processes of the savannah ecosystem.

"The research would help us understand changes in greenhouse gas concentrations and how they influence agricultural and ecosystem productivity," says Scholes.

The Skukuza tower, erected in 2000, was the first in Africa and today there are about eight scattered around the country. Another six towers will be erected through the Department of Science and Technology's South African Research Infrastructure Roadmap (SARIR), the first project of its kind in South Africa. SARIR is a strategic intervention to provide research infrastructure across the entire public research system that builds on existing capabilities and considers future needs. ⓒ

FROM 'CRISIS' TO OPPORTUNITY:

Picture: Lauren Mulligan

LESSONS FROM CAPE TOWN'S WATER SHORTAGE

South Africa has always been a country with problems of water scarcity. The ominous Day Zero narrative in Cape Town has brought water security into our daily lives and has made us pay closer attention to issues of water demand and availability. Additional challenges, including pollution, poor management and infrastructure maintenance, wastage and excessive consumption, burden our resources. ***Schalk Mouton*** *explores how we can learn from the current crisis and turn South Africa into a water-secure country for all its citizens.*

We've heard it so many times before. Every time a government official speaks about water issues in South Africa, they mention that South Africa is a "water-scarce" country. However, until the current water 'crisis' fully developed in Cape Town, and the ominous-sounding phrase 'Day Zero' became a daily headline in newspapers, few were actively mobilised around water as a valuable resource.

Water has always been cheap and, for the middle-class South African at least, there has always been a constant, reliable supply of water. But will such a situation continue without careful risk management and planning?

The current water situation in Cape Town can teach us a number of lessons that could assist us in working towards a more water secure Gauteng – and the country as a whole.

"What is going on in Cape Town, scientists argue, is the 'new normal' with climate variability and climate change," says Professor Coleen Vogel, Distinguished Professor in Climate change, Vulnerability and Adaptability at the Global Change Institute. "Although we cannot say with certainty when droughts will occur, projected outlooks are that we could experience more frequent events, such as drought occurring with greater magnitude."

South Africa is a dry country. It has an annual surface water runoff (from rain) of 49 billion cubic metres. With an annual rainfall average of 490mm, South Africa has just over half the annual rainfall of the global average of 814mm. Of the water that we do have, 98% is already allocated for use, which means we have only 2% left over as a useable resource.

Various provinces, including Limpopo and the North West Province, have struggled with serious droughts in the past 10 years, and the Eastern Cape and parts of KwaZulu-Natal are suffering from water shortages. Gauteng was saved from a serious drought in 2016 (some would argue not necessarily by careful water planning) when good rains fell.

South Africa is also struggling to manage water effectively. According to the Department of Water and Sanitation's (DWS) National Water and Sanitation Master Plan, "A call to action", the country "is facing a water crisis driven by a massive backlog in water infrastructure maintenance and investment, recurrent droughts driven by climatic variation, glaring inequalities in access to water and deteriorating water quality".

"This crisis is already having significant impact on economic growth and on the well-being on everyone in South Africa, which will be exacerbated if it is not addressed," the DWS says.

The DWS Master Plan estimates that:

- by 2030 we will have a water deficit of 5%, yet 35% of our municipal water is lost through leakage.
- 41% of our municipal water does not generate revenue, which, at a unit cost of R6/m^3, amounts to R9.9 billion each year.
- 5.3 million households do not have access to safe household drinking water, while 14.1 million people do not have access to reliable sanitation.
- 56% of the country's 1 150 municipal waste water treatment works and 44% of the 962 water treatment works in the country are in a poor or critical condition and in need of urgent rehabilitation, while 11% of this critical infrastructure is dysfunctional.

The country's rivers are not faring any better. Between 1999 and 2011, the extent of SA's rivers classified as having a poor ecological condition increased by 500% with many rivers pushed beyond the point of recovery.

To achieve water security, the DWS says, an estimated "capital funding gap of around R33 billion per year is needed for the next 10 years".

In order to find sustainable solutions to South Africa's water problems, all role-players in the water sector should start to work together, says Professor Craig Sheridan of the School of Chemical and Metallurgical Engineering and Director of the Centre in Water Research and Development at Wits.

"We need a 'democracy of discipline-values', where policy, economics, engineering, science, social science, law and politics are all treated equally. This can only happen if we can embrace humility as the tool to understanding the other," he says.

Even with rainfall figures declining since 2015 (in 2014, Cape Town got 511mm of rain. In 2015, this went down to 321mm and in 2016 and 2017, the region got only 221mm and 153mm of rain respectively) the Cape Town drought was hard to predict.

Although the water storage graphs for Cape Town's two main water sources (Berg River Dam and Theewaterskloof Dam) show that both have dropped below "very low" levels since 2015, Professor Barend Erasmus, Director of the Global Change Institute, says that declining surface water levels do not serve as a clear "early warning".

An aerial view of the desalination plant at Strandfontein, Cape Town. *Picture: Bruce Sutherland*

"The likelihood of a prolonged drought such as the one in Cape Town is extremely low, so the more years with low rainfall, the less likely it is that a drought will persist," says Erasmus.

"The magnitude of the crisis was too big for a 'business as usual' incremental response. This is a typical example of how a system shift in terms of a different attitude towards water is required."

Gillian Maree, Senior Researcher at the Gauteng City-Region Observatory, says a more proactive approach towards droughts should be implemented throughout the country.

"You cannot solve a major drought quickly. There are no short-term interventions three years into a major drought," she says.

"The concern is that we're still reacting to a 'crisis'," says Vogel. "We need to change the focus of the country. Cities need drought plans and, as far as I know, Johannesburg does not have a focussed drought plan."

Maree believes Gauteng can expect to run into water shortages in the near future, with high levels of urbanisation and growth leading to increased demand pressures on the limited water supply.

"In the past 20 years, Gauteng has experienced such rapid growth that we just haven't been able to keep pace with it," she says. Johannesburg is expected to become a mega-city by 2030, housing a population of over 10 million people. By that time, over 60% (5.05 billion people) of the world's population is expected to live in urban areas.

Some of the earlier Water Balance models from the DWS showed that there would be a water deficit in Gauteng by 2025, says Maree. The idea was to have the second phase of the Lesotho Highlands Water Project (LHWP) operational by that point. Phase 2 of the LHWP is scheduled to increase the current supply rate of 780 million cubic metres of water per year to 1 260 million cubic metres per year. The construction on the project has been delayed.

"The LHWP2 is way behind schedule. There's no way we're going to have large augmentation by 2025. This means that the current and future water demands will have to be accommodated for within the current water availability."

Data on water consumption are very limited and vary greatly across different types of households, but the studies we do have have shown that Johannesburg households consume around 330 litres of water per person per day. This is double the global average of around 170 litres per day.

"The consumption here is very high. For those households who have reliable access to potable water, we use nearly double the global average – in a water scarce part of the world," says Maree.

A 10-POINT PLAN TO MAKE GAUTENG WATER-SECURE

1. Build cities water-wise (incorporate green infrastructure with current water infrastructure)
2. Start to value our water catchment areas
3. Ensure we look after our rivers and wetlands
4. Look at innovative ideas around grey water use
5. Improve and maintain our storm water management systems
6. Become more water aware and water sensitive about how we build the Gauteng City-Region
7. Decrease consumption in Gauteng
8. Advance to the LHWP phase 2 as soon as possible to augment our water sources
9. While taking the basic water needs of all our citizens into account, we have to make water more expensive and place a higher value on it in society
10. Urgently deal with the backlog of maintaining water-treatment plants.

Compiled from recommendations that Gillian Maree made in a presentation to the Gauteng Department of Economic Development and the Gauteng Department of Agriculture and Rural Development.

"We live in a region far from our water supply, we live on top of a watershed, and we spend great expense piping water here (from the Katse Dam via the LHWP). We have to deal with the consumption and wastage issue."

What must also be addressed is the unacceptably high levels of non-revenue water (particularly water losses from poorly maintained and leaking infrastructure) and ensuring that consumers are billed fairly for water, and the revenue collected.

A second aspect of water security is making sure that that the water that we do have is safe enough to use. "We are a heavy polluter," says Maree.

"Johannesburg lies on top of the watershed, so we pump a lot of fresh water up the catchment to use, and then we release return flows that are often very polluted. We don't see the cost of our pollution downstream, and how we waste water."

While industrial wastewater contributes to the problem, Sheridan says the two main sources that pollute our rivers are Acid Mine Drainage (AMD) and broken sewage treatment plants.

"We have to fix AMD and sewage plants," he says. AMD is a massive problem, but – if you've got political will behind it – not difficult to fix. The problem, however, is that AMD is usually just neutralised for pH levels, and many sulphates stay behind in the water. This is not good for rivers.

"Sewage is a disaster," says Sheridan, pointing out that a lot of research is now going into making water treatment plants on a local level resilient and easy to operate and maintain. However, there is no single solution to fix the problem.

"JOHANNESBURG HOUSEHOLDS CONSUME AROUND 330 LITRES OF WATER PER PERSON PER DAY. THIS IS DOUBLE THE GLOBAL AVERAGE OF 170 TO 173 LITRES PER DAY."

Picture: Gauteng City-Region Observatory

"You need to engage with each locality in a different way. You need to consult with local communities and establish their own needs, before you can start to search for a solution," says Sheridan. "How do you design a resilient system for a specific community?"

In order to solve our water crisis, we need to change the way we think about and treat water – from a government perspective right down to consumer level.

Water must be managed in such a way that consumers value it more.

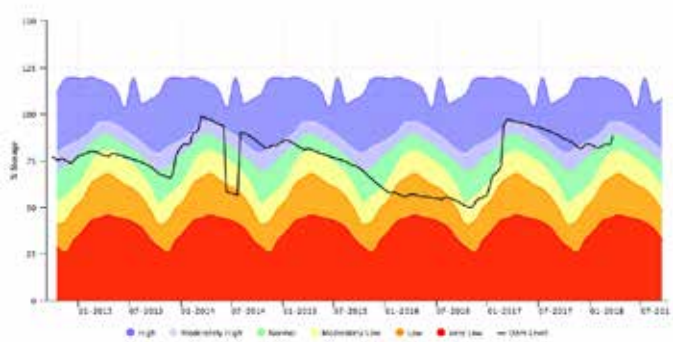
"Effective water management has to be carefully considered," says Vogel. "We need to find socially just ways of ensuring effective water management."

Maree agrees: "We have to deal with the consumption and water wastage issue, which is a technical issue as well as a political issue and leadership issue, around changing behaviour".

We have to see water in a different light and start to respect it as the valuable resource it is. If we put our minds to it, all South Africans should be able to have a sustainable, water-secure future.

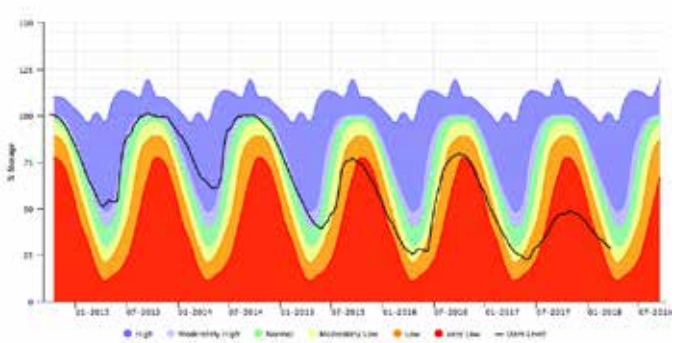
As a friend of Sheridan's said: "With political will, everything is possible. We (the human race) put people on the moon because of political will." ©

Surface Water Storage (Vaal)



The surface water levels of the Vaal dam shows how close Gauteng came to a drought in 2016, only to be rescued by a rainy spell in 2017. Credit: Department of Water and Sanitation.

Surface Water Storage (Berg Olifants)



Surface water levels of the Berg River Dam, one of the major dams that feeds the City of Cape Town's water supply, shows a steady decline from 2014. Credit: Department of Water and Sanitation.

Parched Cape Town, Johannesburg drowning

THE IRONY OF STORMS IN THE **CAPE OF DROUGHT**

BY DAVID OLIVIER

Two meagre millimetres of rain predicted. But in February, Cape Town's driest month, we were grateful for anything.

Sophie, eight months pregnant, was waiting as I pulled up. We usually go for a short walk on the way home from work. The clouds were gathering, like the past two evenings – each time only to clear again as night fell. But this time a few fat drops plopped onto the clay hiking trail.

A mysterious crackling began emanating from the surrounding scrub. It rose to a low rumble, and a hailstorm began drumming the dusty ground. Sophie squealed as a stone the size of an ice block stung her neck. One cracked me on the head. With a roar the full force of the storm unleashed.

In seconds, the dry narrow path became a churning chocolate river. Sophie sloshed on ahead of me. She had her arms over her head, but the hail mercilessly thrashed her bare calves. A blazing pillar of light impaled the path ahead. Thunder rocked the atmosphere.

We were victims of an extreme weather event. One moment the earth is parched, then suddenly your world is awash. We can expect to see more of this in future.

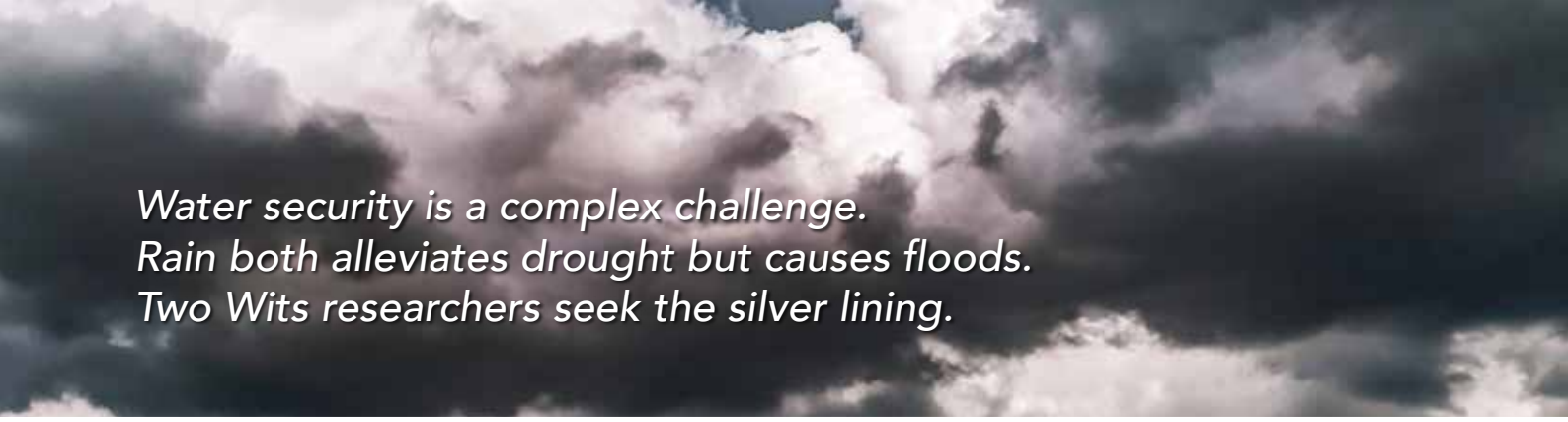
Extreme, unpredictable weather is characteristic of climate change. Experts at the Western Cape Winter Rainfall Outlook Summit in May 2017 concluded that weather in Cape Town for that year would probably be, "drier ... or normal ... or wetter than normal". Talk about hedging your bets.

The City of Cape Town municipality has been lambasted for not preparing for their drought. But how does any city prepare for unpredictable weather events? Cities have a hard enough time procuring funds for vital programmes such as providing decent housing. How would they justify the eye-watering cost of a reverse-osmosis plant for the desalination of sea water that is not needed in the long run, but may be required to get the City through a few dry years sometime in future, maybe?

Water security is not a technological problem but one as multifaceted as a crystal chandelier. The ironic beauty of this problem, however, is that it crushes disciplinary silos and forces academics, governments and civil society to work together – something that is bitterly needed, if we are going to adapt to a changing world.

Sophie and I made it to the car. The seats sucked the rainwater from our clothes and smelt musty for days. Driving home, flotsam smeared the steaming roads and the parting clouds revealed a cobalt evening sky. Within minutes, the storm was over. The parched earth had swallowed the shower thirstily. The drought was not nearly broken, but the rain had pushed Day Zero a little further back. ◻

DAVID OLIVIER
Dr David Olivier is a Postdoctoral Research Fellow in the Global Change Institute. He is currently researching the narratives around the water crisis in Cape Town and how these shape public perception. He earned a PhD in Sociology in 2015, having researched the physical and social benefits of urban agriculture in Cape Town.



Water security is a complex challenge.
Rain both alleviates drought but causes floods.
Two Wits researchers seek the silver lining.

SETTLING YET **(D)RAINING**

BY PAULOSE MVULANE

On November 9, 2016, torrential rains washed over Gauteng and led to flash floods that caused large-scale damage, and even deaths, in parts of the Johannesburg, Ekurhuleni and Tshwane metropolitan areas. This storm was not only a sign of things to come, but also unveiled a host of underlying vulnerabilities within the City of Johannesburg and its surrounding areas.

Urban floods are a major threat globally. These deluges lead to disrupted economies, personal injury and the loss of life – and it is often the most impoverished who are most vulnerable. The City of Johannesburg Disaster Management reported that 862 people in some 373 households were severely impacted by the storm that flooded the Setswetla informal settlement in Alexandra, north of the CBD last November. *News24* reported that some people never managed to return home.

Johannesburg has the highest rate of urbanisation in South Africa. Rapid urbanisation and population growth leads to profound changes in the City's natural landscape. These alterations affect ground surface permeability and interfere with natural water flow and infiltration. As large numbers of people flood the City of Gold in pursuit of a livelihood, they often end up settling on marginal land (such as flood plains and river banks) so they can be near sources of income and avoid paying high rental rates. These settlements are characterised by extreme poverty and almost non-existent basic services. There is nowhere to go to escape hazardous onslaughts like floods. Often these people lose everything they have – sometimes even their lives.

Flooding is not just the result of a heavy downpour or the failure to maintain and clean storm water drains. It is much more than a technical problem to be solved through engineering and top-down interventions such as adherence to by-laws. These tend only to provide solutions for formal developments and do not adequately cover informal settlements. Flooding results from failing to plan, design and maintain our settlements – whether they are formal, or informal.

Effective interventions that address prevailing urban realities are urgently needed. It is important to identify and profile Johannesburg's urban 'hot spots' to mitigate urban flood impact. This will help proactively minimise the risk of different communities within their unique contexts. Local researchers, NGOs, government, community leaders and committees all have a role to play in enabling vulnerable urban communities to adapt and mitigate flood impact. We need to acknowledge that urban informal settlements are an integral part of this City and plan accordingly. ©

PAULOSE MVULANE
Paulose Mvulane is a Master's candidate in the Global Change Institute. His research interest is in environmental management and issues of urbanisation, urban governance, food security, and ways to create sustainable resilient cities. His Master's explores the vulnerability of urban informal settlements to flood risk under climate change.

THE HEAT OF ACID MINE DRAINAGE

Mining is a key contributor to South Africa's economic development but its effect on the environment could spell disaster.

BY DELIA DU TOIT

After a rainstorm hit the area around Carolina, Mpumalanga, early in 2012, emergency notices appeared all over town informing its 23 000 residents that the water had suddenly become unsafe for drinking, cooking and even washing clothes.

The pH level of the water was dangerously acidic at 3.7 and the concentrations of iron, aluminium, manganese and sulphate were above acceptable limits. The standard chlorination and sediment removal treatments were proving inadequate to solve the problem. The Boesmanspruit Dam, which supplies the town's water, had also turned dark green in colour and fish in the spruit and dam were dying.

After much investigation, the probable cause was determined: Acid Mine Drainage (AMD) from coal mining activity in the area. The town was without piped water for seven months.

Terence McCarthy, Emeritus Professor of Mineral Geochemistry in the School of Geosciences, and Dr Marc Humphries, an Environmental Geochemist in the School of Chemistry at Wits were part of the team that investigated the Carolina disaster. McCarthy believes AMD could be the cause of a future catastrophe in South Africa and, while Carolina was a stark and sudden example of the devastating effects of AMD on the environment, it is not the only case. AMD is happening everywhere there is mining activity – albeit slowly.

"The water in the Middelburg Dam is already undrinkable and I believe that the Grootdraai Dam near Standerton, which is in the Vaal River system, could follow suit," says McCarthy. The Vaal River supplies not only Gauteng but also many towns downsteam, including Bloemhof, Welkom, Kimberley and Postmasburg. The major culprits are the coal and gold mines, and because of their location in the upper portions of the Vaal River catchment, their footprint on the water supply is huge.

Aside from metal and acid pollution, the major problem is the increase in dissolved salts into the Vaal River. In order to keep the salt load at tolerable levels, the Department of Water and Sanitation is obliged to release water from upstream dams into the Vaal system to dilute the pollution, thereby effectively wasting water.

"CURRENTLY, THE STANDARD TREATMENT FOR AMD IS TO AERATE THE WATER TO OXIDISE THE IRON AND ADD LIME TO BRING THE pH UP."

Picture: Mark Lewis

AMD occurs when water reacts with pyrite ('fool's gold') in mining cavities beneath the Earth's surface. The water becomes acidic and rich in iron, lead and other heavy metals – a combination that is toxic to living organisms. This water then joins the ground water system, sterilises the soil, and eventually flows into streams and rivers where it could join the drinking water supply system. Currently, plans and methods to tackle the problem are woefully inadequate and those that work cost a fortune.

Reverse osmosis, which entails pumping water through a membrane punctured with microscopic holes that allows water through but keeps metals behind, is already in use at the eMalahleni Treatment Plant in Mpumalanga. The end-product, however, costs five times the price of natural water, because of the extensive energy used in the process, says McCarthy.

"Currently, the standard treatment for AMD is to aerate the water to oxidise the iron and add lime to bring the pH up. The iron then precipitates out – and most heavy metals along with it – in a deep red colour. After that settles, the waste is dumped on old mine dumps – the reason some will have red tops." However, the water still has high sulphate content. "Although it's not particularly poisonous, it's above the World Health Organization's recommended limit and so remains undrinkable," says McCarthy. Another option is to dilute or flush the water using water from clean systems (the eventual solution at Carolina) but this is a massive waste of a precious commodity in a dry country like South Africa. Similarly, wetlands act as natural purifiers, but flushing large quantities of polluted water through these systems destroys them.

Khuliso Masindi, a PhD student in Hydrogeology at Wits encountered AMD in the Witwatersrand area while monitoring ground water in 2012. "The water would be orange or yellow because of the oxidation of sulphites from the mines, and would have a pH of 2 or 3, and that then flowed into streams. Methods can be used to limit AMD at new mines, but the old tunnels always remain," says Masindi, who believes the AMD problem is virtually insurmountable.

And despitethe substantial rainfall in Gauteng and Mpumalanga in the last few years, which helped flush the problem, McCarthy fears dark days lie ahead: "The problem will intensify when that [rainfall] changes. The next drought will be trouble." ◻

WASHING AWAY OUR HERITAGE

The effect of water on rock art is a major concern, particularly due to climate change. Droughts, floods and the building of new dams are all threats to South Africa's heritage of rock art – some of which is over 4 000 years old.

OUR ancestors might have glazed their rock art with egg white, created brushes from acacia trees and sought pigment from blood, or clay to paint memories, stories and objects of their lives and love.

Much of our rock art is undiscovered, and most of it is unprotected as it is under threat – and water is the most common destructor.

Rock art is threatened by a number of sources says Elijah Dumisani Katsetse (MSc) in the School of Geography, Archaeology and Environmental Studies. But water, dampness and moisture has always been the enemy of preserving art, just ask the curators of the Louvre museum.

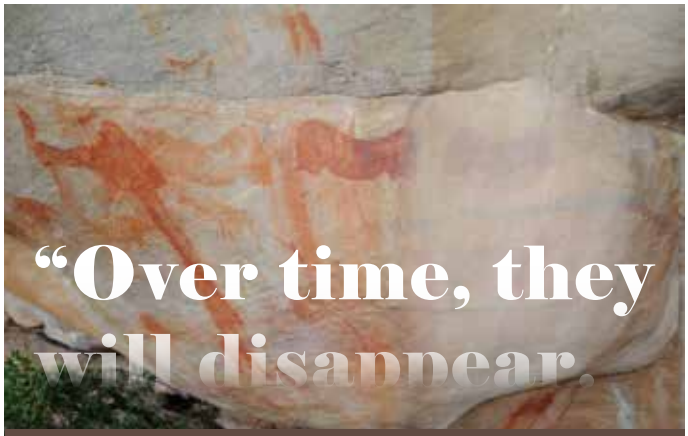
Katsetse's Master's research papers have investigated the *Impact of Water on Rock Art* and solutions, in his subsequent writing, *A Conservation Model For Rock Art In South Africa: A Management Perspective*.

"The evolution of humanity has placed value on artefacts and preserving heritage and developing techniques to do this. Think of your favourite coffee mug. If you are attached to it but it falls and breaks, you would glue it so that you still have the mug with you, in some form. That's the whole notion of conservation," says Katsetse.

Unlike a coffee mug however, rock art goes back to ancient times, where San beliefs about sacred animals which inspired rain, stories of life of old Sotho civilisations and Khoi self-portraits were captured, often in secret, hidden spaces.

Katsetse says some of his favourite rock art is in the Game Pass area of KwaZulu-Natal.

Bird guano and dust have damaged the rock art at the Bonne Esperance site in Limpopo. *Pictures: Elijah Katsetse*



An enhanced image shows the extent of water damage to the rock art at Bushmans Kloof.

Rock art damaged due to water at the Bushmans Kloof heritage site near Clanwilliam in the Western Cape.

“Over time, they will disappear. We don’t even know the size or extent of the art there. They are from 2 000 or 4 000 years ago… different motifs, eland, Anthromorphs.”

The effect of water on rock art is a major concern, particularly due to climate change. “It is a natural element, which means that water varies from place to place. Climate has an effect on the rate of deterioration. With evaporation and condensation over time, water accelerates the rate of decay. We found that guano of birds, when mixed with dust and water, is causing mineral dissolution and deterioration in the Western Cape,” said Katsetse.

Last year, a report by the Wits Rock Art Research Institute (RARI) investigated the removal of rock art affected by the rising of the Clanwilliam dam wall in the Western Cape. While that dam is severely affected by drought, its expansion once threatened Cape heritage. The South African Department of Water and Sanitation built a higher wall at the dam which would have flooded 27 rock art sites. The provincial heritage agency approved the removal of three pieces of rock art in April and May 2016. Removal is one method of conserving the art.

Since then, the drought in that province has not helped with art preservation. Along with wind, wildfires and drier conditions, rock art could be adversely affected by salt deposits from evaporation.

Professor David Pearce at RARI says dams are problematic when at capacity, and can literally wash the art away. “We also have a lot of sandstone that is permeable by water, which can destroy the entire rock. But water can assist in some ways too. Mineral deposits from water can act as a sheen and protect rock art by adding a layer of minerals like calcium oxalate.”

But Katsetse says while water is a major risk to destroying rock art, he has compared conservation practices in South Africa to that in Australia, America, and Egypt and found another issue.

Katsetse found in South Africa, that there is a lack of conservation intervention planning and research is not directed towards developing conservation treatments or measures that are specific to our climate. Then there are traditional beliefs which come into play, including that only those who have undergone initiation practices can visit some sites.

“We have to draw knowledge from past ways of life and rock art offers a window into the past. We need to preserve this art and access our past, in their context, which means preserving them in their original context,” he says.

“One of the ways to conserve art is to engage with the community and to share the significance of rock art with them. At the same time, we must establish good relationships so whatever systems and methods of conservation we use, the community is educated – and they can educate us too – to create strategies to preserve the material of the past.” ©

HUNTING ALIENS FROM SPACE

BY SHAUN SMILLIE

Wits researchers are using high-tech imagery and biological agents to save our water resources and economy from invasive alien plants.

Lerato Molekoa scans satellite images from high-definition cameras and sensors orbiting Earth. She is hunting for aliens. Not little green men with three fingers. Molekoa, an MSc student in the School of Animal, Plant and Environmental Sciences (APES) at Wits, is hunting for alien vegetation here on Earth. She calibrates the satellite data to detect subtle light changes reflected in the leaves of salt cedar trees. This helps identify alien plants that are using our water.

Molekoa is trying to work out the distribution of three different species of salt cedar trees. One of the trees, *Tamarix usneoides*, is indigenous while two other close relatives are exotics. The problem is that, up until now, only genetic analysis of the three different species can differentiate them.

ALIEN INVASION

Mining houses use all three species to rehabilitate mines by removing contaminants from the soil and water – a process called phytoremediation. Salt cedar trees planted in paddocks at the base of storage dams leech sulphates and heavy metals from the water, and are important to combat acid mine drainage.

"The mines have been using the alien species, which we are not happy about," says Professor Marcus Byrne from APES. "Then we got drawn into finding out how to identify an alien species and what is not."

The two exotic types of salt cedar are invasive alien species, which severely affect South Africa's water resources by consuming ±4% of the annual mean water runoff.

"This is the water that makes its way off the land into rivers and dams, for our use, and instead it is used up by invasive species," says Byrne.

Invasive species also influence the economy, with an estimated annual cost of around R6.5 billion in 2007.

A further problem specific to the genus *Tamarix* is that the exotic species interbred with the local species, resulting in hybrids. This reduces the local biodiversity by diluting the genetic integrity of the native species.

"We knew we had these three species, but we didn't know how to identify them until we did the genetics," says Byrne.
Working out the distribution of the three species would be harder work without satellite imagery.

"DNA is very expensive and time consuming, but with satellites you can basically tell the image to go and find where the species is located within a certain region," says Molekoa, who downloads satellite images free and then uses software to set search parameters to find the colour signature of the trees within the image.

The jury's still out whether it is the exotics or the local species of *Tamarix* that are best at phytoremediation. Sipho Mbonani, an MSc student in APES, believes it is the local species.

"I remember going into the field to look at phytoremediation and we noticed that there were indigenous and alien plants together, and we could tell the aliens by the way their leaves were yellowish in colour. So I don't think they are doing so well," says Mbonani.

PUT A BUG IN IT

The next step to control alien species is to introduce insects as biocontrol agents. The search is on for an insect that eats only the exotic and not the local species. Satellite data also help scientists fight invasive aquatic species like water hyacinths, which choke waterways across Africa.

"A blanket of water hyacinth across a water body blocks out light and oxygen, and uses water. Consequently, the whole nature of

the water system changes, and many native animals and plants disappear from that system," says Byrne.

Eight biocontrol agents have been introduced to control water hyacinth, but no one knows how effective these agents are and how local conditions influence their lifecycles and efficacy.

Water pollution, for example, affects one of these agents, the water hyacinth weevil, *Neochetina eichorniae*. Jeanne D'Arc Mukarugwiro, a PhD student in APES, uses satellites to monitor the extent and movement of water hyacinth, and the wellbeing of the water hyacinth weevils in rivers with high turbidity, in Rwanda. Turbidity is the cloudiness of a fluid. High turbidity results from the suspension of tiny soil particles in water, which might affect weevils living on the plants.

Scientists theorise that the high concentration of particles suspended in the water suffocates the weevil in its underwater pupal state. Further research is required to establish if the weevil faces the same problem in South Africa. Byrne points out that, despite the effectiveness of biocontrol agents (because insects don't make mistakes), only 2% of South Africa's weed control budget is allocated to research in this field.

The water hyacinth might have the upper hand over its biological control agents currently, but the poster-child of biological control in South Africa is *Stenopelmus rufinasus*, the frond-feeding weevil that eradicated red water fern.

DEATH BY MAIL

In the 1940s, the red water fern came from South America, just like the water hyacinth. By the 1980s, red water fern had become a widespread problem. Wits University, the Agricultural Research Council, and Rhodes University collaborated to find a solution. By 1997, they had found the bug that they thought would do the business.

"THE MINES HAVE BEEN USING THE ALIEN SPECIES, WHICH WE ARE NOT HAPPY ABOUT"

Death came to the red water fern via the post.

Farmers who suspected a red water fern infestation sent a photograph to the researchers. On confirmation of red water fern, the scientists posted a polystyrene box containing the weevil.

"We would tell them to open the box and just throw it in the dam, and in six months it will be gone, and we promised if it was not gone, we would come and clear it from them. It worked every single time," says Byrne, of what is considered one of the world's most successful biological control programmes.

Back then, the postal service helped eliminate one invasive species that threatened South Africa's water systems. Now, with the help of satellites and their software, the fight has become high-tech.

"My dream one day is that we have such fine resolution that we will be able to tell from the satellite photo whether the plant has biocontrol agents or not." ◻

Pictures: Lauren Mulligan

Lucia Monge's *Planton Movil* 2011. Photo by Jorge Ochoa. Monge will exhibit *Mi niño, your dry spell, their waterfall at WATERSHED*

A WATERSHED IN THE ARTS AND SCIENCE

What does a polluted river sound like? How does sand-filtered water taste? Will acid mine drainage scald your skin? Do oceans echo? WATERSHED is a programme that enmeshes the arts and science to provoke new thinking about water.

BY DEBORAH MINORS

If a tree falls in a forest and no one hears it, does it make a noise? This philosophical question about a natural phenomenon reflects how disciplines can merge. Similarly, acoustic ecologists map environmental sounds. Take that forest, for example. What is the impact on a local ecology if you remove not all the trees, but only a few?

"Bernie Krause recorded the sounds of a forest continually for a year. After a year there were massive changes in the biodiversity. We tend to privilege the visual over audio, but sound is often more sensitive than the visual," says Lenore Manderson, Distinguished Professor of Public Health and Medical Anthropology at Wits and Distinguished Visiting Professor of Environmental Studies at the Institute at Brown for Environment and Society (IBES), Brown University, USA.

"Shifting our perceptual field away from the visual and attending to the aural [listening] environment deepens our understanding of planetary ecology," writes Manderson in a paper entitled *Rumble Filter: Sonic Environments and Points of Listening* (2017).

"What does a river sound like? What does a polluted river sound like? It's actually quite noisy," says Manderson. The point is that the absence of visual evidence doesn't mean there isn't any impact.

And so it is with water.

WA'TERSHĔD

(waw-) n. **1.** line of separation between waters flowing to different rivers or basins or seas. **2.** (fig.) turning-point e.g. in history.

Since April 2015 Manderson has organised an art-science programme, *Earth, Itself*, through IBES. The aim is to facilitate conversations and build collaborations across creative arts practice and theory, the humanities, and the social, natural and physical sciences.

At Brown, Manderson drew on the elements earth, air, fire, and water and aligned each element with an art practice and research component. *Thinking the Earth* featured dancers who performed on a sprung dance floor covered with wet clay to demonstrate impact. Air was coupled with music and sound to produce *Atmospheres;* fire with ceramics and glass blowing to forge *What fire does*; and water and ice with text to transcribe *Water's edge*.

Now Manderson has brought the programme to Wits where it will manifest as *WATERSHED: Art, Science and Elemental Politics.* This research-enmeshed celebration of water will run from 10 to 21 September 2018 and will include interactive art installations, engineering and scientific displays, and academic symposia across disciplines and faculties highlighting water on the continental divide.

"The artwork is about getting people working outside the academy to engage with water in a way that they haven't before. If you're a dancer, for example, you may never go to a seminar by an earth scientist on palaeogeology, but finding ways to bring together artists and scientists opens up how you understand the world and what you understand to be the issues," says Manderson.

As at IBES with *Water's edge*, collaboration across disciplines defines WATERSHED at Wits. Several artists participating in WATERSHED are visiting fellows in the digital arts, fine arts, and theatre and performance in the School of Arts at Wits.

"The conceiving of the *WATERSHED: Art, Science and Elemental Politics* project and its precursors have always understood artists to be central to the ways in which knowledge production and enquiry takes place. This intersects with the University's commitment to artistic research, the Wits School of Arts' leading role in deepening understandings in and around artistic research, and the ways in which newly imagined futures are generated through inter- and cross-disciplinary practices," says Associate Professor David Andrew, Head of the Division of Visual Arts at Wits.

THE CHAMBER OF MINES AND THE ATRIUM OF ECHOES

Any Witsie who has ventured beyond the Unknown Miner into the Chamber of Mines building knows that the Atrium within resonates with eerie acoustics. Atul Bhalla from Shiv Nadar University in India is a visiting fellow in Visual Arts at Wits. His installation *You always step into the same river: Looking for lost water (Explorations at the Cradle)* will take place in the Atrium.

Bhalla has been involved in projects which highlight the use/misuse of water as well as its religious and mythical significance in his hometown of New Delhi. His work for WATERSHED will examine water as a repository of history, meaning and myth within the context of Johannesburg gold mining, taking references of land and water relations from historical (oral and non-oral) contexts.

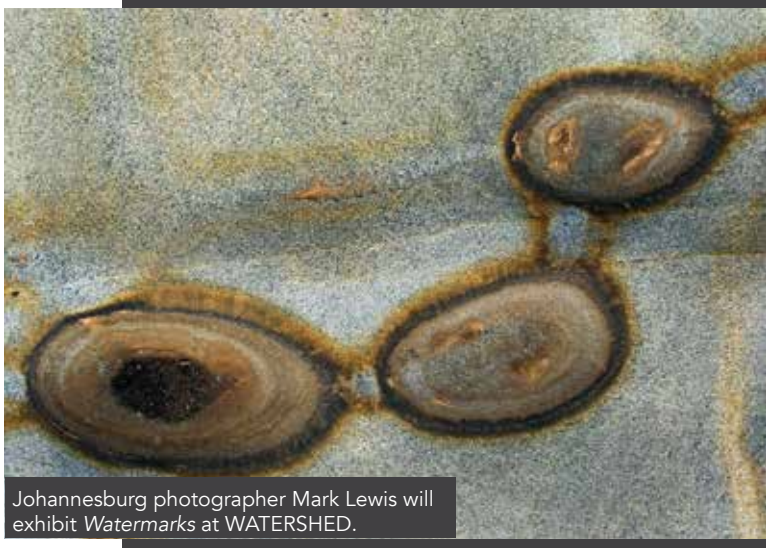
"I'll also attempt to explore how people live and survive in and around the dumps, developing local language/s and words for operations and acts that may not have existed pre-mining days. I intend to use Zulu as the language of communication within the work," says Bhalla.

VALUING ART AND SCIENCE

Professor Craig Sheridan is Director of the Centre in Water Research and Development (CiWaRD) at Wits, Co-Founder of the Industrial and Mine Water Research Unit, and a Lecturer in the School of Metallurgical and Chemical Engineering. He says that the levers that drive change are in the societal domain.

"If you see pictures of people up to their necks in water, it kind of makes you feel a little bit uncomfortable. Or if you see people fighting for water, that's also a very uncomfortable image. So this is where the arts have the influence that engineering doesn't. But we're also using the engineering space to influence the

THE ARTWORK IS ABOUT GETTING PEOPLE WORKING OUTSIDE THE ACADEMY TO ENGAGE WITH WATER IN A WAY THAT THEY HAVEN'T BEFORE.



Johannesburg photographer Mark Lewis will exhibit *Watermarks* at WATERSHED.

Brian House presents *Heavy Metal: Digital conversations on water and mines.*

Atul Bhalla's *Excavated distance* 1.

Lucia Monge's *Planton Movil* 2010. *Photo: Jorge Ochoa*

"THE ARTISTS ARE ALL IN ONE WAY OR THE OTHER ENGAGING WITH WATER"

societal space," says Sheridan, adding that art and science exert influence differently because the value systems of artists and engineers differ.

As a process engineer who "sees systems" (which always work in complexity), Sheridan believes enmeshed research – "not just interdisciplinary or cross-disciplinary" – is key to water management in future.

"I like the idea of having engineers show their little waste water management rigs to people, and to have artists in the same space saying, 'look at these photographs'. We're all responding to the same thing in the ways that we know, using our own internal value systems, and what we start to see is each other's value systems."

WALKING FORESTS, BUILDING WATER

Sheridan's future collaboration with Lucia Monge, a Peruvian artist now based at the Rhode Island School of Design in Rhode Island, USA, demonstrates enmeshed research. Monge will be based at CiWaRD for WATERSHED where she will present a photographic and sound installation, *Mi niño, your dry spell, their waterfall* in the Origins Centre.

"Maps and tools will be my vehicles to explore difference and interconnectedness on water issues," says Monge, who previously used people as vehicles for plants. Since 2010 she has organised 'walking forest' performances in Peru, the UK and USA, where people carry plants across the city in peaceful protest, culminating in a 'plant in'.

HOW HEAVY METAL SOUNDS IN A RIVER

Brian House from Brown, and a Visiting Fellow in Digital Arts at Wits, works on enmeshing nature in the ditigal realm. His work *Heavy Metal: Digital conversations on water and mines* will coincide with the annual *Fak'ugesi* African Digital Innovation Festival curated by Wits Digital Arts and will take place in the Tshimologong Digital Precinct.

House will create a digital artistic rendition of the heavy metals found in waterways, converting real-time recordings of these metals in the water into digital sounds. The metal sheets of copper, lead, aluminum, and iron, vibrate like data-driven musical fountains. House originally created this installation based on heavy metals polluting the Animas River in his hometown of Colorado.

"I am interested in how similar ensembles of geology, industrial history, and current dynamics resulting from ecological instability are present all over the world and interrelated. Having made a piece that's local to me, the chance to work in South Africa in unfamiliar environs will be very productive," says House.

Manderson says the artists are all in one way or the other engaging with water. "They stimulate new ways of thinking about the issues. By people getting together from very different fields, and interacting across different academic disciplines, we begin to play with how we understand the environment, water security, and governance, identify priorities, and determine where the research might go."

And that might be in the direction of how forests think, if fire dances, how thunder tastes and if that tree falling solo makes a sound. ©

WATER FUTURES

WATERSHED will include a scholarly programme comprising symposia and student presentations.

- *Words on Water: Southern African literatures and the oceans* will include academics from the Oceanic Humanities Programme in the Wits Institute for Social and Economic Research (WiSER).
- *Under the surface: justice and politics* will include panellists from the Centre for Sustainability in Mining and Industry who will engage on topics related to water governance and acid mine drainage.
- *On the watershed: urban histories of water* is a seminar that will focus on the watershed of the Vaal and Limpopo rivers. Academics from the Wits City Institute will interrogate the region's history (post) colonial geographies, swimming pools, baths, and guerilla gardens.
- *Action on water: Climate justice and people's charters* will explore activism as a way to address social inequities that distort access to water.
- *Water futures: digital imaginations* is a symposium that will focus on modelling future environments in relation to water insecurity and threats. Here panellists will address the use of big data and digitally generated visuals in assisting water policy development.

A PEOPLE'S WATER CHARTER FOR SOUTH AFRICA

BY VISHWAS SATGAR

A social sciences course at Wits on Empire and the Crisis of Civilisation contextualises water, food and climate crises as systemic and demanding activist solutions.

Illustration: Lauren Mulligan

Climate science has confirmed a heating planet linked to a global system addicted to fossil fuels such as oil, gas and coal. There has been a one-degree increase in planetary temperature since before the industrial revolution (1760-1840), now fast approaching a 1.5 degree increase, based on various climate models. Climate shocks have begun registering through extreme weather changes.

South Africa's drought is happening in the context of this shift. Parts of our food system – such as the production of maize – have collapsed, resulting in an escalation of food prices (particularly of staple foods), and further exacerbating hunger.

Systemic problems require systemic solutions. This prompted my research into systemic alternatives that could advance a deep and just transition to sustain life. These alternatives include a focus on socially owned renewable energy, water sovereignty, food sovereignty pathways, and solidarity economies.

The Climate Crisis: South African and Global Democratic Eco-Socialist Alternatives (2018) profiles some of these ideas, while *Climate Food*, a book in progress, explores the intersection of climate shocks, food sovereignty systems, and water commoning.

The South African Food Sovereignty Campaign (SAFSC) comprises organisations engaged with the agrarian sector, climate justice, food justice, and solidarity economy. Formed out of a Right to Food conference in 2014, the SAFSC translates and substantiates a South African approach to food sovereignty.

SAFSC has taken the country's drought very seriously. Through its hunger tribunal, drought speak-outs, bread marches, food sovereignty festivals, water sovereignty dialogues, and activist schools, the campaign advances an alternative perspective on the need for a food sovereign system – one built through democratic systemic reform and driven by citizens.

Within this context, three tools systemically address water and water solutions: A People's Food Sovereignty Act; the Building People's Power for Water Sovereignty activist guide; and a process to formulate, through bottom-up dialogue, a People's Water Charter for South Africa.

These tools were shared recently with Parliament, frontline water crisis organisations, and some water-stressed communities in the Western Cape. The People's Water Charter will evolve through dialogue and will be launched at a People's Assembly in 2019. ⊡

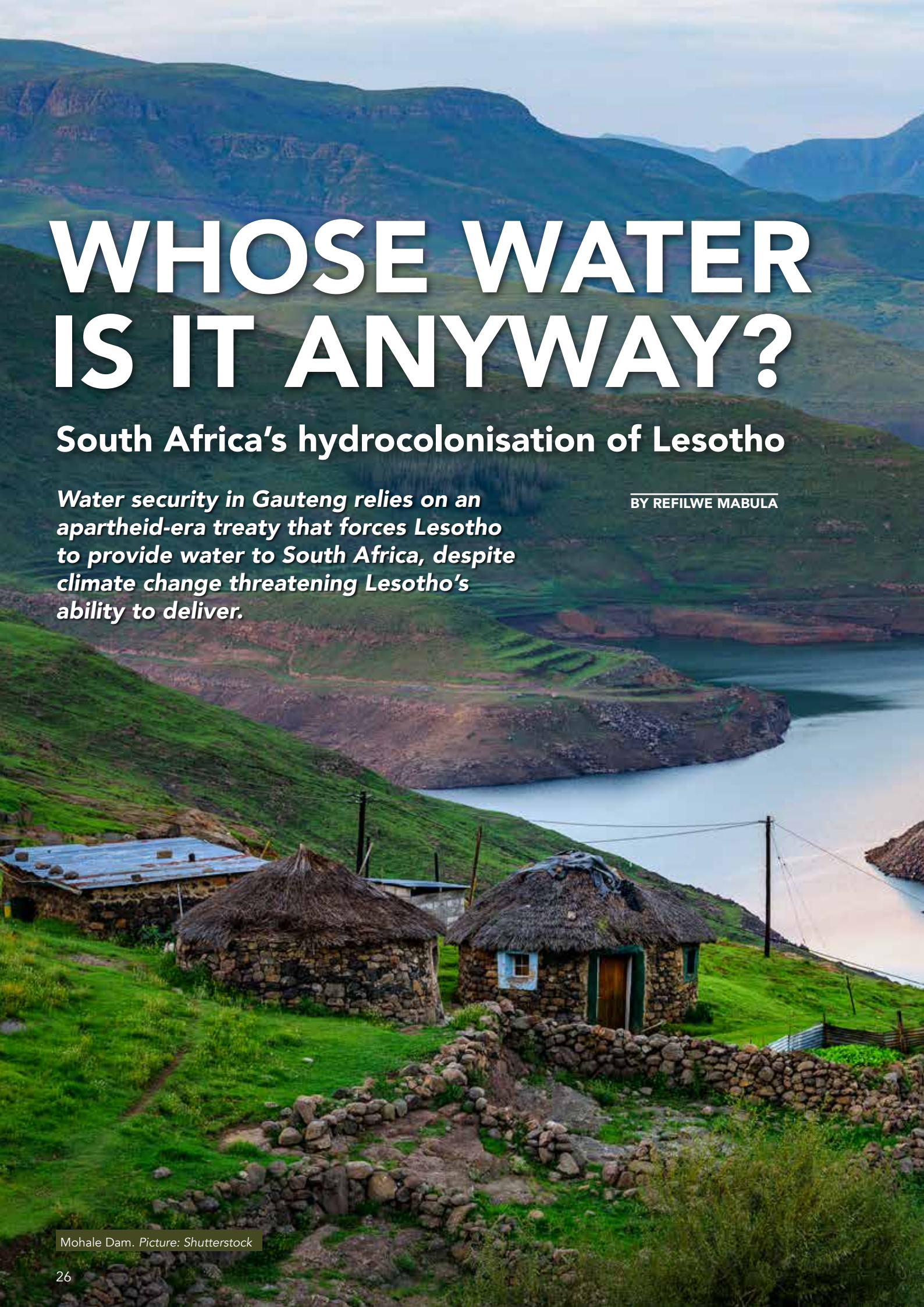
Vishwas Satgar is an Associate Professor in International Relations at Wits. He edits the Democratic Marxism book series, for which the World Association of Political Economy *gave him a Distinguished Contribution Award. Satgar has been an activist for more than three decades. He is currently co-designing a food sovereignty space for food-insecure Wits students in order to advance an eco-centric University.*

WHOSE WATER IS IT ANYWAY?

South Africa's hydrocolonisation of Lesotho

Water security in Gauteng relies on an apartheid-era treaty that forces Lesotho to provide water to South Africa, despite climate change threatening Lesotho's ability to deliver.

BY REFILWE MABULA



Mohale Dam. *Picture: Shutterstock*

Lesotho is a country blessed with an abundance of water. Consequently, in 1986, the South African apartheid government and the government of Lesotho signed the Lesotho Highlands Water Project (LHWP) treaty. This agreement stipulates that Lesotho supplies South Africa with water in exchange for royalty payments, which Lesotho must use to build dams that generate electricity.

The LHWP is being implemented in four phases: Phase 1 was the construction of the Katse Dam, the Muela Hydropower Plant and the Mohale Dam. Phases 2, 3 and 4 will entail the construction of the Mashai, Tsoelike and Ntoahae reservoirs respectively. Phase 2 is now underway.

Gauteng currently receives the majority of its water supply from the Mashai reservoir (phase I) via the Vaal River. The province's future water security is heavily reliant on the completion of the latter phases of the project.

HOW SOUTH AFRICA COLONISED LESOTHO

Research by Clive Vinti, a PhD candidate in Environmental Law, investigates how this treaty has enabled South Africa to take over Lesotho's water resources. He describes this phenomenon as 'hydrocolonisation'.

"The term describes the unlawful appropriation and control of water resources of a certain group or community," says Vinti.

The terms of agreement in the treaty threaten the smaller partner, Lesotho, because the country cannot guarantee an infinite water supply to South Africa due to the impact of climate change on Lesotho's riverbanks.

"In the agreement, Lesotho has to supply South Africa with predetermined amounts of water. There can be no deviation in the agreement of the provision of water. You cannot impair the terms of the contract. Even though we have reached an agreement with Lesotho to give us water, there is a possibility that – with climate change – there is going to be less water available in the Orange River," says Vinti.

MURKY LEGAL ENTANGLEMENT

Despite the treaty, Lesotho gives preference to its domestic water needs before delivering water to its neighbour. Section 5 of the 2008 Lesotho Water Act prioritises domestic use of water over any other use. Section 6 states that, in cases of a declaration of a water emergency, the Minister of Water 'may direct that any persons who have a supply of water in excess of domestic water make available such quantity to other uses as the Minister may specify'.

"What will happen the day Lesotho cannot meet its water commitments towards South Africa? The day is going to come when Lesotho has to decide whether it gives South Africa the water, or it gives its own citizens the water. Ultimately, this treaty will impede access to water for local citizens of Lesotho," says Vinti, who argues that the LHWP treaty does not comply with international water law.

WORLDWIDE WATER PRINCIPLES MAKE WAVES

In his research, Vinti explores international fresh water law principles, which demand that the allocation of water – even if governed by a treaty – must comply with the principles of 'equitable and reasonable utilisation' and sustainable development. These principles are part of South African law and should inform the interpretation of the LHWP treaty, which, as it stands, is devoid of any international water law principles according to Vinti.

"It is imperative that South Africa and Lesotho amend this agreement to comply with these principles. Both the South African and Lesotho Water Acts are premised on equity, access and fairness," says Vinti, but access and equity is not guaranteed for Lesotho as it is for South Africa in terms of the treaty, given Lesotho's legal predicament.

According to Vinti, South Africa has colonised Lesotho's water. "The way the agreement operates is simply colonisation of Lesotho's water resources. Lesotho has no bargaining power." ©

BULAWAYO'S WATER WARS

BY REFILWE MABULA

The history of water inequality in Bulawayo, Zimbabwe, shows that the colonisation of land cannot be separated from the colonisation of water.

The settlement of white colonisers in the Global South robbed Africans of their most precious resources. The occupation of land gave rise to a huge loss of material resources for most black people, as they were moved to water scarce areas and their livelihoods threatened.

So says Professor Mucha Musemwa, an environmental historian at Wits. "The colonisation of water began with land occupation. Land colonisation is synonymous with the colonisation of water. The two are inseparable," he says.

When Cecil John Rhodes and the British South Africa Company (BSAC) established the colonial state of southern Rhodesia (Zimbabwe) in 1890, the initial intention was to find gold. The colonialists imagined that the rich seams of this mineral extended well beyond the Rand goldfields. They were disappointed, however, as Zimbabwe did not have that much gold.

"They never found as much gold as they wanted and they could not turn back. They decided that the land was so good, the climate was so good, and the area that Africans occupied was the main watershed and had the richest soils, good for agriculture."

White settlers turned to agriculture and, with the help of the colonial administration, seized most of the fertile lands occupied by Africans. Most of these lands lay on Zimbabwe's main watershed belt.

With this new discovery – with significant economic and social benefits for the white settlers – Africans were forcibly removed from areas with good rainfall and relocated to areas such as Gwayi and Shangani, which were arid and inhabitable. The Land Apportionment Act of 1930 further systematically banished Africans from fertile land with good water sources and rainfall.

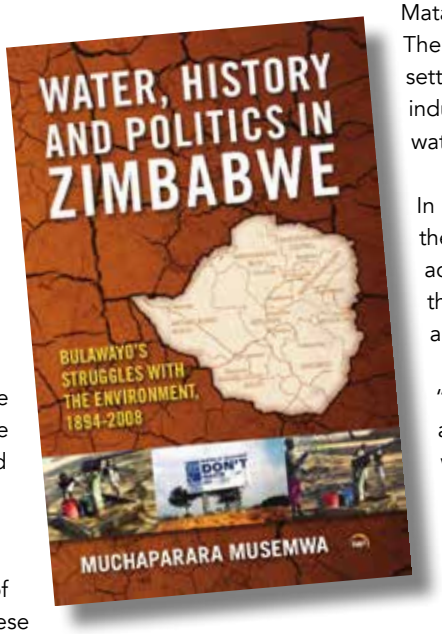
"Land and water were the twin assets at the centre of colonial capitalist development," says Musemwa.

The colonialists settling in Africa hugely influenced the continent's water supply and governance. Race, class, and spatial segregation regularly determined water supply and access. Musemwa, whose research focuses on urban water history, explores these inequalities in his book, *Water, History and Politics in Zimbabwe: Bulawayo's Struggles with the Environment*, 1894-2008, through a comparative case study of white Bulawayo and the African township of Makokoba.

DROUGHT AGGRAVATES INEQUALITY

Bulawayo was established in 1894 for white settlement and industrial development. Makokoba, under white colonial rule, followed a different development trajectory, with scant water resources for domestic consumption and productive use compared to white Bulawayo, says Musemwa.

Historically, Bulawayo was a water-scarce city. This was aggravated by a series of extreme droughts that hit the city and the wider Matabeleland province from 1894 onwards. The simultaneous influx of mostly British settlers and the development of secondary industry resulted in the exponential rise of water consumption in the city.



In response to the growing need for water, the colonial state built more dams to accommodate the influx of settlers. However, these dams only benefitted white Bulawayo and not Makokoba.

"When the dams were built, there was almost guaranteed water supply to the white city of Bulawayo. The state now had to decide who got water and how much. Obviously, white rate payers got the bigger allocation of water, and not Africans," says Musemwa.

While water scarcity for the white population arose because of climate change, for Africans in Makokoba water scarcity was the result of power exercised by colonialists through racial and spatial segregation.

"Political and economic power concentrated in the hands of the white settler state officially shaped the distribution of water supplies to Makokoba," says Musemwa, adding that water colonisation, its governance, and inequitable distribution during the colonial period is not unique to Bulawayo – it was replicated in other Zimbabwean cities and other colonised southern African countries.

A century later and issues around land redistribution are gaining traction in South Africa. Water resource distribution and management issues should be central to the debate, says Musemwa. Despite decades of independence from colonial and apartheid rule in southern Africa, access to water still needs to be decolonised, as it still reflects traces of the colonial water governance framework. ⓒ

(GRACE) UNLEASHES EARTH'S WATER POTENTIAL

BY REFILWE MABULA

A researcher in Wits Geosciences is using Gravity Recovery and Climate Experiment (GRACE) satellites to explore the potential of groundwater as a supplement to municipal water supplies.

Research by Khuliso Masindi, an Associate Lecturer and PhD candidate in the School of Geosciences, evaluates and monitors water resources in the Vaal River Basin. This region covers approximately 198 000 km^2 and straddles the Gauteng, North West, Free State, Mpumalanga and Kwazulu-Natal provinces.

Masindi is using data from the Gravity Recovery and Climate Experiment (GRACE) satellites to quantify and track changes in groundwater storage in this region between 2004 and 2014. The GRACE satellites measure the gravity in the Earth to estimate the quantity of water in the ground.

"A measurement of stronger gravity in the Earth suggests a large volume of water is available, while a weak gravity signal indicates less water,"says Masindi.

GRACE is innovative due to its ability to detect miniscule gravity field variations, says Masindi, which is about 1% of the Earth's total gravitational field. This variation enables the provision of information that was previously unobtainable.

"This 1% is attributed to changes in the mass of the water on and below the Earth surface as a result of seasonal changes and climate changes. GRACE satellites provide a unique opportunity to monitor mass movements associated with continental waters in data-scarce regions such as Africa, which improves prediction of hydrological models and better water management," he says.

The GRACE twin satellites fly at about 220km apart in a polar orbit altitude of approximately 500km. The measurement principle of GRACE satellites is based on accurately measuring the changing separation distance between the two satellites as they encounter strong gravitational pull. The twin satellites are mounted with GPS and microwave ranging systems to precisely measure the position and distance between the satellites.

"A MEASUREMENT OF STRONGER GRAVITY IN THE EARTH SUGGESTS A LARGE VOLUME OF WATER IS AVAILABLE, WHILE A WEAK GRAVITY SIGNAL INDICATES LESS WATER."

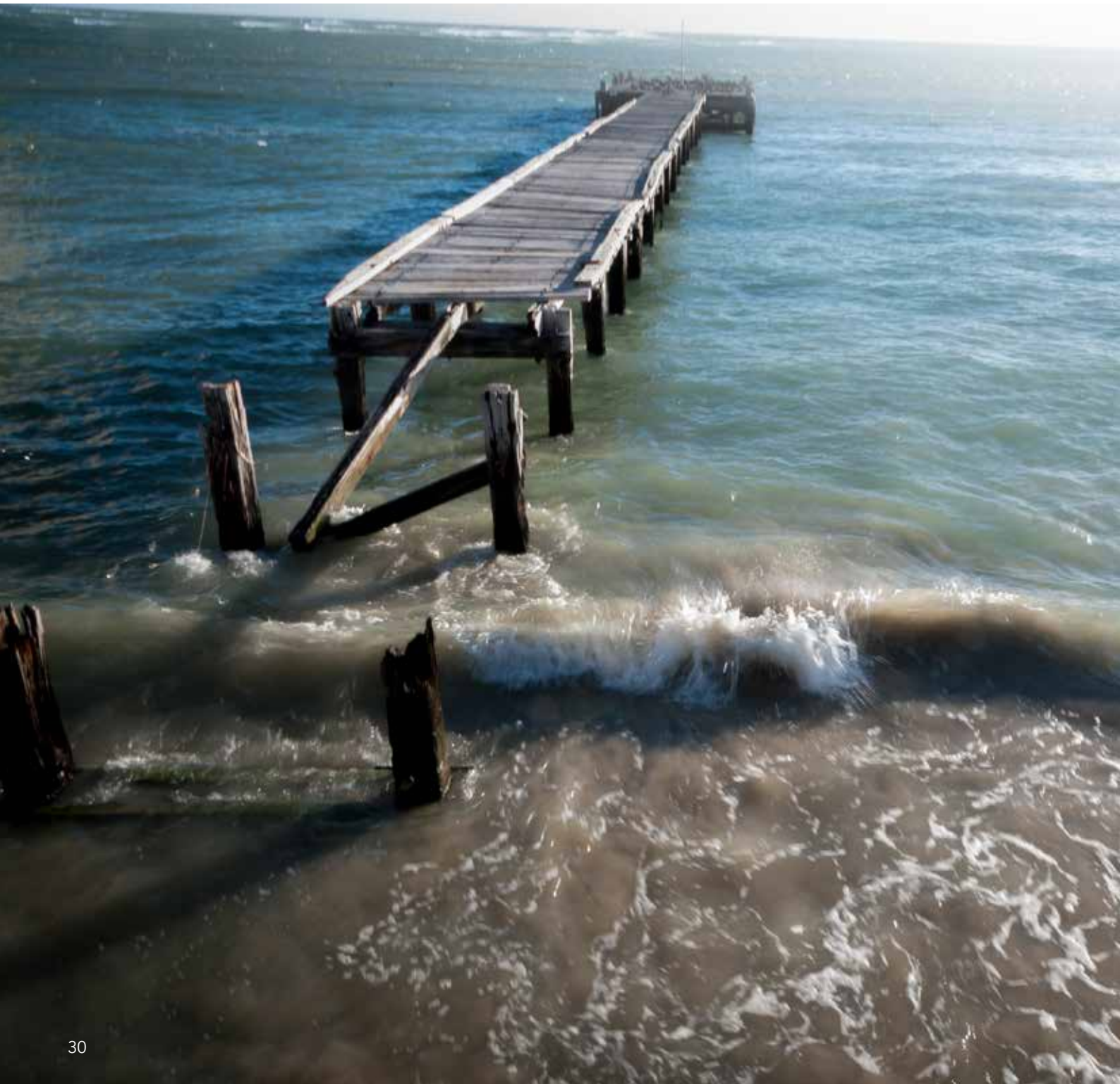
Aside from its advantage of monitoring water storage changes and estimating groundwater storage, GRACE is also the only technology to estimate mass changes caused by continental waters.

"It is cost effective and covers large areas," says Masindi, who hopes to use his research to better understand the hydrological system and develop water management strategies for the Vaal River Basin.

Although the agricultural sector and rural population rely on groundwater for water supply, there is a need to develop groundwater to alleviate the pressure on surface waters, particularly in cities.

"Monitoring and calculating changes in groundwater storage is a prerequisite for water management, which is key in sustaining livelihoods and economic growth," says Masindi.

DIVING DEEPER IN A TIME OF DRYNESS



There's a salty distance between the known and the unknown, as if ocean depths have escaped interrogation despite water, the liquid of life, being impossible to ignore.

BY UFRIEDA HO

Picture: Schalk Mouton

Finding ways to explore water and oceans differently requires a new kind of fluidity, the kind proposed by Oceanic Humanities. This new research and postgraduate project based in the School of Literature, Language and Media at Wits is headed by Professor Isabel Hofmeyr and funded by the Mellon Foundation.

Hofmeyr says oceans are shouting out to be researched by humanities, rather than just from conventional entry points of marine science and engineering.

"Humanities research on oceans has primarily focused on what happens on the surface of oceans, like the backwards and forwards move of people and cargo. We need to go deeper. The oceans are literally getting closer as sea levels rise and climate catastrophe becomes our reality," she says.

It is also imperative that we find solutions to the burdens that our waste has on the oceans, which caused the floating plastic island predicament.

The Oceanic Humanities programme is a platform to tackle wide ranging themes – from finding solutions to our water crisis and reversing our environmental devastation, to exploring hydro-colonisation and the politics of sovereignty claims on mineral-rich sea beds exposed by receding polar ice.

"HUMANITIES RESEARCH ON OCEANS HAS PRIMARILY FOCUSED ON WHAT HAPPENS ON THE SURFACE OF OCEANS, LIKE THE BACKWARDS AND FORWARDS MOVE OF PEOPLE AND CARGO. WE NEED TO GO DEEPER. "

"It's also about slipping under the surface of the ocean to explore things like marine archaeology, or looking at [the impact] of non-human actors like monsoons and cyclones on people and societies. It's re-thinking human entanglement with oceans," she says.

Teaching Oceanic Humanities deserves a shake-up too. Hofmeyr is no stranger to challenging conformity in pedagogy. In 2009 she participated in a project by former Wits students Molemo Moiloa and Nare Mokgotho. They set out to probe the limits of public lectures, the barriers to learning, and the inherent exclusivity of universities and academia. Hofmeyr delivered a lecture – no different from what she would typically give in a classroom at Wits – to random commuters on their everyday train ride between Park Station and Phomolong in Soweto.

Last year Hofmeyr hosted the workshop *Sound on Water* at the Wits Institute for Social and Economic Research (WiSER). It bought together the diverse expertise of a musician, a musicologist, an engineer, and a social scientist. It was billed as "a workshop exploring ways to think with and through water in radically interdisciplinary ways".

The keyword is "interdisciplinary" because Oceanic Humanities seeks to grow connections beyond the limitations of an individual's field. The programme is also founded with strong global south links and emphasises partnerships with Mozambique, Mauritius, India, Jamaica and Barbados.

"It is about learning from each other and [from the] new connections that can change the conversations we are having about our oceans and seas, also our water," says Hofmeyr.

Talking and thinking water in a time of dryness demands collaboration, creativity and innovation. Taking a deep breath and plunging into the murky depths is an invitation to find the clues to make 'human' more resilient, more adaptive, and more respectful of one of our most precious resources. ◘

THIRSTY FOR CHANGE

BY BUHLE ZUMA

As a photographer, swimmer and researcher, Dyani Jeram's life is all about water. She is interested in how companies use and account for water and believes that captains of industry should realise water is more than just a resource to ensure profits for their shareholders.

Dyani Jeram has always been fascinated by water. Whether she is marvelling at the vastness of the ocean or capturing the coastline with her camera, water seems to have a hold on her.

Since the age of 11, Dyani has competed in the Midmar Mile, one of the country's most famous open water swimming races, held annually in Pietermaritzburg, KwaZulu-Natal. The event, which draws thousands of swimmers, has variously been affected by too much or too little water, with participants having to manage varying water levels.

It is little wonder that, whilst working on a project aimed at empowering small urban farmers in Johannesburg, Jeram once again found herself pondering water. Two years ago she had the opportunity to work with farmers belonging to *Izindaba Zokudla* (Conversations about Food), a multi-stakeholder engagement project that promotes urban agriculture and sustainable food systems in Soweto.

The disparities in water supplies to different parts of the community quickly became evident – whilst some farmers had uninterrupted access to water, other subsistence farmers had no reliable water to grow gardens and keep hunger at bay.

"The importance of water to business came from this exposure. My question became: If water could have such an impact at a local level, how then do major companies manage water risks?" asks the Master's candidate at the Global Change Institute (GCI) at Wits, whose research investigates *Water stewardship and resilience in South African businesses: challenges and opportunities.*

WATERED-DOWN PROFITS

Water stewardship means that businesses should adopt a beyond-the-fence approach when it comes to water, and treat it as more than just a resource. They need to see it as an integral part of the environment, society and the economy.

"I am particularly interested in how they [businesses] make use of water and deal with climate change adaptation, how they frame water risks and assess it, who governs water issues, and also the viability of water stewardship and its feasibility for South African companies," says Jeram.

Although South Africa is not the only country facing a prolonged drought – Argentina, Brazil, California in the USA, and Kenya are on a knife's edge and Dublin in Ireland is on high alert – the Cape Town crisis has heightened business awareness in the country.

Analysts predict that the ongoing drought in the Western Cape will slow South Africa's economic recovery. Agriculture, tourism and many other water intensive businesses have felt the impact on their operations and profits. In the face of climate change and drought, water security has become a serious concern.

WHITHER THE WATER?

Due to the complexity of water issues, Jeram is using a multi-pronged approach to measure businesses' relationship with water. As a starting point, she is assessing 40 companies listed on the Johannesburg Stock Exchange that are water intensive, using data from 2010 to 2016.

In addition to using primary data, such as company reports, Jeram is interviewing sustainable development practitioners in major organisations. The National Business Initiative, which is a voluntary coalition of companies working towards sustainable growth and development, has been useful in facilitating contact and easing the data collection process.

An equally important component of her research is to critique the usefulness of voluntary disclosure tools. One such tool is a global water survey administered by international non-profit, CDP (formerly the Carbon Disclosure Project), since 2010. CDP is a worldwide disclosure system that enables companies, cities and governments to measure and manage their environmental impacts. Regarded as the international benchmark, CDP is

Dyani Jeram is a Master's candidate in the Global Change Institute at Wits where she also works as a research assistant to Professor Coleen Vogel. *Picture: Lauren Mulligan*

credited for driving unprecedented levels of environmental disclosure.

Despite such disclosure tools and advances, Jeram believes there is still room for improvement.

"It is important to move away from the tick-box approach to compliance. Companies need to use disclosure tools to bring about change," says the water warrior, whose Master's research will be completed at the end of 2018.

WATER STEWARDSHIP AND PROFITS

Although Jeram is encouraged that companies are making a move towards adopting sustainable practices (with water being just one of many) sustainability departments in companies and their captains struggle to speak the same language, she says. It's a problem of short-term versus long-term gains.

"Most things in nature are long-term. It is sometimes difficult for business leaders to understand the need to change now, when cautioned about their practices. This is why the concept of business stewardship is important," she says.

Johannesburg could see the same problems that Cape Town is experiencing, sooner rather than later, cautions Jeram. The challenges faced by the hospitality industry, for example, which had to mount campaigns to change customer behaviour and attitudes towards water use, highlight these challenges.

It is common to see businesses and schools closing early in Johannesburg when there are water interruptions as a result of infrastructure maintenance and repairs. This reaction, unfortunately, is a sign that the public and businesses are ill-prepared for prolonged water threats.

"We need to change now, so that there is no delayed response when it hits us [Johannesburg]," urges Jeram.

WATER WARRIORS WANTED

For her part, the Lenasia resident tries to educate people about environmental issues and places importance on small changes.

"You don't need to make drastic changes to make a difference. Together, making the small adjustments in our own way can and will contribute towards the change we need," she says.

Jeram considers herself lucky to be working in this field when global attention is focused on climate change and the problem of too much or too little water. Like her name, Dyani – which means "one who gives" – she hopes to make a contribution to water research in Africa.

Her honours research contributed to the City of Johannesburg's Climate Change Adaptation Framework document, led by Professor Coleen Vogel at the GCI. Now Jeram is part of a team of young researchers at the GCI assisting experts in reviewing South Africa's long-term adaptation scenarios.

Using the court to secure WATER RIGHTS

Access to sufficient water is a human right but failures of government often compel people to access this through law.

BY ZEENAT SUJEE

Water is a basic necessity yet thousands of South Africans are living without water. There may be many different reasons for this water scarcity including climate change and droughts, but often it is due to failures of government.

Despite the scarcity of water, Section 27 of the Constitution of South Africa gives everyone the right to access sufficient water. The Water Services Act prescribes 25 litres per person per day as a minimum standard of basic water supply services (or 6 kilolitres per household per month), at a minimum flow rate of not less than 10 litres per minute, within 200 meters of a household and without interruption of supply for more than seven full days per annum.

The Constitutional Court emphasised the state's obligations to fulfill the right to access water. In its judgment on a case brought by Lindiwe Mazibuko against the City of Johannesburg, the Court stated: "At the time the Constitution was adopted, millions of South Africans did not have access to the basic necessities of life, including water. The purpose of the constitutional entrenchment of social and economic rights was thus to ensure that the state continues to take reasonable legislative and other measures progressively to achieve the realisation of the rights to the basic necessities of life."

HOW MUCH IS ENOUGH?

The case of Mazibuko concerned a community residing in Phiri, Soweto. The community challenged the free basic water policy. In 2009, the Constitutional Court dismissed the application, ruling that the requested 50 litres per person per day was not reasonable. The ruling was widely criticised for the Court failing to consider the needs of the community. This case did not deal directly with access to water, but rather with the quantity of water.

GOVERNANCE ACID TEST

Access to water was the focus in the case of the Federation for Sustainable Development against the Minister of Water and Sanitation. The community residing in Siobela, Caropark, Carolina in Mpumalanga had no access to potable water due to acid mine drainage. The municipality installed JoJo tanks to supply the community with drinking water, but failed to refill the tanks. The communities were left with no option but to walk long distances to access potable water.

In this case, the Court ruled that the municipality must act urgently to remedy the violation and ordered that, on an interim basis, the municipality provide potable water to the community and, in the longer term, report on their plans to provide water supply.

YOUR RIGHT TO WATER

TRICKLE-DOWN EFFECT OF POOR GOVERNANCE

The failure of municipalities to provide water, especially in rural areas, has dire consequences. One such case involved five community villages situated at least 30km outside of Marble Hall, Limpopo. The communities stopped receiving water after the municipality shut down a water treatment plant in 2009. The termination of water was unlawful and the community was forced to collect water from a crocodile-infested river, where a child was attacked. Women were violated while collecting water. School children attended school thirsty and with unwashed clothing. Menstruating girls were absent from school.

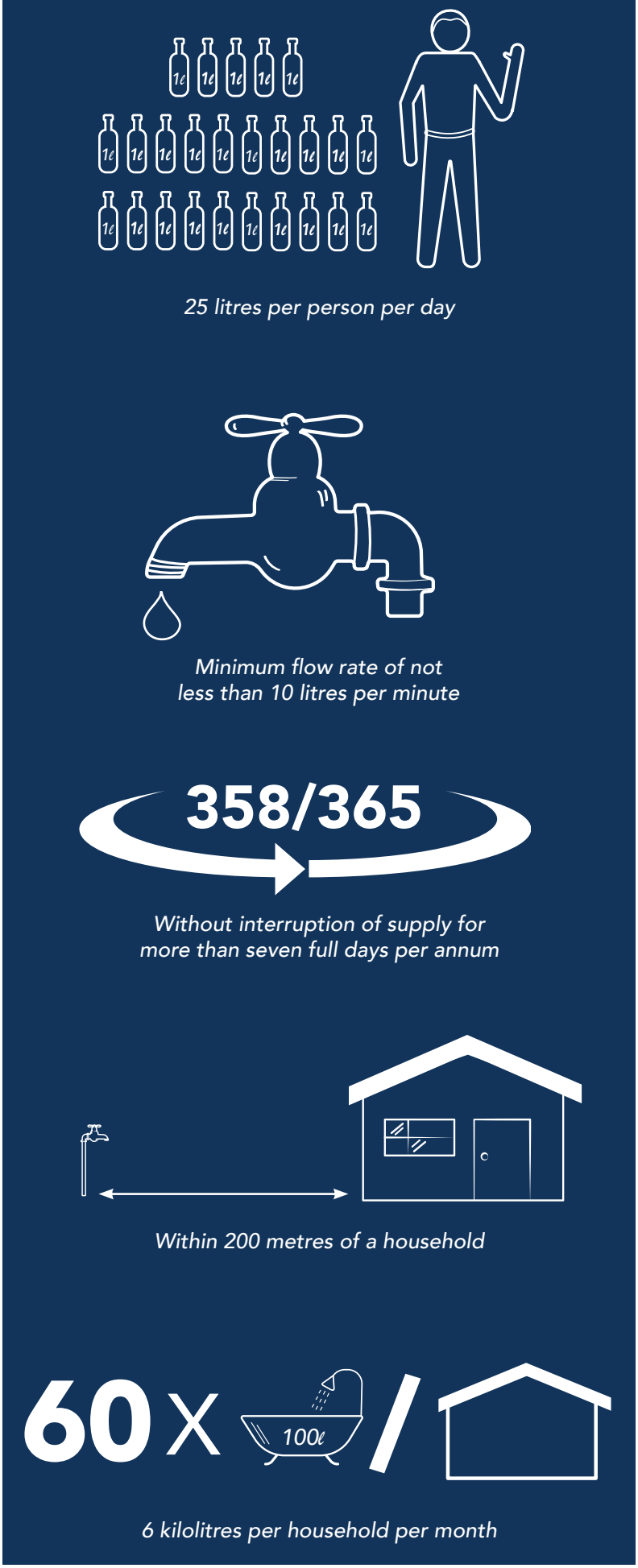
In 2015, these communities, represented by the Centre for Applied Legal Studies (CALS) at Wits, approached the High Court for assistance. Through a settlement negotiation, the Court ordered that water be supplied through JoJo tanks as an interim measure. The municipality failed to comply with the court order. Consequently, CALS initiated contempt proceedings.

The second aspect of the application was to deal with the long-term water supply. In August 2017, Judge Hans Fabricius requested that the parties discuss a workable solution. His view was that the community be treated with respect and that the municipality fulfill its constitutional obligations. Again, the parties negotiated and agreed that the municipality would install more JoJo tanks and deliver water every day. It was further agreed that the municipality would supply water through reticulation twice a week. Judge Fabricius agreed to manage the case.

Again the municipality failed to comply. The community approached the High Court for contempt of court and Judge Fabricius requested that the Minister of Water and Sanitation, Nomvula Mokonyane, intervene. To date, CALS has not received any response from the Minister.

The municipality failed to meet its obligations to supply water in terms of law and it is disappointing that it reacted only once litigation was instituted. Litigation, although not always favoured, is always the last tool – and the only option – for redress when communities have no access to water supply. It is unfortunate that communities must endure a protracted process to secure this basic constitutional right. ⓒ

Zeenat Sujee is an Attorney in the Basic Services Programme in the Centre for Applied Legal Studies (CALS) at Wits. She has litigated in the High Courts and Constitutional Court of South Africa, representing communities in cases concerning access to housing, water, sanitation and electricity. She holds an LLB and postgraduate diploma in Human Rights. She researches the intersection of socioeconomic rights and gender.



WASH
A PIPELINE TO SAVING LIVES

Picture: Shutterstock

Diarrhoea is one of the leading causes of sickness and death in children under five in South Africa. Water, sanitation and hygiene (WASH) interventions could significantly reduce these deaths.

BY DUSCHANKA HITZEROTH

Globally, one in 10 deaths in children under the age of five years results from diarrhoea. In South Africa, it's about one in five children. Research shows that diarrhoea is closely linked to socioeconomic status and has the most adverse effects in South Africa's impoverished communities.

South African children living in poverty are approximately 10 times more likely to die from diarrhoea than their more privileged counterparts. The 2010 General Household Survey (a nationally representative inquiry into the livelihood of South Africans) showed that there were over 60 000 cases of childhood diarrhoea per month, and approximately 9 000 child diarrhoeal deaths in the same year.

Researchers at PRICELESS SA in the Wits School of Public Health investigate how to prioritise South Africa's resources to improve public health, including addressing the high prevalence of diarrhoea. PRICELESS SA is the Priority Cost Effective Lessons for Systems Strengthening South Africa.

"Although diarrhoeal morbidity and mortality cannot be solely resolved through health systems interventions, approximately five million cases of diarrhoea can be averted by 2030 if both health system and other structural interventions are scaled up to full coverage," says Professor Karen Hofman, Director of PRICELESS SA.

Research by PRICELESS SA emphasises the essential requisite for viable water, sanitation and hygiene (WASH) interventions. Dr Lumbwe Chola is lead author of a paper exploring the costs and effects of interventions to treat and prevent diarrhoea in children under five in South Africa.

"The provision of WASH interventions, such as water connection in the home, a better quality water source, improved sanitation, hand washing with soap, and the hygienic disposal of children's stools will prevent more than 50% of the diarrhoeal deaths," says Chola, but points out that more than 90% of the total costs are related to infrastructure to provide safe water and adequate sanitation to millions of poor South African households.

Although South Africa has achieved some of the Sustainable Development Goals related to water and sanitation (90% of South Africans now have access to a clean public water source and over 70% use a latrine or toilet), approximately six million households (46%) remain without access to piped water in their homes and 1.4 million households (11%) still lack access to sanitation services.

Challenges to uniformly implement home water connections and improve sanitation across provinces remain. In the Eastern Cape, the number of children with access to sanitation services has tripled to 82% since 2002, but in Limpopo only 50% of children have basic sanitation.

Income and wealth also play a significant role. For example, in 2015 close to 50% of South Africa's poorest children lived in a household with water on site compared to 96% in the richest quintile.

PRICELESS SA used UNICEF's LiST – the Lives Saved Tool – to show the potential number of lives that could be saved and the marginal cost of doing so. The Lives Saved Tool is software that estimates the survival of mothers and children.

All 13 interventions to prevent diarrhoeal deaths range between an extra R90 and R180 per capita while the WASH interventions would require an additional investment ranging from R80 to R150 per capita, per year.

Chola says, "All these estimated intervention costs can potentially guide policy and budget planning. Considering South Africa's health budget [R205.4bn for 2018/19], the cost of scaling up all 13 interventions should be within arm's reach." ©

BIG BANG, **WATER,** LIFE

We have had some tyrants in our time but not until the last century or so have we ever come up with the idea of taking a dump in our own drinking water.

BY SIMON GEAR

We are the product of an infinite number of existences. We have evolved in a Universe that happened to have just the right balance of Newtonian and quantum forces to not fly apart or collapse. There have likely been billions of Universes that have blown apart, until one day when a Universe Big Banged and happened to be just right to support life.

We live in a Universe where all the physical laws are set just right for it to be able to last the tens of billions of years necessary for interesting stuff to happen. In addition to all that, there is one other quirk of our Universe that makes life possible. Our Universe contains water.

The water molecule has a range of weird qualities. It is shaped like one of those odd, chopper tricycles we rode as kids – two small electro-positive hydrogen atoms at the back, and a big old electro-negative oxygen atom at the front. This gives it some interesting characteristics.

For a start, it allows water to be the universal solvent. Without that, life is stopped in the starting blocks. It also allows water to have a relatively narrow, three-state space, which is why it is the only substance that we observe as a gas, liquid and solid in our daily lives. Not only that, when it freezes, it should become denser and sink. But because of the crystalline structure it forms, it lightens up, so ice floats. Without this property, fairly early on in Earth's history, the oceans would have frozen from the bottom up and none of us would have ever happened.

So here we are at the transect of three of the most amazing flukes in all of space-time: Physical laws that allow all of this to happen; a molecule that makes life within our little corner of the Universe unbelievably sublime; and finally, through a multi-billion-year process, the organisation of countless other little molecules into sacks of stardust that can actually think for themselves (that's us).

IT'S TIME WE STARTED TO APPRECIATE WATER, NOT AS AN INDIVIDUAL CUP BUT AS A FLOW THAT PASSES THROUGH US AND OUR LIVES.

We are the Universe's chance to know itself. Or, if you are from the artier parts of Braamfontein Campus East, we are the eyes through which God surveys his creation. And how do we deal with this magical moment? We take great care to clean the most astonishing life-giving stuff that ever existed, turn it into the most gorgeous of elixirs, and defecate daily in it.

This is not necessarily illogical but may prove that we are not the main drivers in our own evolution, or indeed, the Universe's greatest achievement. Rather, this may show that the world and everything around us, is controlled by our gut bacteria – or, as my Dad (one of the many Gear family Wits alumni) loves to point out, "The chicken is the egg's means of reproducing itself".

Certainly, the bacteria that live within us play a vastly more complex role in our lives than is currently recognised. Despite the obvious things like balancing our digestive regime, they have been proven to influence our mood, our propensity for putting on weight, and even our food cravings. Is that really who we are? Mammalian vessels for a bacterial joyride? Perhaps. But I say let's fight back! Let's celebrate our roles as observers of the Universe, as Creation's mind, eyes and ears. We have a responsibility to our partner in this endeavour – the mighty and magnificent, if not truly magical, dihydrogen monoxide.

Unfortunately, we cannot deal with any of this on the cosmic (or even, humiliatingly) the gastric scale, but we can control what is in front of us. I was lucky to work frequently with the world-famous conservationist and environmental statesmen, Dr Ian Player, in the last few years of his life. There is one point he made that has stuck with me for a decade: "At what point," he mused, "did we just come to accept that you can't drink river water?" Here we are, on a beautiful, blue-green jewel, suspended, mind-bogglingly many miles from anywhere else useful to our purpose. Our little planet is awash with the one liquid that can make us happen, yet, in familiarity breeds contempt.

It's time we started to appreciate water, not as an individual cup but as a flow that passes through us and our lives. It should enter our houses from the sky or be piped in as the best drink there ever was. It should circulate through our kitchens, through our showers, and only then, finally, have a pass through our toilets. After that, let it continue on its journey into our gardens or back into the city's pipes to be cleaned and returned to us again. ©

South African cartoonist, D.C. Boonzaier, depicted Capetonians queueing for water over 100 years ago.

WHAT MAKES WAVES IN WATER CRISES?

Water problems are in large measure problems of people and organisation, not problems of engineering.

BY MIKE MULLER

Since I am a professional engineer and have spent most of my career working in the water sector, people are sometimes puzzled when they learn that I am based at Wits University's School of Governance. But I explain that much of the business of managing water happens in the public sector and that many of the problems we face are more the result of poor governance and management than any water shortage. Consider Cape Town, where the hapless water engineers have politicians from all three spheres of government trying to tell them what to do.

Water problems are in large measure problems of people and organisations, not problems of engineering. The planning and engineering we can do, if only we were allowed to get on with it. But have some sympathy with the politicians. They face three challenges.

The first is simply that planning, developing and managing water resources for large cities are complex tasks. Second, it often requires coordination between a range of different organisations, which often have no accountability to each other and may not even want to work together. Finally, the process often requires decisions to be taken 10 years or more before the water is actually needed.

On the first count, water is a difficult resource to come to grips with, literally and figuratively. It is required in very large quantities – to meet government's minimum standards, 6 000 litres of water (that is 6 metric tonnes of water) have to be delivered to each household in the country every month, reliably. To store, treat and transport such large volumes, large public infrastructure of reservoirs and pipelines are usually needed. Except in coastal cities using expensive desalination, that water is derived from rain, which fills streams and rivers and seeps into underground aquifers [an underground layer of water-bearing permeable rock].

Our rainfall varies dramatically and cannot be predicted from one week to the next, let alone from one year to another; the flow in rivers is even more uncertain; the threat of climate change

introduces more unknowns. Yet modern societies need a reliable water supply for households and the economy.

To respond, the engineering professions, supported by scientists, climate scientists and statisticians use historic data on rainfall, river flows and underground resources to predict possible water futures. They estimate how much will be available at a given level of reliability – typically, for urban supplies, it should only fall below requirements once in every 50 years. If the likely demand and how it will grow can be estimated (which depends on population and economies, as well as whether people's water use habits change, and how effectively suppliers manage water losses), then supply options can be identified.

Usually, the recommendation is made on the basis of cost – it makes no sense to adopt an expensive option while cheaper ones are available. So, for Cape Town, over a decade ago it was recommended that a further river diversion be built on the Berg, followed by development of the groundwater of the Table Mountain aquifer and then the construction of plants to reuse some of the wastewater that, after treatment, was just flowing into the sea. That was expected to get the City to 2030.

"OUR RAINFALL VARIES DRAMATICALLY AND CANNOT BE PREDICTED FROM ONE WEEK TO THE NEXT."

That brings us to the second problem. Someone must then decide what to do next and how to pay for it. Except in small communities, this involves a range of different organisations which have to come to an agreement about how to proceed. In Cape Town's case, water comes from well beyond the City's boundaries. National government has historically built and connected some of the larger dams on which the City currently depends. But they will not do this unless the City agrees to take the water – and pay for it. And, as it happens, about a third of the water from what they call the Western Cape Water Supply System is used by farmers. The provincial government is responsible for looking after their interests, so all three spheres of government are involved.

How do you get all three sets of organisations – and their often fractious stakeholders – to agree on a programme of action? They all need to have confidence in the technical recommendations but, inevitably, they also have different agendas and interests. Farmers want more water at lower prices; in Cape Town, many of the better-off citizens object to big infrastructure which, they say, spoils their environment; for good reasons (efficiency) or bad (potential profits) national government actors might prefer to build a dam, which they control, while the municipal officials would rather reclaim wastewater in its own facility.
So there is plenty of scope for disagreement, which leads to

"THERE WILL BE A WATER CRISIS UNLESS WE CHANGE THE WAY WE MANAGE OUR WATER."

the third problem, the time frame. Most politicians think short term, at best from one five-year electoral cycle to the next. But major projects, from planning and design and construction and commissioning, can easily take twice that. This offers little incentive to political actors to take a decision and the temptation to procrastinate is strong.

A century ago, Cape Town was running out of water as demand exceeded the supplies from springs on Table Mountain. "Will it come to this?" asked a Boonzaier cartoon in 1918, showing a queue of (white) people with buckets in front of the City Hall. At the time, the local village councils were dithering about whether to cooperate to build the Steenbras Dam or one at Wemmershoek.

Around 2000, there was a similar argument (and delay) around the building of the Berg River Dam, which is currently saving the City from itself. In 2018, work began on projects that were recommended, 10 years previously, for completion by 2017. And, because it is being done in a rush, costs are far higher than they need to be. Meanwhile, drought restrictions have cut water revenues, adding to the City's financial burdens.

The Cape Town story illustrates well the conclusion to which water professionals have since arrived: There will be a water crisis unless we change the way we manage our water. My interest is to understand the theoretical issues implicit in that simple statement. At a large scale, I look at approaches to cooperative federal government; at a small scale, at the institutional economics of Nobel Prize laureate, Elinor Ostrom (known for her work in natural resource management and common pool resources), which verges on anthropology. Interesting approaches to 'network governance' may help different institutions to work together.

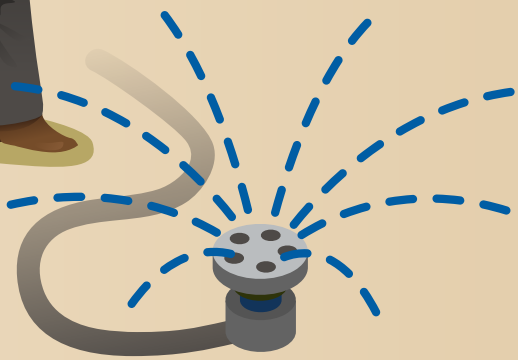
Meanwhile, the technicians increasingly use their complex system models as a framework for discussion to help politicians and other stakeholders understand the issues. The challenge is to turn that theory into practice. ©

Mike Muller is a Visiting Adjunct Professor in the Wits School of Governance. He is a civil engineer with extensive experience in strategic public and development management. As Director General of the South African Department of Water Affairs and Forestry (1997-2005), Muller led the development and implementation of new policies, legislation and programmes in water resources and water services. He now undertakes research on the role of water resource development and management in regional integration in Africa.

THE GOOD THE BAD AND THE DIRTY

Lessons unlearnt from a week in dry Cape Town

BY SCHALK MOUTON



He bent down. He grinned. Of the two teeth in his mouth, one was rotten. The other broken in half.

"Welcome to my humble little abode," he breathed in a strong Afrikaans accent. I couldn't exactly place the smell, but it was definitely not of something recently alive.

It must be a dream … I thought. No, A nightmare!

"Just don't drink the water … because there isn't any!"

He threw back his head and cackled at what I hoped was a joke. The laughter reverberated through the dry Cape Town air, crackling into oblivion … the sound mixed in a strange melodramatic way with the beat of a Pink Floyd song that played on a cheap set of speakers somewhere in the distance.

The sound wafted off. The reek lingered. Pink Floyd wailed. I knew this was real.

I had landed in Cape Town several hours earlier. I was tired, hot and sticky, and just wanted a shower – especially after emerging from the cubicle in the restroom at the airport and reading a sign on the mirror saying that the taps were switched off due to the drought.

"It is MY water," the owner of the Bed 'n Breakfast that I was checking into said, at pains to explain that he had just installed a R200 000 borehole on his property. "Especially the hot water. Don't use it," he said, a crooked smile on his face failing to disguise the seriousness of the underlying threat. I was born and grew up in

Springs and so, by birth right, I can instinctively distinguish between an empty threat and a promise of extreme violence. I instantly decided not to shower for the rest of the week. Unlike a threat from the 150kg mass of meat that I came to call "The Landlord", a little bit of grit would not get me down.

Earlier, on the plane to Cape Town, I'd felt uneasy, uncertain, and even a bit scared, even though I didn't dare to show it. The last time I felt like that was when I was being smuggled into a war zone. We were travelling, at first, on the back of an old, rusty trailer pulled by an antique Turkish farm tractor. Then, dumped into a large cut-open diesel tank that served as a makeshift ferry that smuggled our group of journalists across the river that serves as the border between Turkey and Syria. This all while watching incoming artillery shells hitting the cliffs of the mountain that towered over the village we were headed to.

But I was not heading to a war zone, or even a different country. This was the Republic of Zille. The idyllic resort of the rich and famous. The playground of the fantastic. The destination of choice for all those Gautengers who are dying to emigrate, but can't afford it. A world of absolute abundance … but without any water …

Amidst all the talk and hype about the now infamous Day Zero, I was now deep in the belly of the beast.

Everything in Cape Town is about the current water shortage. Politicians implore "Team Cape Town" in radio advertisements to work together to avoid "Day Zero". Radio talk show hosts share water saving tips – and, more importantly, like traffic updates, provide information on which stores in which areas still have water in stock. At the time, *News24* reported that searches for "compost toilets" and "Day Zero" dominated Google searches in Cape Town. It was on my third day in town that I spotted the "No Shower Sunday" poster for the first time. By then, I had not showered since I had arrived and was desperately anticipating the coming Sunday, when I would return to Joburg and be able to shower. As the week progressed, I noticed fresh-looking Capetonians wearing designer sunglasses turning up their noses and suspiciously sniffing the air as I crossed their path.

It was on the same day that I had decided to go for a run on the beach. It was a beautiful, yet slightly windy evening, and after a number of days stuck in a conference room, perfect to get some exercise. This, as I see it, was my first big mistake – I got thirsty. And sweaty. And even smellier, which led directly to my second big mistake: As Capetonians must do, I thought, I went for a "shower" in the sea.

The water was beautifully temperate, the scenery unbeatable. The sun was setting in the distance in a perfectly blue sky and the Mountain squatted comfortably on the horizon. A herd of kids enjoyed the waves and their surfing lessons while their moms lined the beach, chatting.

I expertly ducked the first wave. I gulped a mouthful of salt water as the second one slightly dunked me, but the third – a massive wall of water of over 2 feet high, I kid you not – rolled me out onto the beach and dumped me at the feet of surfing moms who didn't even bother to hide their little sniggers.

Back at the B&B, I snuck in through the back yard-gate, trying to avoid The Landlord, who was lazily watering his lawn in the setting sun, while quietly whistling the tune from *The Good, the Bad and the Ugly* past his half-smoked cigarette. (Can't he at least try to avoid the clichés, I thought).

"They [the City of Cape Town] just announced regulations for borehole usage," he spat at me, after trapping me in a corner. "It is MY water. I'll be damned if I let my business go down because of someone else's incompetence [to manage water]!"

On the plane back to Joburg, I had a pencil stuck deep in my ear, trying to reach a stubborn clump of sea sand that I have had an ongoing wrestling match with for the previous couple of days. At first, I did not hear the woman's voice, but I caught it in the echo.

"The drought is just terrible, don't you think?" she said, sipping on her bottle of Valpré. I tuned out her monologue after about 15 minutes, more interested in listening to the sound of the ocean stuck inside my ear.

Yes, I thought, the drought in Cape Town is terrible. But it is also ironically beautiful. It gets politicians talking, scientists thinking, the media writing and the consumer at least thinking of saving. Throughout my stay, I saw a number of trucks carrying rainwater containers and delivering them to houses.

There have been serious droughts in provinces like Limpopo and the North West for the past 10 years, but, because they aren't global tourism destinations, there has never been a "Day Zero" for them.

Also, nobody really owns water. People believe water is their personal property but no-one wants to take responsibility for it. No one takes ownership of taking care of water while we've got enough of it, but everyone will guard to the death what they believe is their share, if there is a shortage.

Cape Town demonstrates the new normal that we are going to have to get used to. Water has been a serious issue for South Africa for a long time, and it is going to get worse. We need to think much more carefully about how we treat water and deal with water issues – including sanitation.

Water – and the situation in Cape Town – is not a joke. But it is the start of a hopefully enduring conversation.
As a sustainability researcher once told me: "Everybody likes a good drought!" ©

THE 180-MILLION YEAR OLD QUIRK

BY PROFESSOR TERENCE MCCARTHY

The story of why rainfall at Wits dispenses to the Atlantic and Indian Oceans respectively is a tale as old as Africa itself.

Wits University is located right on top of the watershed that divides the Limpopo and Vaal-Orange river basins. This means that rainwater that flows off the front roof of the Great Hall discharges into northerly draining rivers, ultimately entering the Indian Ocean via the Limpopo River. Rainwater flowing off the back roof, however, flows southward into the Vaal River and is ultimately discharged into the Atlantic Ocean via the Orange River.

This quirky watershed was created hundreds of millions of years ago when the Supercontinent, Gondwana, broke into the continents of Africa, Antarctica, Australia and South America.

The separation of southern Africa from South America to the west and Antarctica to the east resulted in two very asymmetrical drainage systems: The Karoo-Kalahari River System rises far in the east, almost on the eastern escarpment, and flows westward across Africa to discharge into the Atlantic Ocean. The Zambezi-Limpopo System in the north rises along the western escarpment and discharges into the Indian Ocean.

The Limpopo River of today is a small vestige of what it used to be. In the Cretaceous Period (before 65 million years ago), its tributaries included the upper Zambezi, Kafue and Okavango Rivers, and it was the main drainage of southern Africa. It is for this reason that the Limpopo Delta is the largest on the African continent. At that time, the ancestral Orange River (the Karoo River) discharged into the Atlantic Ocean much further south than it does today (near the mouth of the Olifants River), and what is today the lower Orange River was part of a separate river system named the Kalahari River.

These ancient river systems have undergone substantial adjustments since the Cretaceous Period. Crustal warping, (which is the bending of sedimentary strata), severed the upper Limpopo from its tributaries (upper Zambezi, Kafue and Okavango rivers), resulting in the large Lake Makgadikgadi.

The lower Zambezi cut inland and progressively captured the Luangwa, Kafue and Upper Zambezi rivers. Consequently, the size of Lake Makgadikgadi was greatly reduced. In the south, the Kalahari River captured the Karoo River to form the modern Vaal-Orange System.

Notwithstanding these changes, the original drainage asymmetry and the Wits watershed, implanted in time immemorial when Gondwana broke up, remain evident today.

Terence McCarthy is Professor Emeritus of Mineral Geochemistry in the School of Geosciences. He has wide research interests in the earth sciences, including economic and environmental geology, geochemistry and geomorphology, and is a leading expert on the geology of wetlands, especially the Okavango Delta in Botswana. For more on why water from Wits flows to two oceans, read The Story of Earth and Life: A Southern African Perspective on a 4.6-Billion-Year Journey, *which he co-authored with Professor Bruce Rubidge in the Centre of Excellence in Palaeosciences, as well as* How on Earth? *by McCarthy and Professor Bruce Cairncross.*

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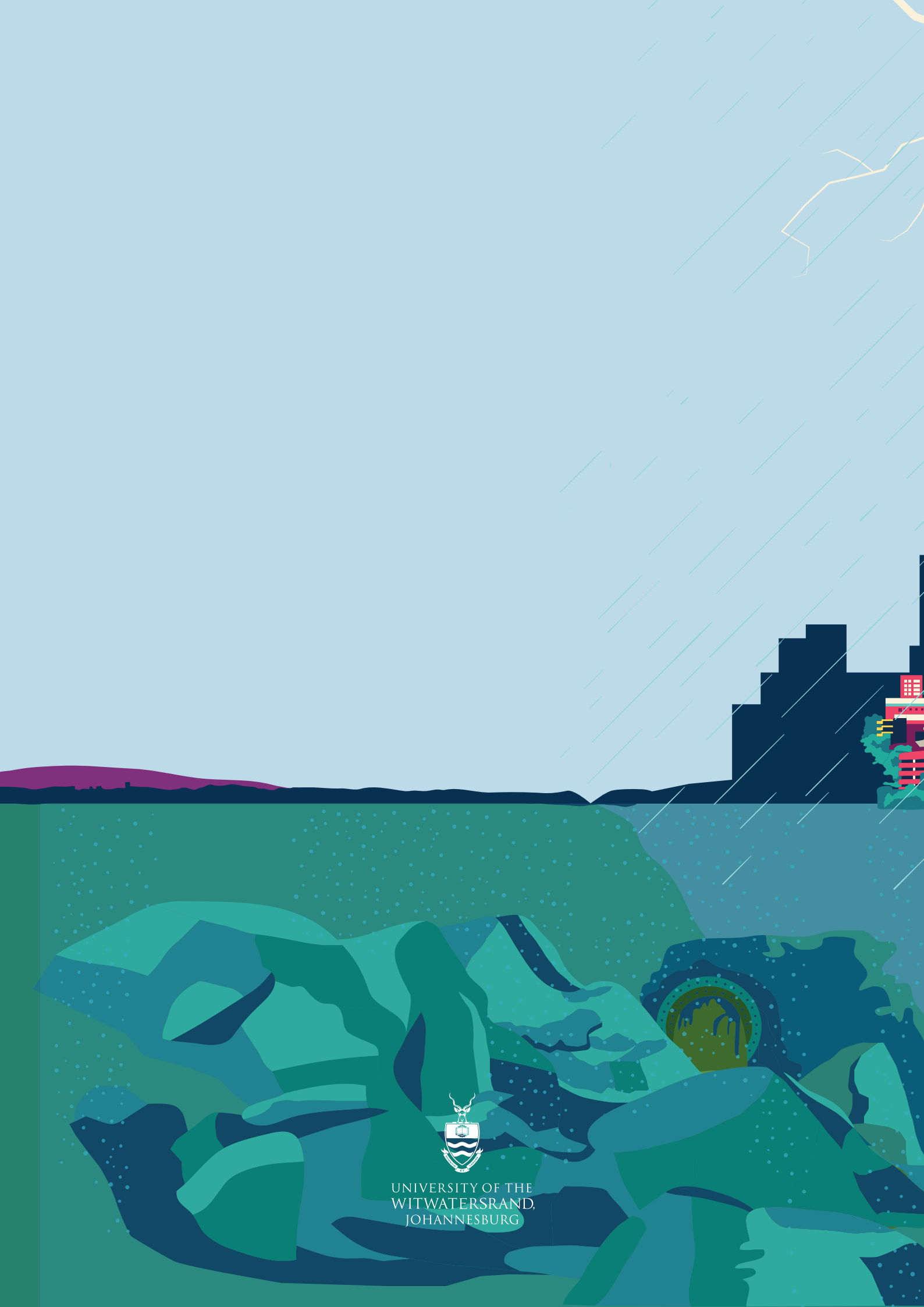
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