THE WATER WHEEL

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AGRICULTURE AND WATER

South Africa's agricultural water scenarios: The future we choose?

WATER AND HERITAGE

Saving sacred waters: The future of Mohokare Valley sacred sites and water resources

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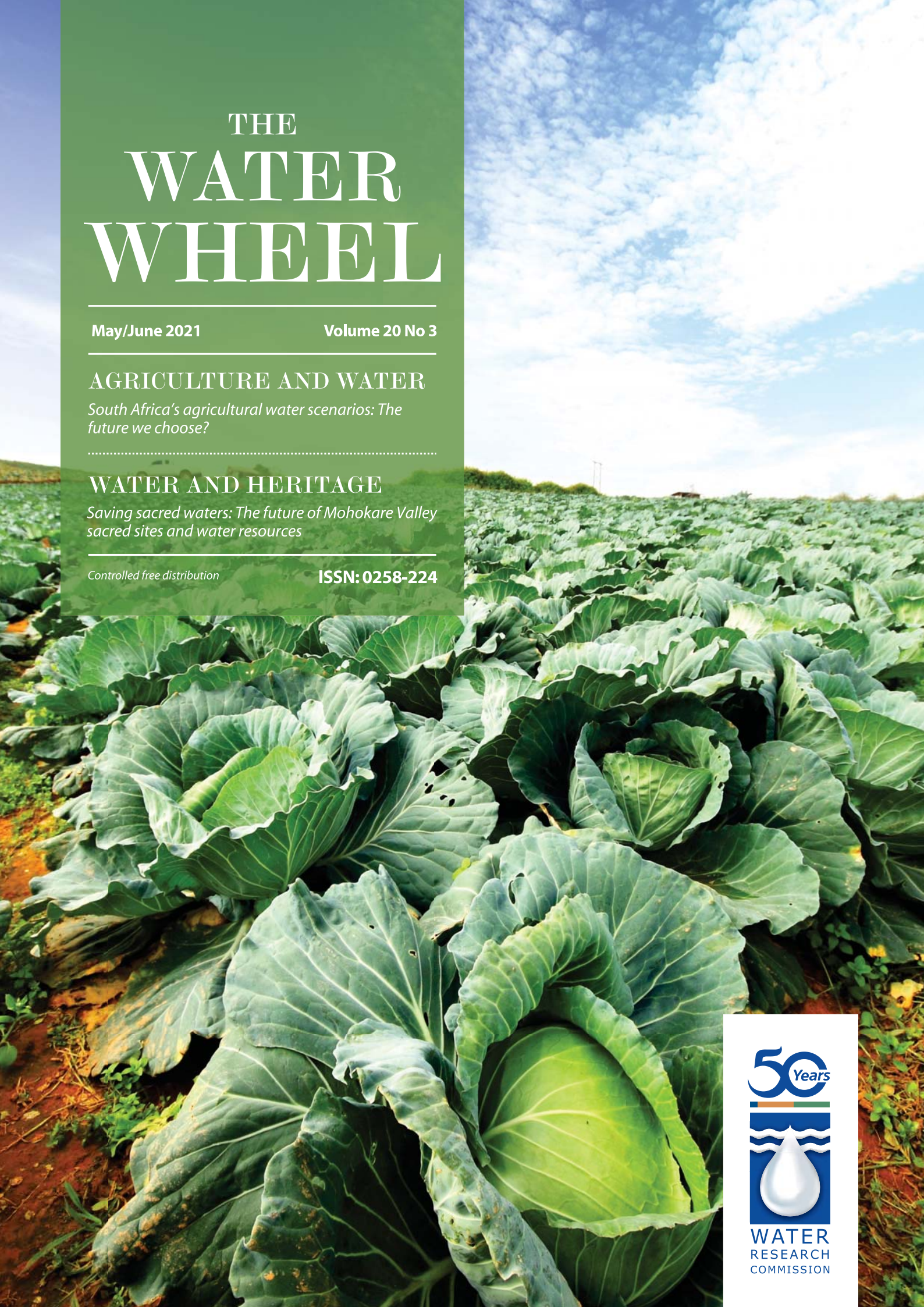

50 Years

WATER RESEARCH COMMISSION

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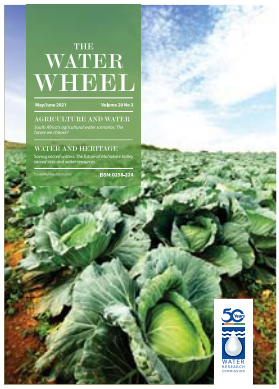

A Water Research Commission-funded project investigated various water futures for South Africa's agricultural sector to adequately inform policy responses and adaptation practices.

FLUID THOUGHTS

WRC CEO, Dhesigen Naidoo

Finding spring in the heart of winter

The following message was conveyed at the 2021 graduation of MSc students at IHE Delft.

The year 2020 was almost uniformly, across the world, a Global Winter Of Discontent. We are still greeted on a daily basis by the updates of the COVID-19 pandemic's new infections and mortality numbers reminding us that in spite of a vaccine roll-out in most parts of the world, we are far from declaring a decisive end to 21st century plague. In fact, the hope that 2021 will be the last year of the epidemic is seriously in doubt.

And the other three horses of the modern apocalypse show little sign of abating. The first is the global climate crisis. We have been on a downward slide since Kyoto, with a renewed glimmer of hope in Paris. We then had to endure four very hard years as the fossil fuel lobby almost succeeded in relegating the Paris Agreement to the dustheaps of history. In fact, in these years the climate crisis led a quartet at the top of the World Economic Forum's Global Risk Register, a perception survey of the leadership of the global economy.

The other three members of this quartet are extreme weather events, biodiversity loss and the water crisis. The latter refers to overall water security, quantity and quality dimensions as a primary constraint to development and the attainment of the United Nations (UN) Sustainable Development Goals (SDGs) on the one hand. And the local, regional and global general security and conflict matters on the other. The implications of water geopolitics in a weakened multilateral water diplomacy environment are a cause for great concern.

At a much broader level, this is, in fact, the third horse of the apocalypse, the very weakened, highly fractured multilateral system. This is in the political arena, the development arena, the domain of global human rights, and the domain of international justice. The global trade system has in recent years fell into a deep gorge of trade wars; the United States-China trade conflicts have hogged the headlines, but this has been replicated in varying degrees across the world. Rounding off this is the deepening economic crisis. The pandemic called a halt to every level of economic activity everywhere in the world. The impact has been devastating, plunging the global growth rate close to the margins of an unprecedented -10%. This winter is dark, cold and hard.

But, the most dismal of winters always gives in a warming, a thaw, a rejuvenation – a Spring of Hope. Class of 2021, this Spring of Hope operates in three distinct theatres of operation. The first is the political arena. January 2021 kicked off with the Climate Action Summit. Hosted by the Netherlands, it was attended by 30 global leaders, 50 ministers and leaders from business, labour and civil society and youth leaders. It set out the aspiration of a global adaptation agenda on the one hand, and potential resurgence of a revived spurt of multilateral action on the other. UN Secretary General, Antonio Guterres, set out the call for 50% of climate finance to be redirected to adaptation actions holds great promise for water and sanitation development.

"The only way we are going to get close to the SDG 6 targets by 2030 is on the back of smart new innovations in water and sanitation."

The second arena is economic recovery and development. The World Economic Forum convened virtually for its January 2021 meeting under the banner of "The Great Reset". A powerful acknowledgement from the joint leadership of the global economy of the destructive nature of the current fossil fuel driven trajectory of the world's economic apparatus, and the need to the Great Reset. A rest in the direction of sustainable development, a stemming of biodiversity loss, a decline in the world's fossil fuel addiction and, perhaps most importantly, striving toward a less unequal world. Actions have followed rapidly, with major investment funds declaring a timeline on their exit from fossil fuel based and high carbon enterprises. A concrete example is Sweden's $37.5 billion pension fund which has recently withdrawn its high carbon investments worth $4.5 billion and will certainly catalyse a movement by its partner funds. A redirection of investments are not only for the corporates, but as the Economics of Biodiversity review led by Prof Partha Dasgupta points out, we must all exercise and mobilise our individual agency in this domain, as we know in the water world "every drop counts".

The third stage is yours class of 2021 – that of science and innovation. The only way we are going to get close to the SDG 6 targets by 2030 is on the back of smart new innovations

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in water and sanitation. We have to turn over the current constraint of trying to solve 21st century water challenges with 20th century technologies and 19th century operating rules. We have to take advantage of the new knowledge and innovations contributed to by this very 2021 IHE Cohort as the means to empower the political declarations and provide a toolbox to achieve the economic aspirations that are being expressed at the various pulse points, including the World Bank/IMF Spring meetings convened under the banner "Economic recovery: toward a green, resilient and inclusive future". This space has to transition to diversified water sources world operating in a One Water paradigm with recycling and reuse teaming with high demand efficiencies and point-of-use quality solutions. This will be accompanied with the 4th Industrial Revolution toolbox of digitalisation, automation and enhanced intelligence solutions. We look forward to the required investments in the potential already laboratory proven water-energy-food nexus solutions. All this with an enlarged cohort of water and sanitation practitioners – in number, representivity and discipline for the ideal 21st Century Water Team.

To conclude, UNESCP IHE Class of 2021, let me reflect on some characteristics of this special resource water and the lessons they hold. Lao Tzu, the founder of Taoism in the 6th Century BC reflected that "nothing is softer and more flexible than water, yet nothing can resist it". To underestimate water interventions and its impact on society – both positive and negative - would be a serious mistake. The second is the acknowledgement that water is a great carrier of energy, as we observe in great storms and tsunamis, and yet its real power lies in persistence. Those great gorges caved by rivers bear testament to this quality of perseverance. In the water sector, with its great conservatisms and technology lock-ins, you as the young leadership will have to express much of this characteristic to turn around our global and local water challenges. The third characteristics I wish to cite is for me the most endearing one. Hydrogen bonding. This unique property allows water molecules to connect and collaborate in partnership while still in a high energy liquid state. This affords an unbelievable strength as anyone that belly dived into a swimming pool can attest. In this great quest to future water prosperity, the partnerships and collaborations built inside the water sector and between the water sector and various others – horizontally and vertically as with H-bonding will be a key to success.

IHE Class of 2021, you are the lead company in the Spring of Hope battalion. The current leadership and water practitioners look to you as the catalyst for positive change. Congratulations on your phenomenal achievements and good luck in the journey to build back better, build forward greener and help us get to a resilient, and more equal world.

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NEWS

SU warns against the reuse of laundry greywater following study

For the sake of the soil in which your plants must grow and thrive, think twice before deciding to reuse laundry greywater in your garden. If you really want to use it as part of your greywater system, at least then choose liquid washing detergent over washing powder, as it still degrades the soil, but not as much. That is the message from soil scientists at Stellenbosch University (SU), who published the first ever comprehensive research on the topic in the ***Journal of Hydrology***.

The study was led by Dr Ailsa Hardie of the Department of Soil Science in the Faculty of AgriSciences at the university. It is based on the MSc work of one of the co-authors, Ncumisa Madubela. Dr Cathy Clarke and Vink Lategan, also of the SU Department of Soil Science, contributed to the study.

Laundry greywater is one of the largest and easiest sources of greywater to reuse, as it simply requires extending the washing machine drainage hose, whereas direct access to drains is required for reusing other sources such as bathing water. It, however, has its drawbacks.

"When Day Zero loomed for Capetonians, many admirably responded by reusing greywater to irrigate their gardens. While it serves to keep some of plants alive, the reused laundry water isn't benefitting the soil in which they are planted," says Hardie. "The same chemicals in washing detergent that strip dirt and grime from clothing also strip beneficial humus from the soil. Humus is the best part of the organic matter in soil, and contributes to its health, fertility and water holding capacity," she explains.

This "stripping effect" causes clay particles in the soil to disperse and blocks soil pores. This, in turn, causes a crust to form on the surface that seals the soil.

"It becomes difficult for water to soak into soils and increases runoff when it rains or when you water your garden. In essence you are then actually wasting water, because in time very little water gets to penetrate into the soil to reach plant roots," says Hardie.

The blocking of soil pores also decreases the water holding capacity of soils. In times of drought this makes soils even drier. Soils become increasingly saline (brackish) and alkaline.

"Plants cannot thrive in such soils, or take up water and certain essential nutrients," explains Hardie. "The degradation sets in from the very first addition of laundry greywater to your soil. In time, it becomes very difficult to fix."

During the course of the study, it was found that powdered laundry detergent greywater is far more harmful to soils than liquid laundry detergent greywater. This is because of the difference in their main chemical ingredients. Washing powder is very alkaline (pH 9-10) and contains a lot of sodium carbonate, while water is the main ingredient of liquid detergents. Both types contain a host of ionic and non-ionic surfactants, ion sequestering agents, bleaching agents and enzymes that help to remove soil and grime from fabrics.

"It makes sense that by their very nature detergents would also therefore degrade and strip soil when used for irrigation," explains Hardie. "Powder detergent greywater should not be used to irrigate soils due to its aggressive soil degrading qualities. Liquid detergent-based greywater should be used cautiously," says Hardie.

The study was conducted using soil samples from Cape Town and Stellenbosch, and showed that certain soils are more susceptible to the negative effects of washing powder-based laundry greywater than others. "We found that sandy soils are the most susceptible to the stripping effect that washing powder greywater has on soil humus," says Hardie

To access the original journal article, visit: https://doi.org/10.1016/j.jhydrol.2021.126059

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New CEO for the SA National Biodiversity Institute

Cabinet has concurred with the recommendation by the South African National Biodiversity Institute (SANBI) Board to appoint Shonisani Munzhedzi as the CEO of the entity.

Both the Minister of Forestry, Fisheries and the Environment, Barbara Creecy, and Deputy Minister, Makhotso Sotyu, have welcomed Cabinet's concurrence of Munzhedzi's appointment.

"Munzhedzi's appointment comes amid the public consultation into the Revised National Biodiversity Framework 2019 to 2024, which is an important policy instrument for the management and protection of species and ecosystems. SANBI is closely involved in the preparation of the National Biodiversity Framework, and a bioregional plan or biodiversity management plans," the Department of Forestry, Fisheries and the Environment said in a statement.

SANBI, an entity of the department, contributes to South Africa's sustainable development by facilitating access to biodiversity data, generating information and knowledge, building capacity, providing policy advice, showcasing and conserving biodiversity in its national botanical and zoological gardens.

"Munzhedzi brings with him a wealth of experience, having most recently served as the Deputy Director General: Biodiversity and Conservation in the Department of Forestry, Fisheries and the Environment. He has served in numerous environment and conservation portfolios in his more than 26 years of experience in public service. This has included serving the department in areas of Climate Change Adaptation, Conservation and Biodiversity Management," the department said.

Munzhedzi served as the Senior General Manager responsible for Environment and Tourism in Limpopo province. He holds a Master's Degree in Environmental Management specialising in Conservation Management and a Masters in Business Leadership. He serves on the boards of the South Africa National Parks (SANParks), the African World Heritage Fund and the South African Wildlife College.

Source: SAnews.gov.za

President welcomes efforts to improve water infrastructure

South African President, Cyril Ramaphosa, has welcomed the renewed focus on improving municipal water infrastructure and related services.

The President said the provision of quality water to all communities is essential for human health and well-being, economic development and the realisation of the constitutional rights of all South Africans. The President made the observation at a meeting of the Presidential Infrastructure Coordinating Commission Council held earlier this year.

The council brought together the President, Deputy President and other members of the National Executive, Premiers, Executive Mayors, and leadership of the South African Local Government Association and state-owned enterprises. The council received a report and recommendations regarding the historical, large-scale strategic integrated projects (SIPs) and an update on South Africa's Infrastructure Investment Plan.

The meeting's key discussion was on municipal water infrastructure, a complex area in which the council has identified challenges ranging from infrastructure failure (sewer spillages, potholes, leaks and solid waste on streets) to infrastructure service delivery interruptions (water cuts, electricity cuts, road closures and non-collection of refuse). Water infrastructure is also affected by a shortage of technical skills in local government, poor infrastructure management practices and inadequate budgeting and expenditure on maintenance.

The council resolved that it will enable the planning and coordination function of the water component of the District Development Model through the implementation of a National Water Programme Management Office, jointly owned by the Department of Water and Sanitation (DWS) and Cooperative Governance and Traditional Affairs (COGTA). It will also strengthen the planning of municipal water infrastructure to access blended finance through the Infrastructure Fund.

Source: SAnews.gov.za

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GLOBAL

Climate change 'has dented global agriculture productivity'

Global agricultural productivity has declined by about 21% in the last 60 years as a result of climate change, a newly published study has found.

The decrease was most pronounced in warm regions such as Africa (30%) and Latin America and the Caribbean (26%), according to research published in ***Nature Climate Change*** which looked at data from 1961 to 2020. The study, by scientists from Cornell, Maryland, and Stanford universities, warns that global agriculture is now becoming even more vulnerable to climate change, despite advances in technology.

Ariel Ortiz-Bobea, professor of applied economics at Cornell University and lead author of the study, noted: "These numbers don't mean that we are producing less than we did back in 1961 – we've actually produced more year after year. Instead, our study is saying that global agricultural productivity almost 21% lower than it could have been in a world without climate change," explained Ortiz-Bobea.

Researchers analysed annual official records of agricultural productivity in 172 countries, along with data on climate parameters. This showed them "how much agricultural productivity rose or fell in a given country, if a specific year was warmer, colder, wetter, or drier than normal," among other variables, Ortiz-Bobea explained.

Once they found this statistical relationship – known as an econometric model – they put it to the test in both the real world, and a parallel world where anthropogenic (man-made) climate change does not exist. To avoid bias, researchers kept the alternative world almost the same as the real one, considering the last six decades in both with the same type of economy, the same use of fossil fuels, and even the same greenhouse gas emissions. "The only difference was that in the fictional world emissions didn't have the ability to alter the climate," said Ortiz-Bobea.

When comparing the two worlds, scientists discovered that climate change caused the equivalent of seven years of stagnation in agricultural productivity. This means that the level reached in 2020 is equivalent to the productivity that could have been achieved since 2013 in a world without climate change, according to a press release from Cornell University.

The slowdown in productivity comes despite significant improvements in agriculture, indicating that scientific and technological developments in agricultural are not translating into greater resilience to climate change, scientists warn.

Source: SciDev.net

Weather-related disasters displacing more people than conflict – UN

Weather-related crises have triggered more than twice as much displacement as conflict and violence in the last decade. This is according to the United Nations refugee agency (UNHCR).

In April, the UNHCR published data showing how disasters linked to climate change likely worsen poverty, hunger, and access to natural resources, stoking instability and violence. "From Afghanistan to Central America, droughts, flooding and other extreme weather events are hitting those least equipped to recover and adapt," said the UN agency, which is calling for countries to work together to combat climate change and mitigate its impact on hundreds of millions of people.

Since 2010, weather emergencies have forced 21.5 million people a year to move, on average.

Roughly 90% of refugees come from countries that are the most vulnerable and least ready to adapt to the impacts of climate change. These countries also host around 70% of people internally displaced by conflict or violence.

Citing the case of Afghanistan, UNHCR noted that it is one of the most disaster-prone countries in the world, as nearly all of its 34 provinces have been hit by at least one disaster in the past 30 years. The country is also ranked the least peaceful globally, owing to longstanding conflict that has killed and injured thousands of people and displaced millions.

Recurring floods and droughts – along with population growth – have compounded food insecurity and water scarcity and reduced the prospects of refugees and internally displaced people being able to return to their home areas.

We need to invest now in preparedness to mitigate future protection needs and prevent further climate caused displacement," said UN High Commissioner for Refugees Filippo Grandi, earlier this year.

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New tool will make it easier for countries to measure ecosystems

An innovative artificial intelligence (AI) tool that will make it easier for countries to measure the contributions of nature to their economic prosperity and well being was launched earlier this year by the United Nations and the Basque Centre for Climate Change (BC3).

Developed by the Statistics Division of the United Nations Department of Economic and Social Affairs (UN DESA), the UN Environment Programme (UNEP) and BC3, the new tool can vastly accelerate implementation of the new ground-breaking standard for valuing the contributions of nature that was adopted by the UN Statistical Commission in March.

The tool makes use of AI technology using the Artificial Intelligence for Environment and Sustainability (ARIES) platform to support countries as they apply the new international standard for natural capital accounting, the System of Environmental-Economic Accounting (SEEA) Ecosystem Accounting.

The new open-source and user-friendly digital tool, called the ARIES for SEEA Explorer, enables, for the first time, rapid and standardised yet customisable ecosystem accounting anywhere on Earth.

"The ARIES for SEEA Explorer is a game changer for governments that want to implement the recently adopted SEEA Ecosystem Accounting standard," stressed Stefan Schweinfest, Director of the Statistics Division. "This application allows countries to jump-start accounts compilation from global data sources, which they can refine with national data or model parameters."

The ecosystem accounts produced by countries will track the extent, condition and services provided by nature's ecosystems – such as forests and wetlands – in the form of physical and monetary accounts and indicators. The adoption of the SEEA Ecosystem Accounting has been heralded as a historic step forward for the Sustainable Development Goals (SDGs) and to move beyond GDP in tracking global progress.

Risenga Maluleke, Statistician-General of Statistics South Africa and Chair of the UN Committee of Experts on Big Data and Data Science for Official Statistics said, "The launch of the ARIES for SEEA Explorer on the UN Global Platform is an important step to mainstream the measurement of ecosystems and their contribution to the economy and wellbeing into global, regional and domestic statistics that will feed into policy and decision making. Better measures of nature will contribute to better policies to save our planet."

The ARIES for SEEA Explorer is available on the UN Global Platform: a cloud-service environment supporting international collaboration among all countries in the world by sharing scientific knowledge, data, methods and technology.

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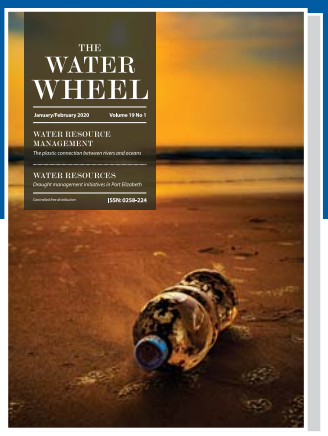

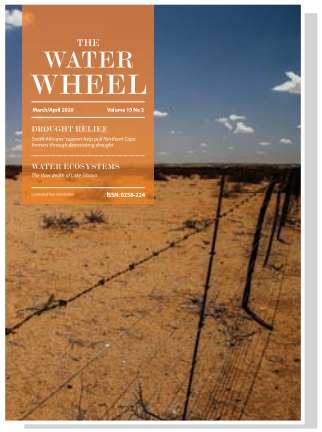

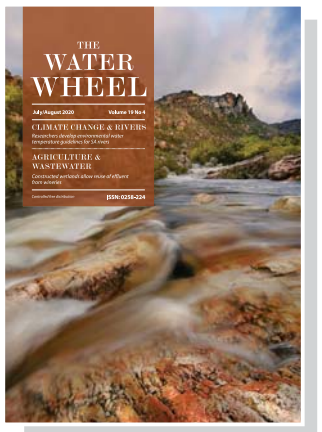

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WATER RESEARCH COMMISSION

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NEW WRC REPORTS

Design flood estimation in urban areas in South Africa: Preliminary results from Tshwane case studies

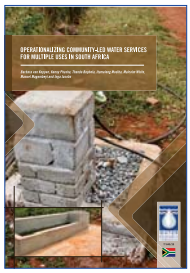
Globally, more people now reside in cities than ever before, with more than half of the world's population living in urban areas since 2005. It is widely accepted that urban development results in a decrease in the permeability of a catchment and will therefore result not only in larger flood peak discharges with a faster catchment response time, but also in larger total flood volumes. However, this assumption does not take into account the constructed water drainage and reticulation systems, and the possibility of retention and attenuation in urban systems due to property boundary walls and/or the levelling of naturally sloping areas, which are typical in many South African urban areas. The need has therefore arisen for the development of a validated and verified estimation procedure to accurately estimate design floods from both formal and informal urban settlements in South Africa, especially in areas with little or no reliable streamflow data. The major aims of this project included improving the understanding of hydrological processes in the South African urban and sub-urban environments; and developing a calibrated design flood estimation method for urban and sub-urban areas, either by updating existing methods, or developing a new method, by focusing on two case studies in urbanised areas of South Africa. A small catchment in Tshwane was selected to use as a pilot study area in order to establish an applicable methodology for the model configuration and calibration applied in this project.

WRC Report no. 2747/1/20

Development and assessment of regionalised approaches to design flood estimation in South Africa

There is a need to update and modernise methods used for design flood estimation in South Africa as many of the methods were developed more than 40 years ago and hence there are longer hydrological records to use in the updating of the methods. The original aim of this study was to develop an improved and refined regionalised Probabilistic Rational Method (PRM) for South Africa, and this objective was expanded to include the development of a Regional Index Flood (RIF) method and a comparison of the performance of the two approaches was undertaken. A critical aspect of regional flood frequency analysis is the identification of homogeneous flood producing regions. Both Region of Influence and Clustering approaches were investigated and forty-two relatively homogeneous flood producing regions were identified using clustering and manual adjustments. The mean annual flood (MAF) and 10% Annual Exceedance Probability C-value (*C10*) for the Rational Method coefficient were selected as scaling variables to produce growth curves for both methods and regionalised regressions were developed to estimate the scaling factors, and hence estimate flood quantiles, at ungauged sites in South Africa.

WRC Report no. 2748/1/20



Operationalizing community-led water services for multiple uses in South Africa

In spite of considerable government investments in water services provision in rural South Africa, service levels are declining. High rates of dysfunctional municipal boreholes, a maintenance backlog, and communities' neglect, illegal connections, if not vandalism, underscore the need for complementary water services models that can restore the dwindling trust in municipalities. The project 'Operationalizing community-led multiple use water services (MUS) in South Africa' (or MUS project) aimed to fill this gap by generating evidence whether and how communities' active participation in planning, design and construction can cost-effectively mobilise local knowledge and innovation, resulting in more and more sustainable livelihoods at scale. In such a model, government and communities co-manage water services. Funded by the African Water Facility of the African Development Bank, the project was designed as an evidence-based change process, managed by the Water Research Commission (WRC). The NGO Tsogang Water and Sanitation demonstrated the step-wise participatory planning, design and construction processes at community-level as a socio-technical facilitator providing technical and institutional support. The International Water Management Institute (IWMI) compiled the evidence of the change processes at community, district, provincial and national levels.

WRC Report no. TT 840/20

Climate change impacts on the safety of concrete arch dams in South Africa

The reality of climate change can no longer be ignored as evidenced by the observed temperature increases. In South Africa the temperature increase is projected to reach more than 3°C by 2050. Existing concrete arch dams were not designed anticipating climate change. Therefore, the temperature rise coupled with possible dry or wet weather will progressively lead to the deterioration of the structural integrity of concrete dams. This study has shown that concrete arch dams are likely to be overstressed in future leading to cracking. This may compromise their structural integrity. Concrete arch dams impound 39% of South Africa's total volume of water in storage reservoirs. Therefore a 'no regrets' approach is recommended to ensure their safety in the long term. Dam surveillance programmes need to incorporate climate change impacts, to ensure that the onset of possible dam failure is detected and resolved before it becomes catastrophic.

WRC Report no. 2749/1/20

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AGRICULTURE AND WATER

South Africa's agricultural water scenarios: The future we choose?

South Africans need to face key water realities and plan accordingly to ensure we use our water resources sustainably whilst promoting economic development and food security. The Water Wheel reports on a comprehensive research project that produced four important future agricultural water scenarios for South Africa. Article by Jorisna Bonthuys.

The challenges of feeding South Africa's growing population in a climate-altered, resource-constrained future are substantial.

The availability of freshwater presents one of the greatest risks to South Africa and the global economy at large. Other priority risks are related mainly to climate change, biodiversity and ecology. These risks would affect a wide range of economic sectors and livelihoods, impact infrastructure and catchment management, and the management of demand into the future.

The challenge is to produce more food with the same amount or less water, given South Africa's water realities. This has been highlighted in new research on the country's water management scenarios for the future.

Experts from the University of the Free State (UFS) have investigated the different drivers and enablers that could determine South Africa's water futures. This has enabled them to develop four detailed scenarios that can now inform policy responses and adaptation practices.

This project, funded by the Water Research Commission (WRC), provides a glimpse of what is to come in future decades. Prof Anton Jordaan, a research fellow at the UFS, led this comprehensive scenario-building process. This is the first study that has attempted to develop an integrated model for coupled water-food systems, including multiple drivers, through the active participation of a diverse group of stakeholders.

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The researchers considered key trends and drivers reshaping the water and agricultural future and the path ahead. They also investigated different policy responses and decision-making on water realities.

Scenarios are not predictions, forecasts, or projections, Jordaan explained. "Rather than just predicting and forecasting future occurrences, scenario planning examines plausible and possible future occurrences," he said. "The underlying idea is that scenarios that display alternative future states of the water system facilitate water managers to make robust decisions and management strategies."

Agriculture and the national water budget

South Africa has already transitioned with a water constrained economy. Water requirements for urban and domestic use account for nearly 30%. The remainder is vital for mining, bulk industries, and as cooling water for power generation.

The use of water is dominated by irrigation, amounting to over 60% of the total water use in the country, the bulk of which is used in a consumptive manner. Agriculture is a major user of the national water budget, generating a vital component of overall food security.

With the amount of water that agriculture uses, the sector contributes 2% to 2,6% of the gross domestic product (GDP). In addition, the agri-processing industry, which is dependent on irrigation, makes up 20% of South Africa's GDP and is an important source of foreign exchange earnings. It is also a crucial source of employment, particularly in rural areas, employing 15% of the labour force.

The sector is facing increasing competition from domestic and industrial users. Water demand is projected to increase with economic growth, increased urbanisation, higher living standards, and population growth. Currently, South Africa depends mainly on surface water resources for most of its urban, industrial, and irrigation requirements.

Poor management of water resources threatens the resource base on which agriculture depends, the researchers highlighted. Water quality has deteriorated in the rivers receiving large quantities of effluent. Climate change impacts could also exacerbate existing water-related challenges and create new ones over the next few decades.

Exploring alternative water futures

The researchers completed this project in four phases. Firstly, they did a comprehensive literature study and reviewed current water management policies, regulations and scenarios. Secondly, they conducted expert interviews and held participatory workshops. The scientists gathered information during interactive workshops, with semi-structured interviews, and at two national symposia from target groups such as academia, government officials, agricultural associations, and water users.

Phase three of the project entailed scenario development based on qualitative and stakeholder inputs. These scenarios were tested with experts during the national symposia and a water symposium organised by Agri SA. The scientists also developed a modelling framework for the scenario development tool. This mathematical model is based on a systems thinking approach and the principle of system dynamics.

The model was simulated for a period of 20 years (from 2010 to 2030). The researchers used data from the Breede River catchment (in the Western Cape) to test the tool for its robustness.

The scenario-building process identified almost 70 drivers that will determine the future of water management in the country. These drivers were categorised under cluster headings (social, technological, human, ecological, economic, natural, global, and political). The researchers determined the importance of these drivers through participatory research and data capturing, system dynamics and game-theoretic mathematical programming.

Unpacking the scenarios

The researchers developed four potential scenarios ranging from a best-case to a worst-case (Z) scenario.

In the **best-case scenario**, political stability, leadership, social cohesion and security are positive, as is the country's natural capital and its management. This helps to produce a sustainable environment for the growth and development of the water and agricultural sectors, directly benefitting the economy.

In this scenario, the private sector works well with the government. There is investment into existing water infrastructure and new water infrastructure projects (with private sector innovation and inputs). Water is seen as a fluctuating resource, as opposed to a finite resource. With policy certainty and a clear national water resource strategy, it plays an important role in developing a strong and inclusive agricultural sector and, in turn, growing the economy.

Climate change adaptation programmes are integrated (mainstreamed) in all policies and projects. Water resource allocations are well managed, with no conflict between agriculture and the mining and industry sectors for water. Efficient water management authorities are in place and there is strict enforcement of water use guidelines. Increased efficiencies in production and water use are achieved through innovative technologies.

The **frustration scenario** is characterised by a strong private sector and civil society involvement but poor governance. Even though political stability, leadership, social cohesion and security are all negative, the country's natural capital, and the management thereof, remain positive. This is driven mainly by a private sector that manages to bypass unclear and contradictory government policies. The result is high levels of frustration felt by all players in the agricultural sector. This scenario represents the 2020 status quo, according to the research.

In this scenario, a hostile political climate exists, deepening mistrust between the agricultural sector and the government. The result is poor governance at the local level and increased social unrest. The gap between the haves and the have-nots widen. Commercial farmers can farm effectively and efficiently,

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Drivers and clusters for scenario planning

#	CLUSTERS	DRIVERS	
1	Natural/Ecological	• Climate change & variability • Water availability • Rainfall • Groundwater • Streamflow • Dams/reservoirs • Climate extremes (droughts / floods)	• Land degradation • Water quality • Water pollution • Soil salinisation • Ecosystem health • Land use
2	Cultural	• Innovative thinking and doing • Dependency syndrome • Entitlements • Productivity	• Cultural values • Values of care for the water • Attitude of the group
3	Technological	• Rainwater harvesting techniques • Irrigation technology • Desalination technology • Water recovery technology • Groundwater recharge • Engineered wetlands	• New Alternative technology (Super oxidants technology) • Water sanitation investment • Adoption of new crops • Precision agriculture
4	Economic	• Capital availability • Shift in production systems (SADC) • Bankability • South African economy • Water sector • Agriculture • Energy price (input costs)	• Subsidies • Economic output • Waterworks investment • Economic prosperity • Globalisation • International markets
5	Human	• Education • Capacity within the water sector • Attitude of individuals	• Cadre deployment • Leadership capacity
6	Social	• Population growth/HDI • Agricultural organisations • Community groups • Civil society involvement • Lifestyles • Poverty	• Inequality • Migration pressures • Urbanisation • Civil action • Rural safety and security
7	Political	• Land reform policy • Racial disparities • Internal political conflict • Level of conflict	• Understanding • SADC collaboration (Lesotho) • Power structure • Policy and political employment
8	Organisational	• DWS, DAFF, COGTA, DEA functionality • The capacity of government organisations to fulfil mandate	• Local governance capacity • Farmers Organisations – AFASA, NAFU, AgriSA • Commodity organisations
9	Infrastructure	• Siltation of dams • Inter-basin transfers	• New water infrastructure • Maintenance of current infrastructure
10	Institutional	• Coordination and collaboration between governance structures • Rules and regulations of water management	• Monitoring • Water management policies

while smallholder farmers struggle. The private sector and society manages natural resources and takes responsibility for water management. This leads to increasing conflict about water use and between water users and the government, especially at the local level. Violent civil action erupts around water supplies (this is exacerbated by the COVID-19 pandemic, highlighting poor water management by the government). Land invasions are on the increase. Some farmers are relocating outside of the country, taking experience and skills out of the sector.

In this scenario, the private sector is strong and functioning efficiently. Water efficiency is good in the private sector, and farming methods and water management are enhanced by innovations driven by technology as part of the Fourth Industrial Revolution (4IR). Good rainfalls enhance production, and land degradation is under control. A functioning education system leads to the responsible maintenance of natural capital (or at

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least an understanding of what needs to be done). However, it comes at a cost – water and electricity tariffs are high. The agricultural sector is heavily taxed.

This scenario is a paradox of strong and weak, good and bad, and, overall, sub-optimal in relation to its potential.

The **conventional wisdom scenario** is characterised by a government with centralised policies that do not support private sector investment and entrepreneurship. That includes the introduction of rules and regulations to control society and limit the private sector's influence. Even though political stability, leadership, social cohesion and security are all relatively positive, the natural capital, and the management thereof, still declines. The government has invested significant resources in agriculture. Still, the priorities are skewed towards subsistence smallholder farming at the expense of commercial agriculture, with unfortunate results. In this scenario, nationalisation is a key focus area for the government, and parts of the agricultural chain are absorbed into the state machinery. Land reform policies lead to an increase in the smallholder farming sector, changing the farming landscape.

There is increasing distrust between the private sector and the government. Food production declines due to changing farming methods, the degradation of soils, and climate change volatility, which is not well-managed due to low levels of innovation in the sector. The poverty trap continues, becoming more pronounced. Food insecurity increases. Farmers are stealing water from each other to survive. Water infrastructure is also constantly vandalised. Many towns are without water as there is poor or no infrastructure. The levels of conflict between water users are high. Water resources are polluted. Due to low standards of education, skills within the sector are thin. Climate extremes continue to disrupt normal agricultural production.

The **Z scenario** is the worst-case scenario. Collapsing political stability, leadership, social cohesion and security are so widespread that the natural capital is affected. The management thereof can also not take place as intended. Poor leadership, both within government and the water management sector, leads to policy uncertainty. The government and the private sector are polarised.

In this scenario, water is exploited for political leverage and votes. The level of conflict between different sectors is high. Water infrastructure is not maintained and is becoming dilapidated. Dams and rivers are highly polluted, and water theft is rife. Citizens and businesses are not paying their water bills, and mismanagement opens up space for further corruption. The government is cutting budgets for dealing with climate change. Skills in the agricultural sector are dwindling. In this scenario, commercial farmers are leaving South Africa and relocating. There are high levels of insecurity in rural areas. Criminals increasingly target farmers. Unrest and unemployment are on the increase. Food insecurity is one of South Africa's major risks and outcomes of this scenario.

Some red flags

Several things might propel South Africa, and specifically agricultural water management, in the wrong direction.

The first red flag is the absence of a social pact between the major stakeholders, i.e. the government, agribusiness, farmers, farmworkers and society at large. "The distrust between the government and the commercial farming sector, and the negative statements from political leaders are issues that need to be addressed," according to the report. "This is also characterised by an increased gap between white commercial farmers and black farmers."

The second red flag is the government's capacity to govern without the albatross of corruption hanging over South Africa. According to the research, this distracts attention from good governance and forces leaders to focus on party-political issues instead of on the state's needs. This is especially relevant at the municipal level, where water quality and water availability are determined by proper service delivery and water infrastructure maintenance.

"Rather than just predicting and forecasting future occurrences, scenario planning examines plausible and possible future occurrences."

The third red flag is centred around the economy and its resilience to withstand the negative impacts of, firstly, the 2015-2019 drought, and, secondly, the COVID-19 pandemic (since 2020). The pandemic serves as an instigator to propel South Africa from the frustration to the traditional and most-possibly the Z scenario. If that happens, the private sector will expand to other investment regions and cease further investment in South Africa, they foresee.

The fourth red flag is the absence of successful land and water reform in the country. Few of the land reform beneficiaries – newly established black farmers – are thriving due to various reasons. "The lack of progress in land and water reform sends out a negative message to citizens, and commercial farmers are blamed for not making land available for land reform (which is not the case since the government holds titles for millions of hectares of unproductive land). Learning from the example of Zimbabwe, it is clear that the lack of progress with successful land and water reform holds the potential to fast-track South Africa to the Z scenario."

A paradigm shift in water management is a pre-requisite to prevent negative scenarios, the researchers emphasised.

Possible water futures

According to the research, the best-case scenario is only possible if the private sector, the government, and civil society together take full and joint responsibility for future water management.

"The worst-case scenario is looming on the horizon if corruption and incompetence are not dealt with effectively in all sectors of society; if the gap between the haves and have-nots continues to increase; and if an environment for job creation and economic development is overshadowed by political opportunism, social unrest and social intolerance," the researchers indicated.

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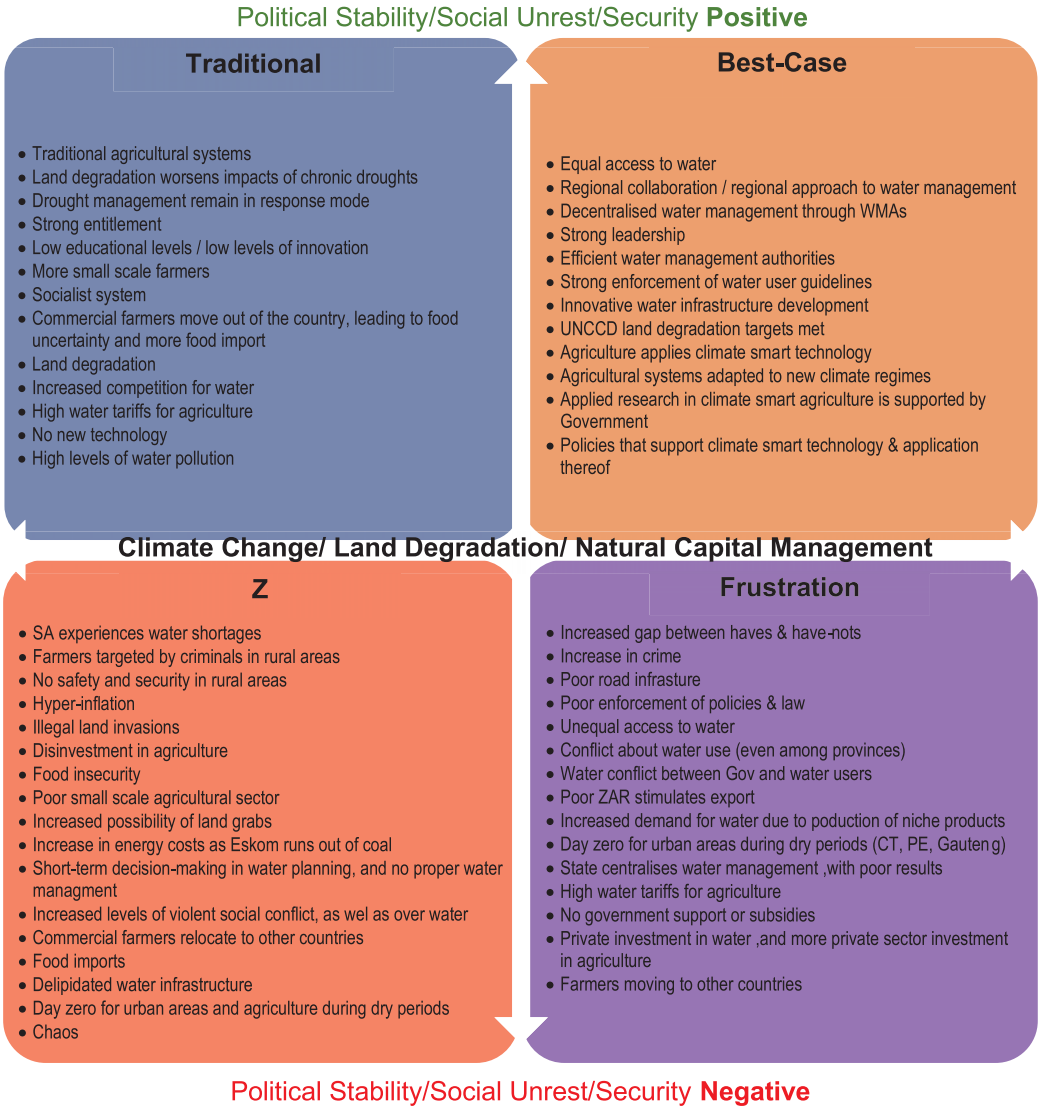

"Best-case scenario is only possible if the private sector, the government, and civil society together take full and joint responsibility for future water management."

"The 2021 position is characterised by frustration for all stakeholders – and this frustration might propel the country to the Z scenario with devastating impacts on future water management if not managed properly."

The private sector is frustrated because it seems that the government has become more centralised and autocratic in its actions, the research indicated. "Our feedback and results indicated that we currently find ourselves in the frustration scenario with a tendency to shift towards the traditional and Z scenarios if the private sector withdraws its investments," the researchers indicated.

In three of the four scenarios, agriculture will be at the losing end. Only the positive best-case scenario outcome will benefit agriculture and the country at large.

The attempt to a best-case scenario is possible through coordinated action, the researchers pointed out. Amongst the most crucial for the shift to the best-case scenario is for all stakeholders to make a paradigm shift to better understand water and its challenges for sustainable management.

All stakeholders need to take responsibility for sustainable water use and water management, Jordaan emphasised.

"As a country, we need to treat our water as life itself," he said. "We need to apply the same vigour illustrated in the management of the pandemic, protecting our water resources."

The final report will be published later this year.

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WATER AND THE ENVIRONMENT

The establishment of a knowledge hub for contaminants of emerging concern

Contaminants of emerging concern have aroused increasing concern due to their ubiquitous presence in the environment and harmful potential. A current research project is aiming to collate existing knowledge on these emerging pollutants in a central, accessible space. Article by Tarryn Lee Botha of the Agricultural Research Council – Soil, Climate and Water and Ashira Roopnarain of the North-West University's Water Research Group.

Historically, society's response to a risk has been based on the level of the current threat and public outcry related to available evidence – whether scientifically supported or not. However, as we are in the information age, the interest and availability of information on the dangers of contaminants in water is gaining ground. Newspaper headlines such as "Testing to begin for 'Forever Chemicals'"- ***The Sun*** or "An invisible killer is lurking in our consumer products, warn scientists"- ***Sky News*** and "Let's turn the tide on plastic"- ***Daily Mail*** are appearing more frequently worldwide.

In order to address this, the Agricultural Research Council (ARC) initiated a project funded by the Water Research Commission (**WRC Project No. 2021/2022-00256**), in collaboration with Tshwane University of Technology and North-West University, to establish an online portal consisting of information relating to newly detected aquatic pollutants. The aim of the Contaminants of Emerging Concern Knowledge Hub (Figure 1) is to develop a database of contaminants of emerging concern (CECs) in South African water resources. The specific objectives are to collate all available data on CECs and display it in a user-friendly online format to enable regulatory bodies as well as researchers to avoid duplication of studies and to establish potential hotspots. Furthermore, it will provide an easily understandable information guide for the public on what CECs are and how they end up in our environment.

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The selection of CECs was based on current information in the literature as well as international databases. The following CECs were selected as the primary contaminants within the Knowledge Hub: Perfluoroctane Sulfonate (PFOS), Alkylphenols (APs) and Alkylphenol Ethoxylates (APEs), Polybrominated Diphenyl Ethers (PBDEs) or flame retardants, Polychlorinated Biphenyls (PCBs), Polycyclic Aromatic Hydrocarbons (PAHs), current use pesticides, Pyrethroid, Cypermethrin, Chlorinated Paraffins, pharmaceuticals and personal care products, microbiological CECs, Triclosan, Microplastics, Engineered Nanomaterials and Heavy metals.

Figure 1: *The proposed Contaminants of Emerging Concern Knowledge Hub logo for WRC project no. 2021/2022-00256*

What are contaminants of emerging concern (CECs)?
The current Target Water Quality Guidelines only include known contaminants. CECs, however, are pollutants that have previously been at levels below detection limits which are now being detected by water professionals in our water bodies. These can include nanomaterials, flame retardants, microplastics, agricultural waste, microbial contaminants, heavy metals, pharmaceuticals and personal care products, which may cause ecological and human health impacts. The continued unregulated use of these products could lead to further ecological risks. The effects of these contaminants on the environment is becoming increasingly important (Pool and Rusch, 2014). Therefore, in order to address this, more research needs to focus on collating currently available outcomes and the results need to be made available to regulators in order to develop environmental laws in a proactive manner.

How do CECs end up in our water bodies?
The production and use of consumer products is the major contributing factor to pharmaceuticals and personal care products (PPCPs) in our water bodies which are either not removed or chemically transformed throughout wastewater treatment processes (Kiesling et al., 2019). If you consider your own morning routine and the contaminant exposure we are faced with on a daily basis (Figure 2), you will be able to appreciate the magnitude of CECs released into our ecosystems. The CECs present in PPCPs each have a function within the product and can range across a variety of classes, e.g. tricolsan (anti-bacterial), phalates (solvents), retinyl palmitate (antioxidant and vitamin A), ethyl alcohol (astringent/ preservative), oxybenzone (absorbs UV-A rays), diazolidinyl urea (stops bacterial growth), lead acetate (colourant in hair dyes), methylene glycol/formaldehyde (hair-straightening products), propyl paraben (antifungal agent), quaternium-15 (preservative), microplastic beads (cleansers and exfoliants), sodium benzoate (preservative), nitrosamines (adjust the pH level or act as wetting agents) and nanomaterials (UV-filters, anti-bacterial).

Figure 2: *Pharmaceuticals and personal care products we use in our daily routine which contain CECs*

Furthermore, population growth has continued to climb over the past few years, which requires more efficient methods of maintaining food security that can include greater use of pesticides and fertilizers, increased pharmaceuticals release, product packaging, goods transport, industrial processes and commercial agricultural practices. As more products are being consumed, the technology for production is advancing and the types and applications of CECs are increasing which, in turn, leads to higher production rates (Benson et al., 2017). Other contaminant classes (organic and heavy metal pollution) can be released during agricultural and mining activities, leading to atmospheric deposition and runoff into aquatic ecosystems. Current risks of CECs are unknown in South Africa even though there have been several research efforts in order to determine the current environmental concentrations.

"Contaminants of emerging concern are pollutants that have previously been at levels below detection limits which are now being detected by water professionals in our water bodies."

An overview of current findings
A scoping study of available literature revealed that the only nanomaterial characterised and detected was titanium dioxide (white pigment in food colouring and UV-filter in sunscreens). However, for microplastics, several publication entries were found for fibres, films, fragments, polystyrene and monofilaments from fishing lines. In the class of alkylphenols (organic industrial chemicals used in the production of lubricating oil additives, laundry and dish detergents, and emulsifiers) the most entries were found for nonylphenol which is a persistent breakdown product.

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The most entries for heavy metals were available for lead (several applications including soldering or welding) and chromium (mined) in the environment. Unsurprisingly the majority of microbial inputs were on ***Escherichia coli*** and coliforms. However, recent studies that have utilised advanced molecular methods such as Next Generation Sequencing, have revealed a plethora of additional potentially pathogenic microbes in several South African water bodies.

Just over 300 entries were found for PPCPs, including acetylsalicylic acid (commonly known as Aspirin), carbamazepine (anticonvulsant medication used primarily in the treatment of epilepsy and neuropathic pain), clarithromycin (an antibiotic), ibuprofen (a nonsteroidal anti-inflammatory drug class used for treating pain, fever and inflammation), sulfamethoxazole (used to treat a wide variety of bacterial infections) and triclosan (antibacterial and antifungal agent added to soaps and body washes, toothpastes and some cosmetics). Several entries were also found for PAHs which are produced due to the incomplete combustion of fossil fuels and burning of organic compounds such as wood. Those detected in aquatic bodies which broadly break down from coal tar included acenaphthene anthracene chrysene, fluoranthene, naphthalene and pyrene.

The way forward

One of the major reasons for CECs occurring in our environment is the lack of knowledge and education related to what they are and how they end up in the environment. We are therefore drawing up easily understandable information sheets for public use and downloadable agricultural practice standard operating procedures, which will assist in avoiding further contamination.

Whilst a thorough literature survey is currently underway to collate all data related to the classes of aquatic CECs selected to be included in the database, we are aware that additional data might be available that is yet to be published or was not intended for scientific publication. We hereby request anyone who is willing to share such data to please contact us. A concerted effort will be required to develop a holistic, up-to-date Knowledge Hub that can provide valuable information to scientists, policy-makers, farmers and the general public. This valuable resource will also guide us in pre-empting any aquatic catastrophe relating to CECs by identifying the problem and taking relevant, informed steps to prevent it from escalating beyond control. In so doing we can collectively preserve and improve the quality of our precious, limited resource….fresh water.

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FRESHWATER ECOSYSTEMS

New movement aimed at saving region's freshwater fish

Many migratory fish species are swimming upstream in the race for their survival. Jorisna Bonthuys reports about efforts underway to connect fish, rivers and people.

Nowhere is the world's biodiversity crisis more acute than in freshwater ecosystems. Around a third of freshwater species are threatened with extinction. Only a third of the world's large rivers are still free-flowing and around 35% of wetlands have been lost in the past five decades.

This stark reality has been outlined in a recent report, ***The World's Forgotten Fishes***. Scientists involved say populations of migratory fish have fallen by three-quarters in the last 50 years. Over the same time, populations of larger species, known as "megafish", have crashed by 94%.

In this report, scientists warned of a "catastrophic" decline in freshwater fish over recent decades. Approximately 80 species were known to have gone extinct, 16 in the last year alone. Much of the decline is driven by the poor state of rivers, mostly due to pollution, dams and sewage ending up in waterways. The report also lists the introduction of invasive non-native species, overfishing and climate change as threats to aquatic biodiversity.

The report was produced by 16 conservation groups, including WWF, the London Zoological Society, the World Fish Migration Foundation, Conservation International and The Nature Conservancy.

Freshwater migratory fish travel throughout rivers to fulfil their lifecycles, some swimming thousands of kilometres during this journey. They navigate using the currents, magnetic fields

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and even their sense of taste and smell. These fish cover vast distances from their place of birth to locations where they can find food or suitable habitats to reproduce. They often depend on free-flowing rivers to survive.

Spotlight on African migratory fish

In Africa, there are many stressors on migratory fish and their habitats. Many migratory fish populations are under-reported, undervalued and under pressure. This was highlighted during a recent webinar organised by the Swimway Africa initiative. At this event, stakeholders in fish research and conservation discussed fish passage and river connectivity on the continent.

Participants in this initiative are creating and driving a network of people in Africa, providing free products and information, creating awareness to influence policy, and starting projects that open up rivers. This initiative is aimed to start a grassroots movement of people and organisations working together across Africa to save migratory fish and free-flowing rivers.

Swimway Africa flows from a partnership between Reaching Rivers, World Fish Migration Foundation, University of Mpumalanga, South African National Parks (SANParks), Oak Consultants and BOKU University (Austria). Participants in this initiative are busy setting up ambitious targets for 2050 to align with international laws and agreements to protect migratory fish and the people who depend on rivers for food and livelihoods.

In Africa, there is very limited data on freshwater migratory species and the effect of fishways or lack thereof on their movements, Dr Kerry Brink, an aquatic ecologist from Reaching Rivers and the World Fish Migration Foundation, pointed out. There is a clear and urgent need to increase the profile of migratory species given current pressures on fish species on the continent, she said.

"There are many gaps in our current understanding of Africa's migratory fish species," Brink said. "We are, for instance, working on a report and database to provide a clearer understanding of the migratory fish behaviour and their routes in sub-Saharan Africa. This information is critical if we are to strengthen measures to protect migratory fish, inspire people and encourage appropriate policy and legislation."

Herman Wanningen

According to Dr Gordon O'Brien of the University of Mpumalanga's School of Biology and Environmental Sciences, river connectivity and fish migration management is a shortcoming of the existing management approach for dealing with multiple freshwater stressors.

Freshwater migratory fish do not only migrate upstream and downstream for their survival, but can also migrate laterally onto floodplains. In the Zambezi River, an impressive river flowing through nine countries in southern Africa, fish species that migrate laterally onto floodplains is a common sight.

Herman Wanningen from the World Fish Migration Foundation said removing old, obsolete and unsafe dams is the best restoration tool to ensure the ecological health of rivers. Many freshwater fish species need to migrate for their survival.

There are still many barriers in rivers that block the migration routes of many fish species. In Europe alone, there are more than a million such barriers. Many dams built in the last century are old and nearing the end of their concession. This means they must either be renewed or removed, Wanningen pointed out. Up to 25% of barriers no longer serve a function.

"The number of barriers worldwide is growing and is expected to continue growing due to climate change," Wanningen said. "To keep our seas and rivers full of fish, we need open rivers."

Where dams and weirs cannot be removed, fishways offer a useful tool to support fish migration. A fishway, also known as a fish ladder, is a structure on or around artificial and natural barriers (such as dams or weirs) to facilitate fish that migrate between the sea and freshwater to spawn or between different reaches within the river system. Most fishways enable fish to pass around the barriers by swimming and leaping up a series of relatively low steps into the waters on the other side. There are also many different types, including "nature-like" bypass fishways.

From as early as the eighteenth century, fishways have been implemented. Since then, knowledge, technology and experience have developed substantially, resulting in many different fishway designs specific for different regions or fish species.

The structures must, however, be properly maintained. Only about a third of all fishways in the Netherlands, for instance, currently work well, Wanningen pointed out.

Dr Mathew Ross, a consultant from EnviroRoss CC, said there are opportunities to provide provisions for fish migration measures in new infrastructure development related to hydropower. He said this offers opportunities to establish innovative fishways in key rivers to protect migratory species.

In his experience, engineers working on large-scale water and hydropower projects in Africa are increasingly open to adding fishways to their project designs. Given the current investment and interest in such projects in Africa, it is possible to motivate for an ecologically sustainable approach to fishways. This approach could, for instance, help to introduce fish-friendly hydropower turbines in such projects.

Fish migrations in South Africa

In South Africa, many fishes with migratory behaviour between marine, estuarine and freshwater ecosystems are considered important to fish diversity. Although migratory fish are largely understudied in South Africa, it is estimated that more than 100

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SanParks

The Kruger National Park has demolished 21 dam structures to improve the health of its ecosystems, including the Kanniedood Dam.

species have requirements for migration to different degrees.

Many of these species are directly affected by water quality and habitat stressors and reduced river flows, affecting connectivity between the rivers and sea.

Robin Petersen, an aquatic ecologist from SANParks, says efforts are underway to protect migratory fish species in the Kruger National Park. He gave an overview of efforts underway to restore river connectivity in this park, considered one of South Africa's flagship conservation areas. Many rivers in the park are transboundary waterways that extend into neighbouring Mozambique, Botswana and Zimbabwe.

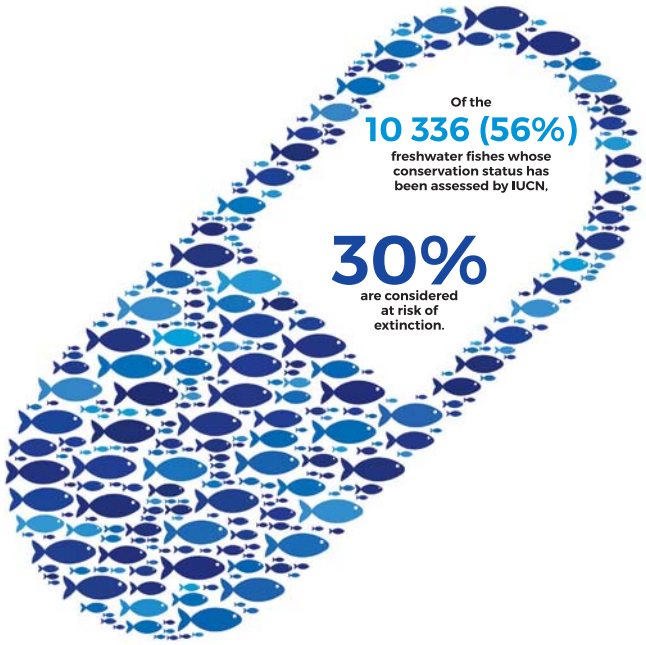
"In Africa, there is very limited data on freshwater migratory species and the effect of fishways or lack thereof on their movements"

The park is considered a "hotspot" for aquatic biodiversity. It is home to 48 fish species (of 359 freshwater fish species in southern Africa), of which more than 20 are considered long-distance migratory species. This park has 600 km of perennial river systems and 30 000 km of seasonal and ephemeral streams (dry stream beds that flow as rivers or streams after rainfall periods).

Efforts are underway to eliminate selected redundant and obsolete dams and weirs in the park and establish completely free-flowing catchments in the area. "The park's rivers are situated in a sea of (historic) dams," Petersen pointed out.

In 1931, the first concrete dam was constructed in the park, and since then, 53 concrete and earthen structures have been built along various watercourses. "With hindsight and significant scientific endeavour during the 1990s, it was realised that in many cases, this has led to numerous ecological problems and general degradation of the landscape in many parts of the park where water did not naturally occur previously," Petersen indicated.

A total of 21 dam structures have already been demolished, including the Kanniedood Dam and the Mingerhout Dam, situated in the Shingwedzi and Letaba catchment area, respectively. These efforts are providing data that will inform



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further river restoration efforts in the region, he indicated.

The Kanniedood Dam has, for instance, had major ecological and physical effects on the river system. "Fish species richness in the Shingwedzi River declined after it was built," Petersen said. "In 1988, 11 years after the dam was completed, 19 fish species were no longer found downstream. A total of 13 species were absent upstream.

"When dam removals is not an option, fishways are a great alternative to improve river connectivity."

After completing a fishway in 1992, some improvements were noted in the Shingwedzi. The number of fish species in the river at present is, however, still lower than before the dam was built. "This indicates that the construction of the dam possibly caused the irreversible local extinction of species," Petersen said.

In South Africa, more than 60 fish passage facilities (fishways) exist, of which only about 20% are known to be functional and 33% are ineffective. The functionality of the rest has not been evaluated. This can be compared to more than 610 formal dams and more than 1 430 gauging weirs that act as human-made barriers to fish migrations.

There are now 16 fishways in the Kruger National Park, including the Engelhardt fishway along the Letaba River. These structures were built in the 1960s and 1970s. Many of them are not considered effective anymore, Petersen indicated.

Studies are underway to determine the ecological benefits of removing redundant dams and barriers on river connectivity, natural flow regimes, sediment and nutrient dynamics and the possible re-colonisation of locally extinct species in the park.

Meanwhile, the new natural water distribution work in the park yields multiple benefits not only for the ecosystem and abundant biodiversity it contains within the savanna landscape and its river systems.

"Clearly, this is only the beginning of understanding the long-term changes for the betterment of the the park's ecosystem, the river system more broadly and for those that depend on them downstream," Petersen said.

Herman Wanningen

The Kruger National Park is home to 48 fish species (of 359 freshwater fish species in southern Africa), of which more than 20 are considered long-distance migratory species.

Healthy rivers remain key

Healthy freshwater ecosystems are essential to sustain thriving populations of freshwater fishes in Africa. Dr Gordon O'Brien, an aquatic ecologist at the University of Mpumalanga's School of Biology and Environmental Sciences, said river connectivity and fish migration management is a shortcoming of the existing management approach for dealing with multiple freshwater stressors.

River connectivity and fish migration management practices should be elevated to contribute to the sustainable use of water resources and ensure the resilience of fish populations in the region, O'Brien highlighted. More research is needed to ensure science-based decision-making and natural resource management. The Swimways Africa initiative can play a key role in this regard, he said.

Brink said the initiative provides a platform and network to exchange information and research across the continent and will help prioritise research to support migratory fish populations.

"By protecting and restoring natural flows, water quality and critical habitats while working to ensure swimways in rivers, we can make a decisive difference for migratory fish populations," he said.

Freshwater fish facts

More fish are found in freshwater than in the ocean
Approximately 51% of all fish species are found in freshwater – that is more than 18 000 different species.

Healthy freshwater fisheries equal healthy rivers, lakes, and wetlands
Healthy freshwater ecosystems are critical for thriving populations of freshwater fish and for human well-being. Rivers provide at least 2 billion people with their drinking water and support a quarter of the world's food production.

60 million people rely on freshwater fish for their livelihoods
At least 200 million people rely on freshwater fish as their main source of protein. Today, 60 million people depend on freshwater fish for their livelihoods.

Nearly one-third of all freshwater fish are threatened with extinction
Freshwater fish populations are collapsing. Nearly a third of all freshwater fish are threatened with extinction. In 2020, 16 freshwater fish species were declared extinct. Since 1970, megafish – those that weigh over 30 kg – have declined in number by 94%. Migratory freshwater fish saw a 76% decline during the same period.

Source: The World's Forgotten Fishes

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CAPACITY BUILDING

Helen Dallas – A career dedicated to the conservation of southern Africa's freshwater systems

This article forms part of a series of profiles on high achieving water researchers supported by the Water Research Commission as part of the Commission's 50-year celebrations.

Dr Helen Dallas is the Executive Director of the Freshwater Research Centre in Cape Town.

Over the past three decades, Dr Helen Dallas has made a significant impact on the advancement of freshwater science in South Africa, so it may come as a surprise that she started out as a desert ecologist. Sue Matthews spoke to her about her career achievements and challenges.

After completing her Honours degree at Rhodes University in 1987, Dallas spent 18 months as a research assistant at the Desert Ecological Research Unit in Gobabeb, Namibia, then went backpacking for a year before finishing her time overseas with a six-month scholarship at the Mitrani Centre for Desert Research in Israel. Soon after her return to South Africa at the end of 1990, she visited the Zoology Department at the University of Cape Town (UCT), where she'd done her undergraduate degree, in the hope of finding a job.

"Fortuitously, I knocked on Jenny Day's door in the Freshwater Research Unit, and she said she'd just got the go-ahead for a project funded by the Water Research Commission (WRC), and needed a research assistant. Within six months the senior researcher had left, so I went from being very green and knowing very little to taking on much of the project. It was a baptism by fire, but writing the review on 'The effects of water quality variables on riverine ecosystems' brought me up to speed quickly."

The review, first published in 1993 and updated in 2004, remains one of the most cited documents on water quality worldwide. The initial project was followed by another WRC-funded one on tools for evaluating regional water quality guidelines, and during that period Dallas was also on the project team tasked with

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writing the national water quality guidelines, published in 1996 by the then Department of Water Affairs (DWAF).

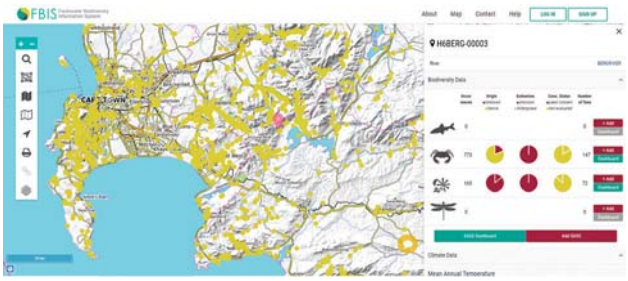
The initial project also introduced her to bioassessment methods, and, more specifically, the South African Scoring System (SASS), which became the subject of her MSc thesis, submitted in February 1995.

"I was really lucky in that project because I got to work with two of the gurus of freshwater science. One was Arthur Harrison, who took me to his original sites that he worked on in the 1950s and showed me the ropes so that I could do field surveys at the same sites. The other was Mark Chutter, who'd got funding from the WRC in 1994 to develop a rapid bioassessment method, which was SASS, building upon his biotic index from the seventies. Part of his project was to test it in different parts of the country, and I was so keen that I got to do it in the Western Cape. With Jenny as my mentor, I then did my Master's on evaluating SASS as a tool for assessing water quality."

Over the next decade, Dallas played an instrumental role in the South African River Health Programme, which incorporated SASS as the bioassessment method for aquatic invertebrates, but also made use of indices for fish, riparian vegetation, habitat integrity and geomorphological processes for monitoring ecosystem health. She served as the Western Cape champion for the programme, provided SASS training and accreditation, and designed the Rivers Database for the collation and management of data emanating from the programme on a national scale.

Dallas had gained database expertise when she developed the BioBase, the first version of which was completed with the technical support of Pierre Janssens in 1998. Biobase contained historical published data on macroinvertebrates and water chemistry from various studies on South Africa's rivers, and was one of the products of the earlier WRC-funded project on the effects of water quality variables on riverine biota. She subsequently led the development in 2006 of the Wetlands Database, which was part of a WWF-funded project to identify and collate existing information on the wetlands of the Western Cape.

These three pillars – physico-chemical impacts on aquatic ecosystems, bioassessment and database development – have provided the foundation supporting her research interests to this day. In 2002, she was awarded her PhD for her thesis on spatial and temporal heterogeneity in river systems and the implications for defining ecological reference conditions for macroinvertebrate bioassessment. In the same year she began conducting research and training in Botswana's Okavango Delta through projects funded by Conservation International, the Water Research Foundation of Southern Africa, and the Okavango Research Institute at the University of Botswana.



The Freshwater Biodiversity Information System (FBIS) developed by Dallas and her team currently includes more than 300 000 biotic and 100 000 abiotic data records. It can be accessed at https://freshwaterbiodiversity.org/

This resulted in publications in 2007 and 2020 – co-authored with Belda Mosepele of the Botswana University of Agriculture and Natural Resources – examining aspects of the spatial variability of the delta's macroinvertebrate assemblages and considerations for developing a rapid bioassessment tool. Follow-on papers will explore temporal variability and the development of the Okavango Assessment System (OKASS), a preliminary macroinvertebrate-based biotic index. Dallas also supervised Lulu Kaaya from the University of Dar es Salaam in her doctoral research resulting in the Tanzania River Scoring System (TARISS), and collaborated with the Universities of Glasgow, Aberdeen and Zambia in a project funded by the European Union to develop the Zambian Invertebrate Scoring System (ZISS).

"The Okavango one is a bit different because the Delta is a wetland system rather than a riverine system, although it includes river channels, so it's quite a challenge and it's still a work in progress – people are testing it so that it can be refined," she explains. "But TARISS has started to gain traction, even though it's only been developed and tested in two catchments, while ZISS has students starting to use it, and is slowly gaining momentum within their governmental Department of Water Resources Development. These indices are not as entrenched as SASS is in South Africa, but they work well, and with countries that are under-resourced in terms of finances it's the only way to go."

Dallas recently wrote a review article titled 'Rapid bioassessment protocols using aquatic macroinvertebrates in Africa – considerations for regional adaptation of existing biotic indices', which was published in ***Frontiers in Water*** in February 2021. The article was partly in response to two papers from 2019 detailing the use of TARISS in Rwandan and Ugandan rivers. She points out that rapid bioassessment protocols and biotic indices can be applied in other countries or regions, but they should ideally be calibrated, validated and modified first to ensure their effectiveness.

As for the physico-chemical 'pillar' of her research, Dallas began honing in on the role of water temperature in riverine ecosystems from 2007, funded by the WRC via an initial research consultancy and then a suite of research projects. She is especially interested in the ecological consequences of climate change, and ways of promoting ecosystem resilience to rising water temperatures.

"Water temperature and flow are the two things that are obviously going to change in response to climate change, other than drought and flood events, and in the Western Cape the low-flow periods are in the summer months when it's hottest, so that's the most stressful period for aquatic organisms," she explains. "You can't change what sunlight comes in, but you can change the amount of water in the system by altering farming

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Dr Helen Dallas has conducted freshwater research in several southern African countries, including Zambia, Tanzania and in the Okavango Delta.

practices to avoid abstracting during the peak summer period, so there's at least enough flow in the river to mitigate the increasing temperature. And then if you can maintain the system in as natural condition as possible – with riparian vegetation providing shading, buffer zones reducing pesticide and other pollution, and instream habitat like pools deeper than a metre ensuring cool-water refugia for fish – it's giving the biota the best chance of surviving that very stressful period."

Apart from participating in numerous field surveys to evaluate the influence of water temperature on biota, Dallas has played a leading role in developing laboratory methods to measure thermal tolerance of aquatic insects and fish, as well as sub-lethal effects such as egg development and thermal preference. She pioneered the use in South Africa of the non-lethal Critical Thermal Maxima (CTM) method, which involves observing the behavioural response of aquatic organisms while slowly increasing the water temperature, and removing them when they show clear signs of stress.

"Mayfly larvae, for example, lose their ability to grip onto the mesh and fall to the bottom, while fish lose their righting ability and don't swim well. At that point you take them out, put them back in the starting temperature, and allow them to recover," she explains. "We also did experimental work on the thermal preferences of fish by creating PVC gutter systems with a gradient from cool to hot and observing where they spent the majority of their time."

Most of the temperature-related WRC projects have been conducted with her long-time collaborator, Dr Nick Rivers-Moore, together with other researchers and students, and culminated in the production of the dual-volume ***Environmental water temperature guidelines for perennial rivers in South Africa*** (**WRC Report no. TT 799/1/19 and TT 799/2/19)** in 2019. While Volume 1 provides the background to the project and uses three cases studies to demonstrate the protocol for establishing environmental temperature guidelines, Volume 2 is the technical manual for setting water temperature targets. It serves as a road map for water resource practitioners needing to incorporate water temperature into Resource Directed Measures, including ecological Reserves and Resource Quality Objectives, as well as Source Directed Controls.

"We've recently received the go-ahead for a follow-on three-year project, in which we're going to develop a thermal module to automate some of the tools for water temperature screening and evaluation."

Belda Mosepele of the Botswana University of Agriculture and Natural Resources and Dr Helen Dallas in the Okavango Delta.

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Although the manual includes several tools to facilitate use of the guidelines, such as a screening tool to allow users to check whether they should be particularly concerned about water temperature at their sites, Dallas says that the process will be even easier once a thermal module has been integrated into the Freshwater Biodiversity Information System (FBIS), her latest collaborative endeavour in bioinformatics and databases. In 2017 she successfully applied for funding from the JRS Biodiversity Foundation in the United States to develop the system, the third version of which was released in July 2020.

Designed with technical partner Kartoza and using open-source software, FBIS currently includes in excess of 300 000 biodiversity records for invertebrates, fish and algae in South African rivers, as well as 100 000 abiotic data records. These emanate from the Biobase, Rivers Database and various research projects, and data are also harvested from GBIF – the Global Biodiversity Information Facility. The system has several base layers and more than 40 spatial layers to contextualise and filter data.

"We've recently received the go-ahead from JRS Biodiversity Foundation for a follow-on three-year project, in which we're going to develop a thermal module to automate some of the tools for water temperature screening and evaluation," says Dallas. "We're also developing a mobile app for some components of FBIS so that users can upload data, such as SASS data, even while still in the field. We are hoping FBIS becomes an indispensable resource for decision-making in South Africa, and we also intentionally developed it in a generic way, so that it can easily be transplanted to another country. We already have an instance of FBIS running in Rwanda, where I have trained a team of biodiversity data scientists, and it looks like there may be further expansion to other regions in Africa and Europe – all very exciting!"

Dallas is also co-ordinating a Freshwater Bioinformatics in Africa seminar series, where other JRS grantees are able to share their experiences in developing information systems for serving freshwater biodiversity data. "It was supposed to be a workshop in Cape Town in March 2020, but the pandemic meant we had to switch to online sessions, although we hope to all meet in person in April 2022. It's really been a great learning and sharing opportunity, and going online has actually meant we can include more like-minded folks in our sessions and discussions."

Dallas notes that the FBIS has been welcomed by the freshwater community in South Africa and strong partnerships have been forged with several institutions, including South African National Biodiversity Institute (SANBI), South African Environment and Observation Network (SAEON), and Department of Human Settlements, Water and Sanitation (DHSWS), amongst others.

"We are hoping the Water Research Commission will join us as a partner in the new phase. The long-term sustainability of FBIS will best be achieved through multiple institutional financial support to ensure that these valuable data are available for decision-making. The final custodian of FBIS still needs to be agreed upon, but it may be SANBI, which provided some co-funding for the first phase of the project."

She points out that given the harsh funding climate in South Africa, ensuring that the Freshwater Research Centre (FRC), which she co-founded in 2012 and heads up as Executive Director, can keep going without dedicated institutional funding is a demanding responsibility. The need to source project funding and meet deliverables within tight time frames compromises her ability to publish scientific papers as often as she'd like, although she has about 50 peer-reviewed publications to her name to date. She's currently an NRF C-rated researcher, and an Honorary Research Associate at both UCT and Nelson Mandela University.

"It's been an enormous challenge to keep my academic hat on and continue trying to produce high-quality, peer-reviewed research articles," she says. "I know a lot of my FRC colleagues would like to publish their work too, but there isn't support for researchers who are not in salaried positions at universities or government institutions. Even though I received WRC funding for almost 30 years, there doesn't seem to be a mechanism to keep senior researchers funded so that they can mentor the younger ones. There are unfortunately too many researchers who have done excellent work, but have now been let loose and are struggling to fend for themselves."

"My journey in freshwater science has been incredible and I really am so grateful for all the opportunities that have come my way, and to my mentors, colleagues and students who I've worked with over the years. I've always been known as a bit of a gypsy, so have been lucky to be able to combine my passions for travel and freshwater ecology, by working in such special places in Africa."

Dr Helen Dallas has dedicated much of your career to conserving the region's freshwater ecosystems. This love of nature has also been shared with daughter, Kayla.

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WATER AND HERITAGE

Saving sacred waters: The future of Mohokare Valley sacred sites and water resources

Water resources and aquatic ecology are rarely associated with matters of heritage. Dr Stephanie Cawood and Dr Tascha Vos of the University of the Free State have been studying the link between the socio-cultural dynamics of heritage and water quality at sacred sites in the Mokohare Valley since 2008.

Stephanie Cawood

Makashane Ntlhabo, Dr Tascha Vos and Dr Stephanie Cawood sampling at Mautse.

The fertile Mohokare Valley follows the flow of the Caledon River in the eastern Free State and, prior to the outbreak of the COVID-19 pandemic, played host to a vibrant pilgrimage movement to a series of sacred sites, ***Motouleng*** (a sacred cave between Fouriesburg and Clarens) and ***Witsie's Cave*** (at Monontsa, Witsieshoek), the sacred valley of ***Mautse*** (between Rosendal and Ficksburg), and the sacred places associated with the prophet Mantsopa (at the Anglican St Augustine's Priory and Mission Station at Modderpoort near Ladybrand). These sites are places of pilgrimage for spiritual purposes and performing rituals and were found to be repositories of vast resources of living heritage, including undocumented oral histories and indigenous knowledge.

All these sites contain freshwater bodies within their boundaries or are situated close to water bodies, and many of the rituals and human activities documented at these sites are dependent on water from springs, pools, rivers, streams, and seepage. While also used as sources of potable water, many of these water sources are considered sacred and the water used for spiritual and medicinal purposes.

At Mautse, at least ten sacred sites were documented directly related to water, such as ***Sedibe sa Moshoeshoe*** (spring), the sacred pool at ***Tempeleng***, the cascading pools at ***Diepsloot***, the waterfall and pool inside ***Yunivesithi***, ***Sedibe sa Madiboko*** (small seepage waterfalls), the pools of ***Khanyapa***, ***High Court***,

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Stephanie Cawood

Inside Witsies cave.

and ***Letsha la Tsonolo*** and the Nkokomohi wetlands. ***Motouleng*** cave is situated on the banks of the Little Caledon (Mohokare) River, which includes a sacred waterfall and pool upstream, as well as seepage under the sandstone overhang. At ***Modderpoort***, ***Mantsopa's Spring*** is considered sacred by pilgrims. Water also played an important spiritual role at the baptismal fonts where the Prophet Mantsopa is said to have conducted ritual baptisms for adults and children. On route to ***Witsies Cave***, pilgrims pass by a spring and a stream, providing water for spiritual and practical purposes.

The sites associated with Mantsopa and Witsies Cave (declared provincial heritage sites on 8 April 2016) generally fall under some form of authority, such as the church and a local traditional authority, which regulate access to the sites and apply some form of management regime to maintain the sites, although the management and protection protocols are not uniformly applied. The sites of Mautse and Motouleng were found to be informally declared heritage sites, in other words, recognised and actively used, but not formally declared as local, provincial, or national heritage sites or protected by management protocols.

From 2008 to 2010, the heritage of these sites were explored in a research project funded by the National Heritage Council and, while rich repositories of tangible and intangible heritage were discovered, the environmental condition of the sites deteriorated visibly and rapidly over a short period of time. Given the centrality of freshwater bodies at these sites for both mundane use and spiritual and medicinal purposes, Drs Cawood and Vos decided to study the water quality of Mautse and Motouleng water bodies using physical, chemical, and biological analyses.

Physical and chemical risk were found to be insignificant, but the biological results were revealing, with high concentrations of faecal coliforms indicating increased human and animal activity. Water quality varied from moderate to poor and, while certain water bodies were mesotrophic, key sacred water sources were becoming increasingly eutrophic over the sampling period, a clear indicator that Mautse and Motouleng were showing escalating signs of stress, which correlated with observations of increased numbers of pilgrims and human activity where water usage, waste disposal and sanitation all appeared to be unregulated. The findings documented a masking effect where clear water (due to the rocky substrate) masked the presence of high bacterial loads and created the illusion of being safe for consumption.

"It has become clear that, should circumstances continue and deteriorate as it has over the last few years, the sites may deteriorate to such an extent that all heritage and intrinsic value are lost, rendering them unfit for any form of use by humans." (Cawood, 2010).

A cycle of risk was identified where human, animal, and ecological risk factors interacted to amplify the vulnerability of these sites, with water quality as the common denominator between the environmental integrity and public health of an informal heritage site and the heritage associated with those sites (Vos & Cawood, 2010). Living heritage sites such as these depend on the sustainability of the heritage-related practices to remain active, so ecological risks such as poor water quality will increase the risk to pilgrims and heritage practitioners and

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ultimately the heritage associated with those practices will be lost if the sites become ecologically degraded to such an extent that it becomes unsafe for human use.

Drs Cawood and Vos devised a comprehensive bio-cultural screening model for heritage sites inspired by the Physico-Chemical Driver Assessment Index (PAI), one of the indices for biomonitoring aquatic ecosystems, which include the parameters of oxygen, temperature, total dissolved solids (TDS), nutrients, and bacterial load. However, this comprehensive approach would be more appropriate to formal heritage sites with access to formal management and funding.

For informal heritage sites where there is no management protocol or little funding, an abridged bio-cultural screening version was proposed called Rapid Integrity Appraisal (RIA) for a quick and effective assessment of site health. Of all the available biological water quality measurements, bacterial analysis and turbidity proved the most meaningful to quickly ascertain the general ecological health of the Mohokare sacred sites or similar heritage sites that may be undeclared, informally used and poorly managed.

Therefore, RIA is a deconstructed version of the conventional Physico-Chemical Driver Assessment Index (PAI) and solely consists of one physical parameter, turbidity, and the biological/bacterial parameter of ***E. coli.*** (Cawood & Vos, 2016). The choice of the biological/bacterial parameter is logical given the potential of human impact, while turbidity is included because of its inverse role in the masking effect.

RIA is specifically aimed at the rapid assessment of the ecological condition of sites for immediate decision-making and may lead to the implementation of the comprehensive bio-cultural screening model where resources may allow. South Africa has immense challenges with resources, which has worsened due to the COVID-19 pandemic, and resources for informal heritage management likely will remain scarce going forward making RIA a more expedient alternative.

In the conclusion of the National Heritage Council report in 2010, the researchers remarked how unfettered human activities at these sites and increasing pilgrim numbers and permanent residents were "putting stress on the environment" and manifested in "the visible environmental degradation of the sites in a very short time frame" (Cawood, 2010). The findings from studying the impact of water quality on sacred sites between 2008 and 2010 by Dr Cawood and Dr Vos signalled that these sites would not be sustainable in the long run without serious intervention and anticipated the eventual closure of these sites. The sites of Mautse and Motouleng were arguably the most popular pilgrimage destinations of all Mohokare sacred sites, but they were also more vulnerable due to their undeclared status with no management or preservation protocols in place. In 2016, Mautse was closed, and, at the time, the environmental degradation was so severe; it was no longer considered safe for humans.

Early in the first government-imposed lockdown in March 2020 due to the COVID-19 pandemic, all pilgrims were evacuated from Motouleng, which was subsequently damaged by fire. Of the Mohokare sacred sites, Mantsopa and Witsie's Cave, the only sites subject to some form of management and protection regime, remain intact, while the informal sites have perished.

The closure of Mautse and Motouleng in conjunction with the COVID-19 pandemic, lockdown restrictions and containment measures have had a devastating effect on the Mohokare pilgrimage movement, which currently is dormant. However, the hope is to re-open not only the intact sacred sites once it can safely be done, but also to revive both Mautse and Motouleng, in a more sustainable manner. Concerned stakeholders, including local traditional faith organisations, traditional leaders and healers, landowners, and scholars, are actively working towards this goal. Free State heritage professional and PhD student in Africa Studies, Mr Makashane Ntlhabo, is working closely with local authorities and stakeholders to develop practical management protocols for the Mohokare sacred sites that also include appropriate COVID containment measures to be tested at Witsies Cave.

Fundamentally, the Mokohare pilgrimage movement has always been a grassroots movement and will be better served if interested stakeholders work together to develop practical management protocols and a formal stakeholder forum to address issues pertinent to the sites which in the long run could evolve into a Section 21 company or non-government organisation eligible for funding. Possible stakeholders include the landowners, pilgrims who regularly visited the sites, local community leaders, researchers, traditional authorities, tourism boards, heritage institutions such as the Free State Provincial Heritage Resources Authority, the Free State Department of Sport, Arts, Culture and Recreation and other legitimate stakeholders. To be sustainable in the long term, such a forum must be a mandated forum with a planning agenda and official authority to act in the best interest of the sites and manage them accordingly.

Stephanie Cawood

Mantsopa's Spring, including baptismal fonts; and the Rose Chapel

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Water is a key indicator for ecological degradation and environmental threats to intangible heritage which needs material locations to anchor their meaning. Tangible and intangible heritage are therefore closely integrated and cannot be separated. The RIA (Rapid Integrity Appraisal) model was field tested from 2018 to 2019 on the water resources of the Mohokare sacred sites and can provide a quick and efficient barometer not only of the general health of a site, but also a snapshot of the nature of human activities occurring during a sampling interval. In the absence of existing standardised management and protection protocols across the board, Dr Cawood and Dr Vos argue that the RIA model should be included as a monitoring tool in the development of management protocols devised by stakeholders. In this way, the current hiatus of the Mohokare pilgrimage movement can be productively used to restore all sacred sites and sacred water resources and to reset the pilgrimage movement in a post-COVID world to make it more sustainable without needing formal declaration and protection, which can be time-consuming and expensive.

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The sacred valley of Mautse.

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WETLANDS

High mountain splendour: Ingula joins the list of globally-protected wetlands

The Ingula Nature Reserve, a spectacular mountain wetland and refuge for vulnerable birds and other wildlife has become South Africa's 27th protected area listed as a Ramsar Wetland of International Importance, writes Tony Carnie.

CF Pienaar

There is a very distinct line high up in the Drakensberg mountain range that determines the future of almost every water droplet that falls here. If drops of rain fall on the north side of this line, most water will coalesce into the streams and rivers that eventually tumble westward into the Atlantic Ocean via the Wilge, Vaal and Orange rivers. But if rain falls on the other side of the mountain line, the drops will flow southwards into the Klip and Thukela rivers to eventually empty into the Indian Ocean on the other side of the continent.

Not surprisingly, this watershed line also forms a provincial boundary between the Free State and KwaZulu-Natal and plays a crucial role in inducing orographic rainfall, where moisture drops from the clouds as they climb upwards to the towering Drakensberg Escarpment.

More recently, this lofty line has assumed another surprising role – alleviating the Eskom power crisis. Due to the sharp drop in altitude between the Free State and KZN, this area was seen as a perfect spot to build a new kind of Eskom power station, which harnesses the power of water.

Known as a pumped storage scheme, the system involves storing water in a big dam at the top of the hill and then

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releasing it into a dam at the bottom of the hill. The power of the water racing down a concrete tunnel is captured to drive turbines and generators to produce electricity during times of peak demand. Then, when power demand is low, the water is pumped slowly back up the hill again, to repeat the process.

The principle is relatively simple. But when Eskom announced plans in 1998 to build the new power scheme in the Ingula area, north of Ladysmith, it triggered immediate concern by conservation groups worried about the implications for the unique high mountain grasslands and wetlands in both provinces.

And for good reason.

Subsequent studies have shown that the wetlands and grasslands near Ingula are a haven for birds and other forms of wildlife, many of them vulnerable species, which are running out of living space in a country where large areas of land have been developed, degraded or put under the plough. Happily, however, a compromise was reached to protect this unique area through a partnership involving Eskom and two conservation groups, BirdLife South Africa and the Middelpunt Wetland Trust.

And now, just over two decades later, the Eskom-owned Ingula Nature Reserve has been granted global recognition and listed by the Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat, an international treaty for the conservation and sustainable use of wetlands Also known as the Convention on Wetlands, it is named after the city of Ramsar in Iran, where the convention was signed in 1971.

South Africa now has 27 wetland sites listed under the convention, covering a surface area of 571 089 hectares. They include areas such as Langebaan, Lake St Lucia; the chain of five coastal lakes at Kosi Bay; the Orange River Mouth and the remote Prince Edward Islands.

Elsewhere in the world, there are now more than 2 400 Ramsar Sites covering more than 2.5 million square kilometres. This network of Ramsar Sites is truly global, and includes coastal and inland wetlands of all types. The countries with the most sites are the United Kingdom, with 175, and Mexico with 142. The first site added to the list was the Cobourg Peninsula in Australia, designated in 1974. The largest sites are Rio Negro in Brazil (120 000 square kilometres) and Ngiri-Tumba-Maindombe in the Democratic Republic of Congo and Queen Maud Gulf in Canada (which each cover over 60 000 square km). Others are as small as one hectare.

The Convention has several mechanisms to help member parties designate their most significant wetlands as Ramsar Sites, and to take the steps necessary to manage them effectively and maintain their ecological character.

Back at Ingula, the journey towards Ramsar status began about

CF Pienaar

The Drakensberg escarpment forms an orographic barrier – with high rainfall on the seaside, and a rain shadow inland.

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20 years ago, soon after Eskom entered into negotiations with BirdLife and the Middelpunt trust on ways of limiting or mitigating the impacts of inundating two large wetland areas to form the new Bedford and Braamhoek storage dams. This decision to cooperate and form the Ingula Partnership followed a protracted period of appeals, legal challenges and a hearing in the High Court.

As part of the Environmental Authorisation conditions for Ingula, Eskom was asked to purchase adjacent farms containing sensitive wetlands and grasslands to compensate for the residual impacts on wetlands and ecosystems that would be lost during the construction of the power station. Following further engagement with landowners, Eskom bought more than 8 000 hectares of land in the vicinity to establish a new nature reserve that was formally established in 2013, three years before the new pumped storage station was commissioned.

More than 341 species of birds have been recorded on the Ingula Nature Reserve, including a number of priority species – the White-winged Flufftail, Blue Crane, Grey Crowned Crane, Wattled Crane, Secretary Bird, Martial Eagle and the Southern Bald Ibis. One of the rare plant species found at Ingula is the African Weed Orchid (***Disa tysonii***).

Ingula is also home to 34 mammal species, including Aardvark, Chacma Baboon, Blesbok, Bushbuck, Bushpig, Caracal, Dassie, Grey Duiker, Black-backed Jackal, Rough-haired Golden Mole, Large Grey Mongoose, Water Mongoose, Yellow Mongoose, Oribi, Cape Springhare, Cape Clawless Otter, Striped Polecat, Porcupine, Common Reedbuck, Grey Rhebok, Mountain Reedbuck, Serval, African Wildcat and a number of small rodents.

In addition, the nature reserve has 69 recorded species of butterflies and 29 species of reptiles, while the endemic Sungazer lizard (also known as 'ouvolk') is found on adjoining properties.

"Only a little more than 10 percent of the world's wetlands remain; they are our most endangered ecosystem, and we can't build back better without them. The time has come to give wetlands protection and ensure the wise use they deserve: Our lives could depend on it." - Martha Rojas Urrego, Secretary General of the Ramsar Convention on Wetlands

Carina Pienaar, the Ingula Grasslands project manager for BirdLife SA, says the organisation is proud to be part of a project that has received international recognition as a model for how industry and conservation organisations can work together for the benefit of the natural environment. "BirdLife South Africa has been an integral partner in ensuring that consistent monitoring of avian biodiversity has taken place throughout the construction of the Ingula power scheme."

CF Pienaar

The grasslands of Ingula are dominated by Eragrostis curvula, Tristachya leucothrix.

The research and monitoring opportunities at Ingula Nature Reserve since 2003 had led to valuable discoveries about the seasonality of bird species' presence on the site, as well as their habitat and climatic requirements. "When the scheme was originally proposed, BirdLife South Africa objected because it was feared that the habitat for the Critically Endangered White-winged Flufftail at this site would be forever lost.

"However, in ensuing negotiations with Eskom, it became evident that more could be achieved if we were to work together on the environmental aspects of the project. The milestones reached in first obtaining national protection for the wetlands and grasslands, and subsequently international recognition through the recent designation as a Wetland of International Importance, has proven that environmentally sustainable development is possible, if opposing parties should choose to embrace collaborations."

Barbara Creecy, the national Minister of Forestry, Fisheries and the Environment, has also welcomed the latest Ramsar declaration noting that it falls within the Northern Drakensberg Strategic Water Source Area (SWSA) and is also a National Freshwater Ecosystem Priority Area made up of hillslope wetlands, pans/depressions and floodplains.

"Despite their significance to human life, wetlands are threatened nationally and globally. The 2018 National Biodiversity Assessment found that at least 79% of South Africa's wetland ecosystems are threatened. That report emphasises the role of rivers, wetlands and their catchments as crucial ecological infrastructure for water security and often complementing built infrastructure," she said.

Creecy says her department has invested more than R83 million in the rehabilitation and maintenance of at least 75 wetlands in the current financial year, coordinated through the Working for Wetlands Programme.

"Since its inception in 2004, the Working for Wetlands Programme has rehabilitated over 1 749 wetlands countrywide, thereby contributing to increased healthier water supplies

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improving the economic benefits of natural and agricultural habitats. This has also created more than 40 274 jobs and skills development opportunities for South Africans."

Eskom says the Ramsar listing is the culmination of many years of hard work by the Eskom team in partnership with BirdLife and Middelpunt trust.

"While the Department of Environmental Affairs required Eskom to conserve the unique wetland and high-altitude grassland area, Eskom went the extra mile and ensured the formal protection of the 8 084 ha with the formal declaration as a Nature Reserve."

"The Ingula partnership has received international acclaim as a pioneering example of how industry and non-government organisations can cooperate towards achieving conservation sustainably."

In 2019, the Ingula Partnership also won the Stewardship category at the South African Wetland Society Annual Awards. It is also registered as an internationally Important Bird Area (IBA). Ingula is made up of two adjoining sections, the upper part in the Wilge River catchment of the Free State and a lower section in the Thukela River catchment in KZN.

Perched at an altitude of between 1 260 and 1 900 metres above sea level, the land mainly consists of dry grassy plains – which are partly cultivated and irrigated – interspersed with extensive wetlands. It is situated along the northern-most part of the Drakensberg mountain range, where the crest of the escarpment forms an orographic barrier - with high rainfall on the seaside, and a rain shadow inland.

Eskom notes that prior to initiation of the Ingula project, much of the land was degraded and in poor condition due to decades of poor farming practices. Erosion threatened a large marsh further downstream and the Free State Department of Tourism, Environment and Economic Affairs spent close to R1,3 million on wetland protection measures.

While the continued erosion and degradation of the area through overgrazing and agriculture has been halted, there is still a significant amount of work to be done on historic erosion and wetland restoration in the main conservation area.

Large areas of alien vegetation have also been cleared and Eskom has purchased equipment to combat fires that often occur in the region and has also undertaken to mitigate against fish hybridisation and potential inter-basin transfer of fish between the separate Vaal and Thukela catchments.

Over time, Eskom managers are hoping that Ingula will become the core of a much larger conservation area and that surrounding land owners will use make use of opportunities for tourism related activities and to enhance the biodiversity of their land.

Malcolm Drummond of the Middelpunt Wetland Trust recalls that the trust rang alarm bells in the early 1990s because it was

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The administration building and visitors centre at Ingula.

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CF Pienaar

Eskom and its partners have tried to integrate man-made structures with the crucial natural wetlands.

worried about the future of the Bedford Chatsworth marsh. "As one of only nine sites in South Africa that the 'Critically Endangered' White-winged Flufftail is known to visit, any threat to one of these locations is of huge concern to Middelpunt Wetland Trust.

"As in any successful relationship, it has been a process of learning and earning trust and respect."
Two decades down the line, the bells are still ringing – but this time in celebration of the Ingula Partnership's latest achievements.

Eskom

Water cascades down the Braamhoek dam.

South Africa's List of Wetlands of International Importance

1. Barberspan
2. Blesbokspruit
3. Bot - Kleinmond Estuarine System
4. Dassen Island Nature Reserve
5. De Hoop Vlei
6. De Mond
7. Dyer Island Provincial Nature Reserve and Geyser Island Provincial Nature Reserve
8. False Bay Nature Reserve
9. Ingula Nature Reserve
10. Kgaswane Mountain Reserve
11. Kosi Bay
12. Lake Sibaya
13. Langebaan
14. Makuleke Wetlands
15. Natal Drakensberg Park
16. Ndumo Game Reserve
17. Ntsikeni Nature Reserve
18. Nylsvley Nature Reserve
19. Orange River Mouth
20. Prince Edward Islands
21. Seekoeivlei Nature Reserve
22. St. Lucia System
23. Turtle Beaches/Coral Reefs of Tongaland
24. uMgeni Vlei Nature Reserve
25. Verloren Valei Nature Reserve
26. Verlorenvlei
27. Wilderness Lakes

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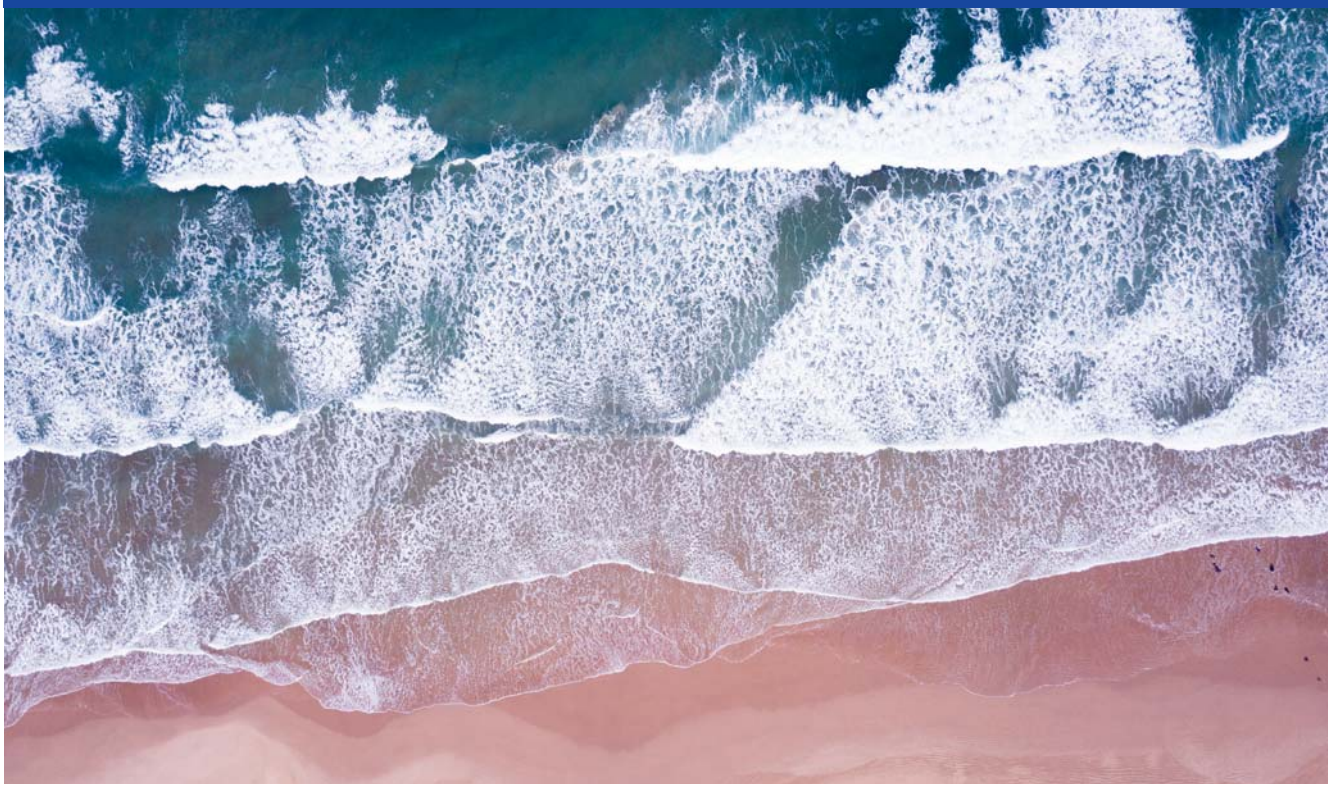
WATER INFRASTRUCTURE

Re-thinking desalination: The value proposition of water as an infinitely scalable, renewable economic commodity

There can be little doubt as to the strategic importance of man's ability to convert seawater into freshwater; it is very comforting to know that with reverse osmosis and ever-cheaper renewable energy, we can produce freshwater from a near infinite resource of seawater, especially in a time when we face daunting environmental and climate challenges. So writes Dawid Bosman from the Trans-Caledon Tunnel Authority.



But for a mature technology with such a compelling value proposition, desalination is still a rarity outside of its established market of the Middle East, North Africa (MENA) and Gulf Cooperation Council (GCC) countries. And where desalination has been adopted outside of these markets, it has frequently been relegated to a role of contingency infrastructure, used ad-hoc or even politicised as an opposition folly, but seldom given its rightful place as a highly assured, climate-independent, infinitely scalable water resource.

A strategic technology misunderstood?

Tentative and haphazard implementation strategies have not helped; examples abound of small-scale, short-term contracts that defy sound business principles, which inevitably result in poor economics and exorbitant water prices. Similarly, Day Zero emergency situations that require the design and build of a small plant in less than ten weeks will probably result in poor value for the public funds expended. One simply cannot transplant a technology that is best suited to large-scale, continuous-flow operation into a small-scale, intermittent operating environment and expect good outcomes.

When comparing the desalination water costs achieved in the mature MENA and GCC markets, characterised by stable and

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consistent policy environments and large-scale, continuous operation plants, with the not-so-mature Australian, US and even South African markets, where desalination is still largely regarded as drought insurance, a stark difference emerges. In the mature market, all-in water costs of $0.40 to $0.50/kl are now consistently being achieved from new seawater reverse osmosis (SWRO) projects.

In the emerging markets, the costs are invariably higher, often by several multiples. Of course, some input factors are simply not comparable, such as energy and labour costs, but these fall well short of explaining the vast disparity.

It can therefore be argued that so far, in the South African market at least, desalination has not been managed as the strategic technology that it is. However, if we consider the prominent role given to desalination in the National Water and Sanitation Master Plan, to help avert a growing national water deficit over the next nine years, then we need to urgently implement and capacitate the National Desalination Strategy of 2011 (Now appended to the National Water Resources Strategy of 2013).

Desalination in the Master Plan

It is worth noting that the National Water and Sanitation Master Plan aims to close the national water deficit through both demand and supply-side interventions; by 2030, some 2 060 million cubic metres per annum (MCM/a) in demand-side saving should be achieved through reductions in domestic consumption and reticulation losses, while a similar quantum of some 1,977 MCM/a should be added on the supply side, through augmentation coming from surface, ground, sea and reuse. Of this latter amount, some 588 MCM/a (or 30%) is earmarked to come from desalination; the sea has become a substantial element of national water resource planning.

Thus, what will this quantum of desalination look like, when it is built? Plant capacity is usually expressed in megalitre per day, or Ml/d; the thirty-odd existing plants in South Africa are typically smaller than 10 Ml/d; the largest seawater plant is a 15 Ml/d unit at Mossel Bay, and a hybrid seawater-reuse plant of 47.5 Ml/d is under development in Durban. The total existing inventory amounts to about 215 Ml/d, but many of the plants are not operational. The 588 MCM/a of new desalination capacity stated in the Master Plan translates into 1 610 Ml/d, which is some eight times larger than the current installed capacity; this capacity will need to be established over the next nine years.

Using an South African-adjusted capital cost benchmark of $1.4 million per Ml/d installed capacity (DesalData), and an exchange rate of R15 to the US Dollar, this indicates an outlay on desalination plants of about R34 billion, spread over nine years, across perhaps 10 to 15 separate projects. This will be a vast undertaking, with a total magnitude similar to Phase II of the Lesotho Highlands Water Project.

Approaching this undertaking in an ad-hoc manner is not advisable; the procurement of desalination is fundamentally different from conventional water infrastructure, especially around the placement of technical and project risk. Instead, a carefully considered to-market strategy needs to be developed and used for guidance throughout.

Towards cost-effective desalination

As a first step towards cost-effective desalination, it is necessary to know what the international cost benchmarks are; the next steps would be to explore what are the factors that drive costs up or down, and to gain an understanding of how these might be influenced.

Figure 1 below reflects the comparable "all-in" product cost benchmarks achieved by Independent Water Producer (IWP) bids on numerous large-scale desalination projects in various countries since 2000, using seawater reverse osmosis (SWRO) technology. The trend towards lower costs and a narrower spread in recent years can largely be ascribed to lower cost of capital, a decline in EPC costs and cheaper renewable energy. As a result, the current benchmark is around the $0.50 mark, well below the global average water tariff of $1.21/kl. It is ironic that desalinated water in an arid region should be cheaper than the global average water tariff.

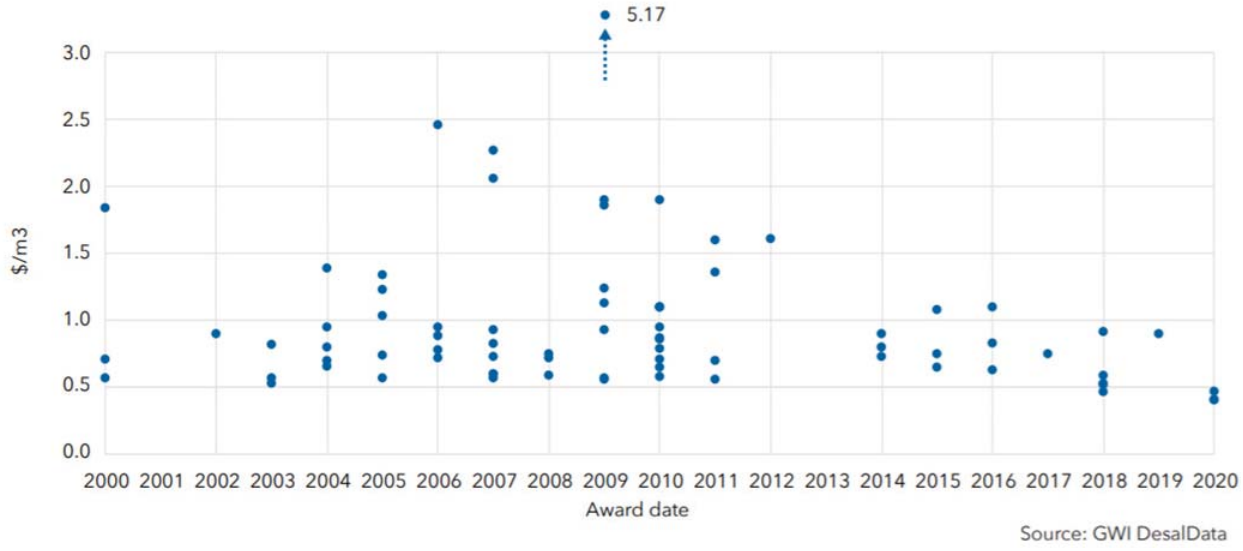

Figure 1: Price of desalinated water from IWP's since 2000 .

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"One simply cannot transplant a technology that is best suited to large-scale, continuous-flow operation into a small-scale, intermittent operating environment and expect good outcomes"

The problem of course, is that these benchmarks are largely determined by data points from projects in the GCC and MENA regions: Israel, Saudi Arabia, the United Arab Emirates and so forth. The formidable challenge to the emerging desalination markets, such as South Africa, is to achieve similar prices, or just close to it. While the aim of this article is not to unpack the full dynamics of the various cost factors, the following are worth considering:

- Developers and EPC (engineering-procurement-construction) contractors value policy stability and predictability. Since South Africa cannot become a stable, mature desalination market like the UAE overnight, we could project stability to the market through policy certainty, integrity and a firm commitment to continuous off-take of the product. The antithesis would be the ad-hoc, drought insurance approach followed by most of the emerging market.

- An important element of going to the market, is to procure and contract in a manner that places risk where it can best be managed. Even though there would be a cost involved in the outplacement of risk, if it is then managed optimally, all parties will ultimately benefit. This dynamic is at play in the trend towards IWP (independent water plant) contracts, at the expense of DBOM (design-build-operate-manage) contracts.

- A strategic decision will be whether to own the desalination infrastructure, or not; this has far-reaching implications. Owning the plant does mitigate some fundamental risks, but it is the more onerous option; internal technical capacity is required to drive the complex procurement of a technology partner to design, build, operate and maintain the plant. Add to this the need for a strong balance sheet and the ability to raise considerable capital, and most South African water service authorities (WSA's) would not reach the bar, save for a few metros. The other option would be to pursue the market for independent water producers, offering a long-term concession to a site that had been properly vetted for the purpose. In this instance, the main obligations involve the site selection, a well-considered product water specification and the ability to commit to a robust, long-term water supply agreement; critical here, would be to demonstrate that tariff revenue can and will be collected from consumers.

- Further factors to consider would be the scale of the plant (ideally 150-200 Ml/d to allow good economy), contract duration (for the capital outlay to be amortised), production flexibility (a plant that can keep going through a red tide will cost more), and ideally access to low-cost renewable energy, within the range achieved by Round 4 of the REIPPP (Renewable Energy Independent Power Producers Programme) (R0.68-R0.82/kWh).

- After many years of desalination being relegated to a role of drought insurance, and frequently mismanaged in application, its time has come; it is now a prominent element of national water resource planning, as a base-load resource.

Furthermore, there is now evidence that the cost of large-scale desalination can be managed within reasonable parameters - provided that certain project-related and procurement-related guidelines are adhered to. Insight into the economics of desalination has deepened significantly over the past 18 months, largely due to the costing transparency from numerous IWP contracts awarded in the GCC region; future implementations in other markets stand to benefit from this. What is needed now is a strategic approach to establishing the planned capacity.

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COVID-19 AND THE ENVIRONMENT

COVID-19 and unquantified ecological health risks from sanitisers and disinfectants

To limit transmission of the COVID-19 virus, surfaces are regularly cleaned using disinfectants. However, these disinfection efforts are underway largely without considering potential impacts on the environment. A current research project is building knowledge critical to understanding ecosystem responses and the risks of introducing large amounts of disinfectant and anti-viral chemicals to aquatic ecosystems and biota. Article by Ndeke Musee of the Emerging Contaminants Ecological and Risk Assessment Research Group, Department of Chemical Engineering, at UP.

March 2021 marked one year since the declaration of the COVID-19 pandemic by the World Health Organisation (WHO). By the beginning of May, the number of global infections stood at 155 million, with over 3.2 million fatalities since the declaration of the pandemic. Sadly, these grim statistics are firmly on an upward trend.

In a race to fight the pandemic, a two-pronged approach has been adopted worldwide: non-pharmaceutical interventions (NPIs) and pharmaceutical interventions (PIs). The NPIs include wearing masks, regularly sanitising hands, disinfecting surfaces to inactivate the SARS-CoV-2 virus, and social distancing. Conversely, PIs entail the use of active pharmaceutical ingredients (APIs) to treat hospitalised patients.

Both approaches have contributed positively to the effective management of the COVID-19 pandemic. Their downside, however, has been the release of large quantities of chemicals into the ecosystems over a short period arising especially from the wide use of sanitisers and disinfectants. The risk of these sanitisers and disinfectants to human and ecological health remain, however, unknown. As a result, this has raised concerns among governments, regulators, scientists, and agencies mandated to protect natural resources, as well as the general public across the globe on the potential unknown implications of numerous chemicals incorporated in sanitisers and disinfectants.

Similar concerns have been raised in South Africa. As a result, the focus of a current project funded by the Water Research Commission (WRC) in partnership with the University of Johannesburg (Prof P Nomngongo), University of South Africa (Prof K Mbatha), and University of Pretoria (Prof N Musee) is to establish the implications of sanitisers and disinfectants to the country's ecosystems. Further, the project aims to propose practical approaches that can be proactively adopted to mitigate

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plausible deleterious implications from numerous chemicals incorporated in these products.

Currently, our ability to understand the likely threats of sanitisers and disinfectants arising from variant chemicals to ecosystems remain challenging. This is because chemicals from these products in South Africa remain largely unqualified in variant ecosystems e.g., rivers, wastewater treatment plants, dams and sediments. As a result, our ability to define with any definitive certainty suitable management options, particularly with a focus on candidate chemicals of significant concern, remains impeded. For example, without identification of chemicals incorporated into these product categories, there is difficulty in isolating candidate chemicals to monitor, evaluate risk, and manage proactively.

As the saying goes "you cannot manage what you cannot measure", therefore, the first step in this project focuses on identifying both sanitisers and disinfectants brands widely commercialised and accessible to the general public in South Africa. The second step is to identify constituent chemicals incorporated in variant brands of sanitisers and disinfectants. These aspects have been achieved through a two-pronged approach. One, by visiting most major stores in South Africa to identify variant brands in the retail market, and secondly, identifying brands based on online marketing platforms. The chemicals incorporated in variant sanitiser and disinfect brands were then sourced from the list of ingredients in a given product brand, and/or online published patent information for a specific brand in question.

From the market search carried out from October 2020 to February 2021, 41 and 57 brands of sanitisers and disinfectants, respectively, were identified as available in commerce and widely accessible to the general public in South Africa. Based on different data sources, and concomitant analysis, a total of 72 and 74 different chemicals were found to be incorporated in sanitizers and disinfectants, respectively. The chemicals are for variant functions, including killing microbial organisms, moisturising, emulsification, just to mention a few. Eleven of the chemicals were found to be incorporated both in sanitisers and disinfectants. Further, about 50% of the 11 chemicals had antimicrobial properties.

What are the implications of the chemicals in the database developed in this project? First, it offers insights into the chemicals widely used in sanitisers and disinfectants in the South African market. This is important as it is not possible to generalise chemicals used in sanitisers and disinfectants as they vary from country to country – although certain similarities cannot be ruled out. Hence, the results of this project aim to sharpen focus on chemicals of significant concern arising from both product categories in the South African commerce. This implies that common chemicals in both product categories are among the most likely candidates for release in large quantities into the ecosystems.

One key aspect that stood out was the large use of chemicals either for antimicrobial or fragrance purposes. In addition, several chemicals incorporated in sanitisers as fragrances were either already prohibited or used under strict control in many jurisdictions across the globe. Yet, several prohibited chemicals were identified to be incorporated in four popular sanitiser brands in South Africa. Such chemicals raise and pose double-edged sword concerns. Firstly, plausible adverse health effects to consumers, and secondly, potential deleterious implications to aquatic organisms following their release into ecosystems in light of current scientific knowledge.

A further concern is that increasing the release of chemicals with antimicrobial properties can trigger antimicrobial resistance. This may result in far-reaching adverse implications to both human and ecological health. For example, the most common function of chemicals incorporated in disinfectants are antimicrobial agents accounting for 27% of the total 74 chemicals identified in the disinfectants from our study. Further, of the most commonly used chemicals in disinfectants were the quandary ammonium compounds (QACs) and found in 12 brands widely commercialised in South Africa.

To illustrate the implications of antimicrobial resistance; let us consider the case of benzalkonium chlorides (BACs). BACs are among the widely used class of QACs in numerous sanitiser and disinfectant brands in the South African commerce. Scientific studies have demonstrated that certain microbes after long time exposure to BACs can be rendered less susceptible to these antimicrobial chemicals.

More worrisome is that they make commonly used antibiotics to treat variant diseases less effective. Therefore, wide use of antibacterial chemicals e.g., BACs, may trigger both antibacterial and antibiotic resistance. For the former, this may mean serious distortion of the ecological integrity. Conversely, in the latter case, this outcome has far-reaching implications to human health, including a trigger to undesirable multidrug resistance. To date, the challenge of antibiotic resistance is of global concern, including in South Africa, and the problem is likely to be significantly exacerbated by the wide use of sanitisers and disinfectants in response to COVID-19.

The information in the established database is essential to decision- and policy-makers. As an example, it can aid to track trends on pollution arising from the variant chemical classes over time from product categories, including sanitisers and disinfectants. Further, it can offer scientific evidence – and is of urgent necessity to support mapping a pathway towards the design and development of sustainable benign alternatives. For instance, in cases where certain chemicals incorporated in sanitizers and disinfectants are identified as of concern, such information can form a pro-active basis to examine alternatives hinged on green-chemistry design principles without compromising the products' efficacy and functionality.

The database can also serve as an additional arsenal to regulatory authorities to consider options including: (i) definitive specification of allowable concentrations per article for certain chemicals, (ii) enactment of total bans of chemicals with no justifiable benefits to the human health as recently demonstrated for the case of triclosan and triclocarban, and, (iii) develop a framework aimed at identifying safe products in an endeavour to safeguard against potential impairment of human health during the use phase; and to protect environmental health. Overall, policy-makers and regulatory authorities need, as a matter of priority, established science-evidence based pre-authorisation mechanisms for products including sanitizers and disinfectants under extraneous circumstances as currently imposed by COVID-19. The findings from this project seek to contribute towards achieving this outcome.

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EXPLORING OPPORTUNITIES FOR EQUAL ACCESS TO WATER SCIENCE

The conference held various panel discussions featuring prominent women scientists.

Opening statements by WRC CEO, Dhesigen Naidoo.

Ministerial advisor, Jurgen Kogl, delivered the address of the Minster of Human Settlements, Water and Sanitation, Lindiwe Sisulu.

WRC Board member, Dr Mosidi Makgae, addresses delegates.

The Water Research Commission (WRC) over the years has through its multiplier effect made a huge contribution to the plight of women in research science, not only in South Africa, but on the African continent. Through its different programmes and knowledge dissemination efforts in collaboration with key local and international partners, the WRC has made inroads into changing the water research science landscape and building new images of scientific work. Women are now playing a significant role in ensuring water supply for the country's future needs. On 18 and 19 March, the WRC held a conference titled 'Women in water and science and the impact of COVID-19'. This conference, which was held during National Water Week 2021, formed part of the WRC 50-year campaign and reflected on the role of women in water research science over the past 50 years. It illustrated the gradual transformation of women from being treated predominantly as 'subjects' in water research science to key drivers of change. The conference not only placed the spotlight on the transforming role of women in water research science but also highlighted the opportunities for investment in the development of women in science and as such catalyse gender equality in water research science. To weave this narrative together, women from across the continent had the opportunity to present research outputs, exhibit, share knowledge and network using some of their key impact programmes, initiatives and innovations in the water research science field.

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DEEPLY ROOTED IN SOUTH AFRICA WATER SOCIETY

www.wrc.org.za

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

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

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

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