THE WATER WHEEL

September/October 2020 Volume 19 No 5

ESTUARIES

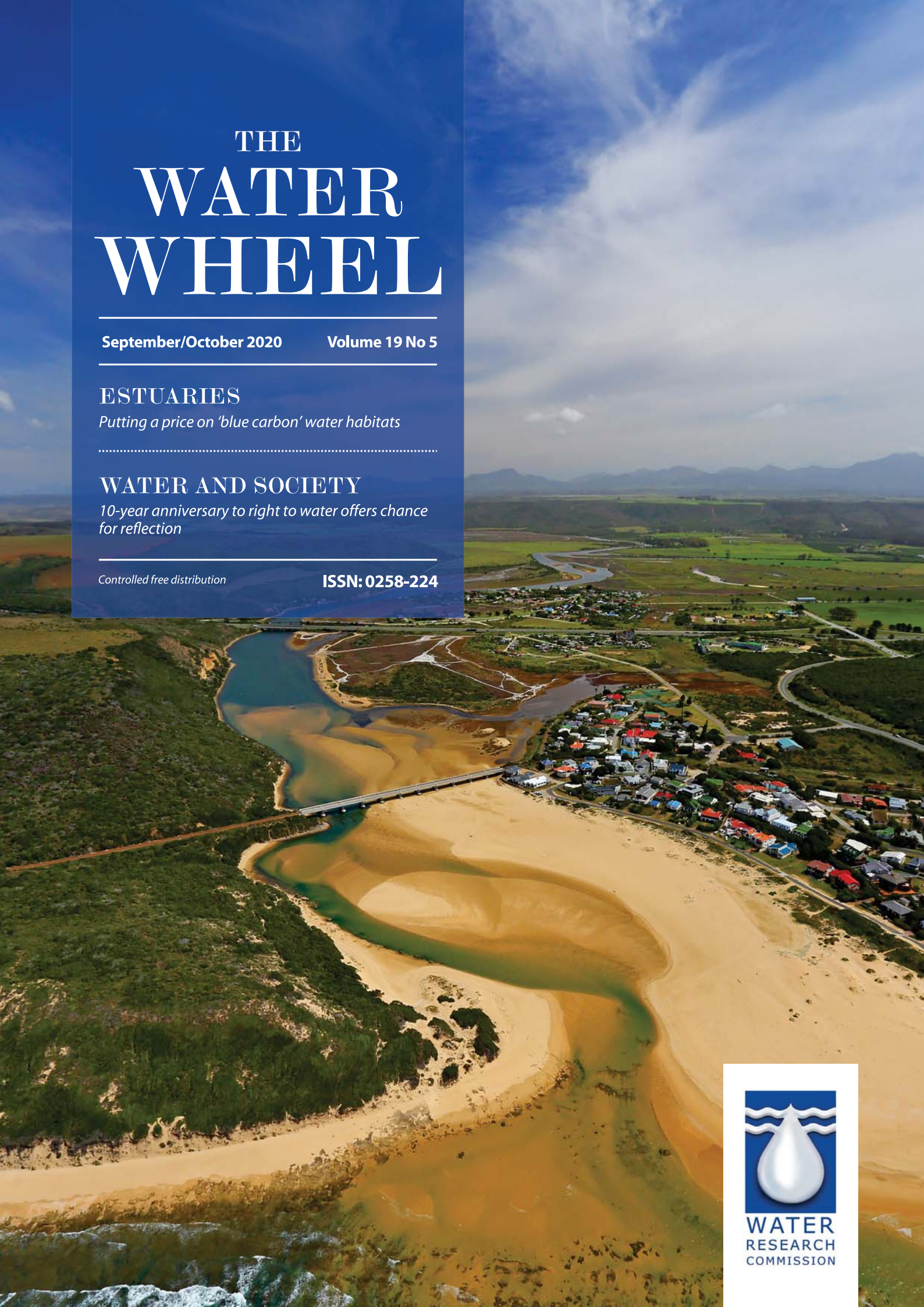
Putting a price on 'blue carbon' water habitats

WATER AND SOCIETY

10-year anniversary to right to water offers chance for reflection

Controlled free distribution

ISSN: 0258-224



WATER RESEARCH COMMISSION

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

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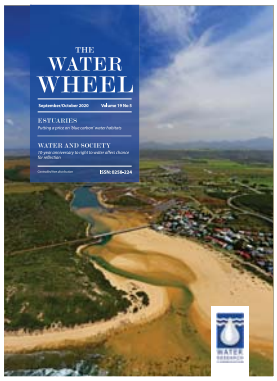

A Water Research Commission study, led by the Nelson Mandela University, has highlighted the importance of estuaries as carbon stores. See the article on page 12.

FLUID THOUGHTS

WRC CEO, Dhesigen Naidoo

Water – core to beating Covid-19 and gaining global health security

We are in the throes of an unprecedented global pandemic. Perhaps unexpectedly with a variant of a virus that we collectively contained and managed in the SARS epidemic of 2002-2004.

This new SARS-CoV-2, or Covid-19, has thrown the world into a storm, with no corner on Earth unaffected. Its impact has already been severe on the social, political, economic, security and health fronts. Our anxiety for personal and collective safety has risen to understandably high levels. Our governments are investing in war-like strategies, such as lockdowns and total isolation, to flatten the infections curve and maintain the numbers with levels that our mostly fragile, and under-resourced, health systems can manage.

The world as a whole has trudged through seven months since the acknowledgement of the Covid-19 global pandemic. For some, the curve of infection increases has not yet stemmed sufficiently to mark the end of the wave. At the time of writing we stood at 24 million cases and already had an estimated 817 000 deaths. Dark times!

Water is central to both the containment of infections, as well as the treatment regimen of those who are infected and ill. Regular washing, in particular handwashing, is one of the better lines of defense against the further spread of the virus. Handwashing campaigns have moved to the top of the list of many national interventions. What this has inevitably done, as crises generally do, is put a magnifying glass on the issues of water security and safe sanitation access. And once again, worldwide, but mainly in the Global South, we have been found wanting.

Using the budget prioritisation for emergency measures, water access has become a key objective with tanker services, water harvesting and storage tanks being key short-term measures. Similarly, access to safe sanitation and organising for rapid de-densification of settlements and slums are key interventions in the Covid-19 response plan of governments. This, together with the measures to ensure short-term food security and a measure of economic safety nets, will help us toward being in reasonable shape both as individuals and nations – both through, and especially beyond, this crisis. One of the many risks associated

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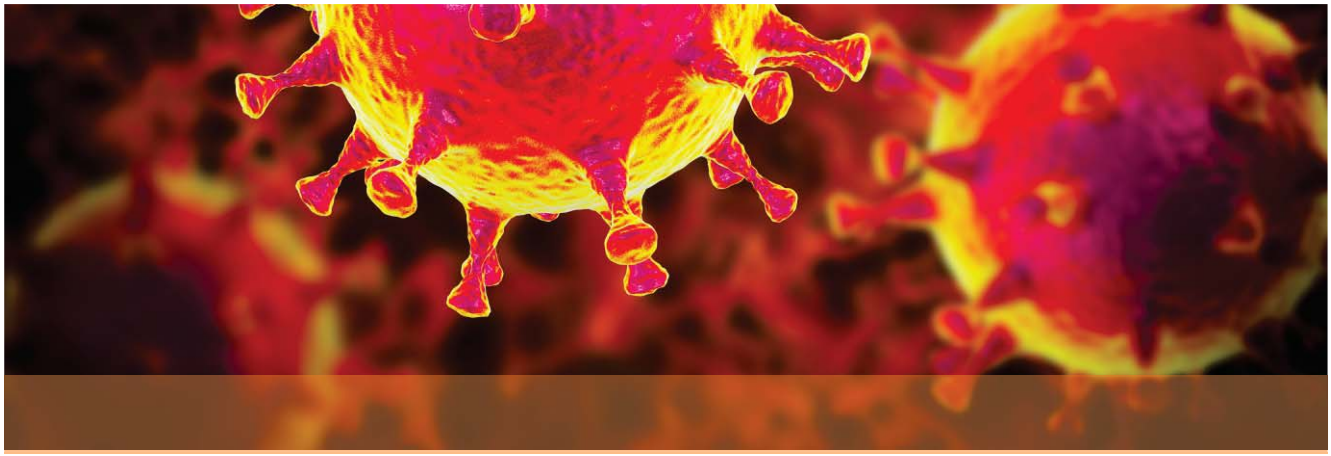
with this pandemic is the slowing of the pace in the achieving of many development targets, including the Sustainable Development Goals. There is a high probability that SDG 6, the goal for water and sanitation, will be further delayed. Depending on the global recovery time from the crisis, this could be for a long time.

In this flurry of emergency responses, it is important to note that we also have the opportunity to do the opposite. We can, in fact, accelerate our efforts toward the SDGs in the medium term, and be firmly on the pathway to sustainable development and a lower carbon economy in the long term. This is the moment when, in many countries in the world, unsafe water and poor sanitation are key Covid risk factors on the one hand, and core to the containment and recovery strategy on the other. The UN system, with UN Water as the anchor, has launched the Global Acceleration Framework and the Decade of Action to nudge world leaders to achieve SDG 6 in its entirety by 2030.

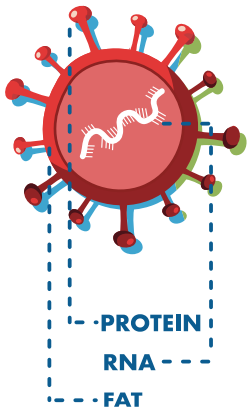
The timing is opportune as water and sanitation matters are enjoying political attention in the public sector and huge focus in the private sector. This must be the right time to engage in catalytic actions to leapfrog the current system constraints to universal access to safe water and sanitation with concomitant, smarter, eco-friendly waste and wastewater treatment. This should be complemented by the industrialisation of the beneficiation of waste and wastewater to produce fertilizers, energy, high-value chemicals, lipids and proteins. These actions will prove transformative – economically, socially and environmentally.

To make this a reality, there are some critical success factors. Firstly, we have to heighten our efforts to translate the accumulated scientific and technological knowledge in this domain to tangible products and services for immediate use on the ground. There will have to be substantive support to product and business development and an overhaul of our archaic regulatory rules and operating procedures.

Secondly, we need new economic models to effect large-scale implementation and sustainable operations and maintenance. Thirdly, we need to bolster our partnerships between science and society, governments and business, local and international. Covid-19 has introduced a ray of hope for new global solidarity. Coronavirus has emphasised that we are unarguably friends in need, let us become friends in deed!



Information resources on water and Covid-19



The following Covid-19 and water related resources are available:

- Water Research Commission http://www.wrc.org.za/corona-virus/
- International Water Association https://iwa-network.org/news/information-resources-on-water-and-covid-19/
- Global Water Research Coalition http://www.globalwaterresearchcoalition.net/
- World Health Organisation https://www.who.int/water_sanitation_health/news-events/wash-and-covid-19/en/
- Water Supply and Sanitation Collaborative Council https://www.wsscc.org/2020/03/31/covid-19-transmission-and-sanitation-and-hygiene-services/

NEWS

Construction to start on Eastern Cape pipeline

Construction of the Tsomo Ngqamakhwe bulk water pipeline in the Eastern Cape was set to commence in August, reported the Department of Water and Sanitation (DWS).

The pipeline is one of the water projects to be undertaken by the department this financial year and it is set to improve water supply to Ngqamakhwe, Butterworth and surrounding areas. Project designs have been completed and the project engineer is on site while awaiting the Department of Labour to satisfy itself with all the necessary requirements needed before the commencement of any construction work.

"Upon completion of the work by the Department of Labour, the project site will be established. The department is satisfied with the preparatory work done so far, and it is confident that the ball will get rolling as soon as all the consultative work has been completed," it said in a statement.

Phase 1 of the project which consists of the construction of a pump station, reservoirs and a pipeline from Tsomo Water Treatment Works to Ngqamakhwe is expected to cost approximately R481 million.

Phase 2 consists of the construction of a bulk water pipeline from Ngqamakhwe to a reservoir and the last phase will be the construction of another bulk water pipeline from the command reservoir to a water treatment works in Butterworth.

"The DWS is steadfast in constructing water infrastructure that will meet the needs of communities and ensure adequate water supply for generations to come," it said.

Source: DWS

Final decision on raw water tariff increases awaited

The final decision on raw water tariff increases will be taken by the Minister of the Human Settlements, Water and Sanitation once all inputs have been considered.

This is according to a statement by the Department of Water and Sanitation (DWS).

The DWS recently held consultations with various waters users in the country as per the requirements of the NWA's legislative process on the proposed raw water use charges for the 2021/22 financial year. In terms of the National Water Act of 1998, the department is required to establish an annual raw water pricing strategy after consulting widely with different water users that include mines, industries, agriculture, energy and domestic users. Consultations were done through virtual meetings, physical meetings and emails. In terms of the capital unit charge, tariffs will be set to ensure that the debt is fully paid by the end-user within a reasonable time period (not longer than the life of the asset), after considering affordability and future augmentation of the scheme. It is also envisaged that the debt will not overlap unreasonably to another project thus causing financial strain on that project.

The capital unit charges may be phased in during the construction period and interest will generally not be capitalized after completion of the construction. The proposed raw water charges for water resource infrastructure in domestic and industrial use envisage an annual increase limited to PPI (April 1,2%) plus 10% up until the target for development charge is achieved on Government Water Systems. Tariff increases range from 0% to 11,2% in agriculture irrigation charges; the depreciation charge will be capped at 1.5c per cubic metres at PPI (April 1,2 %). Operation and maintenance cost increases will be limited to 50% a year.

Source: DWS

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Environmental scientists call for increased protection for threatened SA freshwater fish

Cape Town – A recent Foundational Biodiversity Information Programme (FBIP)-funded endeavour has turned the tables on the conservation status of a freshwater stream fish, the Maloti minnow, thought to be extinct.

Ezemvelo KZN Wildlife freshwater ecologist, Skhumbuzo Kubheka, presented his finding to a recent Symposium of Contemporary Conservation Practise to a wild round of applause. Scientifically known as ***Pseudobarbus quathlambae***, the Maloti minnow was last collected 80 years ago when original collections were made in the upper uMkhomazana River in KwaZulu-Natal in 1938.

Minnows form part of the Cyprinidae family, and are the largest and most diverse fish family – they feed largely on freshwater invertebrates and vegetation, thus contributing to the maintenance of ecosystem structure and related provision of ecosystem services to humans downstream.

The Maloti minnow prefers small streams with a water depth of about 0.5 m, and slow to moderate flowing water, with boulders and cobbles as the dominant substratum.

Kubheka said that between the time of the original collections in 1938 and the early 1960s scientists had documented 'extermination' of minnow populations due to predation by trout and habitat destruction. By 1966 scientists had all but concluded that the Maloti minnow was extinct.

According to Kubheka, the impending 'extinction' caused doubt and consternation in freshwater science circles whereby some thought that the 'original' Maloti minnow were brought from Lesotho. But one scientist, Dr Paul Skelton, a freshwater fish expert, maintained that the uMkhomazana River was the 'type locality' of ***P. quathlambae***. It followed that on the 26 April 2017 ***P. quathlambae*** was 'rediscovered' by Kubheka and three colleagues (Nkanyiso Ntuli, Snazo Gqola, and Nozipho Mkhabela) at the adjacent Mzimkhulu River System – a first record for this river system. The discovery was made during a survey to map the distribution and determine the status of trout in the province.

Follow-up surveys have revealed the species in four other locations, but they are confined to a small area, which Kubheka says is 'scary' and highlights a conservation concern. According to Kubheka the Mzimkhulu River find also lends weight to the theory that ***P. quathlambae*** was once widespread in and around the Drakensberg Mountains.

Khubeka said the threat to the Maloti minnow created obligations and responsibilities on all parties, especially the conservation authorities responsible for the area, to ensure the long-term survival of the species in South Africa. "It will be sad if we do not do much to protect what we thought we've lost," he said.

Source: FBIP

South Africa's National Climate Change Adaptation Strategy approved

South Africa's National Climate Change Adaptation Strategy (NCCAS) has been approved. The Strategy supports the country's ability to meet its obligations in terms of the Paris Agreement on Climate Change.

"This Strategy defines the country's vulnerabilities, plans to reduce those vulnerabilities and leverage opportunities, outlines the required resources for such action, whilst demonstrating progress on climate change adaptation," said the Minister of Environment, Forestry and Fisheries, Barbara Creecy.

The NCCAS outlines a set of objectives, interventions and outcomes to enable the country to give expression to its commitment to the Paris Agreement. Developed in consultation with all relevant stakeholders and approved by Cabinet, it aims to reduce the vulnerability of society, the economy and the environment to the effects of climate change. It gives effect to the National Development Plan's vision of creating a low-carbon, climate resilient economy and a just society.

"Adaptation to climate change presents South Africa with an opportunity to transform the health of the economy and build resilience, thus strengthening the social and spatial fabric, and enables the country to remain globally competitive," said Creecy.

It will ensure that food production is not threatened, infrastructure is resilient and enable continued sustainable economic development.

"This Strategy is an important step forward for South Africa. We now have a common reference point for climate change adaptation efforts in South Africa in the short to medium-term, providing guidance across all levels of government, sectors, and stakeholders affected by climate variability and change," said the Minister.

The ten-year plan, coordinated by the Department of Environment, Forestry and Fisheries, will be reviewed every five years.

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GLOBAL

Report unpacks water as reason for migration

A new report from the United Nations University Institute for Water, Environment and Health unpacks relationships between water and global migration.

Global migration has been increasing since the 1990s. As millions of people are exposed to multiple water crises, daily needs related to water quality, lack of provisioning, excess or shortage of water become vital for survival as well for livelihood support. In turn, the crisis can transform into conflict and act as a trigger for migration, both voluntary and forced, depending on the conditions.

The report, Water and Migration: A Global Overview, aims to start unpacking relationships between water and migration. The data used in this Report are collected from available public sources and reviewed in the context of water and climate.

A three-dimensional (3D) framework is outlined for water-related migration assessment. The framework may be useful to aggerate water-related causes and consequences of migration and interpret them in various socioecological, socioeconomic, and sociopolitical settings.

A case study approach is adopted to illustrate the various applications of the framework to dynamics of migration in various geographic and hydrological scenarios. The case studies reflect on well-known examples of environmental and water degradation, but with a focus on displacement /migration and socioeconomic challenges that apply.

The relevance of proxy measures such as the Global Conflict Risk Index, which helps quantify water and migration interconnections, is discussed in relation to geographic, political, environmental, and economic parameters.

To access the report,
Visit: www.shorturl.at/svAZ0

Lack of water remains a problem for millions of school children globally

The most basic defence against Covid-19, namely handwashing, remains out of reach for millions of students and their teachers.

This is according to figures released by the World Health Organisation and Unicef in August.

Around 43% of schools globally have nowhere for their pupils to wash their hands with soap and water. In sub-Saharan Africa, where a million Covid-19 cases have now been reported and thousands have lost their lives, this figure rises to nearly threequarters of schools (74%) that lack soap and water for handwashing.

Jean-Bosco Twizeyimana is a student at Group Scholaire Kibungo in Bugesera in Eastern Rwanda. The school has a basic water harvesting system, but it's not enough to meet the needs of all the pupils. "There's no water to wash hands after using the toilet, so we don't wash them before coming out of class. At home, we don't wash our hands, the problem is we don't have the water."

As Covid-19 spread around the world, schools closed to prevent the spread of the virus. Whilst many pupils have had access to some level of digital learning, a whole generation of children in developing countries risk being left further behind. The poverty gap may continue to widen between children who are able to continue to access education and those who cannot.

WaterAid is calling for governments to make hygiene, water and toilets in schools a top priority now and for post-Covid-19 and to make funding available to get proper handwashing facilities in all schools. "Too many schools are still built with no clean water or toilets which means they cannot provide a safe or good quality education," the organisation said in a statement. "Donors and development agencies must commit to stopping this dangerous practice so that pupils do not have to worry everyday about where they will get a drink or go to the toilet."

The schools data can be found here, https://washdata.org/data

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Alaska getting wetter is bad news for global climate

Alaska is getting wetter. A new study spells out what that means for the permafrost that underlies about 85% of the US state, and the consequences for Earth's global climate.

The study, published in Nature Publishing Group journal, ***Climate and Atmospheric Science***, is the first to compare how rainfall is affecting permafrost thaw across time, space and variety of ecosystems. It shows that increased summer rainfall is degrading permafrost across the state.

As Siberia remains in the headlines for record-setting heatwaves and wildfires, Alaska is experiencing the rainiest five years in its century-long meteorological record. Extreme weather on both ends of the spectrum – hot and dry versus cool and wet – are driven by an aspect of climate change called Arctic amplification. As the earth warms, temperatures in the Arctic rise faster than the global average. While the physical basis of Arctic amplification is well understood, it is less known how it will affect the permafrost that underlies about a quarter of the Northern Hemisphere, including most of Alaska. Permafrost locks about twice the carbon that is currently in the atmosphere into long-term storage, and supports Northern infrastructure such as roads and buildings; so understanding how a changing climate will affect it is crucial for both people living in the Arctic and those in lower latitudes.

"In our research area the winter has lost almost three weeks to summer," says study lead author and Fairbanks resident Thomas A. Douglas, who is a scientist with the US Army Cold Regions Research and Engineering Laboratory. "This, along with more rainstorms, means far more wet precipitation is falling every summer."

Over the course of five years, the research team took 2 750 measurements of how far below the land's surface permafrost had thawed by the end of summer across a wide range of environments near Fairbanks, Alaska. More rainfall led to deeper thaw across all sites. After the wettest summer in 2014, permafrost didn't freeze back to previous levels even after subsequent summers were drier. Wetlands and disturbed sites, like trail crossings and clearings, showed the most thaw.

"This study adds to the growing body of knowledge about how extreme weather – ranging from heat spells to intense summer rains – can disrupt foundational aspects of Arctic ecosystems," says Merritt Turetsky, Director of the University of Colorado Boulder's Institute of Arctic and Alpine Research and a co-author of the study. "These changes are not occurring gradually over decades or lifetimes; we are watching them occur over mere months to years."

Study tracks Covid-19 in wastewater from planes, cruise ships

Testing wastewater systems on long-haul planes and cruise ships could provide crucial information on detecting the presence of the Covid-19 virus in incoming passengers.

A new paper in ***Journal of Travel Medicine*** reported that testing of aircraft and cruise ship wastewater upon arriving at their destination had detected genetic fragments of the Covid-19 virus, SARS-CoV-2, a step forward in using this test as an additional public health management tool. Researchers from The University of Queensland (UQ) and Australia's national science agency CSIRO worked with transport companies to test on-board wastewater from lavatories.

CSIRO Chief Executive, Dr Larry Marshall, said rapidly pinpointing hotspots for Covid-19 will help keep all Australians safe as we start to travel again. "Responding to a pandemic is not just about the race for a vaccine, Australian science is supporting our economic recovery by delivering for partners like Qantas," Marshall said.

"Our relationship with air travel goes back to the 60s, and today our unique coatings already protect aircraft, so it's great to be trusted to keep Australia flying while helping to stay ahead of any potential new outbreaks."

Paper co-author and Professor Jochen Mueller from UQ's Queensland Alliance for Environmental Health Sciences said this tool could help as governments and transport industries develop plans to minimise transmission associated with resuming international travel.

"This could provide additional peace of mind to track and manage infection and play an important role in opening up long-haul flights or cruises resuming," Prof Mueller said.

The test provides an early warning of infection, as the virus sheds in the stools of infected passengers even before they show symptoms.

Lead author and CSIRO researcher Warish Ahmed said the virus fragments in the wastewater were unviable, so not infectious. "The study indicates that surveillance of wastewater from large transport vessels with their own sanitation systems has potential as a parallel data source to prioritise clinical testing among disembarking passengers."

To access the paper,
Visit: www.shorturl.at/koEXY

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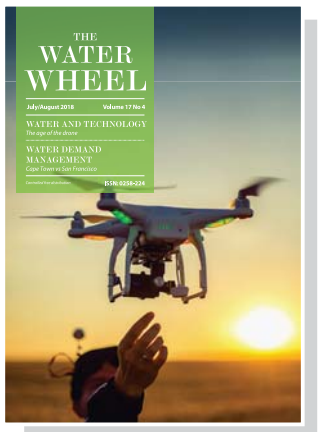

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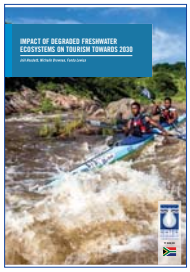
NEW WRC REPORTS

A win-win solution for mine waste cleanup: The remediation of mine contaminated sites, the recovery of metals, prevention of water pollution and job creation
Over 120 km of the Witwatersrand is affected by the legacy of gold mining. Many dumps have been reprocessed and are being reprocessed but the roots of the dumps are left behind causing continuous pollution. The mine dump residue continually drips acidic water into the Witwatersrand catchments impacting on the Vaal- and Crocodile River systems. To stop the continual pollution of the waterways and to improve the health of the people affected by the dump residue, the WIN-WIN team approached the WRC to fund a feasibility study for the clean-up of the dump areas by a women-headed and women-driven team. A leading objective was to create employment and opportunities for entrepreneurship.
WRC Report no. 2845/1/20

The returns on investments in Reserve determinations in the last 20 years
This short scoping project attempted to address the valuation of the investment in RDM Reserve studies in the past 20 years. The Reserve concept followed from a period of extractive use and wide-ranging impacts prior to the 1960s. The National Water Act (No. 36 of 1998) made provision for determining Resource Directed Measures (RDM), which includes the ecological Reserve and the Basic Human Needs Reserve. The Reserve concept sought to achieve a balance between development (water used by, and impacted on, all sectors) and protection (securing water quantity and quality for basic human needs and sustaining the resource base). Since the method development of the Reserve concept, numerous studies of varying costs, in various catchments were completed. A need was identified to review the returns on investment of the different RDM studies.
WRC Report no. 2939/1/20



Impact of degraded freshwater ecosystems on tourism towards 2030
A better understanding of the links between the condition of ecosystems and the sustainability and growth of the tourism sector creates the potential for tourism to unlock incentives for environmental management and restoration that will support tourism and thereby its capacity to drive economic transformation for South Africans.With a specific focus on freshwater ecosystems, the objectives were to:

- Demonstrate the links between natural capital, tourism and global change and the influence such links have on the development potential of the tourism sector and its contribution to generating economic benefits and supporting Small, Medium and Microenterprise (SMME) development
- Generate recommendations regarding policy and further research needs to promote environmental management and ecological restoration through tourism The study also incorporated a capacity development component with youth in the case study areas. These activities sought to raise awareness about nature-tourism linkages as a building block towards empowering youth to recognise sustainable tourism opportunities.

WRC Report no. TT 828/20

Integrated land use and water use in water management areas, with a view on future climate and land use changes
Accurate quantification of the water balance in catchments is fundamentally important in the planning, management and allocation of water resources, especially in arid and semiarid regions. Some components of the water balance, such as evapotranspiration (ET), streamflow and groundwater recharge are directly related to land use. The overall aim of this project was to determine water use from agricultural land, natural ecosystems and urban areas (domestic and industrial water use) using a combination of remote sensing and geographical information system (GIS) products, and provide the information in the format of user-friendly summary sheets and guidelines for integrated land and water use at WMA/provincial/municipal level.
WRC Report no. 2520/1/20

Knowledge exchange to improve implementation of irrigation water measurement/metering at farm and scheme level
Irrigation water measurement is critically important when aiming to improve water-energy-food security. Without wide-scale, accurate measurement, it is not possible to determine how much water is used by the irrigation sector, or to create benchmarks from where water resource management institutions and growers can set targets to become more irrigation efficient and water productive. Whereas the discourse in the past has focused on the advantages and disadvantages of water measurement and metering, the publication of regulations by the Department of Water and Sanitation (DWS) (Government Notice 131 of 17 February 2017 and Government Notice 141 of 23 February 2018) has required the taking of water for irrigation purposes to be measured, recorded and reported, shifting the focus from the "why" to the "how". This triggered an urgency among growers and water user associations (WUAs) to know more about the implementation of water measurement and metering, and the value it will add to water management. It was this project's objective to support the uptake of water measurement and metering in commercial irrigated agriculture and the uptake of the WRC's research in this regard by generating content and stimulating participation that specifically address key questions of commercial irrigators and WUAs.
WRC Report no. TT 826/20

To download a free copy of these reports Visit: www.wrc.org.za.

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ESTUARIES

Putting a price on 'blue carbon' water habitats

Shallow water river estuaries have provided a rich variety of benefits to humanity for thousands of years. More recently, a Water Research Commission study has thrown light on their undervalued role in climate regulation and carbon storage. Article by Tony Carnie.

Janine Adams

South Africa has 290 river estuaries spread along its nearly 3 000 km long coastline. These are the meeting places where freshwater and nutrients have tumbled down from the land to mix slowly with the salt water of the ocean.

Because they are mostly shallow, vegetated and sheltered from the crashing waves and predators of the open sea, estuaries provide an ideal nursery ground for marine fish, as well as crabs, snails, worms and other aquatic creatures. For millennia, this abundance of food, water and vegetation has attracted human communities as well as birds and animals. In some estuaries, coastal mangrove forests also provide people with firewood or timber for home building, fencing and other uses.

Yet estuaries have another critical role that is less well known or appreciated: the long-term capture and storage of 'blue carbon'. This is a term coined by coastal researchers to describe habitats such as mangrove forests, salt marshes and seagrasses which help to capture and store large volumes of carbon dioxide in 'blue' aquatic environments.

These coastal systems also capture and store carbon at a much faster rate than land-based forests, potentially for millions of years. Dr Jackie Raw, a postdoctoral researcher and member of the DSI-NRF Research Chair in Shallow Water Ecosystems at the Nelson Mandela University's Ocean Sciences Campus, says one of the reasons these habitats are so effective is because the carbon is stored in anoxic (oxygen-depleted) sediments below the waterline.

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Raw says these carbon-rich sediments build up in thick layers in these habitats, where they are locked up – thereby reducing the increasing volume of carbon dioxide which heats up the Earth's atmosphere. Conversely, if these habitats are degraded or destroyed, they release disproportionately higher volumes of carbon.

Raw was one of the lead researchers of a recent report to the Water Research Commission entitled 'Climate Change and South Africa's Blue Carbon ecosystems'. The research team included Nelson Mandela University colleagues, Prof Janine Adams, and PhD student, Sinegugu Banda; Prof Tommy Bornman of the South African Environmental Observation Network (SAEON); Dr Anusha Rajkaran of the University of the Western Cape and Dr Lara van Niekerk the Council for Scientific and Industrial Research (CSIR) in Stellenbosch.

Their study, conducted in several estuaries, was the first attempt to quantify carbon capture and storage capacity by blue carbon habitats in South Africa. At a global level, these areas cover just 2% of the ocean, yet are believed to capture up to 70% of the carbon stored by the sea.

Raw says the baseline data gathered in the study could be used to explore the potential for carbon credit trading schemes which aim to reduce global greenhouse gas emissions.

Carbon trading, which can incorporate the buying and selling of carbon "offsets", may also create financial incentives for ecosystem restoration and conservation projects.

At a global level, mangrove habitats are being lost at a rate of 2% per year. Experts from the International Blue Carbon Initiative estimate that carbon emissions from mangrove deforestation account for up to 10% of emissions from deforestation globally, despite covering just 0.7% of land coverage.

Tidal salt marshes are being lost at a rate of 1-2% per year. They now cover roughly 140 million hectares of the Earth's surface after losing more than 50% of their historical global coverage.

Seagrasses cover less than 0.2% of ocean floor, but are estimated to store about 10% of the carbon buried in the oceans each year. Seagrasses are being lost at a rate of 1.5% per year and have lost approximately 30% of historical global coverage.

According to the new WRC report, blue carbon estuarine habitats in South Africa are threatened by increasing freshwater abstraction, urban development, pollution, climate change and sea level rise.

It says that the continued loss of estuarine ecosystems reduces their capacity to act as carbon sinks and this has the potential to release large quantities of carbon into the atmosphere as CO2.

Prof Adams and her colleagues note that coastal wetland conservation projects linked to carbon markets have been launched in Kenya, Madagascar, Indonesia and other tropical nations.

Janine Adams

The salt marsh succulent (Sarcocornia tegetaria) at Wavecrest.

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Lucienne Human

A sediment core from the salt marsh in the Swartkops Estuary.

The Mikoko-Pamoja mangrove restoration and reforestation project in Kenya is one example of a community-based conservation scheme financed by voluntary carbon credits.

In Cameroon, a Clean Development Mechanism (CDM) scheme aims to conserve coastal mangroves to ensure that they continue to sequester carbon into the future. This project involves coastal fishing communities who burn mangrove trees to smoke fish. While a traditional smoking oven typically consumes up to 1 205 kg of red mangrove wood to prepare the fish over 53 days, a modern cinderblock oven is said to consume only 122 kg of mangrove wood and to reduce the smoking time to 5 hours.

Adams says research on local mangroves, seagrass and tidal marshes can help to guide South Africa's climate policies, incentivising the need to protect and restore coastal wetlands and estuaries. She also notes that the South African coastline is currently the southern range limit for east African mangrove species and this provides a unique opportunity to study their response to climate change.

"Globally, mangroves are expanding into warm-temperate salt marshes in response to rising temperatures . . . It is therefore necessary to investigate whether mangroves can potentially expand their habitat range and how these communities and salt marshes respond to climate change."

Overall, the aims of the research project was to determine the extent of blue carbon ecosystems in South Africa and to estimate blue carbon storage using UN Intergovernmental Panel on Climate Change (IPCC) assessment methods.

To assess historical changes, the researchers studied aerial photographs dating back to the early 1930s and compared these to current Google Earth images. On site measurements were also made at estuaries such as Nxaxo , a permanently open estuary at Wavecrest, near Butterworth in the Eastern Cape.

This site was selected as the estuary has a relatively equal area of white mangroves (***Avicennia marina***) and the salt marsh succulent (***Sarcocornia tegetaria***), while seagrass (***Zostera capensis***) is also present.

To study sea level rise, the research team also installed several high-precision measurement devices known as rod surface elevation table (RSET) equipment, in estuaries at Knysna, Nxaxo and Nahoon. Surprisingly perhaps, the research suggests that only 20% of South African of estuaries support submerged aquatic vegetation.

Raw notes that these species are sensitive to changes to water level, turbidity, nutrients and salinity. "We have noted that when an estuary experiences closure to the ocean, then seagrass is lost. Many South African estuaries experience seasonal closure that is natural but can also be caused or exacerbated by freshwater abstraction.

"Even in fairly natural systems we have noted that seagrass appears and disappears from year to year. Seagrasses are also influenced by human activities that can be destructive, such as anchoring of boats."

The researchers have made a strong case for the restoration of threatened and degraded estuaries, so they can regain their potential to store blue carbon and provide other free ecological services.

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This is because many estuaries are facing the twin pressures of "coastal squeeze" – a variety of human pressures on the landward side, and sea level rise on the other. This means that there is little or no space for blue carbon habitats to persist in the face of a warming climate and further development.

The report says buffer areas need to be identified to allow for landward expansion of these habitats in response to sea level rise. Adjacent properties for landward migration also need to be identified and protected and, in some cases, purchased from landowners.

"Pressures such as infrastructure development, flow reduction, artificial breaching, mouth manipulation and overfishing have increased their vulnerability to climate change. A strategic programme is needed to restore health so that these blue carbon habitats can continue to provide the ecosystem services of flood regulation, nutrient cycling, nursery habitat, and recreational and tourism opportunities."

These coastal ecosystems are among the most threatened natural systems globally with estimates showing that 50% of salt marshes, 35% of mangroves, and 29% of seagrasses have been lost or degraded by human activities in recent history.

Apart from their critical role in storing carbon, studies show that mangroves also limit the impact of storms by reducing the energy of wind-generated surface waves by 20% per 100 m.

Other studies by Adams et al. show that approximately 50% of blue carbon habitats have been lost in South Africa, and within the Eastern Cape roughly one hectare of mangrove forest is lost every year. As a result, there is increasing interest in restoring mangrove forests along the coast.

On the issue of using carbon taxes and carbon trading to benefit local estuaries, the researchers say that South Africa is one of the top 20 most carbon intensive countries in the world (currently ranked number 13) because of a high dependence on coal, crude oil and natural gas.

South Africa is also the largest CO_2 emitter in Africa and in 2016 it signed the UN Paris Agreement, a voluntary pact to limit greenhouse gas emissions. Last year, South Africa also became the first country in Africa to pass a carbon tax to slowly drive down greenhouse gas emissions.

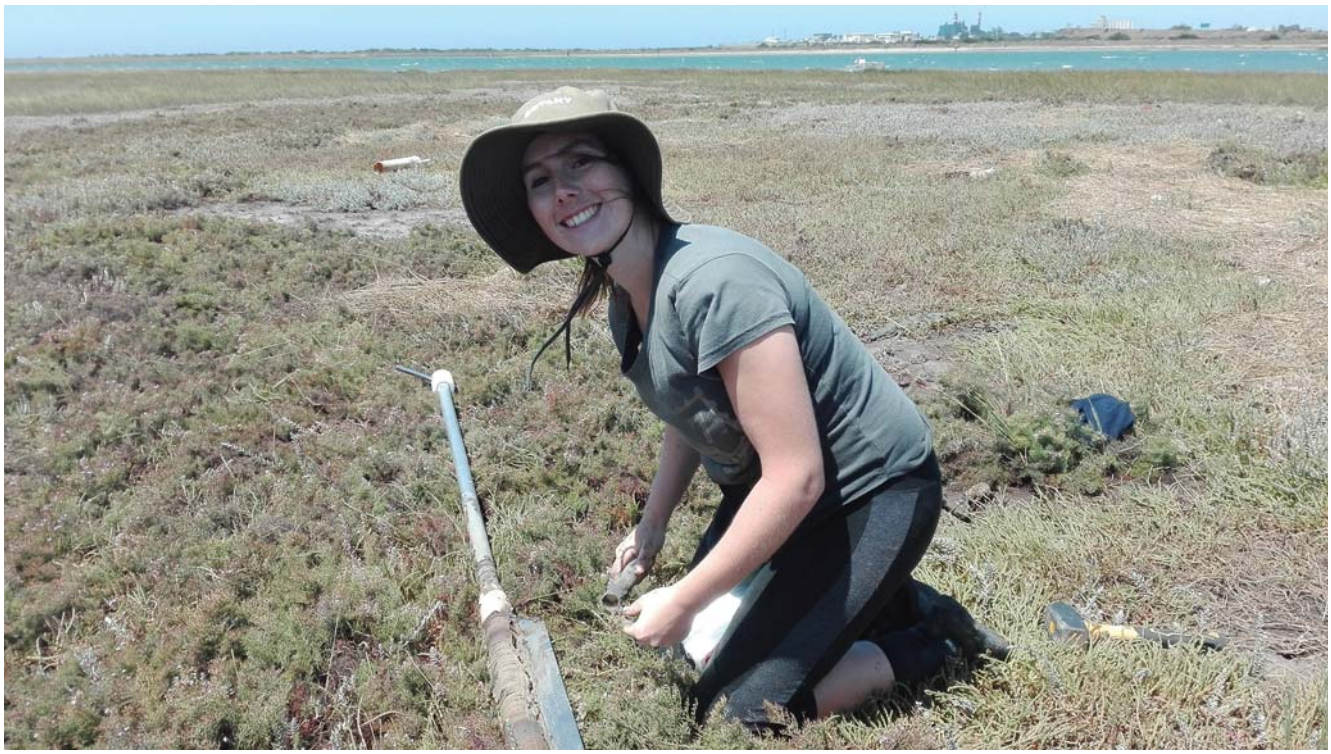
Companies are now required to pay a tax rate of R120 per tonne of carbon emissions released – but because of allowance schemes, the effective tax rate can be as low as between R6 and R48 per tonne.

In the context of finding new ways to finance estuary conservation, the WRC report says carbon markets are based on generating carbon credits by either avoiding greenhouse gas emissions or by removing these gases from the atmosphere through carbon reduction projects.

Janine Adams

Jennifa Mohale, Imtiyaaz Malick and Jackie Raw at one of the an RSET installations at Nahoon Estuary.

Lucienne Human



Researcher Jessica Els collects a sediment core at the Swartkops Estuary.

Janine Adams

Oceanographic technician Imtiyaaz Malick (SAEON) checks an RSET installation at Nahoon Estuary.

CONCLUSIONS

"Our study estimated that blue carbon habitats in South Africa can potentially remove 10.3 million tCO2eq yr-1, an amount higher than the projected sequestration potential from land-based habitats (8 million tCO2eq yr-1 as reported in the National Terrestrial Carbon Sink Assessment, DEA, 2014)."

The research team says this value is comparable to the emissions reduction potential of blue carbon habitats in southeast Australia, reported to be 9.63 million tCO2eq yr-1.

Overall, South Africa's salt marsh habitats made the highest contribution to this value.

The total value of blue carbon habitats was estimated to be between R1.2 billion and R10.6 billion per year (when carbon is traded at a high price) and between R120 million and R150 million per year when carbon is traded at lower carbon prices.

"Based on our results, we suggest that blue carbon Payment for Ecosystem Services (PES) or offset projects will only be economically viable in South Africa if the credits are traded at a higher price in the voluntary markets, which at present are the more attainable options for blue carbon pilot projects."

The researchers suggest that further studies are needed to quantify blue carbon storage in several other places (particularly the Mhlathuze and St Lucia estuaries in KwaZulu-Natal) to provide a more comprehensive carbon inventory base.

"It is also important to note that in South Africa, our blue carbon habitat area is quite small compared to the rest of the globe and major habitat losses (6.9% of mangroves and 44.5% of salt marshes have occurred due to development and agriculture."

Nevertheless, the study has moved South African estuaries a step further towards using carbon trading to protect and conserve these critical habitats, the report concludes.

To view the report, Climate change and South Africa's blue carbon ecosystems (**WRC report no. 2769/1/19**), Visit. www.shorturl.at/cqGJS

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WATER AND THE ENVIRONMENT

Microplastics pollution: African research focus moves to freshwater and human impacts

The spotlight on global plastic pollution has fallen mainly on the marine environment, with disturbing images showing sea creatures choked or strangled by floating plastic debris. Now the science research focus is shifting upstream towards the land and the potential health impacts for Africa's people and freshwater habitats. Article by Tony Carnie.

Tony Carnie

Should we be worried about an ever-growing volume of microscopic plastic particles building up in South Africa's rivers, lakes or tap water? Can these tiny fragments of synthetic pollution harm our health and other life forms? This is the thrust of a series of local research projects initiated by the Water Research Commission to measure the impacts of very small particles of plastic in the country's freshwater environments.

The scope of the research was set out in a recent article in the ***SA Journal of Science*** by WRC research managers, Drs Eunice Ubomba-Jaswa and Nonhlanhla Kalebaila. They note that plastic products are now ubiquitous, with production of this synthetic material increasing from just 1.5 million tons in the 1950s to approximately 322 million tons today.

On the African continent, South Africa tops the list with a production of about 8 987 kilotons of plastic, followed by Egypt (3 977 kilotons) and Nigeria (2 308 kilotons). On a per capita basis, this translates into South Africans consuming more than twice as much plastic compared to people in Nigeria, Kenya or Ghana.

"Huge amounts of plastic are also imported into Africa, contributing further to local plastic consumption," say Ubomba-

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Jaswa and Kalebaila, who note that plastic products can also contain several potentially-hazardous additives such as plasticisers, flame retardants, thermal stabilisers or light and heat stabilisers. Largely within a year of production, most of the plastic generated for single-use products (packaging, straws, bottles, bags) has been disposed of as waste, often incorrectly.

The problem is compounded by rapid urbanisation and poor waste management in many African cities, with the result that plastic often ends up in landfill sites, gets burned or is simply dumped into the surrounding environment.

Freshwater environments, such as streams, rivers and lakes, which are in close proximity to plastic waste on land, often become the pollution pathways leading to the sea. "As plastics are not biodegradable, they never truly disappear but continue to break down into smaller and smaller pieces."

This breakdown process can involve exposure to ultraviolet light, mechanical action or animal action, with macroplastics breaking down into secondary microplastics and finally into nanoplastics.

The WRC research managers say that while literature on land-based plastic flows is available, specific research in Africa on the impacts on freshwater and marine environments is only now gaining momentum.

"So far, available information has clearly demonstrated that microplastics are present in both raw water resources and treated (drinking water) sources that reach the consumer. Concentrations ranging from 0.00015 to 12.6 microplastic particles per litre have been reported from studies conducted on raw water sources in China, Europe and the USA. However, to date, very few studies have quantified levels of microplastic particles in drinking water."

Two years ago, in a study commissioned by the WRC, plastic particles were also detected in surface water and groundwater in some provinces and from drinking water (tap) samples collected in Johannesburg and Tshwane.

While concentrations of plastic particles were much lower in comparison to those in freshwater environments in industrialised countries, total microplastic particle concentrations of up to 0.189/L and microfibre counts up to 1.8/L were reported. Preliminary findings from the study also indicated a higher proportion (88%) of finer microplastic particles (sizes of between 20 µm and 300 µm) than that of larger particles in the final treated water.

"Similarly, 83% of samples analysed in a global survey of tap (drinking) water were found to contain microplastic particles. Almost all of these (99.7%) were fibres in the concentration range 0–57 particles per litre." However, due to the lack of standard protocols for microplastics detection and quantification in drinking water, there is narrow scope to compare findings between different reports.

Ubomba-Jaswa and Kalebaila say it is clear that plastic waste generated from industrial and domestic use are the main contributors of microplastics entering the aquatic environment.

"The discharge of inadequately treated waste-water effluent is one route by which microplastics enter the drinking water value chain and also the marine environment. Consequently, water service institutions are under pressure to retrofit existing treatment trains to optimise the retention and removal of microplastics during water treatment. Conventional treatment processes, such as filtration, are reportedly able to remove up to 97% of microplastic particles larger than 300 µm.

"Advanced treatment processes, such as membrane filtration, have been reported to remove 85–99.9% of microplastics in water. Other technologies that have been investigated include

Dr Eunice Ubomba-Jaswa and Dr Nonhlanhla Kalebaila of the Water Research Commission have noted that plastic products can contain several potentially-hazardous additives such as plasticisers, flame retardants, thermal stabilisers or light and heat stabilisers.

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Photo supplied

Researchers Duan van Aswegen and Carina Verster collect water samples as part of a Water Research Commission study that included analysis for microplastics in freshwater in parts of North West, Gauteng and the Free State.

dissolved air flotation that is capable of removing up to 95%, and disc filter, with a removal efficiency of 40–98.5%."

In most studies, higher removal efficiencies have been reported for larger microplastics, whereas lower efficiencies have been observed for smaller particles with diameters of 20–300 µm.

"Thus, depending on the size and composition, microplastics may not be completely removed during wastewater treatment and there is a high chance that they may enter receiving raw waters, potentially even accumulating in the final treated (tap) water."

Removed particles from waste-water treatment plants have also been detected in sludge. The routine practice of applying biosolids from wastewater treatment plants onto agricultural land as fertiliser results in the accumulation, over time, of microplastics in the soil. This suggests that sludge from treatment plants could be a driver for microplastic contamination of soil.

"Although still to be explored, there is potential for plastic to be remobilised in soil under certain conditions, such as flash flooding, resulting in the contamination of freshwater systems."

According to the two WRC research managers, attempts to understand the uptake of fine particles, including plastic, in mammals and humans have not yielded conclusive findings.

"The inconsistencies in microplastic detection and quantification protocols, as well as lack of epidemiological data, limit the interpretation of the current concentration data sets into meaningful risk assessment. Therefore, more collaborative research among the science community (both academia and water service institutions) is needed in order to understand the flow of microplastics from source to sea, and their removal during water treatment, both waste water and drinking water, and to assess the potential exposure, and risks, to consumers via drinking water."

Since April 2019, the WRC has funded **Project no. K5/2919**, a study that aims to develop more effective biomonitoring of microplastics in South African water resources.

Ubomba-Jaswa says that when completed in 2022 or early 2023 (depending on the potential delays due to the Covid-19 pandemic) there should be greater understanding of novel end points in organism growth, development and survival that can be used as accurate predictors of the effect of short-term and long-term exposure to various shapes and sizes of plastic monomers as well as their additives.

"A greater understanding of the unique eco-threat that microfibres pose will also be elucidated from the WRC project. This will be a key finding as, historically, the unique health effects of microfibres when compared to microbeads have been difficult to assess, even in the marine environment."

The health impacts of plastic in adults can also be quite different compared to babies in the womb, while exposure to phthalates in plastic can cause allergies and asthma, while BPA (bisphenol A) exposure shows in social and behavioural problems (particularly in childhood).

"Population groups with the highest risk of developing a plastic exposure related condition include those that work directly in the plastic industry (extraction and transport, refining and manufacture and waste management) as well as communities situated next to plastic production centres or plastic dumpsites, and whose air and water quality are affected by various plastic emissions.

"Although the body of evidence of the health effects of nano and microplastics continues to grow, there is still a great deal of experimental and observational research needed before a direct link between exposure to these particles and subsequent illnesses can be confirmed."

However, preliminary research findings have shown that nano- and microplastics may be even more harmful, because not only do they serve as carriers and vectors for other harmful chemicals, metals and pathogens, but due to their size, they might be able to physically injure the lung and gut at a cellular level through ingestion or inhalation.

"Any accurate determination of the health risk of exposure to plastics is largely unknown in Africa or among African populations. Consumption patterns of microplastics and subsequent health implications depend on the concentration of exposure and the type of plastic involved. For this reason,

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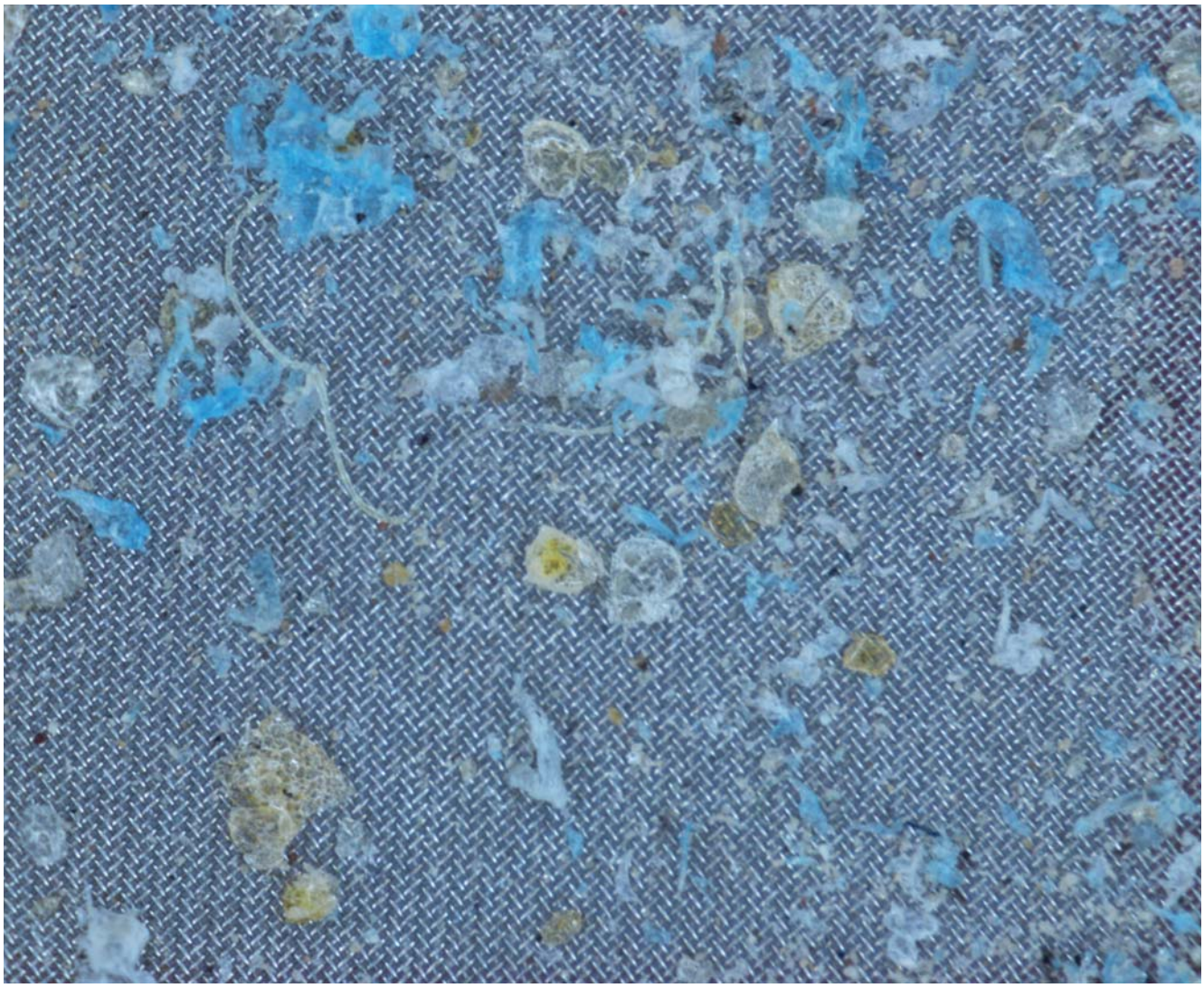

Tiny fragments of plastic which were sieved from freshwater samples. Municipal tap water samples were also collected from the City of Johannesburg and Tshwane. Microplastics in tap (drinking) water generally had much fewer plastic fragments compared to the raw water samples.

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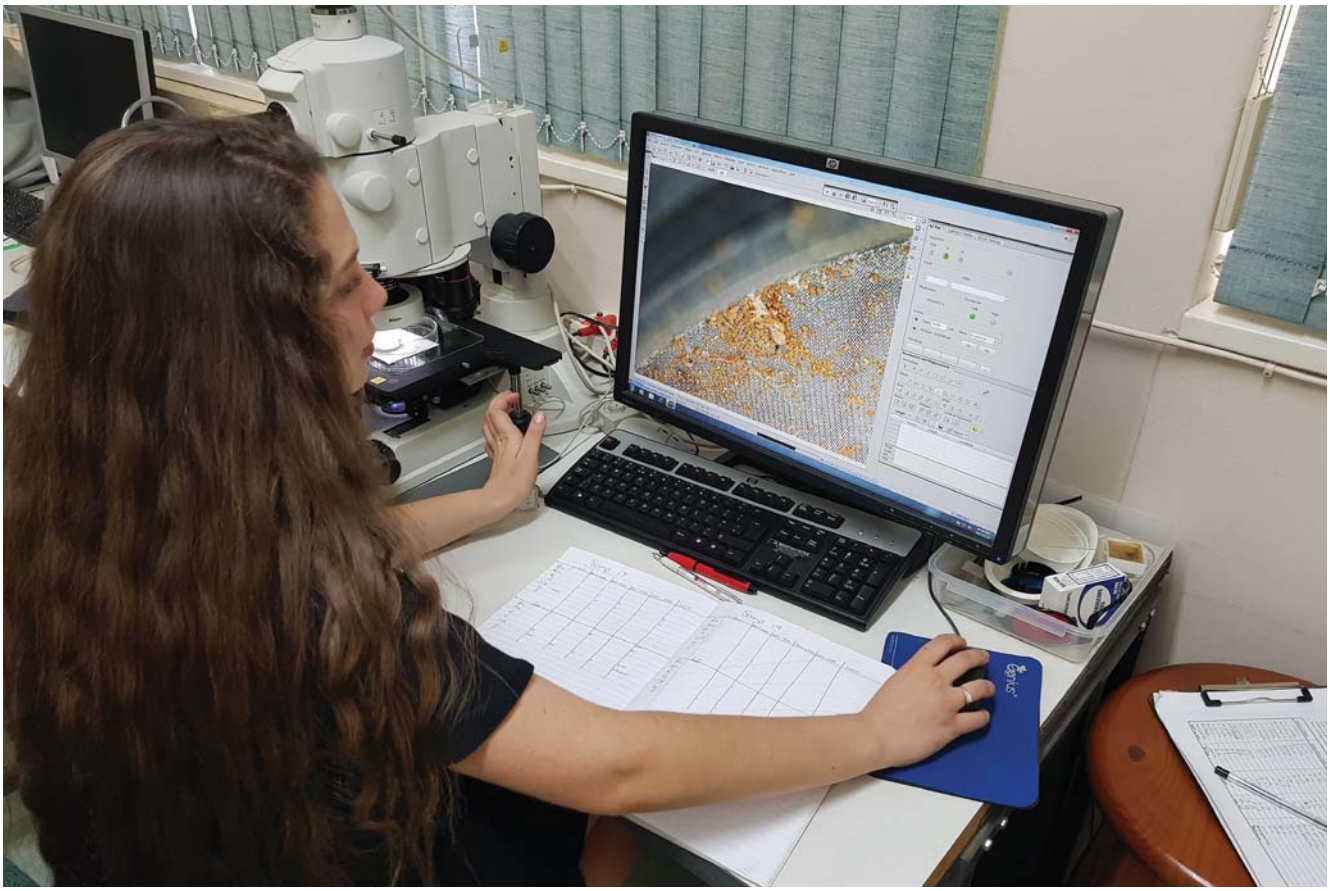

Photo supplied

Carina Verster of North West University examines microplastics filtered from freshwater samples.

human health risk values calculated for population groups outside Africa are not reliable as a true reflection of exposure, because exposure patterns are different and cannot necessarily be extrapolated."

A separate three-year WRC-funded study, that began in April this year, will also investigate the ecological and human health effects of microplastic contaminants in the Diep and Plankenburg rivers in the Western Cape Province. By the conclusion of this study, there should be baseline data on the human health effects and risk that the local population around these two rivers face.

The WRC hopes that the health and ecological risk models and training information from this study should also be available for use by other African countries which have similar plastic and waste management issues.

Ubomba-Jaswa says South Africa is actively involved in the global fight against environmental pollution and the WRC will continue to fund and support research to assess the health risks attributable to plastic-contaminated water. She notes that there will be particular focus on mixtures or "cocktails" of chemical/plastic exposure rather than on single chemicals alone.

It will also be important to conduct toxicity studies that consider increased exposure and dosage concentrations to plastics in light of extreme weather events.

"Cohort studies which, for instance, involve pregnant women and their children until they reach adulthood, are also key to understanding the long-term effects of plastic exposure in relation to different illnesses (developmental disorders, cardiovascular diseases, etc.).

"As we gain a better understanding of how best to mitigate against the negative effects of plastic on our health, it is clear that reducing the production, use and disposal of plastic in South Africa and throughout Africa will be key to protecting human and environmental health."

Photo supplied

Khaya Mgaba from Rhodes University is conducting ecotoxicity tests on fish embryos using plasticizer samples.

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WATER AND SOCIETY

10-year anniversary to right to water offers chance for reflection

The Water Research Commission hosted a webinar in July in celebration of the 10th anniversary of the United Nations Resolution on the human right to water and sanitation. Article by Sue Matthews.

JohnHogg/World Bank

It's been 10 years since the United Nations General Assembly adopted UN Resolution 64/292 on the human right to water and sanitation. More specifically, it recognised "the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights." The resolution called upon states and international organisations to help developing countries scale up their efforts to deliver such water and sanitation services, by providing financial resources, capacity building and technology transfer.

So how well is the world doing in upholding this human right, and what more can be done to provide international assistance and cooperation? And how far has South Africa come, in its efforts to reverse historical inequities and achieve universal access to water and sanitation services?

These were some of the topics addressed by panellists during a celebratory webinar hosted by the WRC on 28 July 2020, the 10th anniversary of the Resolution's adoption. Minister of Human Settlements, Water and Sanitation, Lindiwe Sisulu, pointed out in her opening address – delivered in her absence by her Special Envoy, Jürgen Kögl – that South Africa had enshrined a rights-based approach into all facets of the Constitution drawn up by the new democratic government 25 years ago. This, together with the pioneering leadership of the then Water Affairs Minister, Prof Kader Asmal, had prompted a total rewrite of water legislation, and the introduction of safeguards to individuals' human right to basic water, which were given effect through the Free Basic Water and Sanitation policies.

"To date, we have been able to increase water supply to 88%

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of households, while 79% of households now have access to safe sanitation," noted the Minister. "Still, the number of people without access to reliable water supply and decent sanitation remains unacceptably high."

She added that the Department of Water and Sanitation had put a Water Master Plan in place towards the end of last year, which sets out the framework for managing water resources and provision of water and sanitation services in the short, medium and long term. But the COVID-19 pandemic had necessitated immediate action, so water is being made available to thousands of households via water tankers dispatched to vulnerable communities in some of the most inaccessible parts of the country.

During the panel discussion, facilitated by WRC CEO Dhesigen Naidoo, UN Water's Vice-Chair, Dr Olcay Ünver, remarked that – at a global level – a lot has happened in 10 years.

"While we should celebrate our achievements, it is important to remember that, for many of us, things haven't changed that much," he added.

Indeed, the Sustainable Development Goals (SDG) Report 2020 shows that 2.2 billion people around the world still lacked safely managed drinking water in 2017 (the most recent available data). And while the population using safely managed sanitation services had increased to 45%, the remaining 55% represented 4.2 billion people worldwide.

The relevant SDG 6 targets are to achieve universal and equitable access to safe and affordable drinking water for all by 2030, as well as access to adequate and equitable sanitation and hygiene for all, while paying special attention to the needs of women and girls and those in vulnerable situations. But these targets won't be met at the current rates of progress.

"We are off-track to achieve SDG 6 on water and sanitation," said Ünver. "Why is this? There are two main reasons – the lack of political will, and the fragmentation in the water-related sectors. This means that water does not get prioritised, and that we end up with sub-optimal solutions in sectoral silos, missing the opportunity to use synergies and manage trade-offs."

In an effort to speed up progress, on 9 July the UN launched the SDG 6 Global Acceleration Framework, which forms part of the UN Secretary-General's Decade of Action to reach the SDGs by 2030. The Framework encourages the international community to improve support to countries through four action pillars:

- Engage – ensuring swift responses to country requests through leveraged expertise and mobilisation,
- Align – coordinating approaches across sectors and actors through unified strategies and initiatives,
- Accelerate – unlocking bottlenecks through five accelerators, and
- Account – strengthening accountability through joint review and learning.

The five accelerators deal with financing, data and information, capacity development, innovation, and governance.

But panellist Dr Amanda Loeffen, the CEO of Human Right 2 Water, does not believe the solution lies in international financing.

"We're not going to achieve SDGs by throwing money at it – there isn't enough money available," she said. "The World Bank estimates that achieving these targets will cost approximately $14 billion per year between now and 2030, and that's only the cost of constructing the infrastructure, not including operation and maintenance."

Loeffen believes the human rights approach gives the option to be more innovative and creative about solutions. She feels the focus should be on local solutions provided by local enterprises and local government, combining in public-private partnerships and blended finance options.

However, Dr Sunita Narain, Director-General of the Centre for Science and Environment in India, expressed concerns about whether the human rights approach was most conducive to bringing about action in the coming years, given the current global leadership.

"The fact is there can be no bigger human right than the right to clean water and sanitation – there is absolutely no doubt about that," she said. "But with the terminology of human rights having been so politicised, we should consider whether that would mean countries would baulk at the idea of discussing the human rights of water resources, because they see it as another stick that would be used against them."

JohnHogg/World Bank

The webinar organised by the WRC in celebration of the 10th anniversary of the United Nations resolution on the human right to water and sanitation included (from top left) Dr Sunita Narain, Dr Amanda Loeffen, Mr Ashton Busani, Mr Dhesigen Naidoo, Dr Olcay Ünver, Cllr Thembi Nkadimeng and Ms Khosi Jonas (facilitator).

Instead, she noted, it had become abundantly clear in this age of the COVID-19 crisis that without clean and safe water, we cannot have health. "It's in this context that we need to put water on top of the agenda, and reframe the agenda of health from the point of view of prevention, and the role of water and sanitation," she said. "Because the other thing that has become very clear, as never before, is how interdependent we are – the rich and the poor are interdependent, and the countries of the world are interdependent. It is the poor of the world who have suffered the most as a result of the pandemic, both because their livelihoods have been affected by lockdowns, and because they live in congested environments, and in places where there is no safe water and sanitation. But because of this interconnectedness, if the poor live in densely populated areas without access to clean water, the rich are also vulnerable."

The UN certainly recognises that the pandemic offers an opportunity to accelerate delivery. Ünver explained that apart from emergency investments, there's also significant stimulus and economic recovery investment coming up in the post-COVID era.

"The main message is to ensure that governments think about the longer-term future when they are making these investments, and use them as building blocks towards water and sanitation for all, and – in a broader sense – a sustainable future for all," he said.

Issues around poverty and inequality were also highlighted by the fourth member of the panel, Ashton Busani, who is the National Lead for South African Young Water Professionals and a

Meeting the SDG 6 targets relating to water and sanitation by 2030 is going to require a rapid acceleration in service delivery worldwide. While access to basic water supply and sanitation has increased by on average 1% per year between 2000 and 2017, progress in providing safely managed services needs a much sharper escalation over the next decade

In July the United Nations launched the SDG 6 Global Acceleration Framework to drive progress on water and sanitation issues, in support of the Decade of Action to deliver the Sustainable Development Goals by 2030.

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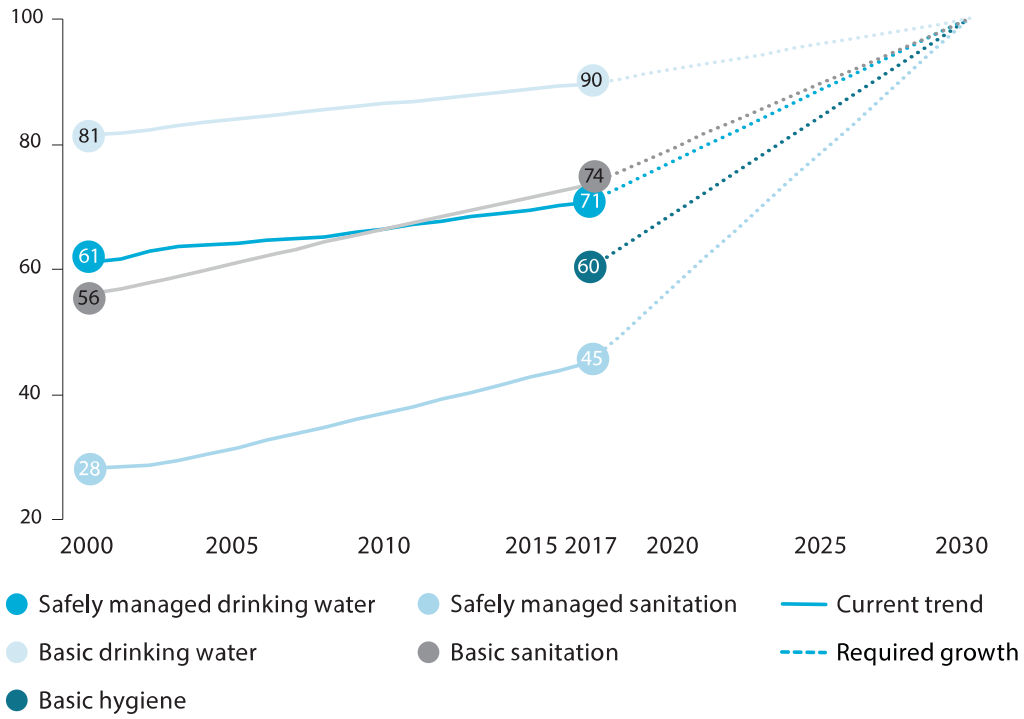

Meeting the SDG 6 targets relating to water and sanitation by 2030 is going to require a rapid acceleration in service delivery worldwide. While access to basic water supply and sanitation has increased by on average 1% per year between 2000 and 2017, progress in providing safely managed services needs a much sharper escalation over the next decade.

Reference: Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G., Woelm, F. 2020. The Sustainable Development Goals and COVID-19. Sustainable Development Report 2020. Cambridge: Cambridge University Press.

water sector analyst at GreenCape. He began by quoting Nelson Mandela, who said: "***Massive poverty and obscene inequality are such terrible scourges of our times – times in which the world boasts breathtaking advances in science, technology, industry, and wealth accumulation – that they have to rank alongside slavery and apartheid as social evils***."

"This is the reality that the young people are facing today – the issues of poverty and inequality, particularly referring to the inequalities around access to water and sanitation," said Busani. He noted that while the youth are cognisant of the advances that have been made since 1994, this is simply not enough.

"To the young people of today, without these basic services, there is no freedom," he stressed. "So the youth are beginning a new revolution, and that revolution is taking education as the way forward." He pointed out that putting education at the forefront of the revolution would encourage the innovation needed to come up with solutions.

Just a few days after the webinar, the WRC and the United Nations Development Programme (UNDP) issued an open call for innovations addressing South Africa's water challenges, specifically for water access and provision. The call requested applications from local innovators developing technologies or solutions for water challenges that have been exacerbated or introduced during the COVID-19 pandemic. It noted, for example, that many rural schools had been unable to reopen following lockdown due to their inability to meet the basic safety requirements, including the provision of water and sanitation facilities.

The webinar's closing remarks were made by Cllr Thembi Nkadimeng, President the South African Local Government Association (SALGA) and Executive Mayor of Polokwane. She reported that SALGA had been doing an assessment into the ability of municipalities to respond to the water challenges associated with COVID-19, and this had highlighted the critical skills shortages in municipalities in rural areas. It had also become clear that the lack of access to water undermines women's rights, forcing women to live under difficult conditions, and exposing them to the risk of rape and murder if they need to go deep into rural areas to fetch water.

"So we need to listen to what our young people are saying – provide space for them to participate so they can bring knowledge, innovation and technological skills," she said. "That way, the financial partnerships we have will be able to invest money into what can be speedily turned into access to water in our communities."

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CAPACITY BUILDING

Towards a transformed sector – Tracking South Africa's water doctorates

A first-of-a-kind study, commissioned by the Water Research Commission (WRC), sheds light on the career path of PhD graduates in the water sector. Article by Petro Kotzè.

In the academic field, the highest degree attainable from a university is the coveted Doctor of Philosophy or, a PhD. The degree entails the generation of original research. "It's a proxy or indicator that you can measure as our capacity for knowledge generation," says WRC research manager for water governance, John Dini. The qualification is regarded as essential in a knowledge-based and complex economy.

Dini managed a WRC-funded tracer study of local water and sanitation-related PhDs. Tracer studies typically aim to find and make contact with PhD graduates for an understanding of their career paths. Relatively common the world over, it's the first to zone in on the water and sanitation sector in South Africa and internationally.

The WRC has a long history of supporting doctorate candidates. The inclusion of masters and doctorate students in research projects are often required of funded studies. There are multiple reasons why we invest in PhDs, says the WRC's Shanna Nienaber, Programme Manager for South Africa's Water Research,

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Development, and Innovation (RDI) Roadmap. At its simplest level doctorates are a way of indicating high-end skills in the water sector, and there is assumption that you need this to grow the research and innovation potential, she explains.

The WRC, like many other funders in the research sector, tracks and reports on the students that its supports annually. However, there is not a formal tracking system for these students once they are no longer attached to a project or contract. Over and above that, the WRC is one of a handful of funders of doctorate studies, resulting in the information that is available being scattered.

"We've known for a long time anecdotally that PhDs add value to the system, but we've never put that into a formalised methodology," says Nienaber. As result, though it is known how many PhDs are produced in South Africa annually, it's not that clear what the impact of the qualification is on the graduates' career path afterwards or, by default, the sector that they work in.

Information like this is valuable for numerous reasons.

Why track PhDs?

Tracer studies give valuable insights to many sectors beyond academia. Results give an indication of trends in employment opportunities and salaries for doctorate holders, and can be used to evaluate the effectiveness of equal opportunity efforts. It can show funders what the impact of their grants are and where their funds should be allocated in future. The studies can show in which sectors research capacity and, assumedly, innovation is growing, and in which sectors its lacking. This is important for policy makers.

One example in South Africa is our Water RDI for 2015 – 2025. The document is a framework for RDI necessary to implement national policy, strategy and planning for the country's water resources. The Roadmap was developed by the Department of Science and Innovation in partnership with the WRC and Department of Water and Sanitation and lays out a vision of a South Africa that is a leader among middle income countries in the development and deployment of water management practices and technologies. One key to achieving this vision is increasing the number of relevant PhDs produced, to an average of just over 200 PhDs annually, increasing to over 500 in 2025/26.

Tracer studies can measure if goals like these are on track.

Common in European countries, the United States, China and Australia, to name a few, only very limited tracer studies of doctorate graduates have been done here.

"It is of critical importance to South Africa to start monitoring the performance of the PhDs," says the University of Pretoria's Prof Anastassios Pouris, Director of the Institute of Technological Innovation. Pouris initiated the study, and was the project leader.

The study can be seen as a first step in that direction, says Dini. The objectives were to find out if the work experience of water-related PhDs could be traced; if too many or too few water-related PhDs were trained; how mobile doctorate-holders are between sectors; when they leave research for a career in management; and, if water-related PhDs remain in the country.

Finding the answers was not a clear-cut process.

On the hunt for water-related PhDs

Water research is a multi-disciplinary field that covers an array of disciplines. Since there is no one specific field of study dedicated to water and sanitation, and there is no system keeping track of this specific area of specialisation, the researchers had to think outside the proverbial box to first identify the right PhDs and then, to find the graduates.

Pouris explains that information on higher education is collected by the Department of Higher Education. The number of PhDs that graduate is monitored, but the information is not classified into specific disciplines. We know, for example, that we produce fewer PhDs in engineering than in social sciences, but we don't know what is happening in sub-specialties within these fields, he says.

"As a result, it is difficult to identify PhDs related to water."

The project team turned to the National Research Foundation's open source Nexus database. The database contains information on approximately 150 000 South African research projects, including current and completed theses and dissertations on all fields of science since 1919. Information includes the project titles and abstracts in English.

We collected all the PhDs over the five-year period from 2013 to 2017, explains Pouris. This produced 12 500 theses. Then, to identify those relevant to water, says Pouris, they searched the titles for a list of relevant keywords. These included terms like arid, aquifer, borehole, riparian, sanitation and sludge, to name a few. Now, they were left with 300 theses. From this selection, the abstracts were checked for accuracy. A thesis was excluded if its topic, although including one or more of the relevant terms, could not inform any of the issues mentioned in the Water RDI Roadmap. The team was left with 112 relevant doctorates.

"There is an element of subjectivity to the selection process," says Dini. Yet, the exercise was deemed a good starting point for such processes in future.

To find the graduates, the websites of relevant universities and databases indexing academic articles were investigated. Unexpected help also came from social media. "We could find information about the graduates on social media that we couldn't find from individuals," says Pouris. This included data such as job progression and how quickly they were employed.

Dini says the use of social media, in particular, was interesting. The study showed that it's a massive source of information to be harvested for studies of this kind. Even if contact details were not found, social media still allowed researchers to find at least some information on almost all identified graduates.

From the 112 identified relevant theses, contact details were obtained for 100 doctorate graduates. Five candidates were

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not traceable and for seven, no contact details could be found, though limited information about employment and places of residence were traceable. Questionnaires were sent out to 100 doctorate graduates, of which 48 were completed and returned.

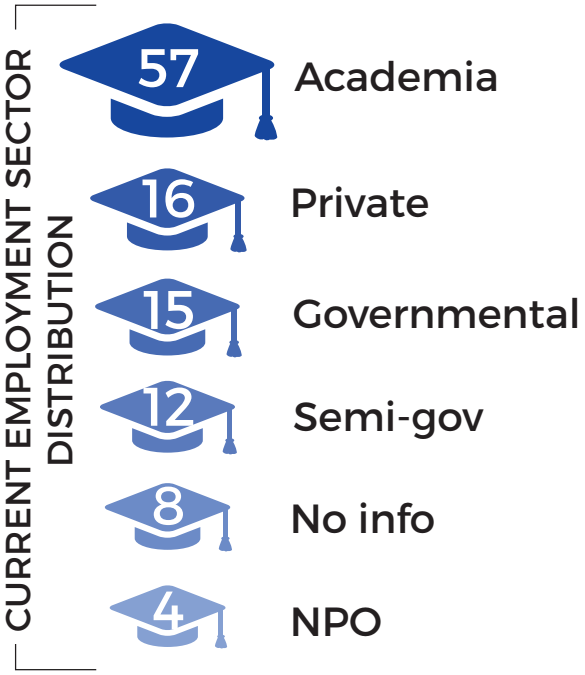
The questionnaire was divided into six different modules dealing with different aspects of issues of interest. These were doctoral education, early career research positions, employment situation, international mobility, career-related experience and personal characteristics.

What are South Africa's water-related PhD graduates up to?

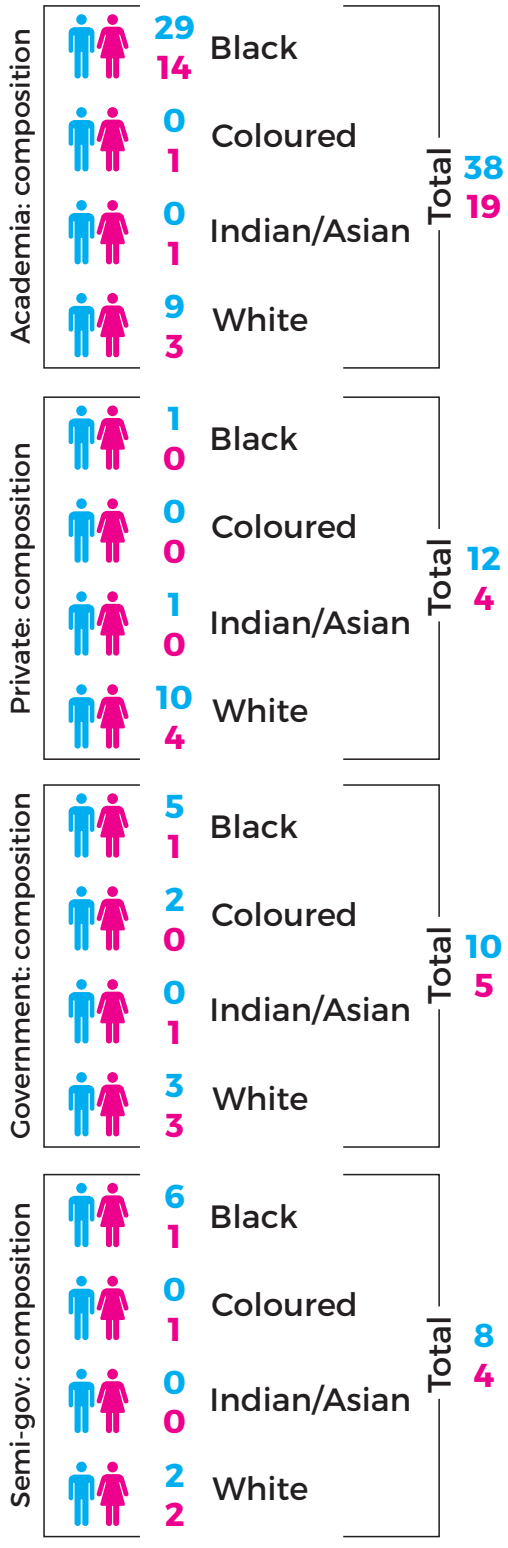
According to the project report, the main findings were as follows:

- All PhD-holders were engaged in jobs. Employment profiles were traceable for 104 graduates, all of who were found to be employed.
- More than 50% of the PhD-holders occupied positions in the university sector. Of those in the university sector roughly 23% held post-doctoral positions.
- Approximately 30% of the PhD-holders were in other African countries having gone back to their country of origin.
- Approximately 90% of the respondents were in occupations related to the water and sanitation sector.
- Mobility between sectors was identified to be 16%. Eighteen out of 112 graduates identified to have transitioned between sectors.
- The work experience of 40.1% of the PhD holders was identified to be between two to five years.
- Twenty PhDs (18%) declared that they had management experience.

The study also found the number of male graduates to be almost double (63.4%) compared to the female graduates (32.1%).



They also looked at gender and race within employment categories (see figure below).



The semi-government category consisted of science councils and research institutes affiliated to the government whereas NPOs included not for profit organisations that did not have governmental stake holding. A 2:1 gender ratio exists across all main categories. Within the NPO category an equal gender distribution was noted with two males and two females. The racial distribution consisted of two white males and one black female and one white male. The NPO category is not represented graphically because of the small size of the category.

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Digging deeper into the details

While the study wasn't able to say whether supply meets demand, it was able to infer that supply is currently not exceeding demand, notes Dini.

For Pouris, this is one of the key findings, especially for a country like South Africa with high unemployment: people with PhDs in a water-related subject find jobs. Pointing out the low unemployment rate indicated in the result, Pouris says that "in this country, having a group in which so few are unemployed is really extraordinary."

Dini says he also found the results on demographics useful, and thought the spread in terms of race and gender better than he expected, though there is still much work to be done regarding gender balance in particular.

Furthermore, Pouris points out that 90% of respondents remain in the field of water. While one of the advantages of a PhD is that a graduate can easily adapt to different disciplines, the finding that graduates remain in the water sector must mean that there is a high demand for these graduates.

An area of concern that has been highlighted by the findings is the number of water-related PhDs leaving the country. "If 30% of graduates leave to return to their country of origin, this means that the South African water sector has access to a significantly lower number of individuals than graduate from its universities," says Dini. From a policy perspective, this has implications for the investments made towards PhDs, and the current attempts to retain those skills gained as a result, he says.

Furthermore, says Pouris, "there are a number of indicators that are pointing to the fact that we need more PhDs on water." The first is to be found in South Africa's National Development Plan (NDP), which calls for a vast increase in South African doctoral graduates – to over 5 000 per year by 2030 against the figure of 1 420 achieved in 2010. "Water is part of the bigger issue," he says. "We need to increase the number of water PhDs as part of attempts to reach the NDP objectives."

Second, Pouris points to the goals of the RDI roadmap. The number of water-related graduates identified in the study concludes that about 15 to 30 are produced each year – far short of the 200 PhDs called for in the roadmap. However, Nienaber sees the results in a different light. The roadmap's targets are based on an assumption of what a research system that produces optimal research outputs looks like, and how many PhDs need to be produced over time to achieve that. The targets were aspirational, and set intentionally high, she says. The idea was to inspire a sector to strive to a big goal, in order to stimulate activity within a system. Though it's the most broadly consulted document we have, she adds, it's not uncontested.

The study's final report also points out that the numbers are much better in comparison to what can be expected from current research and development (R&D) funding in the country. Water R&D expenditures constitute just below 1% of the country's total expenditure. If the expected number of doctorates was 1% of the 1 263 that graduated in all disciplines during 2015, the actual number is almost three times that. "As such, it's clear that the human resources produced, related to water, are more than what was expected from the relevant inputs".

Still, Nienaber points out that the bigger understanding from the study comes from what happens to the graduates, and not how many they are. "The biggest take home for me is that there is sense in funding PhDs. People that go this path will at least spend a significant time in this sector."

The way forward

The study should be seen as a first step in the way forward, says Dini. From this starting point, adds Nienaber, there are areas to be debated. These include, as a first, which database should be used to identify the doctorates. A scaling up of the methodology is necessary. Then, she says, social media as a data source is an area that is set to grow, and we need to look at how to use it optimally. Another area of debate is how long the graduates need to be tracked for meaningful information.

The study has set the building blocks in that direction in South Africa and, says Dini, confirms the beauty of the reference group model that the WRC uses for its research projects. This allows for broad and cross-sectoral consultation of project methodologies and study results. The reference group for this study included representatives of the Department of Higher Education and Training, the Department of Science and Innovation (DSI), the NRF and select universities.

"The bigger question was whether what we are seeing is unique to the water sector, or representative of what's happening across the board and sectors for all PhD's," says Dini. Another question was if we are doing something right in the water sector that others can learn from, he says.

Steps to answer these questions are now being taken. The DSI has provided funding to the University of Stellenbosch, via the WRC, for another, broader tracer study. This project will aim to trace every PhD graduate across all disciplines from South African universities from 2000 to 2018. Already, over 30 000 PhDs have been identified as part of the 18-month project. From the first exploratory steps that have been put in place, this will make even larger strides towards filling a significant gap in South Africa's push to increase doctoral graduates in the country.

To download the report, Trace study of water PhDs in South Africa (WRC Report no. 2851/1/20), visit: www.shorturl.at/szBW0

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WATER HISTORY

South Africa's first state dam is a memory of greener times

Vanwyksvlei in the Northern Cape is not associated with water. Ongoing drought has turned the landscape to dust, but even before, the region was described as one of the driest in South Africa, already a dry country by international standards. The landscape is now nearly devoid of vegetation, nevermind water but, signs that things were once different are rife. Petro Kotzé reports.

On local farmer, Vasie de Kock's property, tracks of tractors and harvesters are still implanted in the earth. Like his father and grandfather that farmed here before him, de Kock also planted crops like Lucerne. He remembers a time when boat rides were a fun activity. "Eventually you got tired of all the water," he says of the view as they went.

The source of these memories is the Vanwyksvlei Dam, located just outside the town that it was named after. Completed in 1884, it was South Africa's first state dam and was built on the dream of sustainable irrigated farming operations. Now, the near-defunct infrastructure stands as testimony of the complexities involved when man tries to tame nature, and the ripple effect when water is harnessed, and disappears.

The history of the dam

Economy is synonymous with water at Vanwyksvlei, wrote JCS van der Merwe in his 1979 regional historic sketch of the region. The first migrant farmers (***trekboere***) in the region depended on rainwater that gathered in eddies, marshes and pans, and when these dried up, dug holes in the riverbanks to capture seepage. Later, reservoirs were built and water hauled from wells, that were progressively dug deeper as the water table fell.

Garwood Alston, a surveyor that settled in South Africa in 1856, eventually on the farm Botterleegte in Vanwyksvlei, saw the potential for an irrigation dam. At the place he had in mind, the ridges lie close to each other and the valley that would feed the

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dam had a large catchment area.

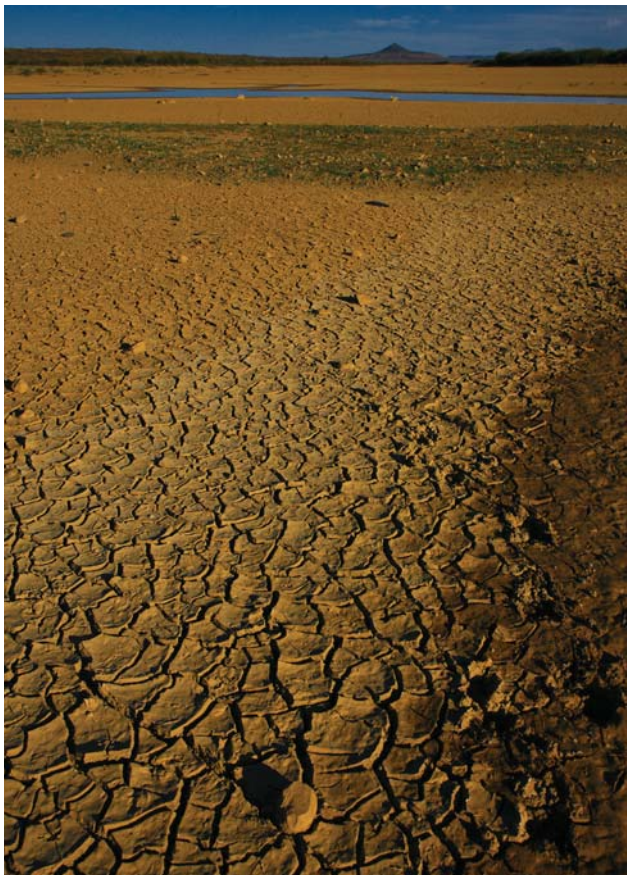
Alston describes the location in an 1891 article published in the ***Transactions of the South African Philosophical Society*** as on an affluent of the main river draining the Carnarvon Division and about seven miles above the junction of two streams.

Designed and constructed by South Africa's first appointed hydraulic engineer JG Gamble, construction started in 1882. The wall was built from gravel and sealed with clay to prevent seepage. Donkeys and oxen pulled bowl graders and wheel graders the haul the building material to the site. Van der Merwe wrote that the roads used by the donkey and oxen-pulled carts were still visible against the slopes of the ridges. Cowhides with wooden carriers inserted on each side could also be filled with soil and carried by two men. The final dam wall was 311 m long and 9.7 m high, with a watermark height of 8.2 m.

The water service was regulated from a tower that was built at the eastern point of the dam wall. Five sluices (from the United Kingdom) were mounted on it, and was opened and closed with a meter-long key. Access to the tower was via 13 iron steps, but once the water level reached four meters it could only be reached by boat. A bridge to the tower was later built in 1883 from the dam wall.

Van der Merwe said that the wall cost £33 000 at the time. According to reports, the large dam was completed in 1883, a six-mile distribution furrow was made in the summer of 1884/5 and the arable lands were put under cultivation in 1885. There was also a supply furrow of nine-and-a-half miles long.

Chris Marais/Karoospace



Vanwyksvlei Dam, in the Northern Cape, was the first dam to be constructed by the state in South Africa

"It is calculated that if filled to the depth of 27 feet (measuring to the sill of the discharge pipe) the reservoir will contain 35 000 000 000 gallons – thirty-five thousand millions! Say even hundred times as much as can be stores by all the Cape Town reservoirs together, or eighty times as much as the Beaufort West dam can contain," writes Alston.

However, at the time he wrote the report, the dam had never saw that much water. The irrigation farming operations that developed were also still at the mercy of the seasons.

"There being no permanent streams in the neighbourhood, the dam is entirely dependent on periodical floods for its catch of water, and the area cultivated is again dependent on the quantity of water at command in April or May (the beginning of the sowing and end of the rainy season) each year," wrote Alston.

Though the land for irrigation was described to be limitless, at least "probably two thousand morgen (1 713 hectares) within the triangle" (formed by the two streams) and another two thousand on the right bank of the main stream, only an average of 300 morgen (257 hectares) per annum were sown for the six years from 1885 to 1891.

In an 1886 report Alston mentions that he limited irrigation to 560 hectares (700 morgen) but that he could add another 616 hectares should the main canal be enlarged three times, especially since the season for ploughing was so short, and all the farmers needed water at the same time.

Six years after the dam was complete, Garston wrote that the experience shows that "drainage from four hundred square miles enables us to cultivate one square mile under wheat crop. The cultivation of garden ground and supply of water stock may perhaps reduce this extravagant proportion to, say, 300 to 1 as effective power of the dam." Then, he said of the area, that "few dams catch so much more water during the rainy season that will be lost by evaporation and soakage during the whole year, as will enable the owner to irrigate more than a small patch below each dam."

Though mention was made of increasing the catchment area to the dam, Garston thought it premature, due to the constant loss of water to seepage and evaporation.

"Under the natural conditions, as stated, the dam is found to catch but little more than enough water to meet its loss by evaporation and infiltration. The loss being provided for, nearly all the water supplied by the canal is a clear gain, and the water at command for irrigation purposes is very much augmented."

He describes the impact of the extra water being made available by the dam as follows: "The difference is akin to that between having just enough to live upon and having enough to live upon and something to spend on luxuries."

Still, originally a farm, the construction of the dam led to the growth of Vanwyksvlei as town. Early developments included residential home, a church, school and store.

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More than a century later

Today, the dam still contains water at times but the irrigated agriculture it was meant for is a mere memory. Gawie van Dyk, the DWS Director for Water Use Regulations, based in Kimberley, says that the department is in the process of formally dissolving the long-defunct Vanwyksvlei irrigation board.

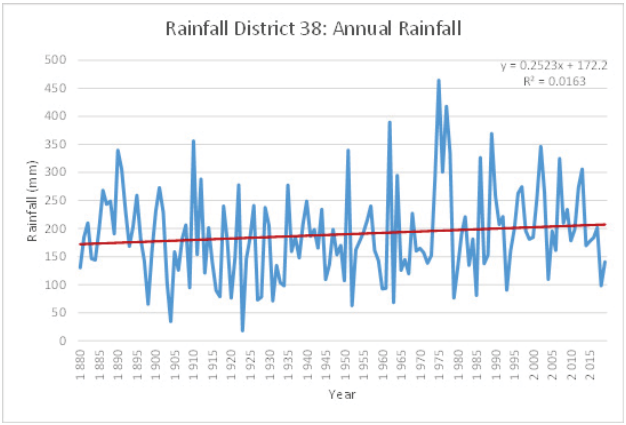
Yet, De Kock remembers very well when they used to tap water from the dam. During a good year, he could cut around 1 600 bales per harvest. "That water came from Vanwyksvlei Dam," he says. Then, three transport trucks drove the Carnarvon road "to dust" careening the harvests to and fro.

De Kock also remembers the 'water fiscal' (named after the bird, also known as a Jackie hangman) that cycled along the water canals on his bicycle, checking that each farmer does not take more water than his share.

"The last lucerne died on the field," he says. "Since then, it just doesn't get water anymore." He says it must be around a decade since they last planted.

Mostly, the ongoing drought is fingered as reason for the demise of irrigated agriculture from Vanwyksvlei Dam. An article in ***The Water Wheel*** (March/April 2020) reports that since 2013, the area has been unusually hot and dry. The lowest rainfall in the province since 1922 was logged in 2019, while that year, with 2015, can be considered to the two hottest in South Africa since at least 1951 (about 1.1 degrees Celsius above the 1981 to 2010 average). The drought is reported to be unusual not only because of that, but also because only the late forties and early fifties, and the first half of the sixties show a similar scale of grouping of dry years since at least 1921.

Data from the South Africa Weather Service (SAWS) allows us to look even further back. Dr Andries Kruger of the SAWS says their data for Vanwyksvlei go back to 1879. Though the past couple of years have been very dry, he says, there is however no long-term decrease of rainfall.



Rainfall data for Vanwyksvlei from 1880.

"Long-term rainfall trends show negative tendencies only in the South-west Cape and the far north eastern parts of South Africa." He adds that dam levels obviously depend on rain in the entire catchment area.

Chris Marais/Karoospace

The Vanwyksvlei Dam is more often than not dry.

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The thirsty Prosopis

Alston himself might have unknowingly contributed to water scarcity in the Vanwyksvlei area. In a letter to the editor of the ***South Africa Agricultural Journal***, he writes that he was sent a few seeds of mesquite (***Prosopis dulcis***) and screw-bean trees (***Prosopis pubesceens***) some 35 years earlier by a John Marquard. Their interest was in the plants for fodder and shade in the arid Northern Cape. He notes that he failed to grow mesquite but the screw bean "took kindly to the ***brak*** soil and ***brak*** water, growing and seeding freely on my old homestead."

A 2012 study published in the ***Journal of Arid Environments on Water relations*** and the effects of clearing ***Prosopis*** on groundwater in the Northern Cape, reports that several ***Prosopis*** species introduced to South Africa have become invasive. In fact, the IUCN has declared the plant one of the world's worst invasive species. In the Northern Cape, the report continues, the largest density is to be found in the alluvial floodplains of the province, where their invasion has increased from 127 821 ha in 1974 to 1 473 953 ha in 2007, roughly doubling from 2004 to 2007.

The project's study site was conducted within the riparian zone of the Rugseer River, approximately three kilometres southeast of Kenhardt (about 130 km from Vanwyksvlei). In the study area, mean Prosopis tree density was approximately 700 plants per ha.

However, the density of ***Prosopis*** at and around Vanwyksvlei, including the catchment area of the dam is said to be substantial too.

Through isotope analyses, the study demonstrated that plant is deep-rooted, reduces groundwater levels and leads to a decline in borehole levels. They found that savings of up to 70m^3/month can be achieved for each hectare of ***Prosopis*** cleared.

Source: Water relations and the effects of clearing invasive Prosopis trees on groundwater in an arid environment in the Northern Cape, South Africa by S. Dzikiti, K. Schachtschneider, V. Naiken, M. Gush, G. Moses and D.C. Le Maitre

"There being no permanent streams in the neighbourhood, the dam is entirely dependent on periodical floods for its catch of water."

However, according to Kobus Streuders, Acting Provincial head of the DWS Northern Cape, the drought is a minor contributor the dam falling in disuse. "The fact that all the runoff water that used to flow into the dam is now being used upstream, caused it."

In particular, with the development of sow-dams (***saaidamme***) upstream of Vanwyksvlei Dam in the seventies and eighties, not much water flows from the catchment area to the dam anymore. "Almost all the water is diverted and used upstream," he says. It's only during floods that water now reaches the dam.

Streuders adds that due to salinisation (***verbrakking***) the water is not suitable for irrigation after only about six months. Due to the low inflow and bad water quality sustainable irrigation from the dam, like in the early 1900s, is not possible anymore, he says.

In her blog on life at Vanwyksvlei (karooblog.wordpress.com) author Leonette Smit writes that the dam has been a good place for locals to relax for many years. In a February 2017 post she says that there was not one drop of water in the dam when she and her husband went there for a sundowner. A couple of days later, after some rain fell in the area, the dam had water "as far as the eye can see," driving a visiting journalist to take a dip dressed in his underwear. De Kock remembers this too, noting that he had to wash himself in a nearby dam afterwards because of all the mud.

In answer to how life has changed since the dam does not fill substantially anymore, de Kock says that to an extent, it has led to unemployment, but that they have little choice but to continue nevertheless. "You simply adapt."

Drought the constant companion of Vanwyksvlei

Drought is a constant companion in the Vanwyksvlei area. In the ***South African Irrigation Department Magazine*** (Volume 2 Number 3) of July 1923 the Circle Engineer gave an account of the experience of farmers in the area: "The settlers are in a very bad way, owing to the drought and consequent losses of stock, in addition to the fact that owing to the reservoir [Vanwyksvlei Dam] having been so dry for so long no ploughing has been possible…Many of the settlers are so poor to be living on donkey flesh and as a measure of relief the Water Bayliff was empowered to employ some of the most needy residents as labourers to clean and widen the main furrow from the dam."

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WATER AND TOURISM

Investing in freshwater ecological infrastructure for a resilient tourism economy: A call for action

Investing in freshwater ecological infrastructure can support growth and sustainable development in the tourism sector in the context of climate change. The Water Wheel reports about the latest research in this regard.

The Umngeni area is a hub for water sports, including the Midmar Mile and the Dusi Canoe Marathon.

Tourism is a key strategic sector for economic growth and social change in South Africa. Tourism is also dependent on natural capital and the ecosystem services it provides. These 'services' provide the benefits that humans derive from nature, including natural flood control.

South Africa's natural environment is considered one of its greatest tourism resources. Yet the base of the country's nature-based tourism industry – its natural wealth – is at risk. The degradation of freshwater ecosystems caused by many anthropogenic factors – including tourism – is also threatening the future of the tourism economy. So, what can be done?

Researchers involved in a project titled ***The inland water-related tourism in South Africa by 2030 in the light of global change (*WRC project no. 2620*)*** explored how investing in freshwater ecological infrastructure can benefit tourism growth and small-business development. This project, funded by the Water Research Commission, stretched over three years.

The research team included Joël Houdet from The Biodiversity Footprint Company and the University of Pretoria's Albert Luthuli Centre for Responsible Leadership, and Fonda Lewis and Michelle Browne, both from the Institute of Natural Resources. The team investigated the links between natural capital, tourism and global change, with a focus on freshwater ecosystems.

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Fishing on the shores of the Inanda Dam, KwaZulu-Natal.

The researchers considered several case studies, including the Dusi Canoe Marathon and Inanda Dam (in the uMngeni River catchment) and the Loskop Dam and the associated recreational fishing activities (in the Olifants River catchment in Mpumalanga). Their methodology involved stakeholder engagement, analysis of how government policies integrate natural capital and small, medium and micro business considerations, as well as modelling the economic impacts of water-related global change scenarios on the tourism economy.

Spotlight on tourism

Before the arrival of Covid-19, South Africa was ranked the top tourism destination in sub-Saharan Africa. According to the World Travel and Tourism Council, the 2018 contribution of the tourism sector in South Africa directly accounted for 2.8% of GDP, which amounts to R139 billion.

The indirect contribution of the tourism sector to the country's GDP in 2018 stood at an even higher 8.2%, according to the Department of Tourism. In addition, the tourism sector direct employment accounted for 4.2% of total employment in the South African economy in 2018, while tourism's indirect contribution to total employment stood at 9.2% for 2018.

Climate change, natural resources and tourism

Climate affects the seasonality of tourism, tourists' selection of destinations, the available tourist activities and attractions, and the overall satisfaction of visitors' vacations, the reports highlights.

Climate change has the potential to affect the sustainability and long-term variability of global tourism, according to the authors. Tourism businesses and tourists can, for instance, perceive risks differently when faced with water-related climate change impacts on tourism. In the towns of St Francis Bay and Cape St Francis in the Eastern Cape, tourists demonstrated greater concern for the risk of flooding, sea-level rise and the degeneration of beaches than the tourism business owners. A study by Hoogendoorn et al published in 2016 highlighted that owners of tourism accommodation establishments in these towns were mostly concerned with day-to-day changes in weather.

The number of extreme climate-related events, such as extreme droughts ,is expected to increase over the next few decades. These extreme events could have significant negative impacts on water-based tourism assets and activities in many parts of the country, the researchers highlighted.

The country's tourism and recreation sector is already sensitive to droughts (when demand for water exceeds water supply), which is likely to be exacerbated by climate change. Expected changes in global precipitation patterns due to climate change will have significant impacts for already water-scarce destinations, including several provinces. If one considers the indirect water requirements of tourism, such as for the production of food, building materials and energy, local water shortages could have significant impacts on tourism in drought-prone regions like the Western Cape. The Breede-Gouritz and Berg River area could suffer particularly from extreme drought events, the report highlights.

The negative impacts of water shortages or restrictions on tourism have already been documented throughout the world. In South Africa, water shortages during the water crisis in Cape Town in 2018, for instance, raised fear of tourists staying away due to water restrictions. "Extreme drought and rainfall events could directly affect tourist numbers, especially foreign visitors whose behaviours can change quickly based on negative perceptions about the climate and weather of potential destinations," the researchers indicated.

Case study No. 1: Spotlight on the "Dusi"

In terms of tourism, the uMngeni area receives the highest proportion of visitors to KwaZulu-Natal. Various tourism attractions rely on natural resources in the uMngeni catchment area, especially water-based natural capital. The region is a hub for water sports, including the Midmar Mile and the Dusi Canoe Marathon (also known as the 'Dusi').

The Dusi marathon is an annual three-day paddling race held along the uMsunduzi and uMngeni rivers between Pietermaritzburg and Durban. The race is the largest canoeing event on the African continent attracting between 1 500 and 2 000 paddlers each year. In 2017, the event generated an estimated direct economic impact in the region of R4 million and an indirect economic impact of up to R9 million.

"Climate affects the seasonality of tourism, tourists' selection of destinations, the available tourist activities and attractions, and the overall satisfaction of visitors' vacations."

From 2006, the number of participants slowly declined each year – barring a slight increase in the number of participants in 2014. In 2018, the total number of participants was the lowest in 18-years. It is possible that the recent drought had a major impact on participation, as well as on canoeing as a sport.

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Measurements and targets for the tourism sector in South Africa

Indicators/measures of performance	2015 baseline	2026 target
Increase direct contribution to National Gross Domestic Product	R118 billion	R302 billion
Increase total (direct and indirect) contribution to National Gross Domestic Product	R375 billion	R941 billion
Increase the number of direct jobs supported by the sector	702 824	1 million
Increase the number of total (direct and indirect) jobs supported by the sector	1 551 200	2,2 million
Increase tourism export earnings	R115 billion	R259 billion
Increase capital investment	R64 billion	R148 billion

While the water quality of the uMngeni River has been good for many years, it is showing signs of deterioration. Water quality concerns include high nutrient loads from farming, sewage effluents from commercial, industrial and residential areas, and pollutants from industrial discharges. The water quality of the uMsunduzi is also notably poor, with a high faecal coliform content and nutrient enrichment. In recent years, anecdotal evidence from the Dusi marathon also points to increasing concerns related to water quality and water-related illness. The years 2008 and 2016 showed a spike in ***E.coli*** levels and a corresponding spike in the number of race participants affected by diarrhoea (so-called "Dusi Guts").

Unless water quantity and quality trends improve, there are "serious concerns" about the resilience and sustainability of this event and the local economy it supports, the researchers warned.

Case study No. 2: Loskop Dam area

Loskop Dam is located about 32 km south of Groblersdal in Mpumalanga, in the upper catchment of the Olifants River. The dam is a freshwater angling hot spot and popular tourist attraction.

The dam is surrounded by the 25 000 ha Loskop Dam Nature Reserve. Loskop Dam and associated activities like fishing competitions, water sports and lodges play an essential role in the economy of the area. But without investments into new tourism assets and the associated activities (including tourism facilities), there will not be a significant increase in tourist numbers in the area. This investment is at risk due to water quality issues. The Olifants River is considered one of the most highly threatened aquatic ecosystems in the country.

Deteriorating freshwater resources could have a negative impact on businesses, especially small startups. More than two thirds (71%) of the business owners interviewed indicated that the water quality in the dam had declined in the last decade or so. Recent improvements were noted following the lobbying of upstream and local contributors to water pollution. Entrepreneurs indicated that a decline in water quality would harm their businesses because tourism in the area depends on "nature and clean water". Poor water quality would, for instance, make the area less attractive (including for birdwatching), and there would be fewer tourists and less sales.

"The findings suggest that there is a potential risk to tourism at Loskop Dam, given that much of the tourism is dependent on recreational fishing and fishing competitions. Efforts to maintain water quality in the catchment remain crucial to prevent negative impacts on fishing competitions," according to the report. "Potentially, there is a risk of the tourism industry in both areas (in the Dusi and Loskop Dam study) collapsing if water-related problems and its effects on tourism are not addressed."

Key policy challenges

While the South African government has recognised the importance of the tourism sector for the economy, this study has highlighted some policy gaps.

"The country's National Tourism Sector Strategy has a limited focus on environmental issues, besides raising concerns over the impacts on inbound tourist numbers of carbon taxes on the aviation industry, and the need for South Africa to appear to be a responsible tourism destination to help mitigate this risk. In practice, this equates to funding support for environmental management activities for a selection of tourism businesses and assets, including support to protected area management.

"There is no explicit and clear recognition of the importance of water source areas and ecological infrastructure linked to freshwater ecosystems (rivers, wetlands) as enablers of tourism activities, businesses and jobs.

"While the Department of Water and Sanitation Master Plan has recognised key water source areas, the tourism sector has yet to formally embrace such an approach."

Currently, environmental activities in the tourism sector focus on improving the environmental management of selected sites (mostly national parks) and businesses (mostly hotels). This approach is not sufficient to sustain the freshwater ecosystems and associated ecological infrastructure on which tourism relies, the researchers believe.

There is also an "urgent need" for government departments to work together, with the tourism sector, towards the development and implementation of a freshwater ecosystem "source-to-sea" conservation and restoration strategy and action plan.

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The Midmar Mile draws thousands of competitors each year, from serious international athletes and Olympic medallists to purely recreational swimmers.

At the national scale, the research highlighted the additional effects of the various climate change scenarios on tourism GDP and employment.

"While these results should be interpreted with caution, they emphasise that climate change, characterised by water-related extreme events, can negatively affect any growth pathway for the tourism and travel industries," the researchers emphasised. "These effects would be particularly acute when the tourism spending and sector growth rate is low or negative (including in times of global, regional or national economic crisis)."

Freshwater-related extreme events can have significant impacts on the tourism industry and stakeholders, especially in rural areas with weak institutional support and limited community skills, where tourism systems are small or weak.

Securing natural capital for the future

The report argues that the degradation of natural ecosystems (including capital and ecological infrastructure) caused by human-made factors, including tourism, threatens the future of the tourism economy. This affects all tourism stakeholders, including tourism businesses, local communities, employees and the tourists themselves. Trends most be reversed to support the 2030 NDP and SDG goals, according to the report.

There is also an "urgent need" for government departments to work together, with the tourism sector, towards the development and implementation of a freshwater ecosystem "source-to-sea" conservation and restoration strategy and action plan, the researchers indicated.

Efforts to mainstream natural capital and ecological infrastructure in the tourism economy may involve mainstreaming interventions at one or more pilot sites, including potential natural capital impact avoidance and minimisation (innovative infrastructure design, based on green infrastructure principles), natural capital restoration and rehabilitation (for example as part of tourism product development) and offset measures (including through stewardship site declaration).

There is a "clear need" to unlock financial and institutional support to harness tourism potential in critical source-to-sea pilot areas (including for the iSimangaliso World Heritage Site), the researchers indicated. This could happen by establishing financially independent and multi-stakeholder water funds to ensure alignment in public-private sector policymaking and implementation throughout the pilot sites, among others.

In the uMngeni catchment, various financing mechanisms to support the implementation of catchment management and restoration efforts to secure the hydrological services of the catchment are being investigated.

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Umgeni Water – the local water service utility – is exploring a fund to finance investment in the ecological infrastructure of the catchment generated through an additional charge attached to the water tariff.

The eThekwini Municipality (lower uMngeni catchment) have expressed an interest in establishing a water fund to address water security issues through ecological infrastructure interventions as a component of the municipality's integrated water management programme.

The report highlights the need to establish a comprehensive, integrated tourism socioeconomic and ecological strategy and action plan. From an ecological perspective, this calls for strategically investing in freshwater ecosystems, it is argued. ""Given the importance of tourism to the economy, the sector has an opportunity to strategically influence decision-making, financing and investment in ecological restoration at a meaningful and effective scale," the researchers indicated. "The tourism sector must act collectively to effectively lobby for, and support, ecological restoration as a key component of the green economy to safeguard South Africa's tourism sector, its growth potential and SMME opportunities."

Lastly, from a socioeconomic perspective, an extensive programme of capacity building is needed to empower rural and marginalised communities, and particularly the youth, to recognise and harness tourism opportunities and to embed and understanding of the linkages and interdependencies between tourism and natural capital. Such a programme needs to focus not only on aspects directly regarding tourism and its value chains, but also on the issues needed to provide an enabling environment for tourism, including water and waste management, pollution reduction and crime control.

To download the report, ***Impact of degraded freshwater ecosystems on tourism towards 2030*** (**WRC Report no. TT 828/20**), visit www.shorturl.at/hkvOR

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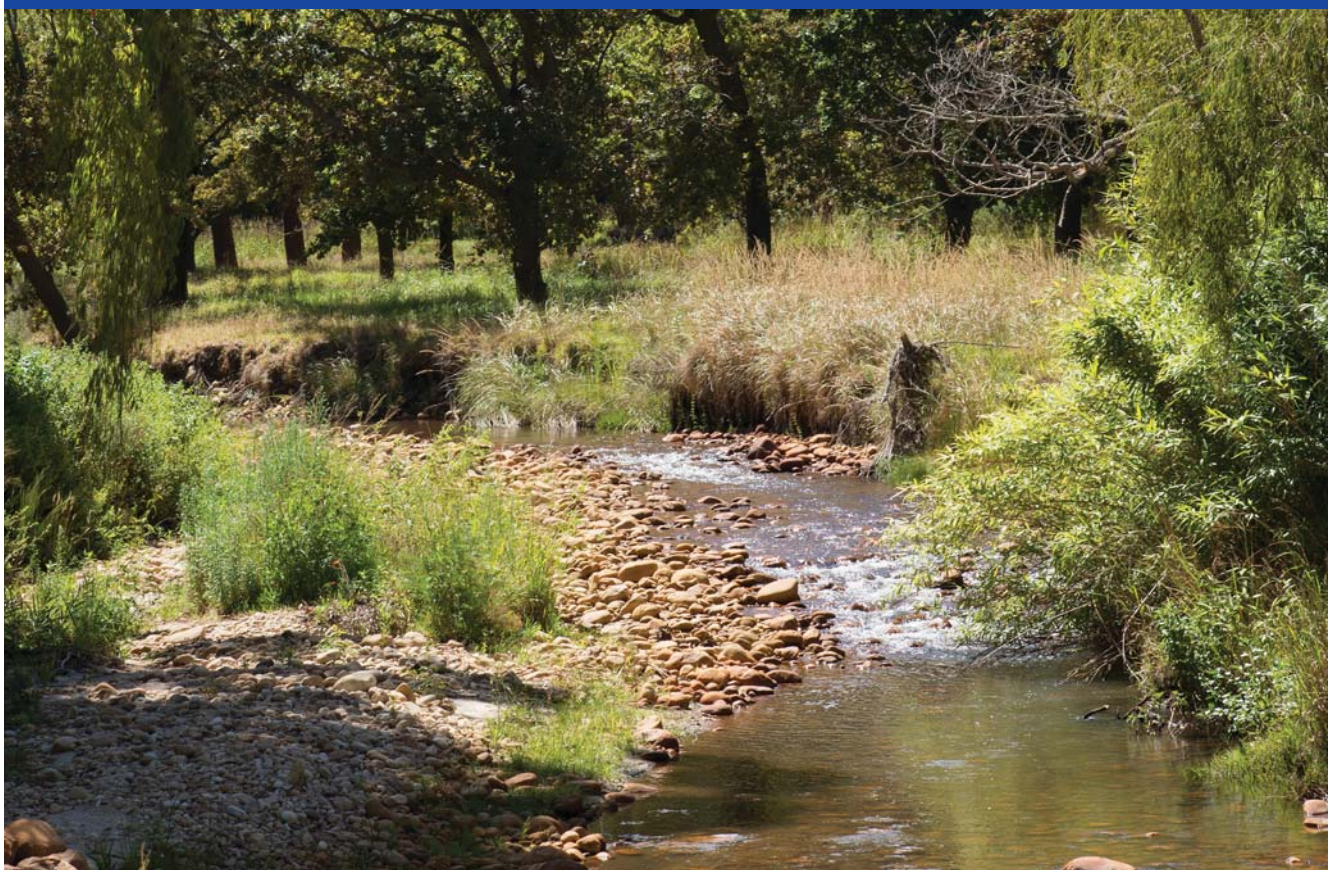
WATER AND THE ENVIRONMENT

Constructed wetlands to deal with pesticide pollution

A Western Cape wetland study has demonstrated that green infrastructure has the power to filter pesticide polluted water. Article by Petro Kotzé.



Using the power of nature to manage the impact of people on the planet is not revolutionary anymore. Constructed wetlands, in particular, have grown in popularity. These green engineered systems use plants, soil and organisms to treat wastewater, and they are relatively common in the treatment of municipal or industrial wastewater, greywater or stormwater.

In recent years, artificial wetlands to treat effluent have also become somewhat more commonplace on farms. In the Western Cape, it has been punted as a cost-effective choice to treat wastewater generated during the wine production process. On some farms, wetlands are also used to treat sewage to irrigation water standards.

Lesser known in the country is that one of the earliest studies internationally that proved the capacity of constructed wetlands to filter pesticides before it enters streams and rivers, also took place in the Western Cape. Though this has now been proved successful in different countries, it's not widely applied, or common knowledge on local shores.

"We did a good job of finding things out, and did a bad job to sell it to society," said Prof Ralf Schulz, from his office at the University of Koblenz and Landau, Germany where he heads

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the Ecotoxicology and Environment Group. What they did find out, was that an artificial wetland close to Somerset West was "extremely effective" at not only the task it was built for, but also the one they tested it for – filtering out pesticides before it entered the Lourens River.

Once, there was a wetland

Schulz spent time in South Africa for a post-doc at the University of Stellenbosch in the early 2000s, during which time they came upon a wetland constructed on a tributary of the Lourens River. The Lourens is a 23 km stream, declared a Protected Natural Environment by the City of Cape Town. In the very upper reaches in the Hottentots Holland Mountains it remains pristine, but on its way to where it spills into the Atlantic Ocean at Strand it travels through surrounding farmlands, residential, commercial and light industrial areas. Downstream, the river is plagued by pollution and alien vegetation. In a 2004 water quality study of the Lourens River, high levels of pesticide contamination downstream of multiple farming areas were also found.

In this way, the Lourens River is not unique. Water pollution from agriculture has been well documented, though it is complex and multidimensional. Soil erosion from farming activities, for example, impact water quality and quantity downstream. Poorly applied fertilisers can leech into rivers, polluting water sources and causing algal blooms that deplete the water's dissolved oxygen, produce toxins and kill aquatic life.

Pesticide pollution is another outcome of the growing need to produce more food, the impact of which ripples far beyond the target crop the poison was meant to protect. The resulting destruction of communities of invertebrates is well known. Over and above the negative consequences for ecology, drinking water quality can be affected once the pesticides filtrate to groundwater, which will necessitate treatment, rippling out to an added economic impact.

The term pesticides embrace a range of manufactured substances or biological agents. Insecticides (to protect crops from insects), herbicides (to protect crops from weeds) and fungicides (for protection against fungal diseases) all fall under the umbrella of pesticides. Surface water is often on the receiving end. Worldwide, pesticides that enter streams after being washed off the fields (runoff), or carried to it with the wind (spray drift) account for the majority of contamination.

Schulz explained that the impact of the pesticides on the broader environment depends to a large degree on its solubility. Insecticides generally have a lower ability than herbicides and fungicides to dissolve in water. As such, insecticides are less likely to filtrate to groundwater, but would probably enter surface water bodies with contaminated runoff or spray drift.

Because the affected water quickly flows away, leaving behind little trace of the contaminating agent, the impact of insecticides is often underestimated, says Schulz. In comparison, traces of herbicides and fungicides may occur for months on end.

The artificial wetland in question, located on the Vergelegen Estate, received water from a tributary that flowed through pastures of fruit orchards. The estate is well known for its large scale investing in sustainable farming and land rehabilitation. At the time the organophosphorus insecticides Azinphos-methyl (AZP), chlorpyrifos and endosulfan were applied to orchards.

According to research reports, the wetland was constructed in 1991 to retain soil washed from surrounding farmlands before it could enter the river and eventually, be lost to the sea. At the time, the wetland was 0.44 ha in size, (134 m x 36 m), free of plants for the first 30 m, and then mostly covered with bulrush (***Typha capensis***). A small part (around 10%) was covered with dune slack rush (***Juncus kraussii***) and there was also a bit of papyrus (***Cyperus dives***).

By the time the researchers found it, it had accumulated up to 1.2 meters of sediment at some points. "So, we thought, if it works so well for the sediments, why not pesticides," said Schulz.

When pesticides meet wetlands on their way to a stream

It was not a completely new thought. Researchers at the United Stated Department of Agriculture's Agricultural Research Service had been studying the capacity of constructed wetlands to mitigate the impact of pesticides. Back in South Africa in 2000, the researchers found Vergelegen's retention pond too, to be effective to reduce pesticide contamination during rainfall-induced runoff, as well as spray drift. In fact, the wetland did this tremendously well.

High levels of chlorpyrifos and endosulfan introduced via runoff were not detectable in samples taken at the outlet. Between 77% and 93% of water diluted AZP introduced via runoff was retained. About 51% of the AZP introduced via spray drift was retained. Bio-assays of bloodworms above and below the wetland showed a reduction in toxic contamination from 41% to 2.5%. The wetland trapped 78% of total suspended solids, 75% of orthophosphate, and 84% of nitrate during wet conditions.

The principle idea is that the flow of the contaminated water slows down in the wetland, said Schulz, allowing particles to settle down, where it is trapped by the sediment. The second aspect is the vegetation, which act as biofilters that reduce the amount of pesticides in the water, allowing it to degrade over time while it is trapped in the wetland.

Although there was a tremendous layer of sediment that built up over the years, Schulz said, only the very upper centimeters still contained pesticides then in use. In the deeper layers they only found traces of an old pesticide that has been discontinued in South Africa. "We assume there is no accumulation of pesticides in the wetland," he said. To maintain the constructed wetland as an efficient filter for pesticides, their only recommendation is thus to dig it out every couple of years, and preferably, return the nutrient rich soil to the farmed land – something which is already common practice today.

Schulz said the study turned into one of the first, world-wide on the capacity of constructed wetlands to mitigate the impact of pesticide contamination. At the time, he said, their work was exciting enough for another wetland to be constructed on a neighbouring farm along the river.

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However, almost two decades down the line, the results of the so-called Lourens River artificial wetland study remain relatively unknown in South Africa.

Finding the Vergelegen wetland

Vergelegen confirmed that the structure is still used as retention pond to capture silt and remains roughly the same size as described in the project reports. Since then, however, the land use activities in the catchment area has changed significantly, as have the type of pesticides they now apply on the farm, in general moving ever towards more environmentally friendly options and practices as these have become available.

Next door at Lourensford, vineyard manager Pieter Uys has been with the farm since 1991. Though he was not familiar with the study he could also located the second wetland that was later constructed from an old photo that Schulz sent. Uys remembers that the retention pond used to accept run off from a nursery and compost plant, though neither exist anymore. Coincidently, the structure was cleaned just recently, which entailed trimming the reedbed and scooping out the accumulated sediment to returned to the fields.

Though the concept of using wetlands to mitigate the impact of pesticides is not widely known in South Africa, it has since been more extensively studied elsewhere.

International examples of the capacity of wetlands to filter pesticides

A literature study on pesticide mitigation by vegetated treatment systems completed in 2010, identified 24 studies published between 1996 and 2009. In these cases, the majority of pesticide concentrations originated from runoff and spray drift. The majority (27 systems) of the studies evaluated systems in the United States, with only one system in Australia and one in Norway. Two were analyzed in South Africa (the Vergelegen retention pond, and the second at Lourensford, though data from the latter was never published).

In the evaluated studies, 34 pesticides were evaluated, including 9 herbicides, 23 insecticides, and 2 fungicides. The majority of retention performances were over 80%, with only a small proportion of the
pesticide trapping efficacies below 40%.

Another example is the Live Environment ArtWET project that took place from 2006 to 2010 in Europe. The project entailed the construction of artificial wetlands to investigate whether they were a sustainable and promising option to treat runoff and spray drift pesticide pollution, particularly from wetlands. Six wetlands were built in three European countries for this purpose. The wetlands achieved a pesticide retention performance of between 40% and 88%, even when very young. After monitoring total concentrations of 18 pesticides it was expected that efficiency would increase more as the systems and vegetation matured, to achieve a 73% reduction in the total load estimates.

The ArtWET project showed that bioremediation (the use of microbes) can totally remove some pesticides such as glyphosate. Additionally, a recirculation of water – for example through biomass-beds – achieved an efficiency of 99.8% for pesticides mitigation even with strong concentrations of active ingredients widely used in vineyards, such as metalaxyl, penconazole and chlorpyrifos. High efficiency of mitigation was also shown for several herbicides used in corn, wheat and tomato crops.

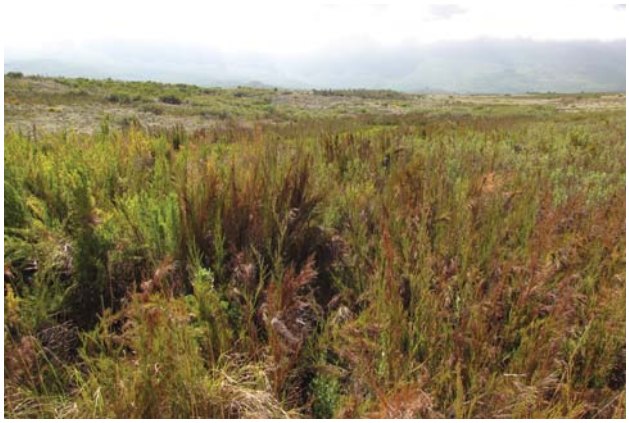
What to treat with wetlands?

Schulz says that wetlands are a particularly good option for the retention of insecticides before the toxins reach downstream surface waters. For herbicides and fungicides wetlands could be less efficient because these are more soluble and likely to filter to the groundwater first. Furthermore, wetlands are a particularly attractive option to mitigate the impact of insecticides because the infrastructure is permanent, and works constantly, negating the need to locate the affected water for treatment.

In order for such an application to work best, he says, among other considerations is the correct location that makes the most sense. Tributaries where the wetland would be the most efficient need to be located. Then, adequate space is necessary, preferably in areas not used for agricultural production.

Today, this knowledge is widely available and accessible and, said Schulz, many of the papers have been written specifically to be as applicable as possible, with guidance on how to move forward.

Back at Vergelegen, the retention pond that quietly became the topic of the now pioneering study, is still quietly doing its job and much more. In their constant and ongoing efforts to keep the river clean, Vergelegen takes bi-annual water quality samples all along the Lourens River as it runs through their property to measure any impact on the river and ensure it remains minimal. Though the input to the constructed wetland has changed through the years, results still show the water to be of similar or better quality below the outflow of the retention pond, in comparison to samples taken just up-stream where there is no effluent from their farming activities that can enter the river. According to Vergelegen, this is proof as good as any study, that farming in collaboration with nature, through the use of green infrastructure like artificial wetlands, can result in a minimal impact on the very system they depend on to do it.



Vergelegen Estate

The Vergelegen wetland

WATER POLLUTION

What does water pollution cost? Towards a holistic understanding

Wesley Evans from the Institute of Natural Resources unpacks the cost of water quality deterioration increasingly being faced by South African river systems.

Freshwater systems are one of the most threatened ecosystems on the planet. In almost every populated catchment on the planet, humans have to a greater or lesser degree increased the discharge of pollution, altered flow regimes, degraded catchments and/or modified the morphology of rivers (Vörösmarty ***et al***., 2010). Surface water quality (WQ) deterioration has become a serious concern worldwide primarily due to increased pollution.

It is estimated that, globally, over 80% of urban and industrial wastewater is released to freshwater systems without adequate treatment (IPBES 2019). The increasing pressure on freshwater ecosystems is threatening the use of water resources for human needs and has resulted in a loss of biodiversity and ecological functioning of these systems. At the time of writing, Vörösmarty ***et al***., (2010) estimated that 65% of global river discharge, and the aquatic habitats supported by river flows, were classified as moderately to highly threatened.

Effects of water pollution can be varied and widespread. It poses a risk to food and water security and the economy and it has the potential to impact human health, tourism, property values, commercial fishing, recreational businesses and many other sectors that depend on clean water. Water pollution also cultivates inequality as it disproportionately affects the poor, women and children. Given the wide-ranging risks associated with it, it is unsurprising that the pollution and degradation of freshwater systems incurs significant social and environmental costs.

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Linking such costs (whether they are economic, ecological or social) to deteriorating water quality provides a clearer perspective on the value of water quality and pollution management for policymakers and the public. Among other stakeholders, the Department of Water and Sanitation (DWS) and Catchment Management Agencies (CMAs) specifically need to have a good understanding of the costs of deteriorating water quality as they are responsible for water pricing and protection. Theoretically, accurate costing of water should allow DWS and CMAs to recoup the true cost of water from its users.

While it is not possible to place a monetary value on all the impacts, and their significance to different people, of deteriorating water quality, the framework suggests methods that can be applied towards a better, more holistic understanding of the economics of water pollution management.

However, answering the question 'What does water pollution cost' is no simple task. Some costs are relatively obvious. As an example, consider the financial cost associated with treating water to a required standard. A study in the USA found that phosphorous and nitrogen pollution costs the US government and citizens at least US$4.3 billion annually, due to increased water treatment requirements (KSU, 2008).

While it is not possible to place a monetary value on all the impacts, and their significance to different people, of deteriorating water quality, the framework suggests methods that can be applied towards a better, more holistic understanding of the economics of water pollution management.

There are also many less obvious costs incurred by water users and broader society, such as impacts on ecosystem services. Freshwater ecosystems provide a variety of services, many of which are overlooked and undervalued. These services include water purification and food provision. Most financial estimates of ecosystem services focus on those with market value, rather than those with non-market value such as regulating services and cultural services. Therefore, costs related to the loss of the harder to measure regulating and cultural ecosystem services are often undocumented, such as the loss of the recreational amenity value associated with rivers. These undocumented costs are often unknowingly passed onto the public.

The costs of deteriorating water quality vary greatly based on spatial scales, geographies, intended use, quantity and nature of pollutants and the affected parties. The range and context specificity of the impacts of deteriorating water quality make it challenging to gain a holistic perspective of the full cost of WQ deterioration in different settings and at different scales.

As a first step towards characterising the costs of deteriorating

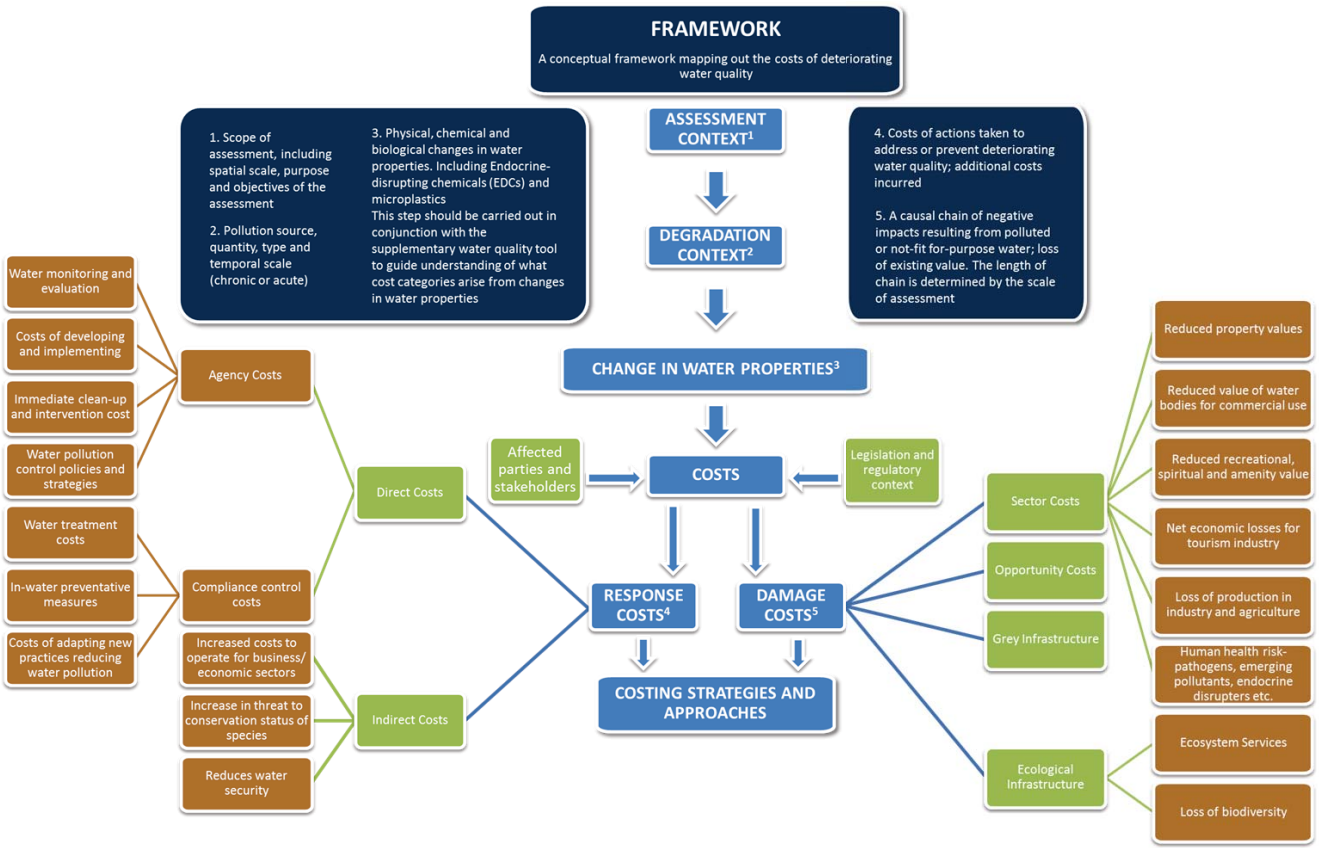

Figure 1: Conceptual framework for the costing of deteriorating water quality

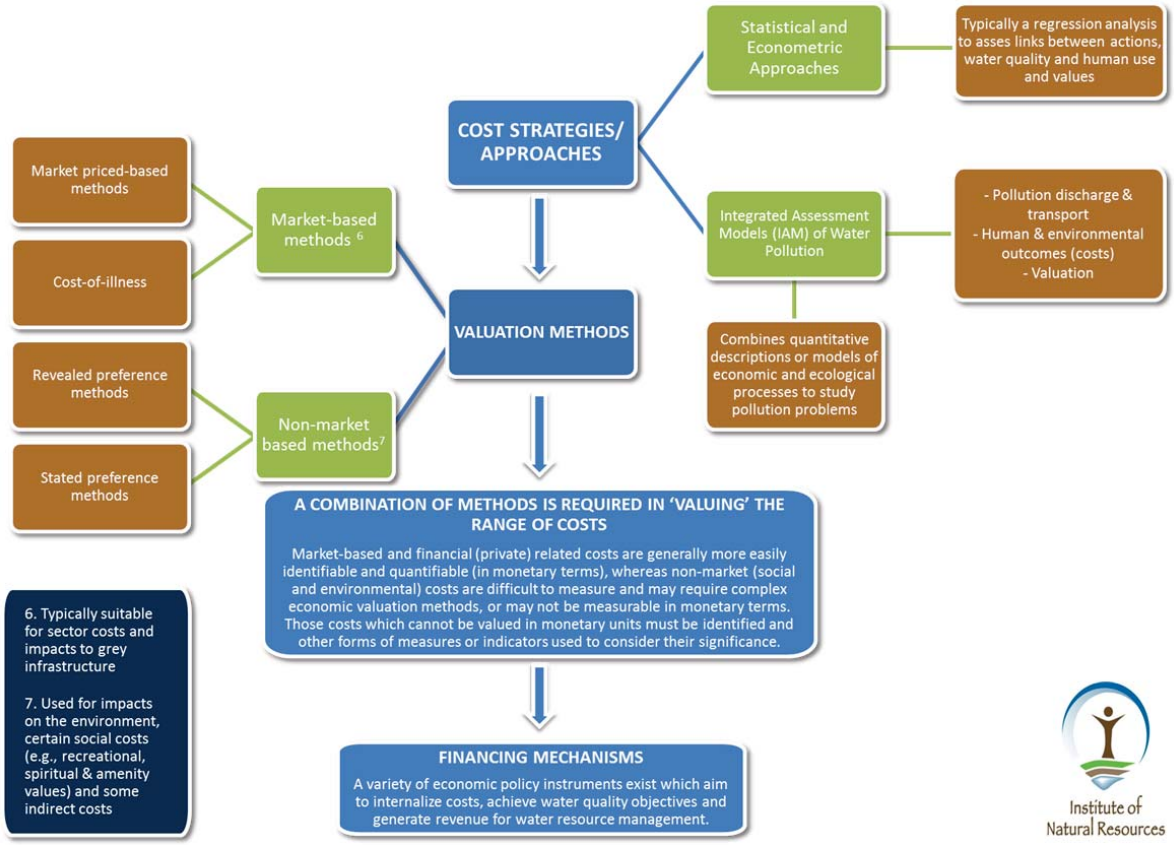

Figure 2: Conceptual framework for the costing of deteriorating water quality (continued)

water quality, a recent study (**Project no. K5/2948**) funded by the Water Research Commission under the research management of Dr Eunice Ubomba-Jaswa, and led by a team (Leo Quayle, Wesley Evans, Michelle Browne) from the Institute of Natural Resources NPC, aimed to develop a conceptual framework mapping out a range of potential costs associated with deteriorating water quality. Importantly, this conceptual framework did not attempt to quantify costs, but instead aimed to guide the user to consider a range of potential costs linked to deteriorating water quality.

The framework is not exhaustive, but highlights the range of potential cost categories and 'maps' these out in a structured manner. Expressing these costs in terms of their economic value can further contribute to identifying appropriate strategies and funding models for water quality management.

While it is not possible to place a monetary value on all the impacts, and their significance to different people, of deteriorating water quality, the framework suggests methods that can be applied towards a better, more holistic understanding of the economics of water pollution management. The framework is intended as a starting point towards implementation and further development into a comprehensive water quality costing model.

The conceptual framework was initially developed based on a thorough review of a variety of literature which provided a foundational understanding of water quality issues and related costs. In addition, a case study was used to inform the conceptual framework. In August 2019, several tons of caustic soda and vegetable oil were spilled into the Baynespruit and uMsunduzi Rivers in KwaZulu-Natal. The spill, which occurred at a Pietermaritzburg edible oil manufacturer, was the result of an accident on site. Interviews were carried out with several interested and affected parties to uncover some of the hidden social and economic costs.

The draft framework was then presented to a variety of water sector professionals, governance officials and researchers in a workshop setting where it was validated and amendments were made. A number of foundational principles were also developed out of the workshop to support the use of the conceptual framework, guiding the user towards a more holistic set of cost-categories for deteriorating water quality. The four key principles are:

a) In the context of this framework, 'water quality' describes the biological, chemical and physical characteristics of water as defined by the National Water Act.

b) Costs of deteriorating water quality are related to the intended use of the water; water 'use' includes human needs (water user requirements) and the protection of aquatic ecosystems.

c) Potential / projected climate change impacts on water supply, water quality and water uses / demands should be considered in identifying and assessing the costs of deteriorating water quality.

d) The condition of the water resource prior to the pollution

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discharge must be considered. In assessing the costs associated with a point source discharge incident, the condition of the site prior to the incident is the point of reference (rather than the desired state). However, the desired state and cumulative impacts need to be borne in mind in considering the overall social costs of deteriorating water quality.

The conceptual framework, illustrated in Figure 1 and Figure 2, is to be used sequentially, starting with "Assessment Context", where the user considers the scope of assessment, including spatial scale, purpose and objectives of the assessment.

A water quality analysis / assessment tool was also developed to be used in conjunction with the conceptual framework. The tool links exceedances of established thresholds in water quality properties with potential consequences. The Microsoft Excel-based tool requires the input of water quality data which is compared to water quality guidelines outlined by the Department of Water and Sanitation. The user is then provided with potential consequences associated with the exceedance of the guideline levels. For more information on the project and the tool, go to the Water Quality Costing Framework Project page on the Ecosystems Theme page of INR website (https://www.inr.org.za/focus-areas/ecosystems-2).

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SPLENDOUR OF MPUMALANGA – BLYDERIVIERSPOORT DAM

Open a tourism brochure of Mpumalanga and you are bound to see a picture of Blyderivierspoort Dam. Constructed between 1971 and 1975, the Blyderivierspoort Dam is one of the major dams in the Olifants River system, in Mpumalanga. The dam was built to augment water supply for Phalaborwa and to stabilise the supply of water to the irrigators in the Blyde River Irrigation District.

The dam site is located where the Blyde River reached a base level of erosion and offered a favourable basin with average depth of 21 m. Although the river had cut its bed into granite basement rock along this reach, a local depression in the granite floor provided a site underlain by resistant quartzite and conglomerate with thin interbeds of shale of the Wolkberg Group. Blyderivierspoort Dam was constructed as a concrete gravity arch. The dam has a maximum height of 71 m, with a crest length of 240 m and a maximum wall thickness of 30 m. Blyderivierspoort Dam has a maximum capacity of 54 million m^3.

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DEEPLY ROOTED IN SOUTH AFRICA WATER SOCIETY

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