THE WATER WHEEL

July/August 2018 Volume 17 No 4

WATER AND TECHNOLOGY

The age of the drone

WATER DEMAND MANAGEMENT

Cape Town vs San Francisco

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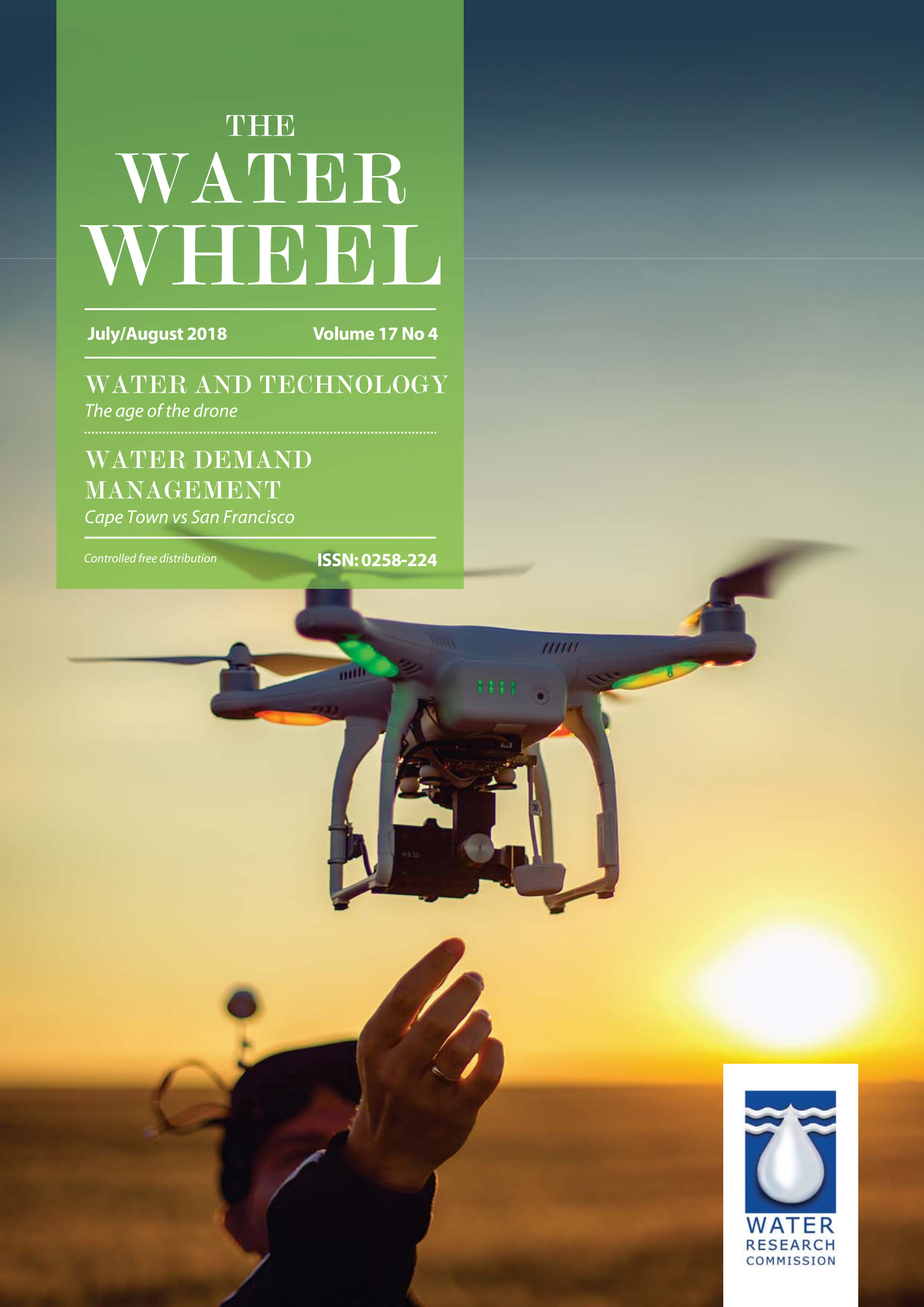

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An initiative of the Department of Science and Technology and the Water Research Commission

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03 Credible technical information

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06 Growth of SMMEs and enterprise development

07 Technical advice using scientific protocols

08 Driving innovations in priority areas of the Water RDI Roadmap and the NWRS II

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- Water boards/ utilities/municipalities
- SMMEs
- Investors/funders (local and international)
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- Technical consultants

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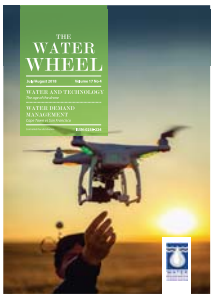

Drone technology is finding an increasing number of applications in the water sector. See page 12

FLUID THOUGHTS

WRC CEO, Dhesigen Naidoo

Planning for future water security in a nexus paradigm

From a water perspective, we live in a 'world of Cape Towns'. That was the banner of the 2018 Water Week edition of ***Down to Earth***, the signature publication of the Centre for Science and the Environment (CSE), India.

The publication had its global launch when the water practitioner community gathered in Cape Town at the biennial Water Institute of Southern Africa congress in June. The special edition magazine was explicit on a few pivotal issues. Firstly, it offered an external analysis of the severity of the extended drought episode we have gone through on the back of the 2014 El Niño event. Secondly, it illustrated once again the class diversity of the water scarcity experience in South Africa; in particular the middle-class inconvenience dominated the media coverage, masking the real threat of socio-economic stagnation on the one hand, and a missed opportunity to highlight the dire need to bring servicing to the poor and vulnerable in South Africa on the other.

The third is the worldwide nature of the challenge. Ten metropolitan cities of the Global South are on the very edge of water crisis. These are São Paulo, Buenos Aires, Mexico City, Sanaa, Karachi, Kabul, Beijing, Bengaluru, Istanbul, and on our own continent, Nairobi. In addition to these, there are 200 cities in the world that are considered water stressed.

When one looks to the predictions of the future, as illustrated in figure 1, we see a spiral with a 2050 end point of one in five developing countries experiencing water shortages. The convergence of the predictions shows that a combination a much larger population with increased longevity, further economic growth as the developing world catches up with the developed world, increasing consumption patterns partnered with the impacts of climate change and increasing pollution levels; will see a global water stressed future. Importantly and in addition, there will be a concomitant stress in both sustainable power access as well as food security. We have the added challenge of these sectors working very separately in response to these joint challenges. Silos as we know are only good for temporary storage.

The Water Research Commission has through its Water-Energy-Nexus Lighthouse programme, and together with its partners, built an important repository of new knowledge in this domain. It has also developed the beginnings of a scientific community of practice to engage both the challenge and the possibility of a future that is characterized by water, energy and food security driven by a Nexus approach. The W-E-F nexus approach means a joint consideration of water, energy and food security contexts and objectives in developing solutions and interventions that are designed purposefully to have collective and individual positive outcomes across the three sectors. This is geared toward creating a critical mass of capacity and resources to achieve higher levels of both security and delivery of water and water services, sustainable energy and food access and security throughout the system.

We, the water science community, have over the years, with a water lens, piloted and demonstrated many nexus solutions like new sanitation, energy-generating wastewater treatment processes with added benefits in the form of chemicals and fertilizer beneficiation for agricultural production. The additional benefit is that these solutions are strongly in line with the sustainable development paradigm with the deliberate goal of a lower carbon budget compared to traditional processes as a stated objective for each of these interventions.

The new climate change legislation seeks to achieve a new industrialisation paradigm as a pivotal contribution to the New Dawn project. The scale-up and roll-out of the suite of Water-Energy-Food Nexus solutions has to be a keystone to this strategy. In the words of Dr Sunita Narain, the Director-General of the CSE, "Cape Town, Bengaluru and Chennai, all have a common present. The question is if they can create a new future that is water secure because it is water wise". The optimised path to this prosperous future can only be one of joint water, energy and food security through a coordinated and synergised approach.

WRC CEO, Dhesigen Naidoo, and Dr Sunita Narain, DG of the CSE at the WISA conference earlier this year.

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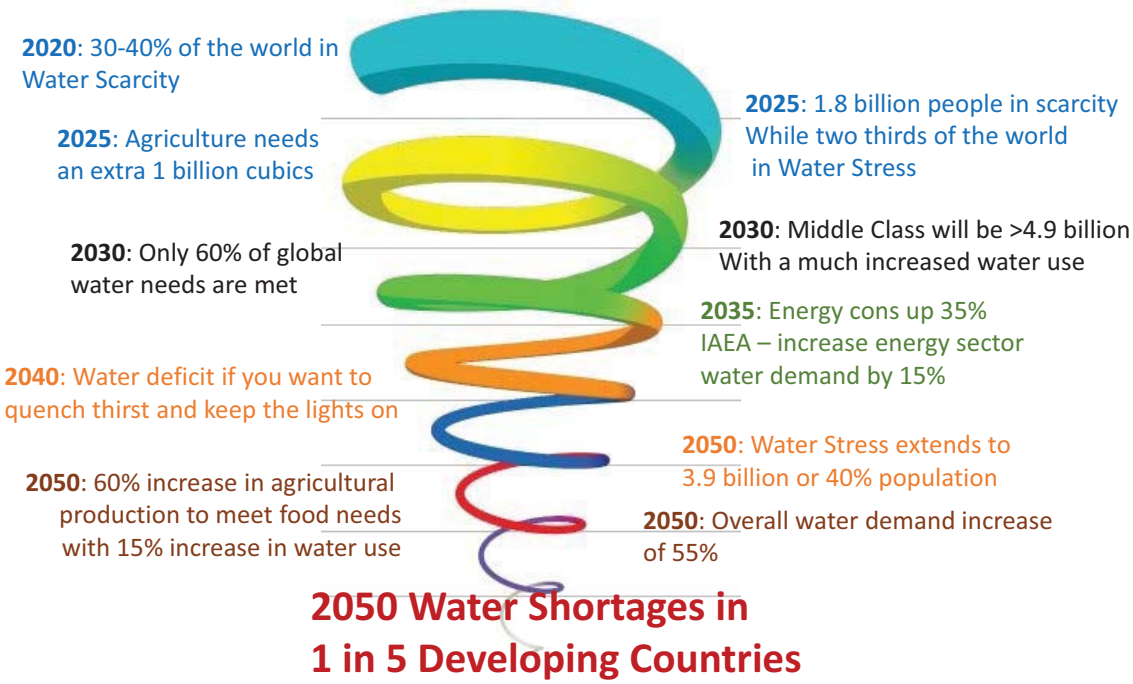

Figure 1. Different scenario and forecasting exercises, using the assumption of the continuation of current practices is a business-as-usual paradigm converge on concomitant and increased pressure on our resources. This is turn compromises water, energy and food security with knock on effects on health, security and stability.

WATER DIARY

Land rehabilitation
August 13-16
The 2018 conference of the Land Rehabilitation Society of Southern Africa will take place at the Champagne Sports Resort, Drakensberg. The theme for the conference is 'Transforming the rehabilitation landscape'.
Visit: http://larssa.co.za/

World water week
August 26-31
World Water Week is the annual focal point for the globe's water issues. It is organised by the Stockholm International Water Institute. The theme is 'Water, ecosystems and human development'.
Visit: http://www.worldwaterweek.org/

Groundwater
September 26-28
The SADC Groundwater Management Institute, together with the International Water Management Institute and the Department of Water and Sanitation are hosting a groundwater conference under the theme 'Adapting to climate change in the SADC region through water security – A focus on groundwater.' The conference will be held at Birchwood Hotel and OR Tambo Conference Centre, on the East Rand.
Visit: www.sadc-gmi.org

Wetlands
October 8-11
The National Wetlands Indaba will take place at the Mittah Seperepere Convention Centre, in Kimberley, Northern Cape. The theme of the conference is 'Drylands and wetlands: connecting and managing heterogeneity across landscapes'. **Visit: www.nationalwetlandsindaba2018.com**

Municipal engineering
October 31-November 2
The annual conference of the Institute of Municipal Engineering of Southern Africa will be held in Port Elizabeth with the theme, 'Innovative Infrastructure Solutions'. **Visit: www.imesa.org.za.**

Irrigation engineering
November 13-15
The South African National Committee on Irrigation and Drainage (SANCID) will be holding its 2018 conference with the theme 'Opportunities to manage climate change'. The conference will be held in White River, Mpumalanga.
Visit: www.sancid.org.za

Science and technology
December 3-6
The 4th National Conference on Global Change will be held in Polokwane with the theme 'Sustainable futures through science and innovation'. The conference is hosted by the Department of Science and Technology and the National Research Foundation, in partnership with the University of Limpopo. Online registration is mandatory.
Visit: www.ul.ac.za/globalchange2018

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NEWS

Water and sanitation department presents sober budget

An urgent intervention is required to re-align project management and planning within the available budget of the Department of Water and Sanitation (DWS). This is according to minister, Gugile Nkwinti. He tabled the department's budget in Parliament on 22 May.

"Urgent intervention is required in our project management as well as contract management to ensure that the project planning is aligned with the available budget, and to prevent our projects from being ahead of the available budget," he noted. Nkwinti's words come amid concerns that the department is faced with historical contractual commitments that were not budgeted for.

He said the preliminary commitments for which contracts have been signed and service providers are currently rendering services amounted to R7.5 billion, of which R6.3 billion is for infrastructure projects and R1.1 billion for operational goods and services.

"Of this figure, R2 billion is expected to be paid to the service providers in the current financial year. We have also noted with concern that in certain instances, contracts without a value have been entered into, and these pose difficulty in accurately budgeting for them, which leaves the department vulnerable."

Nkwinti added that the department's bucket eradication programme falls into this category. This has caused unauthorised expenditure caused by overspending in the bucket eradication programme. "Poor project management within the department has created a situation whereby service providers are accelerating the work at a much faster pace than what the department had budgeted for. A typical example is our project in Giyani which was initially planned to be completed over 5 years; and was budgeted for accordingly. However, the work was accelerated and completed within a two-and-a-half year period. "There is poor alignment between the budget and the project milestones; and, in certain instances, the project milestones are much ahead of the budget."

In the coming year the DWS plans to implement several interventions to bring stability to the department. This includes, among others, reprioritising and streamlining the department's spend to align it with annual performance plans, with a view of reducing unauthorised, irregular, fruitless and wasteful expenditure; reviewing the department's delegation of powers with a view of reactivating and rebuilding the construction unit towards the formation of a State-controlled construction company; hastening the establishment of the transformation of the Water Trading Entity, into a Water Trading Agency to be located in the Financial Management Services Branch; and fast-tracking the establishment of Catchment Management Agencies in the remaining seven regions as well as enforcing the polluter pays principle.

The Minister reported that the department will further engage National Treasury and the Department of Cooperative Governance and Traditional Affairs (COGTA) to address the perennial problem of billions of municipal grant funds that are either unspent or irregularly spent, for which the department must account. "The department is committing to working closer with COGTA to ensure that bulk water projects that were completed in municipalities without reticulation services are provided with such reticulation in the current financial year."

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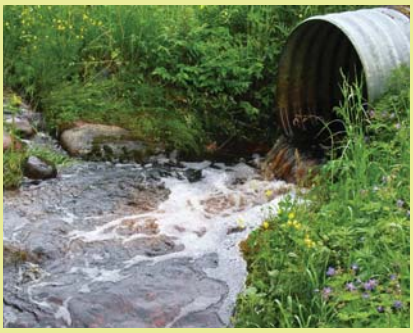
Environmental department hosts Interpol meeting on waste and pollution



From 22 to 24 May the Department of Environmental Affairs hosted Interpol's 23rd Pollution Crime Working Group (PCWG) and Environmental Compliance and Enforcement Committee (ECEC) Advisory Board meetings at Skukuza, in the Kruger National Park.

This is the first time the PCWG met in South Africa. The working group network meets annually to discuss new and growing global concerns relating to pollution crime, share best practice in dealing with existing and emerging pollution threats, plan joint operations and also to develop strategies going forward.

The objective of this year's meeting was to, among others, consider key trends and emerging threats linked to pollution crime, discuss challenges and opportunities in achieving effective enforcement against pollution crime, especially through international and multi-agency cooperation, and to identify opportunities and risks associated with information and intelligence sharing, data management and analysis.

Government pledges support to struggling municipalities

Cooperative Governance and Traditional Affairs (COGTA) Deputy Minister, Andries Nel, has welcomed the release of the audit outcomes for municipalities, saying government will provide support to distressed municipalities.

This is after Auditor-General, Kimi Makwetu, released his report in Parliament on the outcomes of municipal audits for the year 2016/17. According to the Auditor-General there had been an overall regression in municipalities that received clean audits in the period under review compared to the previous year.

"The Ministry of COGTA welcomes the audit improvements in some municipalities, and we express serious concerns regarding those that have regressed. We congratulate those 33 municipalities that have received unqualified audit opinions," noted Nel.

He added that the outcomes of the audit provides a basis for government to intervene to support struggling municipalities.

"While the number remains low, COGTA does note from the Auditor-General's report that 145 (or 56%) of municipal outcomes are classified as unqualified. We believe that this represents a basis for national and provincial governments' ongoing support programme to improve financial management in municipalities. We are encouraged that in the ongoing efforts to improve municipal audit outcomes, there are municipalities that do get things right and do become examples for others to follow," said Nel.

Source: SAnews.gov.za

Summit calls for enabling environment to support Africa's innovators

Greater investment and the creation of enabling ecosystems are required to support Africa's innovators.

This was one of the key messages that emerged from the African Innovation Summit (AIS) held in Kigali, Rwanda, earlier this month. The AIS is an Africa-wide initiative to mobilise investors, policy-makers, researchers, the youth, innovators and thinkers into a coalition for collective action to foster an enabling environment for innovation in Africa.

Speaking at the summit, Rwandan Prime Minister, Edouard Ngirente, said that initiatives such as the AIS were critical for Africa's development. "The challenge facing Africa is building robust ecosystems of innovation," the Prime Minister said. "I am happy that AIS is helping our countries build a culture of innovation as a way of life. It is a critical element of development and economic growth".

Delegates at the summit agreed that a multi-sectoral and multi-stakeholder approach was needed to ensure that policies, investments and enabling ecosystems were put in place to empower and propel African innovators and their solutions forward.

The summit concluded with a call to action addressed to innovators, government leaders, the private sector, civil society and academia: "Let us throw out the boxes that have caged us."

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GLOBAL

Tackling corruption 'from the top down' essential, declares UN chief

Corruption and complicity know no geographical boundaries, and it is society's most vulnerable who get hurt the most. By tackling corruption, governments can show they mean business.

This is according to United Nations (UN) Secretary-General António Guterres. He was speaking at a high-level event marking the 15th anniversary of the UN Convention Against Corruption.

In his remarks, Guterres also underlined that in addition to robbing vital resources from public services such as schools and hospitals, corruption also fuels human trafficking and the black market in natural resources, weapons, drugs and cultural artifacts.

"It fuels conflict, and when a hard-won peace is achieved, corruption undermines recovery. Corruption and impunity are corrosive, breeding frustration and fostering further corruption when people see no other way of achieving their goals," said the UN chief, calling for greater political and popular support for the fight against corruption.

He described the Convention Against Corruption as one of the most effective tools the world has to achieve the common goals of good governance, stability and prosperity. "The UN will continue to support member states every step of the way, from helping to engage and empower citizens in this fight, to helping build and enhance institutions that can deliver on their promise," Guterres concluded.

Hunger surges amid deadly conflicts, poor weather conditions – FAO

Despite ample food supplies, persistent conflicts and adverse climate shocks are taking a toll on global food security, according to a new report from the UN agriculture agency, the FAO.

The publication, *Crop prospects and food situation,* reveals that since FAO's last report in March, the number of countries requiring external food assistance has jumped by two, namely Cabo Verde and Senegal, to 39.

According to the report, civil war and insecurity in Africa and the Middle East have displaced millions – resulting in high hunger rates. "Poor rains have hit cereal production prospects in South America and Southern Africa. Unfavourable weather conditions are also placing a heavy burden on pastoralists in West Africa."

The African food insecure countries on FAO's list are: Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of Congo, Eritrea, Ethiopea, Kenya, Lesotho, Madagascar, Malawi, Mali, Mozambique, Niger, Nigeria, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Swaziland, and Zimbabwe.

Turning to cereal production, FAO foresees a 1.5% annual drop from last year's record high, with a larger decline in some areas, such as South and North America and Southern Africa. "Conflicts have choked agricultural activity in swathes of Central Africa, notably in the Central African Republic and parts of the Democratic Republic of Congo, where access to food is further hindered by surging inflation," FAO elaborated.

On a brighter note, after consecutive seasons of drought-reduced harvests, fresh rains point to cereal production gains in East Africa.

To download the full report visit: http://www.fao.org/giews/reports/crop-prospects/en/

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Earth's climate to increase by 4 degrees by 2084

A collaborative research team from China has published a new analysis that shows the Earth's climate would increase by 4°C, compared to pre-industrial levels, before the end of the 21st century.

The researchers published their analysis in ***Advances in Atmospheric Science*** on 18 May.

"A great many record-breaking heat events, heavy floods, and extreme droughts would occur if global warming crosses the 4°C level," noted Dabang Jiang, a senior researcher at the Institute of Atmospheric Physics of the Chinese Academy of Sciences. "The temperature increase would cause severe threats to ecosystems, human systems, and associated societies and economies."

In the analysis, Jiang and his team used the parameters of scenario in which there was no mitigation of rising greenhouse gas emissions. They compared 39 coordinated climate model experiments from the fifth phase of the Coupled Model Intercomparison Project, which develops and reviews climate models to ensure the most accurate climate simulations possible.

The researchers found that most of the models projected an increase of 4°C as early as 2064 and as late as 2095 in the 21st century, with 2084 appearing as the median year. This increase translates to more annual and seasonal warming over land than over the ocean, with significant warming in the Arctic. The variability of temperature throughout one year would be lower in the tropics and higher in polar regions, while precipitation would most likely increase in the Arctic and in the Pacific. These are the same effects that would occur under 1.5°C or 2°C increases, but more severe.

"Such comparisons between the three levels of global warming imply that global and regional climate will undergo greater changes if higher levels of global warming are crossed in the 21st century," wrote"Jiang.

To access the original article, Visit: https://bit.ly/2s7EQEk

Largest-ever global response to cholera targets 2 million people in Africa

The largest cholera vaccination drive in history targeting two million people across Africa has been completed. The drive, which ran between May and June, came in response to a series of recent deadly outbreaks of the waterborne disease.

"Oral cholera vaccines are a key weapon in our fight against cholera," noted Tedros Adhanom Ghebreyesus, head of the World Health Organisation (WHO) in a statement, "but there are many other things we need to do to keep people safe."

"WHO and our partners are saving lives every day by improving access to clean water and sanitation, establishing treatment centres, delivering supplies, distributing public health guidance, training health workers, and working with communities on prevention," he added.

The drive targeted Zambia, Uganda, Malawi, South Sudan and Nigeria. The vaccines were funded by the Vaccine Alliance, a public-private partnership known as Gavi, and were sourced from the global stockpile.

The burden of cholera remains high in many African countries. At the time of writing at least 12 countries were reporting active cholera transmission.

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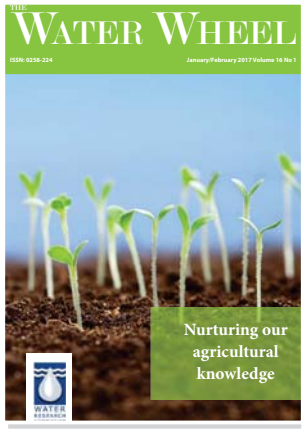

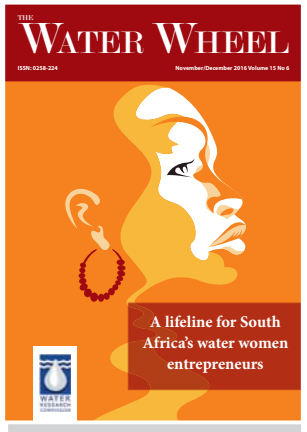

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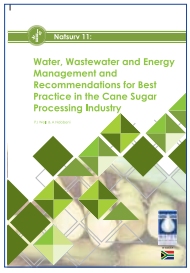
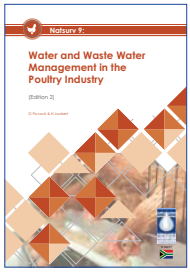


Natsurv 6: Water, wastewater and energy management and recommendations for best practice in the cane sugar processing industry

The main aim of the NATSURV series is to serve as guides and benchmark tools for stakeholders, including local governments and industry players. The aims of this publication are to provide an overview of the sugar processing industry in South Africa, highlighting changes that have taken place since the previous NATSURV was published in 1990; to provide information about generic industrial processes, with an emphasis on water use and wastewater generation and treatment; and to provide information about relevant national and local legislation and bylaws pertaining to water usage and wastewater generation. Similar to other NATSURVs this publication also provides water consumption, specific water consumption and wastewater generation data. Furthermore, it recommends best practices for water use, including intake, treatment and discharge.

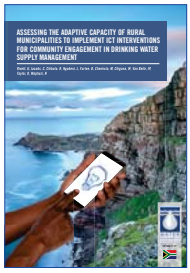
Report no. TT 721/17



Natsurv 9: Water and wastewater management in the poultry industry

The aim of this project was to undertake a survey of the South African poultry industry to obtain an overview of operations, specific water use, specific effluent volume and the extent to which best practices are being implemented. This was achieved by reviewing appropriate literature, disseminating questionnaires, holding workshops, interviewing companies and undertaking site visits. This study follows on a previous NATSURV published in 1989. Since this time the industry has undergone several significant changes such as new legislation, new markets, social attitudes and change in ownership as well as the use of updated technology. In addition, there is growing awareness of the need to optimise water and energy use and reduce the production of waste, and this should be reflected in the specific water consumption and effluent production. It was therefore considered an opportune time to review the water and wastewater management practices of the poultry industry and identify the changes that have been made since the 1989 survey.

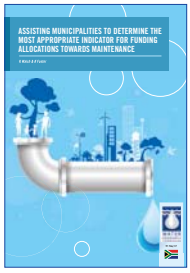
Report no. TT 730/17



Assessing the adaptive capacity of rural municipalities to implement ICT interventions for community engagement in drinking water supply management

This study provides the necessary background information on community engagement in drinking water services delivery and the role of information and communication technology (ICT) in incentivising public participation. The study was based on the notion that an increase in community engagement – particularly in rural areas – would result in an increased understanding of the current shortcomings of drinking water supplies, an increased understanding of the communication challenges between communities, water service authorities and water service providers as well as an improved experience of greater transparency and accountability for all stakeholders. The other report emanating from this project is Design and implementation of an ICT system for community engagement in drinking water supply management (**Report no. TT 744/2/17**).

Report No. TT 744/1/17



Assisting municipalities to determine the most appropriate indicator for funding allocations towards maintenance

The poor state of operations and maintenance of infrastructure in South Africa, not only in water services but across all sectors, is widely bemoaned. It has been found that few municipalities put enough of their budgets aside for infrastructure maintenance. Within this context, assisting municipalities to determine what level of funding they should allocate to maintenance is of vital importance. For this reason the Water Research Commission commissioned this research study.

Report No. TT 736/17

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WATER AND TECHNOLOGY

The age of the drone – Keeping an eye on the nation's water

Drones are taking to the skies for a variety of water-related applications. Article by Sue Matthews.

Time magazine dedicated much of its June 11 issue to a special report on 'The Drone Age', and used 958 tiny drones flying in formation to recreate its iconic cover design. The international open-access journal ***Water*** is calling for papers for a special issue entitled 'Water management using drones and satellites in agriculture', and many scientific and industry conferences nowadays include a session on the use of drones, or unmanned aerial vehicles (UAVs).

It was drone footage of the Western Cape's nearly empty Theewaterskloof Dam that brought home the stark reality of the drought to many Cape Town residents, perhaps prompting them to intensify their water-saving efforts. At the other extreme, drones were used to map the extent of flooding and assess damage to property and infrastructure during the UK's disastrous 2015-2016 floods. The Drone Watch project, led by Cranfield University and funded by the Natural Environment Research Council (NERC), provided detailed aerial imagery at a time when heavy cloud cover compromised the ability to get optical satellite data, and where synthetic aperture radar (SAR) satellite data – able to penetrate clouds – could not easily distinguish water from urban features.

Drones clearly have advantages in terms of providing a bird's eye view and being able to reach relatively inaccessible locations, while also offering better spatial and temporal resolution than satellite imagery. They do have a number of limitations, however, the most restrictive of which is the regulatory environment, particularly in South Africa. The addition of a chapter on Remotely Piloted Aircraft Systems (RPAS) to our Civil Aviation Regulations effectively grounded many drone operators when the amendment came into effect in July 2015, at least until they could comply with the stringent registration, licensing and certification requirements.

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Flight time is also a severe constraint – most of the smaller drones cannot stay airborne for more than half an hour before a change of battery is needed – while wind and rain may make flying conditions unsuitable. Large fixed-wing drones are hardier and can typically fly further than multi-rotor drones, but are in any case limited by the need to remain within view of the pilot at all times, and no further away than 500 metres. An accredited training course for beyond visual line-of-sight (BVLOS) certification has only recently become available in South Africa.

Fixed-wing drones have the disadvantage of being unable to hover or to fly slowly enough for the particularly high-resolution data collection required for certain applications, and most need a runway to take-off and land, although some innovative designs have overcome this limitation. The 'Eagle Owl' manufactured by Aerial Monitoring Solutions, for example, comes with a foldable aluminium launcher and a parachute for retrieval, while Passerine Aircraft Corporation's 'Jumper' has bird-like legs that allow the drone to launch itself into the air and land. Both these companies are South African, based in Johannesburg. In fact, the CSIR has been building drones since the 1970s – primarily for military surveillance and border patrol purposes – and is soon to release an updated design of its Long Endurance Modular UAV (LEMU). The 'petrol version' will have a flight duration of eight hours and a payload capability of 20 kg, allowing it to carry instrumentation for a range of different applications.

Looking at water-related applications, specifically, there are a variety of ways in which drones are being used, both locally and internationally.

Agriculture

The agriculture sector has seen the most uptake of drone technology for water-related applications in South Africa. Drones not only provide an overall perspective of farmland that is impossible to glean from the cab of a bakkie, but can also facilitate 'precision agriculture' – the right input (be it water, fertilizers, pesticides or seeds) in the right amount at the right time and in the right place. Apart from helping to optimise production and minimise wastage, this reduces runoff and hence the pollution of nearby water resources.

Precision agriculture has been taken to a new level with the recent arrival in South Africa of crop-spraying drones, but given the advanced qualifications required to fly them, their use is currently very limited. More typically, farmers are using multispectral sensors on drones to get a picture of crop health via Normalised Difference Vegetation Index (NDVI) mapping, so that they can identify areas of plant stress. NDVI compares reflected red versus near-infrared light, because healthy plants absorb red and blue light for photosynthesis and strongly reflect near-infrared light, while stressed plants reflect more red light and less near-infrared light.

"Once you see there's a problem area, you can go out there and figure out whether it's because of too much water or too little, nutrient deficiency, or some kind of pest or disease," says Arie van Ravenswaay of the Western Cape Department of Agriculture. "Alternatively, if you have a thermal imaging camera on the drone you can tell whether water is the issue, because moist soils will be cooler than dry ones."

The latter method could also alert the farmer to leaking irrigation pipes. Another common use of drone imagery in agriculture is the generation of digital elevation models (DEMs) to inform planning and design of irrigation and drainage systems. Of course, the processing and analysis of drone-captured data for these kind of applications is generally beyond the skillset of a farmer or drone pilot, and uploading massive files to online services can be problematic in rural areas with slow bandwidths. Most drone operators have therefore formed partnerships with agricultural consultants and data-analytics specialists, and farmers can opt for subscription services that include user-friendly mobile apps and desktop software. Cape Town-based Aerobotics, for example, uses machine learning to interpret drone imagery for tree crop farmers, providing them with information on the health, size and canopy area of individual trees, and identifying management zones to plan irrigation probe placement, soil and leaf sampling, and variable-rate fertilizer application.

Wetland assessment

Environmental scientist, Marinus Boon, effectively demonstrated the benefits of drones for aquatic research purposes when he conducted South Africa's first study that used UAV photogrammetry as a tool for wetland delineation and health assessment. The initial research, undertaken for his MSc degree at the University of Johannesburg, used an off-the-shelf digital camera mounted on a multi-rotor drone to take some 1 200 photographs of the study site – a 100 ha channelled valley-bottom wetland system adjacent to the Cors-Air model aircraft airfield in Gauteng.

Together with 20 surveyed ground control points, the photos were processed with Structure-from-Motion (SfM) software to derive ultra-high resolution point clouds, orthophotos, digital surface models (DSMs) and digital terrain models (DTMs). These products allowed for fine-scale mapping of the wetland, with vegetation, inundated areas and features associated with disturbance – for example, invasive alien trees and grass, impoundments, excavations and erosion gullies – all clearly identifiable. Information on factors such as slope, drainage channels and flow impediments provided insight into the movement of water through the wetland, improving understanding of its hydrological functioning.

Subsequently, the research was expanded to include UAV multispectral imagery, with NDVI mapping being used to refine the extent of hydrophilic vegetation and degraded areas in order to assess wetland vegetation integrity. Repeating such surveys over time will allow changes in the wetland to be monitored, and the results used to inform its management.

Marinus has combined his expertise in drone-based technology with his long involvement in the environmental planning industry by establishing a consulting company, Kite Aerial Imagery, to provide 'UAV imagery for better environmental decisions', according to its slogan. He points out that the high-resolution images and detailed data obtained using drones have an important role to play in assessing environmental impacts, because they allow engineers and environmental practitioners to visualise a site and understand its full context even if they cannot visit it.

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Filippo Bandini/DTU

The Riverscapes project, conducted by a consortium led by the Technical University of Denmark (DTU), is developing a drone-based monitoring solution that delivers hydrometric and ecological data to inform catchment-scale risk assessment, channel maintenance and climate change adaption

Riverine assessment

Drones also have considerable potential for the assessment, monitoring and management of river systems. The European Union's Water Framework Directive, for example, requires classification and monitoring of the ecological status of rivers in terms of biological, hydromorphological and physico-chemical elements. The Technical University of Denmark (DTU) is currently heading a collaborative project named Riverscapes, which aims to develop a drone payload package comprising cameras, sensors, radar and sonar instruments to deliver datasets on water surface elevation, bathymetry, water surface velocity, thermal maps and narrow-band spectral reflectance of land and water surfaces, and high-resolution digital surface models of the stream environment. Project leader, Prof Peter Bauer-Gottwein, says that the technology will allow measurement of water levels with a precision of 3-5 cm, and detailed mapping of vegetation in or near the watercourse.

Another research team, headed by Dr Monica Rivas Casado of Cranfield University, tested the use of drones in hydromorphological river characterisation. Existing methods for identifying hydromorphological features include automated algorithm-based identification from commercially available aerial imagery with resolutions coarser than 10 cm. The research team used the same software applied to drone-captured aerial imagery at resolutions of 2.5 cm, 5 cm and 10 cm, and found that riffles, side bars and submerged vegetation were not accurately identified at resolutions coarser than 5 cm. This implies that high-resolution drone imagery would be more reliable than standard aerial imagery for assessment of the reach.

In South Africa, environmental water requirements (EWR) assessments to determine the ecological Reserve are undertaken at representative cross-sections of the river, called EWR sites, within a river reach designated a management resource unit. At each EWR site, specialists assess the various components of the fauna and flora, as well as habitat integrity, geomorphology and water quality.

"In inaccessible areas, drones could be very useful in finding EWR sites," says Delana Louw, of Rivers for Africa eFlows Consulting. "It would save a lot of time and could also give us a good idea of the characteristics of the upstream and downstream reach from the cross-section. Furthermore, using the drone to take photographs directly above the cross-section would be extremely useful."

Locally, drones could also be particularly helpful in mapping riparian invasive plants, erosion hotspots and pollution point sources, as well as monitoring river restoration and rehabilitation efforts.

Water quality and pollution monitoring

Overseas, drones are being tested for water quality monitoring for ecological research and pollution assessment purposes. In most cases this involves lowering a probe into the water column from a hovering drone, but a team from South Carolina's Clemson University experimented with a hexacopter fitted with flotation attachments so that the drone could land on the water surface. This not only preserved battery life and thus ensured more monitoring points could be included, but also eliminated the need for additional sensors for taking measurements at precise depths.

The more advanced water quality meters available nowadays have probes for measuring temperature, conductivity/salinity, depth, pH and dissolved oxygen, but the traditional (and in some cases more reliable, but very time-consuming) approach is to

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take boat-based water samples for measuring physical-chemical properties on board or on shore, or even back in the laboratory. Some researchers have used drones equipped with sampling hoses to suck up water for temporary storage in vials on the drone. A limitation of this approach is that only small sample volumes can be collected, which are not as representative of water chemistry as the one-litre samples typically collected during boat-based sampling.

Global engineering firm, Hatch, overcame this limitation by developing a device for deploying a 1.2 litre Niskin bottle from a drone for collecting water samples from flooded pits and tailings ponds at mine sites. Samples have been collected from as deep as 115 metres, and then immediately analysed for pH, iron species and total arsenic using Hatch's mobile water testing lab. This innovation avoids exposing staff to hazards associated with sampling from steep and unstable banks, such as falling, drowning or contact with toxic chemicals.

Many industrial processes discharge heated effluent into natural or manmade waterbodies, and drones can be used to monitor this type of pollution too. Apart from immersing a temperature probe or CTD to obtain a vertical profile through the water column, drones fitted with infrared thermal imaging cameras can be used to gauge the horizontal extent of the effluent plume.

Drone-based monitoring clearly has advantages where boat access is difficult or impossible, with the added benefit that it is unlikely to disturb the upper layers of the water column as much as a boat propeller or oar.

Harmful algal blooms and nuisance weeds

A number of international research groups are exploring the use of drones for monitoring the presence of algal blooms, particularly cyanobacteria, which may be toxic. The French research programme OSS-Cyano, for example, will be presenting progress as part of a session on 'Optical sensors and drone systems for the monitoring of harmful blooms' at this year's International Conference on Harmful Algae (ICHA2018), to be held in France in October.

While South Africa's Earth Observation National Eutrophication Monitoring Programme (EONEMP) website – developed through a WRC-funded project led by Dr Mark Matthews of CyanoLakes – provides a public information service on cyanobacteria blooms in more than 100 of the country's dams and lakes, these waterbodies are all larger than 2 km^2. This is because EONEMP uses data from the Ocean and Land Colour Instrument (OLCI) on the Sentinel-3A satellite, which has a spatial resolution of 300 metres – too large to resolve detail in small waterbodies.

Drones equipped with hyperspectral sensors can overcome this limitation. In fact, ex-South African Dr Deon van der Merwe, now at Kansas State University, found that even relatively cheap, consumer-grade cameras modified to capture near-infrared and blue light wavelengths are useful for detecting cyanobacteria scum on the water surface or along the shoreline. This could provide a first-level assessment of the potential threat to recreational users and to pets, livestock and wildlife that might drink the water.

Drones have also been trialed for mapping the distribution of nuisance filamentous algae like Cladophora and invasive aquatic weeds, such as water hyacinth and salvinia, with some success.

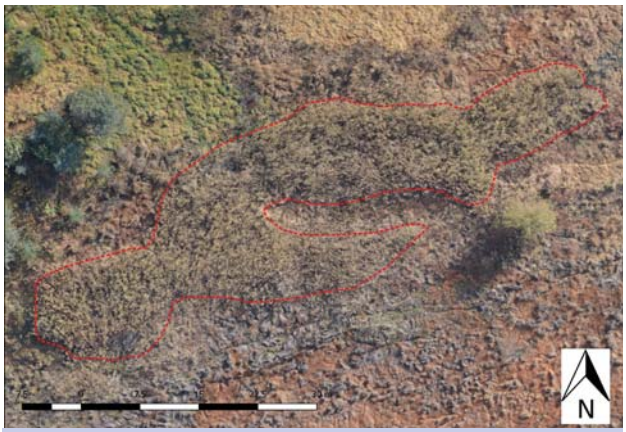
Species conservation

Drones have turned out to be less effective for combating poaching as the hype originally suggested, but they are certainly being used for wildlife research and conservation purposes in many parts of the world. Dr Debbie Jewitt, a conservation scientist with Ezemvelo KZN Wildlife, was tasked with investigating the feasibility of using drones for the organisation's scientific services, and reports that important lessons were learned.

"If we fly a drone over an area, take images, come back and download them, and then have to count the target animals manually, it's just too time-consuming – it's better to count them from a plane or helicopter as you fly over," she says. "File sizes can be huge, post-processing is complicated, and we need algorithms to help us identify animals and count them. But software application is where the industry is going to grow a lot going forward."

"We also need to build up a knowledge base on the impact

Marinus Boon/Kite Aerial Imagery



Small pockets of common reed (Phragmites australis) are delineated on an orthophoto generated from done-based photogrammetry

Debbie Jewell/Ezemvelo KZN Wildlife

Drone-based photography is being used by Ezemvelo KZN Wildlife to count roosting yellow-billed storks and pelicans at Ndumo Game Reserve

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of drone disturbance on different animals, and come up with guidelines so that they can be counted accurately," she adds. "In the meantime, we've been partnering with other people to test how well we can count hippos, crocodiles and bird colonies in wetland habitats. At Amatikulu Nature Reserve, we also visit crocodile nests once the eggs have hatched, the baby crocs have gone into the water and the mother is no longer defending the nest, so that we can count the number of eggshells to get an idea of the laying and hatching success. But it's useful to send a drone over before the time to identify where the active croc nests are. This improves field time because we can go straight there rather than searching the area. It's difficult terrain with dangerous animals, so there's a benefit in terms of safety to staff."

"Drones could also be particularly helpful in mapping riparian invasive plants, erosion hotspots and pollution point sources, as well as monitoring river restoration and rehabilitation efforts."

Other uses

Other water-related applications of drone technology are many and varied. They include checking the structural integrity of dams and bridges, detecting leaks in underground water-supply networks, and locating obstructions in stormwater systems and large sewers. Drones have been used for humanitarian purposes, such as assessing sanitation needs in refugee camps, and for search and rescue efforts during flood disasters. They have even been used to monitor acid mine drainage from abandoned mines and tailings.

The full potential of drones will not be realised in South Africa, however, without some relaxation of the regulations governing their use, particularly with regard to the lengthy and costly licensing, registration and certification process. Fortunately, the Civil Aviation Authority's Executive: Air Safety Operations, Simon Segwabe, indicated in his presentation at DroneCon 2018 in May that the CAA recognises it has a duty to develop the drone industry, and accepts that it needs partners to resolve the challenges.

A stakeholder participation process to review the RPAS regulations has been initiated, and it is likely that a specific operations risk assessment (SORA) approach will be incorporated in future. The approach was one of the main topics discussed at the bi-annual Plenary Meeting of the Joint Authorities for Rulemaking on Unmanned Systems (JARUS), held in Germany in April. JARUS is comprised of representatives of national aviation authorities from 54 countries, including South Africa, working together to recommend a single set of technical, safety and operational requirements for the certification and safe integration of drones. If an achievable solution can be agreed upon, the sky's the limit for drone-based technology, and we can expect to see rapid growth in the development and adoption of water-related applications.

Antoine Lamielle

During floods, drones can be used to plan disaster response efforts and future mitigation measures, search for stranded people and animals, and assess damage to property and infrastructure for insurance purposes.

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WATER DEMAND MANAGEMENT

Two thirsty cities' successful attempts to consume less water

An increasing number of cities around the world are facing water scarcity. Petro Kotzé looks at the water demand strategies of Cape Town and San Francisco.

Today, there are more people on the planet than ever before; a trend that is most acutely felt in cities. More than half (55%) of the world's population live in urban areas, a percentage that is set to increase to 68% by 2050. The accumulation of millions of people is putting pressure on the local resources available to sustain them, especially since climatic conditions are becoming more unpredictable.

In particular, the availability of water is becoming an increasing concern, and reports of urban areas grappling with water-insecurity is streaming in from across the globe. Cities that have been listed in international media as facing extreme water shortfalls in future include Tokyo (Japan), São Paulo (Brazil), Bangalore (India), Beijing (China), Cairo (Egypt), Jakarta (Indonesia), Moscow (Russia), Istanbul (Turkey), Mexico City (Mexico), London (United Kingdom) and Miami (United States), and lately Cape Town.

This situation necessitates management authorities reach further than before in search of water. Strategies involve selective development and exploitation of conventional and non-conventional water supplies, with water being piped from further away, increasingly taken from underground, recycled, or extracted from the sea. However, supplying more water is only part of the overall solution. "As the saying goes: you can't build yourself out of a drought," says Priya Reddy, City of Cape Town's Director of Communications. Dropping the demand for water is crucial to help prevent big cities from running out of water, a role that is well recognised internationally.

Water demand management (WDM) is recognised as key to the survival strategies of two cities that have recently experienced extreme drought. The City of Cape Town (CCT) has been successfully applying WDM for many years, and as a result could drop water use dramatically in a short time when crisis recently hit. Similarly, San Francisco (California, United States) recently

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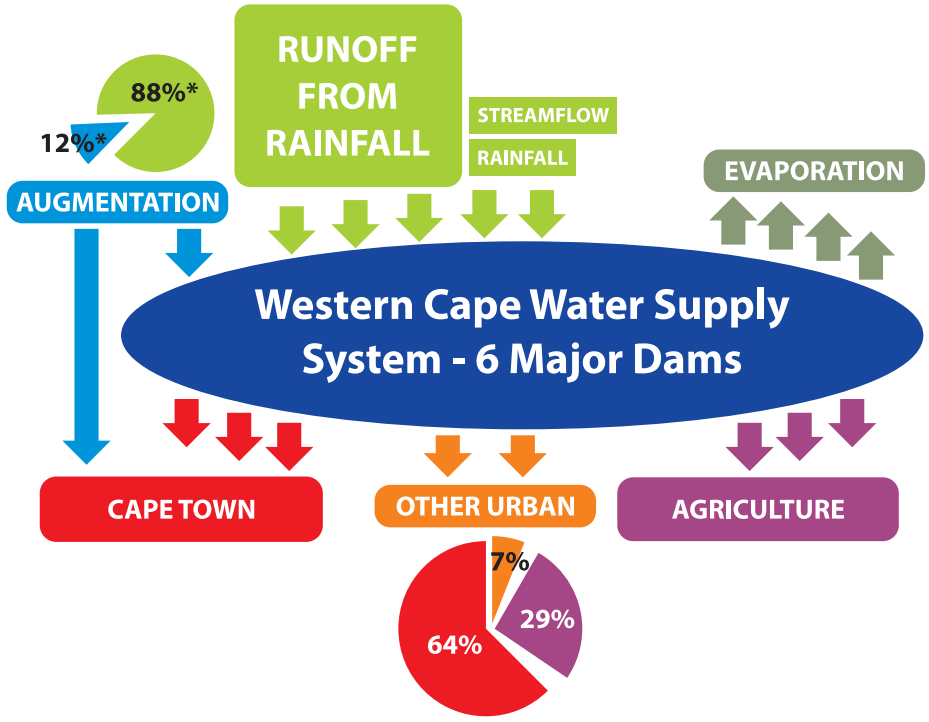

The Western Cape Water Supply System.

emerged relatively unscathed from extreme drought without tapping into new water sources. Both cities serve as examples of burgeoning urban areas in dry climates that are grappling with water scarcity, but emerging more resilient due to the successful application of WDM, and moving forward towards the creation of water wise cities.

What is water demand management?

Successful water demand management (WDM) entails comprehensive reforms and actions to optimise existing water supplies. It is a long-term, integrated approach to water management that aims to conserve water by controlling use, influencing demand and promoting efficient use. WDM involves various role-players across governance structures, technical expertise and a cultural mind-shift to recognise the importance of water and the cumulative impact of individual use (whether it is urban residents, industry or agricultural users) on each other and the water source. The aim is to minimise loss and waste, to protect the water resources and to use water efficiently and effectively.

Managing the demand for water in Cape Town

Cape Town has about 4.2 million residents, with about 610 000 registered residential accounts, in addition to water supply to business, industrial and government users. The City of Cape Town (CCT) is part of the Western Cape Water Supply System (WCWSS), which gets most of its water from a system of dams.

The City of Cape Town's WDM and conservation programme started in the early 2000s, and has been scaled up considerably over the past few years. "The city has been ahead of the curve in many regards, and the pre-existing water demand management programme was an important advantage and foundation for a rapid drought response," says Reddy. As a result, the CCT could facilitate a drop in water use by almost one third in only three years, to prevent the city from running out of water midst an unprecedented three-year drought (with the lowest rainfall in the past 30 years and 2017 measuring the lowest rainfall since the early 1900s).

In February 2015, CCT's peak summer consumption was 1 200 million liters per day (MLD), reduced to 1 100 MLD (under level 2 restrictions) by summer 2015/16. By summer of 2016/17, a peak of 900 MLD was achieved (under level 3 restrictions), stabilising at 600 MLD between June and December 2017. Since January 2018, demand has further been reduced closer to 500 MLD, a saving of 68% during peak summer usage and a saving of 45% on average over the year.

Reducing water demand by managing the distribution system

Though water restrictions have contributed immensely to curbing immediate water demand, some of the most important tools in the CCT's arsenal of WDM strategy has been optimising the distribution system. Among the management actions applied, advanced pressure management has had the biggest impact, contributing an average saving of 55 MLD, says Reddy. First initiated more than a decade ago, pressure reduction has been accelerated and expanded, with the implementation of more automated pressure zones across the metro. Pressure zones force down consumption by throttling zones to the extent of partial supply if user behaviour in the zone is high. Automated pressure zones are at the heart of the programme, allowing the CCT to adjust water pressure remotely.

The CCT has also been in the lead of curbing water losses, currently logging the lowest overall losses of any South Africa metro at 16% in comparison to the national average of 36%.

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Reddy says this is thanks to proactive management of resources and the application of innovative technology. Not only does the CCT fix the leaks of indigent households, but advanced equipment such as a robotic crawler is employed. Fitted with an on-board camera and remotely controlled, the crawler monitors water and sanitation infrastructure, identifying cracks, leaks and obstructions inside a pipeline.

Household flow regulators have also been installed for many years, but will be ramped up to connections of high water users to restrict daily household consumption and safeguard against the impact of leaks. Warning letters are sent to identified users with their municipal bills, which has an important impact on water use behaviour.

CCT is also continuously clearing alien vegetation in the catchments and on city land.

Reducing consumer demand for water

The CCT has been running ongoing, successful and sustained awareness programmes, and maintains a multi-faceted, multi-platform water communication approach to drive demand down and to keep consumption at appropriate levels as the situation requires, says Reddy. This includes extensive messaging and education in a wide range of media and interventions, as part of a dedicated stakeholder engagement philosophy. The CCT website has been of particular importance in this strategy, as "all city water-saving or drought collateral was and continues to be made available in open format to anyone who requests it."

In February 2016, level 6 water and sanitation tariffs was introduced in a further effort to drive behavioural change, but also to recuperate the immense loss in revenue due to usage reduction. At the end of May, new level 6 tariffs were approved, with level 7 disaster scenario tariffs in place. "The idea is that we could move between these tariffs as the situation requires," says Reddy.

"WDM is not just about technology, but about people working together towards a shared objective."

Cape Town has been in the lead of curbing water losses, currently logging the lowest overall losses of any South Africa metro at 16% in comparison to the national average of 36%.

Managing the demand for water in San Francisco

Compare Cape Town's performance with that to San Francisco, a city of 2.7 million residents, served by the San Francisco Public Utilities Commission (SFPUC). In San Francisco, about 68% of residential housing units are in multi-family buildings. Of this, about 30% are two-to-four dwelling unit buildings and 70% are in dwellings over five units. Most residential water use in San Francisco is indoors, and residential outdoor use is typically concentrated in neighborhoods comprised of single family homes with irrigated landscapes.

The SFPUC owns and operates the Hetch Hetchy Regional Water System (RWS), which collects high-quality drinking water from the Tuolumne River watershed (85%) in the Sierra Nevada and protected local watersheds in the East Bay and Peninsula (15%). In 2018, the SFPUC began blending groundwater with surface water supplies to serve in-city retail water customers.

The SFPUC has been running a comprehensive water conservation programme for over 25 years, and has applied almost the entire range of WDM strategies, resulting in significant water use reductions. "Demand management continues to be an important component of our water-supply management approach," says Steven R Ritchie, SFPUC Assistant General Manager, Water.

The state of California is no stranger to drought, but the most recent (2012 – 2016) broke records. A drought state of emergency was declared for California in January 2014, and lifted in April 2017, seeing both the region's driest and warmest year on record (2014), followed by the second driest and hottest (2015).

Ritchie says that demand prior to the drought was already depressed from the estimated 1205 MLD (265 million gallons per day (MGD)) planning level of demand for the RWS, due to the 2008-2009 financial crisis. In 2013, demand was at around 1018 MLD (224 MGD). SFPUC has total system storage triggers to declare rationing, but these were preceded by the declaration of drought emergency. At the height of the drought, SFPUC delivered 822 MLD (181 MGD), with about three years of water supply available in storage.

Over the past 20 years, the replacement of old, high-volume toilets and washing machines have played a major role in reducing indoor water use in San Francisco.

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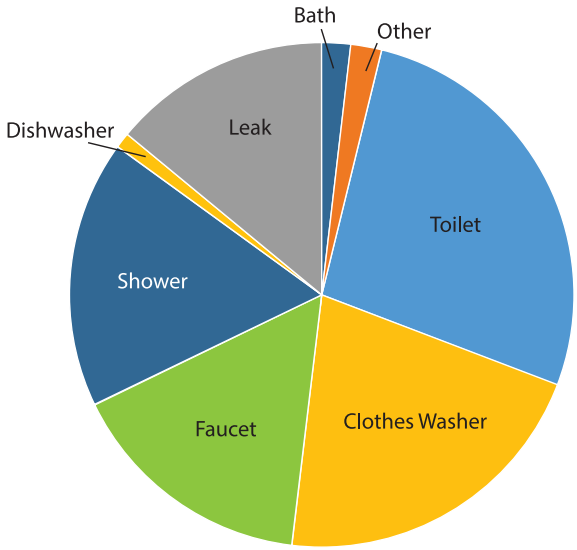
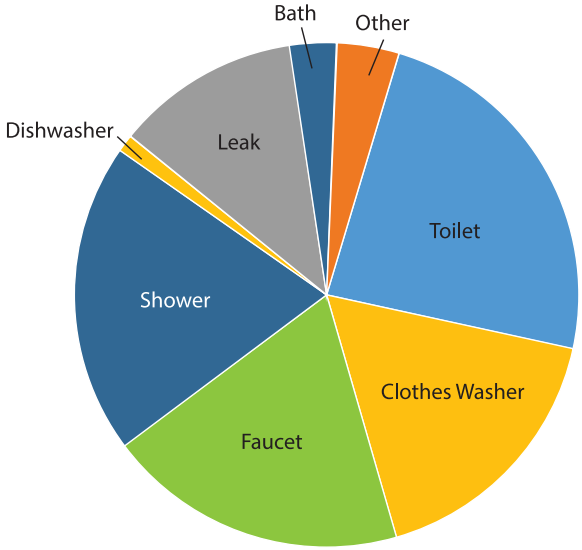
Typical Indoor Residential Water Use in the 1990s



Note: Residentail End Uses of Water Study (REUWS) published in 1999 by the American Water Works Association (AWWA) and the AWWA Research Foundation.

Typical Indoor Residential Water Use in the 2015



Note: Water Research Foundation "Residential End Uses of Water. Version 2"

Services of the San Francisco Public Utilities Commission.

In 2013, (pre-drought) in-city residential water use per person per day was approximately 185 litres (49 gallons). In 2017 (during drought), this dropped to 155 litres (41 gallons). After the drought, in 2018, the figure rose again slightly, reaching around 162 litres (43 gallons) – still, says Ritchie, "one of lowest in the State and almost half the statewide average."

Reducing water demand by managing the distribution system

Some of the most significant reductions achieved by the SFPUC are pinned down to the replacement of old fixtures with water-efficient models. Over the past 20 years, the replacement of old, high-volume toilets and washing machines have played a major role in reducing indoor water use. "Nationwide, the amount of water used for toilets and clothes washers in a typical home has shrunk from about 50% in the 1990s to about 40% today in houses that have new fixtures," says Ritchie.

Elements essential to the success of the SFPUC's WDM programme include:

- **Plumbing code requirements:** Most water savings are attributed to plumbing codes that require efficient fixtures such as toilets, aerators and shower heads;
- **A sound process for estimating potential for water savings and evaluating the effectiveness of different conservation measures,** to determine what mix would be the most practical, cost-effective, and result in the most water savings and other benefits;
- A **water conservation plan** that includes a timeline for activities, the necessary resources and budget, the ability to procure the staff, resources and necessary budget, and a plan to measure effectiveness and adjust accordingly; and
- **An intimate understanding of the customers:** A good understanding of the population you are trying to reach and their water use patterns, and a thoughtful selection of conservation measures that helps meet these needs.

Reducing consumer demand for water

The SFPUC launched a number of outreach efforts to inform San Franciscans about the need to save water and resources available to help, including presentations at neighborhood groups and door-to-door outreach along commercial corridors. These ran along with extensive statewide media coverage about the drought.

In June 2014, the SFPUC launched a multilingual 'Water Conservation is Smart and Sexy' city-wide public education campaign to capture public attention and present everyday water conservation tips and information about the drought. The campaign continued throughout the drought with new artwork and messages communicated through a combination of television, newspaper, billboard, bus, commuter transit station, and social media advertisements. The campaign encouraged individuals to adjust their water use practices and pursue water-efficient plumbing fixture upgrades. It also advised individuals to visit the SFPUC website to learn more about conservation services that are offered. Shortly after launching the campaign, SFPUC water conservation web traffic increased by close to 25%, and was extended to the wholesale service area as well.

The outreach efforts were seen as very effective in motivating residents to use less water, says Ritchie.

Looking back and moving forward

For both water management utilities, the future of their WDM

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strategies entail much of the same, while moving ever forward towards building more resilient cities.

For the CCT, all efforts to date are seen as successful overall and would be repeated if they had to start over, though they might relook timing or scale of certain approaches (for example, how to introduce or communicate initiatives, how to maximise effectiveness and the required implementation capacity).

Similarly, for the SFPUC, "come rain or shine", the focus of their conservation programme will continue to be helping customers use water wisely and avoid water waste from leaks, old or broken equipment, and inefficient water use practices.

Both highlight that a successful WDM strategy is multi-faceted. For the CCT, Reddy says a combination of factors will always be applied, since people are motivated to change behavior differently – for some by a sense of social responsibility, and for others, cost or fear. Measures applied by the SFPUC during times of drought will again including extensive outreach and media campaigns in collaboration with potential mandatory rationing and excess-use fees, home water use monitoring tools, and water-saving incentive programs.

Reddy lists collaboration as integral to the CCT's success. Driving awareness is a sustained, long-term drive to change behavior, and it is critical that the CCT is supported by a range of partners who share the same key messages, she says.

At the same time, the custodian of water supply, such as the CCT, should continue to lead by example and ensures that infrastructure is maintained, innovation is applied and water is considered in all operations across the city. Ritchie adds to this, when listing accountability as a critical element of any water-saving incentive program. For the SFPUC, this means no longer offering measures that provide substantial rebates and incentives for water saving fixtures, devices and equipment without pre- or post- inspection by SFPUC staff to ensure that these are installed and functions correctly.

Going forward, both water management authorities are focusing on long term measures to secure long-term water supply, including water infrastructure, water supply diversification, water transfers, water conservation and water recycling.

Launched in 2014, the San Francisco 'Water conservation is smart and sexy campaign' captured public attention and presented everyday water conservation tips and information about the drought.

Both cities are also embracing new tools and approaches to water resources management. While Cape Town is refocusing its approach towards the more comprehensive concept of 'a water-sensitive city', the SFPUC has adopted an ***OneWaterSF*** approach to managing water resources for long-term resiliency and reliability. According to Ritchie, "The SFPUC has successfully cultivated a shift at the utility from thinking about one project at a time to thinking holistically about the synergies and resource potential across water, wastewater, and energy boundaries, exemplified in the promotion of on-site non-potable water systems that collect, treat, and use alternate water sources for non-potable uses within individual buildings or across multiple properties."

Such future plans are in-line with global perceptions of how cities should function to ensure a sustainable future. According to manager for the International Water Association (IWA) Cities of the Future programme, Corinne Trommsdorff, the application of successful WDM is multi-faceted. Water-wise citizens, decision makers, and professionals should be shaped. Action should also take place at basin level; assessing constraints and the means to minimise risk to water shortage. The way that buildings and neighbourhoods are designed should be reassessed, allowing for minimal consumption while maintaining high livability. The implementation of improvements or modifications to water services - water loss reduction, reuse for different purposes and rain water harvesting – are essential. "WDM is not just about technology, but about people working together towards a shared objective."

Sources and further information:

- www.capetown.gov.za/thinkwater
- www.gwp.org – The Global Water Partnership
- www.iwa-network.org/ - The International Water Association (IWA)
- http://sfwater.org

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WETLANDS

Novel study looks at ecosystem services provided by palmiet wetlands

An investment in palmiet wetlands is also an investment in the benefits society derives from these unique 'ecosystem engineers', according to new research.
Article by Jorisna Bonthuys.

All photographs courtesy Alanna Rebelo

Dr Alanna Rebelo recently received a joint PhD degree from Stellenbosch University (SU) and the University of Antwerp in Belgium on this topic. Her thesis, titled 'Ecosystem services of Palmiet wetlands: The role of ecosystem composition and function', considered the benefits palmiet wetlands hold for ecosystems and people in South Africa. The research was funded by the National Research Foundation and the Department of Science and Technology, among others.

Of all ecosystems, wetlands are considered to be one of the richest in terms of ecosystem services provided, yet the complexity of wetland ecology has resulted in them being the least studied. These 'services' are defined as the benefits that humans derive from nature.

"Many people have heard of palmiet, but do not know what a valuable wetland plant it is and what ecosystem services it supplies to society," says Dr Rebelo.

Currently, South African wetlands and associated river systems are in a critical state, with over 65% reported to be damaged, and 50% estimated to have been destroyed. There is also increasing concern about wetland loss and degradation. Despite the inherent value of palmiet wetlands and their threatened status, there is no comprehensive understanding of where they remain and what the main drivers of change are.

Dr Rebelo's study involved a systematic literature review, fieldwork, mapping and remote-sensing techniques (using satellites). She selected three palmiet wetlands in different catchments for fieldwork: the Theewaterskloof and Goukou wetlands (Western Cape) and the Kromme wetland (Eastern Cape). Despite being situated as much as 470 km apart, these wetlands are remarkably similar in vegetation composition.

Some of her main findings can be summarised as follows:

- Palmiet wetlands have decreased by 31% since the 1940s.
- Severe channel erosion in palmiet wetlands has changed water and soil quality, and caused a shift in plant communities.
- Relative groundwater depth and soil pH are the only abiotic parameters that differ among different wetland plant communities.
- Functional groups and even species in palmiet wetlands appear to be spectrally distinct, and
- Palmiet wetlands provide valuable ecosystem services to society, particularly the sequestration of carbon, water purification and flood attenuation.

Palmiet wetlands are valuable natural assets because of several factors, the research shows.

Valuable 'ecosystem engineers'

Palmiet grows in two main habitats: bordering mountain streams and forming dense monocultures in valley-bottom wetlands. Here, these wetlands have formed on steep slopes that produce high energy runoff during flood seasons.

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These wetlands are subject to extreme water stress caused by soil saturation, water table fluctuations, floods, droughts and fires. It occurs where it should be impossible, possibly due to physiological adaptations through which it provides ecosystem services to society. This includes dense rootstocks, high leaf surface area and clonal growth.

"The proposed ability to transform this stressful environment into a habitat beneficial to itself and other species is why palmiet is thought to be an ecosystem engineer," Dr Rebelo explains.

Palmiet is adapted to both fire (thick stems) and floods (long, thin leaves and flexible shoots). "These and other unique adaptations of palmiet translate into ecosystem services for society," she explains.

"The question is, how did these (palmiet) plants originally come to survive in these conditions? We know that when these wetlands are degraded and the vegetation lost or removed, it is extremely difficult to restore them. During the restoration of the Berg catchment, it has been almost impossible to try and get palmiet to re-establish in the degraded river channel. So how did these dense, valley-bottom wetlands come about?"

Dr Rebelo's novel research methods enabled her to spectrally discriminate palmiet wetland species and functional groups by using satellite techniques, among others. "I was surprised to find such strong correlations between palmiet wetland species and functional traits like leaf area and nitrogen content," she says.

In relation to the patchy appearance of palmiet wetlands as a result of different plant communities, Dr Rebelo identified soil pH and relative groundwater depth as the main environmental parameters explaining these patches. "This finding was surprising, seeing that I had expected major differences in soil structure and chemistry between these communities," she says.

Soil pH was higher for palmiet communities, whereas relative groundwater depth tended to be closer to the surface but more variable for fynbos communities, and deeper below the ground for palmiet. Yet, it is not clear whether these abiotic conditions are driving vegetation patterns, or whether the vegetation is causing these local differences through differences in transpiration and photosynthesis.

To answer this question Dr Rebelo developed three possible alternative theories for these vegetation dynamics, based on evidence from her thesis and work by other wetland scientists, including Prof Fred Ellery from Rhodes University. The first two theories are related to autogenic succession (competition for niche space), which suggests that palmiet plant communities change through time from a pioneer community to a climax one (through processes like competition). The third theory suggests that there is no succession, but rather that all communities within palmiet wetlands are mature plant communities.

"These theories also help us to understand how palmiet wetlands may have formed in such high-energy, steep catchments, and how they may be able to recolonise after natural rates, intensities and scales of repeated cut-and-fill cycles (gully erosion)," says Dr Rebelo. "However, once human impacts accelerate the rate, scale and intensity of these natural processes, it is clear that palmiet valley-bottom wetlands cannot cope, and soon collapse into another, less desirable, alternate stable state."

Key natural assets

The value of palmiet wetlands in terms of water purification (among other ecosystem services) has been overlooked in favour of their potential for food provision, says Dr Rebelo. Their position in strategic water-providing catchments, combined with their ability to accumulate peat, delivers key ecosystem services to society.

As peat forms, carbon is trapped from the atmosphere and stored in these wetlands. This is an ecosystem service of national or global importance, Dr Rebelo explains. "Although palmiet wetlands only make up a tiny percentage of the country's surface area, their restoration and protection are critical in terms of climate change mitigation. When these wetlands erode away entirely, we are talking about the loss of about 5 000 years' worth of carbon storage, which is certainly significant."

Palmiet wetlands perform functions that human-made infrastructure would find very hard to replicate, she says. Water leaving healthy palmiet wetlands is also of high quality. "Pristine wetlands provide about 16 times higher flood attenuation compared to degraded wetlands, according to estimates. These and other findings highlight the value of palmiet wetlands, making a case for their conservation and restoration."

Many people have heard of palmiet, but do not know what a valuable wetland plant it is.

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The palmiet wetland areas included in the study.

"The proposed ability to transform this stressful environment into a habitat beneficial to itself and other species is why palmiet is thought to be an ecosystem engineer."

Yet many of these palmiet wetlands have been ploughed up for agriculture, either for orchards or grazing. The remaining wetlands are threatened by a plethora of problems, including land-use change (for agriculture), pollution (from agricultural runoff), invasion by alien vegetation, extreme flood events (climate change), and inappropriate fire regimes.

"Using these wetlands for agriculture is not compatible with the supply of other ecosystem services, most notably clean water," Dr Rebelo says. "Ultimately, the resulting wetland degradation is neither beneficial to farmers nor downstream beneficiaries or stakeholders.

"When we consider the ecosystem services provided by South African palmiet wetlands, we need to ask ourselves: can we justify the true cost of development, in terms of continuously expanding and intensifying agriculture?

"No human-made infrastructure beats a palmiet wetland in terms of the services that it provides to society. How would we decrease flood force? How would we clean the water? All the 'traditional' solutions like dredging a channel and building water treatment plants are expensive and drastic (changing the hydrology of the catchment permanently) and require costly maintenance. However, we also cannot eat palmiet (or we can – traditionally, some South Africans did – but we don't use it as a food source today). There needs to be a compromise.

"Either we continue to destroy these wetlands and convert these small narrow valleys into agricultural landscapes with fields and canals and berms. Alternatively, we prioritise the protection of the wetlands, and only farm around the wetlands, away from the frequently flooded zone, making sure the agriculture is compatible with protecting the wetlands (low fertiliser and pesticide use). Given their value, it would make more sense to protect these water-providing systems, and focus our farming activities elsewhere more profitable, in less challenging and valuable landscapes."

Arguably, one of the most pressing threats to palmiet wetlands is gully and channel erosion due to headcuts that undermine existing peat beds. Any disturbance to wetland vegetation, such as vegetation removal for agriculture, a road or railway crossing intersecting the wetland, can cause a knick-point whereupon erosion acts. These headcuts can be 3-5 metres deep and several metres wide in places. This represents a substantial amount of sediment loss that cannot be replaced.

"These systems are extremely flashy, meaning that a huge amount of water moves through the valley-bottom during flood events, providing a great deal of energy for erosion," says Dr Rebelo. "It is important to note that this erosion is a natural process. It is even thought that gully erosion plays an important role in palmiet wetland development. However, it is the acceleration of this natural process by anthropogenic activities that becomes problematic.

"It is hard to halt, it decreases water quality, causes sedimentation of dams and may result in a lowering of the water table," Dr Rebelo explains. "This perpetuates the cycle of degradation and can render adjacent agricultural land unusable."

The food versus water, carbon and biodiversity trade-off is something that policymakers and land-use planners need to consider. This is especially in light of the new research on strategic water source areas by the CSIR, she points out. These strategic water source areas are the main sources of the water that feeds our major rivers and urban hubs. They make up only 8% of the country, but capture and supply 50% of our runoff. Palmiet wetlands fall into these critical areas. Some are situated upstream of important dams for large cities, including the Theewaterskloof and Churchill Dams, which provide water for Cape Town and Port Elizabeth.

Dr Rebelo recommends that policy mechanisms change to support landowners who are currently incentivised to produce one ecosystem service (mainly food production) to optimise other ecosystem services, including water provision, purification and carbon sequestration.

"Municipalities could save millions of Rand spent on water purification each year if farmers were not damaging the upstream wetlands."

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With a decline in governmental support for conservation within and outside protected areas, more pressure is also needed to create innovative solutions for endorsing and financing conservation, she argues. "Landowners cannot afford to simply not farm," she says. "It is clear they would need financial support to provide other ecosystem services, to become landscape managers, and thereby protect palmiet wetlands, our critical ecological infrastructure.

"The remaining palmiet wetlands should be bought out (and placed in nature reserves), or payments for ecosystem services schemes should be set up. Such plans could enable farmers to become managers of ecosystem services and to be paid to maximise (or 'farm') these ecosystem services. These options would be appropriate in different situations and depend on factors like landowner willingness and the state of the wetland."

An example could be water purification and sediment retention. Polluted water and sedimentation are two of the most significant threats to dams (water impoundments) in South Africa. With agriculture destroying these wetlands, especially in the Kromme (Churchill Dam), there is increased sedimentation that reduces the lifetime of the dam, as well as a decline in water quality that costs the municipality millions of Rands monthly to treat.

There is the potential for working together in water-providing catchments. Ecological engineering ('soft' solutions) can also be used rather than constantly turning to expensive 'hard' solutions (like chemicals to improve water quality and dredging). At the very least, wetland management should complement traditional engineering solutions (municipal dams, water treatment works), the research highlights.

"Municipalities could save millions of Rand spent on water purification each year if farmers were not damaging the upstream wetlands," Dr Rebelo says. "This is not to mention the cost once the dam is full of sediment."

Many people have heard of palmiet, but do not know what a valuable wetland plant it is.

More about palmiet wetlands

- Palmiet wetlands get their name from a wetland species called 'palmiet', ***Prionium serratum***.
- Palmiet is a peat-forming plant with unique properties enabling it to survive in high-stress valley-bottom environments throughout the Cape Floristic Region.
- Palmiet wetlands provide many essential ecosystem services to society, particularly water regulation, water purification and climate regulation.
- Palmiet wetlands that have high-quality peat are usually almost permanently wet, and decomposition cannot take place, or takes place very slowly, leading to CO_2 being trapped. As palmiet wetlands become degraded, peat dries out, and its quality decreases as decomposition take place.
- Agricultural practices threaten many palmiet wetlands, yet agriculture in these wetlands is marginal due to the challenges of farming a system that experiences severe floods and droughts.

One successful example of this strategy highlighted in her study is that of the Catskill catchment in New York, where holistic farm planning was developed as an attempt to decrease pollution of the watershed. In this system, farmers were incentivised to pollute less by having their operational and capital costs of investment into pollution control covered by the City of New York. Through collaboration, cost efficiency was achieved, and private as well as social benefits realised.

"Prevention is always better than cure, and in the case of damage to palmiet wetlands, the cure – ecological restoration – is extremely expensive," she concludes.

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IRRIGATION WATER USE

In-depth study sheds light on irrigated farming areas, water use

A research team used a novel approach to estimate the total area and water use associated with irrigated agriculture in South Africa. We take a closer look at their findings. Article by Jorisna Bonthuys.

Scientists forecast that farmers will need to double their current water use or produce more with the water available to meet rising food demands by 2050. Given that water has already been fully or over-allocated in many of our catchments, it will likely not be sustainable to expand the area under irrigated agriculture.

Key questions remain, however: Do we know how much water is needed for irrigation agriculture in South Africa? Can we tell which crops are more water efficient in terms of production? And, how can we ensure that we use our water resources sustainably considering future uncertainties?

A four-year-long research project, jointly funded by the Water Research Commission (WRC) and the Department of Agriculture, Forestry and Fisheries (DAFF), focused on these and other related questions. The research team, under the leadership of Prof Adriaan van Niekerk of Stellenbosch University (SU), conducted a study on consumptive water use and irrigation. Prof Van Niekerk is the director of the Centre for Geographical Analysis in SU's Department of Geography and Environmental Studies. The work was done in partnership with Dr Caren Jarmain, eLEAF, the Agricultural Research Council (ARC), GeoTerraImage, and other independent researchers.

The results of this study have now been published. This document, ***An Earth observation approach towards mapping irrigated areas and quantifying water use by irrigated crops in South Africa*** (**WRC Report No. TT 745/17**), forms part of

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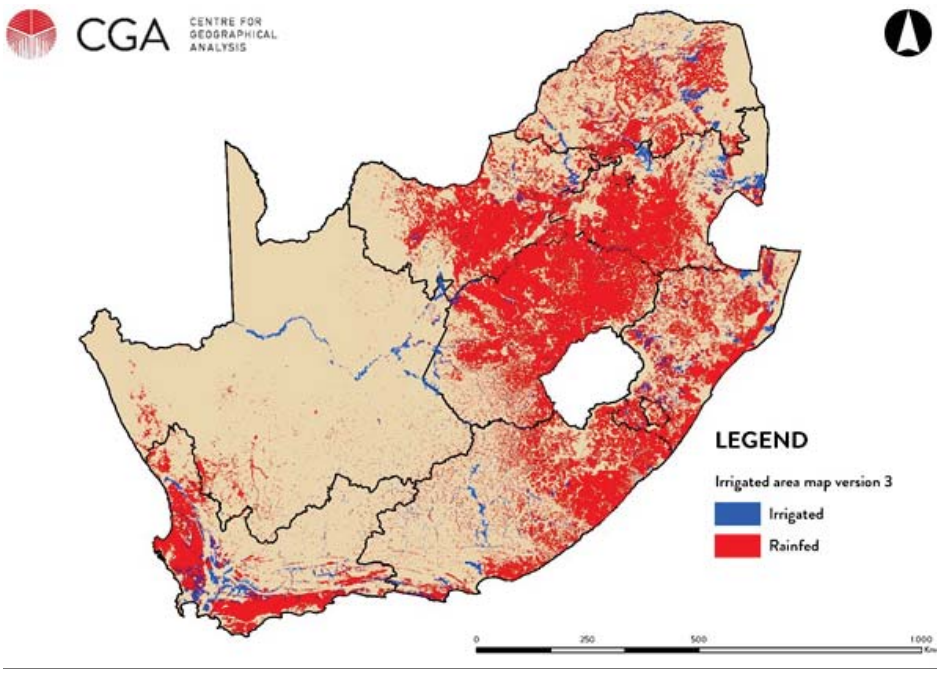

Map showing irrigated and rainfed areas in South Africa.

the earlier WRC and DAFF-funded project titled ***Wide-scale modelling of water use and water availability with Earth observation/satellite imagery*** (**WRC Project No. K5/2401**).

The context

Although irrigated agriculture uses a large proportion of South Africa's available water resources, the importance of this sector for the economy and food security is undisputed.

Agriculture and irrigation matters to our economy. The role of agriculture remains important despite its relatively small contribution to South Africa's gross domestic product (GDP). The direct contribution of agriculture to South Africa's GDP is estimated to be between 4% and 5.3%, while its indirect contribution to the GDP is estimated to be much higher at between 14% and 30%.

Irrigation supports 25-30% of our national agricultural production. It is estimated that irrigation is responsible for up to 90% of the production of high-value crops (including potatoes, vegetables and fruit) and 25-40% of the production of industrial crops (including sugarcane and cotton).

Planning for a sustainable agricultural future remains key given current and future water realities. South Africa's annual rainfall is 470 mm – 80% of this pours down in only five months of the year. With the added pressures of climate change, population growth and the decline in water quality, the need for improved assessments of the current water resources and land uses are critical.

About the research

While irrigated agriculture is certainly the main user of surface and groundwater resources in South Africa, the estimations of the area of irrigated crops are outdated and vary greatly. The volume of water used by irrigated agriculture has been estimated to be between 51% and 63% of total water available. The researchers developed methods that allowed them to map the area under irrigated agriculture, while also estimating the volume of water used. This was done by employing Earth observation, geographical information systems (GIS), energy balance modelling and machine learning techniques. These techniques enabled them to map irrigated agricultural areas and to model actual evapotranspiration (plant consumptive water use) at the national scale.

Essentially, water consumption by crops can be determined by estimating actual evapotranspiration from remote-sensing data, processed with complex algorithms. The model used, named ET Look and developed by eLEAF, splits the evapotranspiration into evaporation and transpiration data.

The scientists fed satellite, land cover and meteorological data into the ETLook model to produce daily outputs that were combined to generate 12 monthly evapotranspiration maps. These maps represent the consumptive water use across South Africa for the period from 1 August 2014 to 31 July 2015. The maps were aggregated into an annual evapotranspiration map, which represents a 'snapshot' of the consumptive water use by vegetation, expressed in mm/year, at a spatial resolution of 250 m.

A machine-learning analysis was performed on datasets derived from a range of medium- and high-resolution satellite images. Machine learning is a data analysis method that uses known data to automate analytical model building. It is essentially a predictive computer program that becomes better over time as it learns from successes and failures. The modelling was carried out in several climatic regions to account for rainfall variations and seasonal influences.

The resulting maps clearly show how water use by crops and

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other types of vegetation vary across the country at different scales. It indicated that 1 334 562 ha or 1.1% of South Africa's land surface was actively irrigated during 2014/15. This constituted 10% of the total area under cultivation (including fallow areas) of the area used for agriculture in 2014/15.

It was found that the Western Cape contributes the most (269 476 ha), with Limpopo having the second largest area under irrigation (218 302 ha). Interestingly, the average water use per unit area in the Western Cape was substantially lower (5 874 m^3/ha) compared to Limpopo (8 841 m^3/ha), which resulted in the former using relatively less water in total.

These differences can be explained by crop types in summer and winter rainfall areas and whether irrigation is done on a permanent or supplementary basis. This analysis and refinement must be undertaken as part of follow-up studies to the baseline knowledge which has now been created with this study.

The national aggregation of evapotranspiration for all irrigated areas in 2014/15 showed that the total consumptive water use from irrigated agriculture in South Africa was 10 221 million m^3/yr. This compares well with previous estimates such as the 1997 ***Overview of Water Resource Availability and Utilisation in South Africa***, which estimated the water use by irrigated agriculture to be 10 740 million m^3/yr, and 7 836 million m^3/yr in 2000 (as part of the National Water Resources Strategy, with the latter based on a 98% assurance of supply).

The water use estimate for irrigated agriculture in 2014/15 was marginally lower than this estimate, despite the 44 430 ha increase under irrigation, implying either improved water use efficiencies or production of crops with lower water use requirements. However, differences in accuracies and methods between the 1997 estimations and the current study may also account for these dissimilarities.

This estimate of total consumptive water use is not to be confused with the volume of irrigation applied, which would likely be higher than the estimate. Ideally, the water applied should not exceed consumptive use (i.e. 100% efficiency), but in practice maximum irrigation application efficiencies are typically only as high as 90% for drip irrigation. More work is needed to investigate the relationship between water applied and water consumed and to improve water use efficiencies and reduce non-beneficial, non-consumptive losses.

Given that many cultivars and crops have been introduced to South Africa over the last two decades, the research unlocks a wealth of information for planning purposes, says Dr Caren Jarmain. Dr Jarmain, an independent researcher, is also a research associate at the SU's GCA, says this data will assist water managers to improve water resource management.

Of the crops assessed, citrus recorded the highest median evapotranspiration values with 911 mm/year and 678 mm/year in the summer and winter rainfall regions respectively. Wine grapes generally used less water, with rainfed vineyards in the winter rainfall region producing the lowest median evapotranspiration values (500 mm/year).

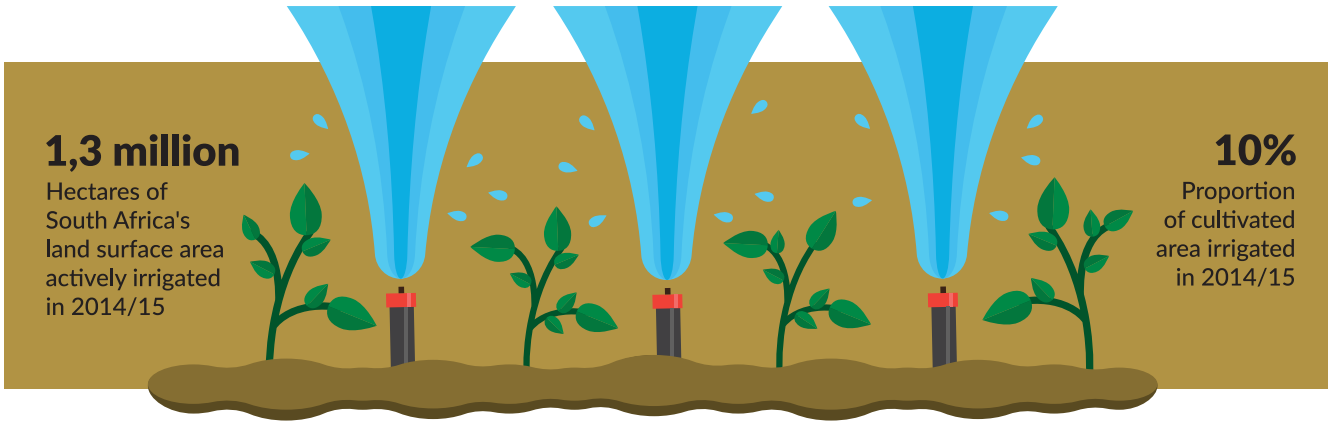
The crop-specific analyses also revealed that the evapotranspiration of irrigated crops is not disproportionate to those of rainfed crops. For instance, the evapotranspiration of irrigated wheat in the summer rainfall region was 737 mm/year, while the evapotranspiration of rainfed wheat in the same region was 611 mm/year, a difference of only 20%.

It should be noted that crop cultivation is highly dynamic and heavily influenced by climatic and market conditions in a particular season, the researchers point out. The estimation of 10 221 million m^3/year for the 2014/15 season should be seen as a snapshot of the total consumptive water use: it is expected that this estimate will fluctuate from year to year.

A water accounting framework was applied to seven secondary catchments throughout South Africa (selected based on characteristics such as population size, agricultural activities and proportion of irrigation). This was done to determine whether water resources are available for the extension of irrigated agriculture.

Using remotely sensed methods further enabled them to show how water accounting can be employed to determine water use and water availability over large catchments. Water accounting describes a catchment's hydrological processes, water flows, and their interaction with land use.

The Water Accounting Plus (WA+) framework was applied to seven secondary catchments throughout South Africa (selected based on characteristics such as population size, agricultural activities and proportion of irrigation). This was done to determine whether water resources are available for



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the extension of irrigated agriculture. The WA+ framework is an international analytical framework used in the field of water resources.

The results showed that in the Mzimvubu, Kowie and the Breede River catchments, the water resources were likely enough to allow for more storage and productive use of (surface) water. This additional water could be used to meet their crop demand in summer or to store extra water in wetter years as insurance for drier years. Alternatively, this water could be used to support the expansion of the area under irrigation in the respective regions.

Research gains

How should these results then be interpreted? ***The Water Wheel*** approached members of the project's oversight reference group for their input.

The need for improved assessments of the current water resources and land is critical, says Dr Gerhard Backeberg, WRC's Executive Manager: Water Utilisation in Agriculture. Actions related to improved water use efficiency and irrigation expansion can only follow once this information is available, he points out. "This project and report have contributed recent and accurate information on water use by different irrigated crops over time (i.e. throughout the growing season) and space (i.e. in different geographical areas). Combining these datasets into a water accounting framework will improve understanding of the actual pressures on water resources with changes in land use, which will better inform water use for irrigated agriculture."

This information can now be factored into the design of irrigation systems, adds André Roux, water and drought specialist in the Department of the Premier of the Western Cape. "Being a water-scarce country, it was actually shocking that no accurate determination of the actual agricultural water use, which is a major water-use sector, was available," says Roux.

The research indicated the value of obtaining information about consumptive water use of various land uses for large areas on a cost-effective basis. "Twelve of the 19 water management areas in South Africa already face a water deficit," says Roux. "There is little room for increased surface water utilisation, although there is a clear need for irrigated agriculture to support crop production, food security, economic development and job creation."

According to Janse Rabie, who heads up AgriSA's Natural Resources Centre of Excellence, the study "represents a breakthrough by providing practical, high-value and relevant knowledge related to irrigated agriculture". "It could not have come at a more opportune time given the current deeply distressing vulnerability of South Africa's water resources," Rabie says. "Accurate information on the area and amount of water used by irrigated agriculture is imperative in informing policy and decision-making about the agricultural industry and – by implication – the state of South Africa's food security."

Rabie also considers the data "invaluable" for policy and legislative development. "It has clear implications for government's development targets and agriculture's contribution to the economy. It is imperative that government includes the results from the study in its present decision-making about water governance. However, the potential future application of the results creates an unprecedented advantage for the agricultural industry, which needs to be capitalised upon."

The study is unique in that it envisages a methodology that can be replicated for other periods. "It is imperative that the recommendations contained in the study be followed-through upon," Rabie says. "This includes that the irrigated area mapping procedure is automated and that funding for implementation of the procedure is prioritised; the irrigated area map is continuously updated; the consumptive water use of irrigated crops is revised on a continuous (seasonal) basis at national scale; and that a water accounting framework is applied on primary catchment level, preferably in all catchments."

Although the National Water Act (NWA of 1998) does not make provision for water conservation and demand management, the definition of water conservation makes these measures an essential component of water resource management. It also relates the effective and efficient use of water to the minimisation of water loss and wastage. "Demand management is not only about reducing water use; it is also about the economic valuation of a scarce resource in the context of irrigated agricultural crop production," Rabie elaborates.

Dr John Purchase, CEO of the Agricultural Business Chamber, says the Earth observation methodology and database developed during the project enables the water and agriculture sector to now far more accurately estimate water availability for agriculture. "One of the deficiencies in the current water legislation is that water allocation for irrigation and the management of that water allocation is not sufficiently dealt with," Purchase says. "Having the methodology and tools to deal with the matter should encourage legislators and government to include improved guidelines in this regard."

As South Africa's water resources become more constrained, the amount allocated to irrigation (~60% of total surface water use in South Africa) will come under far greater pressure. "This necessitates much improved overall management of especially our surface water, and you can only improve management if you can measure accurately," Purchase says. "The results will assist government (catchment management agencies) and water user associations with more realistic quota-setting to lawful users, and even assist in rooting out large-scale illegal water users."

The information allows DAFF to improve planning and estimates of potential agricultural production under irrigation. Purchase elaborates, "The National Planning Commission in its 2030 Vision (National Development Plan) advocates a 50% growth in irrigated agriculture area, but this will have to be achieved through water savings and water use efficiency as no 'new' water allocations will be able to be made to the agriculture sector, except for a couple of new capacity initiatives.

Backeberg concludes, "The study has closed a knowledge gap by using earth observation methods. This is at the forefront of international research practice."

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WOMEN AND SANITATION

Skipping the queue – female urinals successfully tested in KZN, Mpumalanga

Female urinals are being tested as a possible solution to the need for sanitation. Sue Matthews reports.

Any woman who has waited in a long queue to 'spend a penny' in a public toilet may have been slightly peeved at the quick turnaround in the men's loos, due largely to the availability of urinals. This type of facility has long been reserved for men, from the Pissoirs that were installed on the pavements of Paris from the 1830s – but have more recently given way to self-cleaning, unisex Sanisettes – to the UriLifts that pop up at night to cater for Amsterdam's revellers, only to retreat beneath a manhole cover by day.

Over the years, a number of rather fancy women-specific designs for urinals have been developed in Europe and the United States, but they have not been widely implemented. These have typically been the wall-mounted variety, allowing women to adopt the same stance they would take to avoid sitting on a toilet seat. Elsewhere in Africa, however, trough-type urinals are known to have been installed at a number of schools for use by girls, with mixed success. The design often incorporates raised footrests, enabling a girl to squat over a sloped channel and urinate without getting her feet wet. Of course, so-called squat toilets – also known as Turkish Toilets – are the norm in the Middle East and Asia, but those are intended for both defecation and urination.

Urinals have some key advantages, particularly in light of the dire state of sanitation in many South African schools. At those schools that still have pit latrines – where there is invariably some risk of falling into the pit – learners needing only to urinate

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The toilet huts contained a Weestand urinal – a roll of toilet paper and a bin for disposal of used paper as well as signage to ensure learners used the urinals correctly.

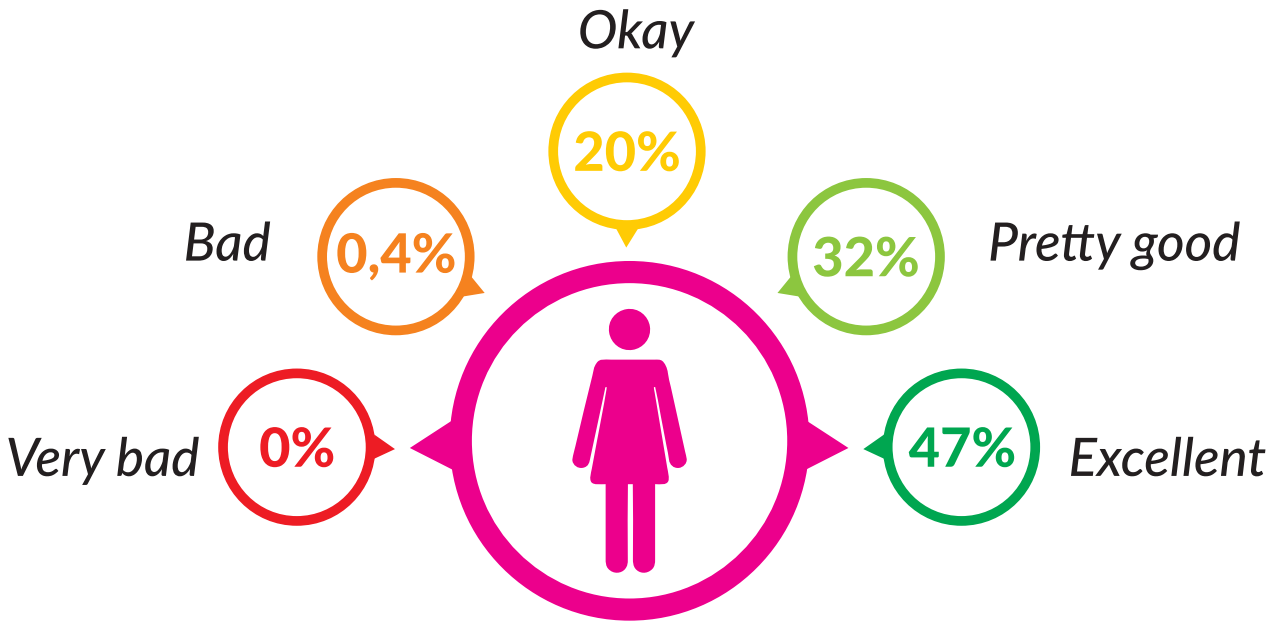
can use the urinal instead, so there is a safety benefit. And since pit latrines must be abolished and replaced with improved sanitation options, urinals can reduce the number of new toilets needed, and hence the cost.

Urinals also reduce learners' exposure to disease by eliminating the need to touch toilet handles and seats, which may be contaminated with faecal matter. In addition, they represent a significant water-saving compared to flush toilets. While municipal bylaws have outlawed automatic-flush urinals in favour of user-activated ones, there are now waterless versions on the market too. Even well-resourced schools like Bishops in Cape Town and St Stithians in Johannesburg have installed these urinals in the boy's toilets, as part of their water-saving and sustainability efforts.

Recognising the potential benefits of waterless female urinals, the Water Research Commission recently funded a research project by Pietermaritzburg-based firm, Partners in Development, to test the acceptability of urinals among girls and women in South Africa. Initially, eight primary schools in the area were visited, and 625 learners – assisted by three female researchers – completed questionnaires on their toilet usage and their opinions of urinals.

Only 44% of the participants reported that they usually or always sit down on the school toilet seats, while 36% said they never do so. The toilets are primarily used for urination, with 28% of participants saying they never defecate at school. When shown pictures of urinals, 57% indicated that they would prefer the wall-mounted design, while 43% preferred the trough version. However, 47% of participants said they would not be willing to put their used toilet paper in a bin, which is necessary to prevent blockages of the urinal.

A field-testing study was then conducted by setting up a female urinal facility at five different schools – three primary and two secondary schools – over a two-week period. The urinals were supplied by LiquidGold, a start-up company founded by Orion Herman to promote the concept of urine being a valuable resource, since it can be used to produce fertilisers rich in nitrogen and phosphorus. LiquidGold's main focus has been on retrofitting existing urinals with non-return valves that prevent urine odours from travelling back up the drainage pipe, and on entering into service-level agreements with businesses to maintain the system and collect the urine. However, it also



RESULTS OF USERS' EXPERIENCE WHILE USING THE FEMALE URINAL.

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worked with students at Vaal University of Technology to develop a gender-neutral waterless urinal, called Weestand, and subsequently installed 14 of these (seven for each gender) in a containerised unit at Osizweni Primary School in Mpumalanga.

Two urinals in individual toilet huts were installed for the field-testing study at the schools, none of which had flush toilets for learners' use. Two researchers remained close by to assist learners before they used the urinal, and then interview them afterwards using a multiple-choice questionnaire. Of the 236 respondents, 70% were primary school learners, partly because it was exam time at the high schools so not all learners were present. Only one learner rated her urinal experience as 'bad', while 79% had a 'pretty good' or 'excellent' experience. When asked what they liked about the urinal, 53% selected the option that it was clean. Some 36% replied there was nothing they disliked about the urinal, but 20% didn't like having to put their used toilet paper in a bin. Only three users out of the 236 said that they would not use the urinal if it was permanently available at their school. All but nine replied that the urinal was better than their existing school toilets, the main reason being that it was clean – yet any toilet facility will become unappealing if not properly managed and maintained, of course.

Urinals also reduce learners' exposure to disease by eliminating the need to touch toilet handles and seats, which may be contaminated with faecal matter.

When asked what they would change about the urinals, about half of the respondents wanted nothing changed, but 20% of them replied that they would like to be able to sit down. However, Orion Herman has indicated that the LiquiGold urinals were deliberately designed to have a very thin edge so that they would be uncomfortable to sit on, as this would limit the likelihood of defecation. Finally, in response to a question about what matters most to them when using the urinal, the learners responded that privacy (40%), safety (30%) and cleanliness (26%) were their main concerns.

The containerised gender-neutral waterless urinal facility installed at the Osizweni Primary School in Embalehle, Mpumalanga.

This highlights the importance of using partitions in girls' toilets to allow them enough privacy to preserve their sense of dignity. In the containerised urinal facility installed by LiquiGold at Osizweni Primary School, the girls' urinals are in individual cubicles with doors, but this may not be necessary for very young children. Many international examples use only dividers of some kind to provide a privacy screen – although this is possibly the main reason why communal urinals for women have not been widely implemented!

User experiences of adult women were not included in the research project's final report, because the number of respondents was too low to provide useful information. The two urinals had been set up at a community Park Run, and it is not clear whether women avoided using them or were unwilling to be interviewed. The initial acceptability study did include adult women though, via a survey conducted at four taxi ranks in the Pietermaritzburg city centre. A total of 93 women representing a range of ages and from both rural and urban areas were interviewed. More than half of them rated the taxi rank's public toilets as bad or very bad for all four criteria – cleanliness, safety, wait time and privacy – and some 30% said they never sit down on the toilet seats. Almost all of the women indicated they would be willing to try a urinal, and also to put their toilet paper in a bin. Some 61% preferred the wall-mounted version, with three respondents expressing concern that older women would have difficulties squatting for the trough version.

This preference is similar to that expressed by the learners, but it would be relatively easy to introduce trough urinals for girls at schools, because all that would be needed are some slight changes to the design already used for boys' urinals. Partners in Development estimate that a toilet block containing a trough urinal with three stalls as well as a handwashing basin could be supplied at a cost of R17 200 per seat. In contrast, the container with wall-mounted urinals offered by LiquiGold cost R350 000 for a 12 metre version in 2017, equating to R25 000 per seat. Both options are considerably cheaper than the estimated R70 000 budgeted per seat for new Ventilated Improved Pit (VIP) toilets in schools.

The Partners in Development project team therefore recommended that the Department of Education add female urinals as an option in their toolkit to address shortages in school sanitation. "Pilot projects using both trough and wall-mounted urinals for girls should be initiated in schools in different parts of South Africa," they noted in their report. "Schools are potentially an ideal setting to test female urinals, as children more easily adapt to new technologies. Should schools prove to be a successful market for female urinals, this technology could be expanded to serve the needs of public toilets in malls and taxi ranks, among other locations."

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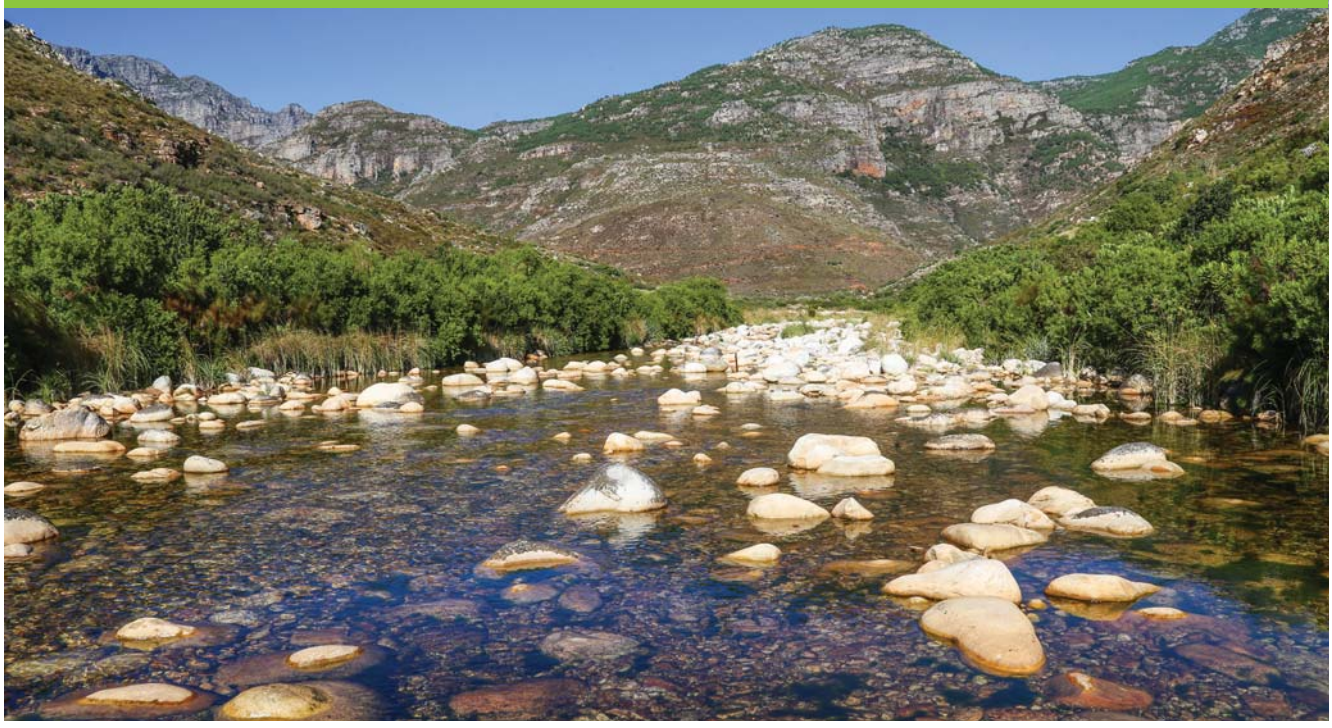
DROUGHT AND AGRICULTURE

Berg River study points to importance of monitoring in managing catchments

A recently completed research project has investigated ways to adapt farming in the Berg River Catchment to drought conditions and urbanisation with increased monitoring and economic modelling. Article by Annabel Horn, Leanne Seeliger, Marlé Kunneke, Willem Hoffman, James Cullis, Nico Rossouw, Lloyd Fisher-Jeffes and Wilna Kloppers.



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Low water levels in the Berg River Catchment have resulted in increased pollution in places, triggering the need for farmers to consider adapting their farming practices to ensure future profitability. The Berg River that rises in the Groot Drakenstein Mountains, near Franschhoek, and discharges in the Atlantic Ocean at Velddrift, supports land uses such as agriculture, forestry, urban development and conservation. It is an important producer of table and wine grapes in South Africa, with more than a fifth of the country's wine cellars located here.

Agricultural experts already expressed concerns in 2008 that deteriorating water quality might affect the ability of the region to export grapes and other fruit. This would have a significant impact not only on the regional economy of the Western Cape, but also the national economy. The area is a major contributor to foreign currency earnings, and is important for the welfare of thousands of people who are dependent for their livelihoods on the agricultural sector in the region.

The current drought conditions in the Western Cape, combined with the possibility that these might be the signs of climate change, the poor state of some treatment plants and the continued rapid rate of urban developments in the Berg River Catchment have further highlighted these risks.

How these conditions might impact on the future water quality risks in the Berg River and the associated options for farmers to adapt to changing water quality risks were the subject of a

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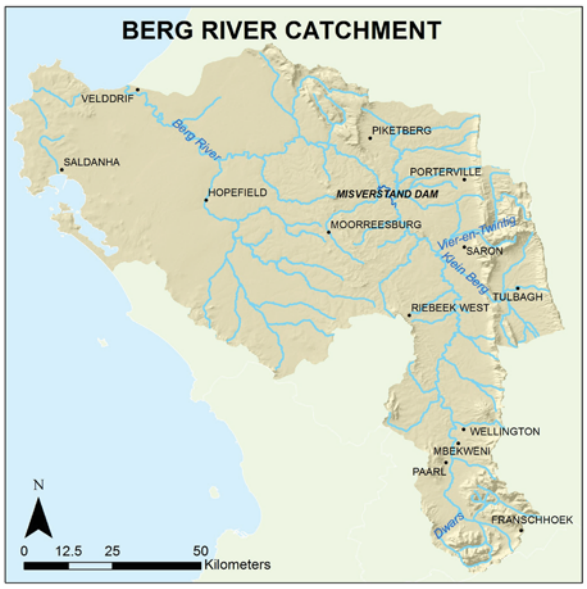
recent study initiated by the Western Cape Government as part of the Berg River Improvement Project (BRIP).

The study modelled three typical economic whole farm scenarios in different regions in the Berg River Catchment to evaluate the likely impacts and associated cost of different on-farm adaptation scenarios. These could then be contrasted against alternative solutions aimed at addressing the root causes of the problems in the catchment, which might be harder to achieve.

In the baseline scenario, farms were modelled to have good quality river water for irrigation and continue to place about 70% of the produce into higher priced export markets. In scenario two, farmers found it difficult to reach the irrigation water quality standards for fruit export and placed the fruit into the domestic market with lower prices and moved from table grape production to wine production. In scenario three, farmers were compelled to put a water treatment system into place for the cleansing of river water prior to irrigation. This significantly affected the capital outlay of farmers.

"The area is a major contributor to foreign currency earnings, and is important for the welfare of thousands of people who are dependent for their livelihoods on the agricultural sector in the region."



The Berg River Catchment.

For scenario 2, the modelling showed that while selected red wine cultivars might fetch a better market price here due to lower yields, overall there would be a significant loss in productivity. Moreover, it was predicted that if farmers switched to wine farming to remain profitable there would be an added infrastructure cost of cellars that would need to be built.

The analyses showed that profitability fell in scenario two, where the modelled farm had to adjust to the lower domestic prices as compared with export prices. In scenario three, where farmers had found a solution to manage the water quality themselves

Inflow into the Berg River Dam was affected severely by the recent drought.

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Wetlands below the Berg River Dam.

with a private water treatment facility, profitability was better than scenario two.

A number of recommendations were suggested to address the situation. These included:

- The continuous monitoring and analysis of water quality in the Berg River, both over time and along the length of the river.
- The inclusion of stormwater management, stormwater quality and timely wastewater treatment work upgrades into municipal services development plans.
- The monitoring and analysis of population and building trends that impact on water quality.
- The recording of water user association data with regular updates and collated information for each section of the river being made accessible to relevant authorities. During times of drought this will enable individual farms to put the required curtailments in place to avert a crisis in both water allocation and water quality in the river caused by reduced dilution.
- The conveying of real-time water quality data to farmers. This could be in the form of bulk short message services via cell phones. This information would be useful for an emergency, like a spill, as monitoring and laboratory analysis takes time and so cannot be completed in real time.
- The possible establishment of water treatment systems for river irrigation water of sensitive crops on farms.

Researchers believe this study has relevance for decision-making in the whole of South Africa and other areas in the world that face challenges like declining water quality, increasing urbanisation and climate change. It pointed to the importance of monitoring water quality and quantity to successfully manage water catchment areas.

Marle Kunneke, DEA&DP, Western Cape Government , monitoring in the Berg River

Acknowledgement: Department of Environmental Affairs and Development Planning (DEA & DP), Western Cape Government, provided funding for this research.

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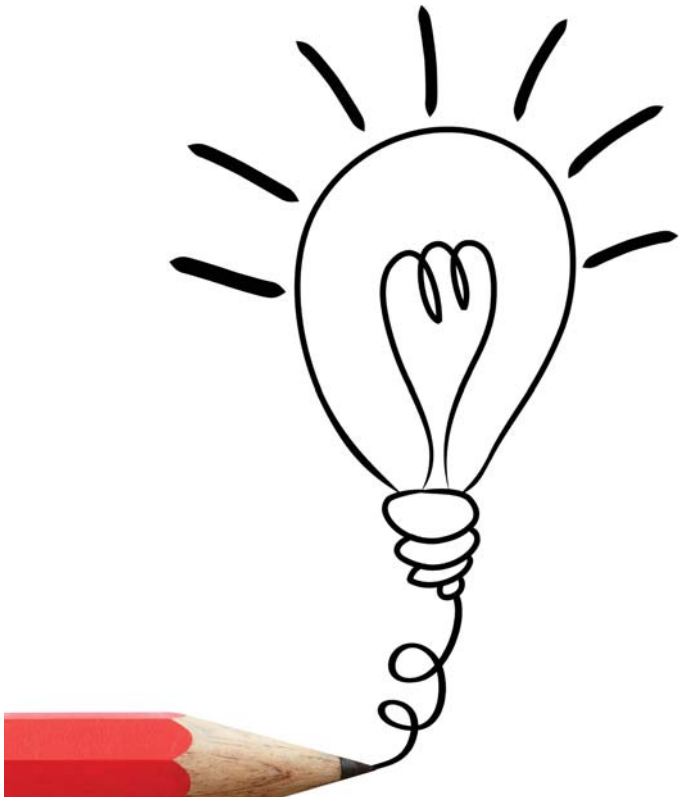
RESEARCH AND DEVELOPMENT

Financing opportunities and models for water-linked research, development and innovation



The ongoing drought in the Cape provinces throws into stark relief the reality that access to, management and optimisation of water will become increasingly challenging for South Africa for years to come. This reality reiterates the findings of the last three World Economic Forum's Global Risk Reports, which have identified water among the top three most important challenges worldwide. Research, Development and Innovation (RDI) is pivotal in optimally dealing with these challenges. So writes Rajiv Paladh, Kevin Foster and Chantal Ramcharan-Kotze.

In 2015, the Department of Science and Technology (DST), the Department of Water and Sanitation (DWS) and the Water Research Commission (WRC) produced the National Water RDI Roadmap. The Roadmap presents a vision for South Africa to be a leading middle-income country in the development and deployment of water management practices and technologies. It seeks to ensure that South Africa competes with leading countries in providing sustainable water sector solutions. However, the investment and financial resource alignment required to ensure that the recommendations of the Roadmap are implemented are estimated at R8 billion between 2015 and 2025.

This investment will require funding well beyond traditional funding sources. The WRC has embarked on an exercise to identify the potential sources of funding for the R8 billion investment to support the water sector in achieving its mandate. Potential funders across the traditional public sector as well as private funding sources were approached and engaged on the areas of the Roadmap that they would have an appetite to partner on or fund. Funding sources that have been identified for each thematic RDI focus area of the Water RDI Roadmap, and their potential to fund are depicted on the funding map, on the right.

Funding for research related to water and sanitation activities

Significant research and development has been, and continues to be, undertaken within the South African water sector. A significant proportion of this has been funded by the WRC, DST, academic institutions and international donors, who all remain important sources for funding. Industry has also

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Table 1: Investment areas identified by the Water RDI Roadmap

RDI Focus Area	Definition
Research	Research related to water and sanitation services.
Advisory units for practitioners	Advisory units for practitioners in the water and sanitation sector (e.g. a professional services centre and knowledge brokering).
Demonstration of technology	Demonstrations of technology to decrease investors' risk in the water and sanitation sector.
Knowledge development	Skills and training for managers and practitioners in the water and sanitation sector.
SMME and enterprise development	Enterprise development and the inclusion and development of Small, Medium and Micro Enterprises (WRC SMME Development Programme).
City scale projects and programmes	Projects that could be rolled out at a city or small settlement scale (e.g. RESILIM, USAID). These could include supply side interventions, such as new infrastructure, or demand side, such as an area-based water stewardship programme.
Infrastructure	Infrastructure projects in the water and sanitation sector.

Funding Map

Potential Funding Source	Research	Advisory units for practitioners	Demonstration of technology	Skills development and training	SMME and enterprise development	City scale projects and programmes	Infrastructure
National Government Institutions							
Local Government Institutions							
State Owned Entities (National							
Development Agencies							
Philanthropic Organisations							
Business							
Private Equity & Venture Capital							
Commercial and Investment Banks							

Strong potential funding source
Possible potential funding source
Unlikely funding source
No data

been a significant funder of applied research, driven by the need for market demands and efficiency and optimisation in operations. Industry's willingness to fund research, will largely be driven by the expected return and commercial potential. All these institutions are vital for ongoing funding and ongoing collaboration in respect of research activities, and have indicated the appetite for doing so.

Local government is also able to fund and provide resources and facilities which could be utilised for research and test beds where it serves to address their specific challenges. Institutions that represent interests of collective groups could also provide funding and partnerships for research. These institutions are particularly interested in interventions related to challenges faced by their members.

Funding for advisory units for practitioners

There is an opportunity to establish advisory units with the requisite capacity to address some of the common challenges facing the water sector. The South African water sector constitutes a varied and diverse institutional landscape. Some of the challenges experienced are unique to certain areas whilst others are common across the water sector. Where common challenges are experienced there is scope for advisory units to be established to assist and share experiences widely with water sector institutions. Where unique challenges are experienced, expertise can be deployed to find solutions to these.

Advisory capabilities exist within certain public sector institutions, such as the Government Technical Advisory Centre. There is potential to create additional advisory units, and draw on existing ones, through funding from the national fiscus. This should be done in the context that any investment in the advisory units could lead to savings in for example, deferred capital expenditure and/or improved operational efficiency.

Funding for demonstration of technology

Emerging technologies in institutions in the water sector face a difficult path to market. These vary from small technologies targeted at individual consumers to large-scale components of infrastructure. There is a need to demonstrate or exhibit these technologies to provide practitioners, consumers and

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decision makers with the assurance that they can be reliably implemented. For investors, there is a need to demonstrate that a viable market exists to justify investments in the technology.

Funds for relatively early stage technology demonstration projects will need to be sourced from public sector institutions and, possibly, philanthropic organisations who fund these types of projects. However, water boards and local government partners can and have provided funding for the demonstration of new technologies that enhance service delivery. Development Finance Institutions may also be in a position to provide funding for large scale technology demonstration projects linked to national priorities, infrastructure and socio-economic development.

Funding for skills development and training

Skills development plays an important role in water sector RDI, with the ability to adapt to and implement new solutions, be they technical, managerial or operational innovations. Implementation of South Africa's innovation plans and policies has proven to be a challenge. A lack of experience and capacity has been identified as one of the primary reasons for the failure to manage, adapt and transform the water sector. Thus, specific training in innovation and the upskilling and education of practitioners at all levels of the water value chain will contribute to embracing the uptake of research and innovation in South Africa and result in improved delivery of services and enhanced security.

Most institutions in the water value chain have budgets allocated towards the training and development of their staff. However, these are not always effectively deployed in areas of skills need. These funds can be accessed for appropriate training and development programmes, and collaboration between all stakeholders will also serve to identify and enhance existing training programmes and develop new ones. The potential exists to develop programmes specific to the water sector that are targeted at senior management or leadership level local government and municipal officials, where the curriculum specifically focusses on innovation. This will better equip key functions to develop key competencies in innovation and adaptive management of solutions focused on dealing with the unique challenges within the water sector.

Funding for SMME and enterprise development

Private sector SMMEs are ideally positioned to offer numerous services and innovations to the water sector. These can enhance the delivery of water services and at the same time promote innovation, economic growth and job creation in South Africa. Emerging entrepreneurs will often require financial, laboratory to market bridging and managerial or leadership support to establish a sustainable enterprise to deliver their services and innovation to the water sector market.

There are several funding sources available for established enterprises with a demonstrable track record, such as commercial and investment banks. However, funding and support for relatively early stage enterprises is not as readily accessible. An opportunity exists to direct the finance from existing funders to SMMEs in the water sector by matching the right entrepreneurs with them. Private equity, in particular impact investors, are an increasingly valuable source of funding and expertise for small enterprises producing goods and services with social impact. There is also the potential to attract funding that organisations are required to spend on enterprise and supplier development as part of the Broad-Based Black Economic Empowerment Act (Act No. 53 of 2003).

Funding for city scale projects and programmes

South African cities are operating within a complex environment that is characterised by uncertainty due to high levels of inward migration, as well as external challenges such as climate change. These challenges can threaten water security. Thus, it is important to innovate to develop projects and programmes at a city scale (city, suburban or small settlement pilot projects) that could contribute to enhanced water security.

Funding opportunities exist via international multilateral partners that are focussed on climate change initiatives, such as the 100 Resilient Cities initiative and the Renewable Energy and Energy Efficiency Partnership (REEEP). Some Metropolitan municipalities also have established partnerships that could be used to access additional funding.

Additional findings

In addition to the funding opportunities that have been identified for the key thematic areas, a programmatic approach needs to be developed to ensure effective implementation of the RDI Roadmap.

The benefits of a programmatic approach include the pooling of relevant skills and resources for project planning and design, structuring and funding, project execution, operation and management. If implemented effectively, a programmatic approach can result in the delivery of multiple projects or projects covering a large area economically (economies of scale). It could provide an enabling platform for learning and transfer of skills to under-resourced project participants, promote cooperation between multiple stakeholders, address bureaucracy (which often impedes project development), and enable gathering intelligence for future advantage.

There is a compelling argument to develop a fund focused on a specific area within the water sector to address identified funding gaps or to release funding to other areas in the water value chain. This fund could be structured based on specific objectives and potentially pool financial and human resources from several contributing institutions to integrate know-how, align support and create the pipeline required in South Africa. Public private partnerships (PPPs) also present a viable option to unlock private sector funding to complement public sector infrastructure development in the water sector. These need to be targeted at strategic projects because PPPs are usually implemented over an extended period, can be complex to structure and execute, and often have high transactional costs. The form and substance of PPPs as they are currently structured by Treasury may not fit the needs of the water sector in all instances, requiring a review of PPPs for a water secure future.

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SMALLHOLDER FARMING

Engaging with local South Africa smallholder farming communities: a necessary effort for improving community preparedness to climate variability

Capacity building, through community and scientific engagements, is paramount when promoting the sustainability of farming practices to managing the impacts of climate variability. This is important because it empowers stakeholders through acquiring requisite knowledge, skills, attitudes and values needed to enhance their adaption capacity in climate change related issues. Article by Luleka Dlamini.

The African population is one of the fastest growing in the world. It has a greater proportion of food insecure people in the world and yet the continent has a large potential for agricultural growth and development. Apart from long-term adaptation necessary to improve food production, immediate needs and food security demand studies focusing on shorter term challenges and how to cope with and better prepare to climate variability that directly impacts year-by-year production.

As a nation, South Africa is food secure but most rural households are food insecure. The rural households mostly practice subsistence agriculture and are mostly dependent on rainfed traditional agriculture for livelihood. Rural farming households are particularly vulnerable to climate variability and other disasters risks and have a low adaptive capacity due to technical, financial and infrastructure constraints.

South Africa's repeated exposure to severe climate events combined with its financial and structural capacity requires exploiting the capacity of climate and crop models to digest enormous data sets into useful tailored information needed for decision making. Although models are only a partial

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representation of reality, their exploration capacity is useful, and they are already currently being used at larger temporal and/or spatial scales. Reduced temporal and spatial scales are, however, indispensable to provide appropriate information that farming communities are continuously requesting.

A current Water Research Commission (WRC) research project explores the application of weather and climate forecasts in agricultural decision-making. The aim of this research is to develop a set of tools that allow for an operational and robust climate-crop-water integrated assessment of the production of medium-scale agricultural forecasts.

One of the objectives of this project is to build on research advances and sustainably empower communities. As a result, two annual workshops were conducted in 2016 and 2017 to engage with farming communities as well as other relevant stakeholders, including extension officers and academics. The community engagements aimed at identifying and clarifying needs of seasonal forecast information in smallholder farming systems. Information gathered during these discussions translated into community driven project objectives, better understanding of project outcomes and to further facilitate adoption of seasonal forecasting and sustainable agricultural productivity.

Community and scientific engagements

Worldwide, people-centered approaches in research has now emerged as plausible in promoting an inclusive and public participation process. In the WRC project, it has contributed to the design of a dissemination model that meets the needs of smallholder farmers.

Workshops were conducted in two smallholder farming communities namely, Raymond Mhlaba Local Municipality (Eastern Cape) and Ha-Lambani (Limpopo), continuing earlier relationships and trust developed through previous consultations. Both provinces have been described as poor and most vulnerable to both natural and man-made disasters.

These engagements or workshops provided a platform for direct interaction with all stakeholders in a two-way fashion. In one way, it ensures that the project visibly and accessibly meets its aims, goals and objectives to continuously inform agricultural and community research and development. The aim of the 2016 engagement was to introduce the overall project to the various stakeholders, specifically farmers and researchers, as well as to create awareness on the value of seasonal forecast information. The 2017 engagement was aimed at assessing the progress in attempting to integrate seasonal forecast information and crop models for improved climate variability management in small scale farming systems.

The engagements were conducted over two days prior to the planting period in 2016 and 2017. The first day was a smallholder farming community engagement. Through facilitated discussions and presentations, the workshop focused on the potential application of integrating seasonal forecast information and crop models. The participants were smallholder farmers, local traditional leaders as well as researchers, agricultural advisors, government extension workers, students and interns.

Workshop participants performing a group exercise in 2016 at Raymond Mhlaba municipality, Eastern Cape.

The second day of the workshop focused on scientific and research engagement with emphasis on integration of seasonal forecasts and crop models. Participants included extension officers, researchers, and students from local universities. Technical presentations and discussions amongst participants were held. Primarily, the engagement introduced the technical scope of the project to stakeholders as well as the present status on application of seasonal forecast information and crop models. The stakeholders further deliberated on strategies to improve use of seasonal forecast information in decision-making in smallholder farming systems.

The second scientific workshop focused on refining the opportunities to further improve farm decision management in small-scale farming. The specific objectives of this engagement were to present the recent research outputs on integration of crop models and seasonal forecasts, ascertain the need and explore the ways to facilitate its use.

Local students had a prime interface with the local communities and were given an opportunity to report on their research findings for constructive feedback. Most presentations concentrated on developing a climate-crop integrated assessment tool that could be used to support agricultural decision making at a monthly to seasonal scale.

Key messages from the engagements

Although there were challenges, such as language barriers and scientific jargon, the engagements were generally successful as they provided a platform for farmers and agricultural researchers to effectively learn from each other on how to better manage the impacts of climate variability.

From the 2016 engagement, it was highlighted that the presentations made during the community engagement were complex and needed simplification in the future. Furthermore, local language translation was suggested to enhance understanding. Given the level of literacy of the farmers and the environment, it is necessary that alternative presentation tools with more pictorial representation be explored (e.g. banners).

It is also important to have good and clear communication channels to ensure that the project's activities, events and outputs are marketed accordingly to reach wider audience. This

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could be attained by inviting local newspapers and community radio stations as well as advertising in local universities.

"I learned about seasonal forecast indicators such that I would further disseminate to farmers and colleagues for the benefit of the community. Crop models are very important for farmers to adapt to conditions", expressed a manager from Limpopo Department of Agriculture and Rural Development (LDARD).

Another striking revelation of the engagements was the importance of acknowledging and use of the indigenous knowledge used when it comes to seasonal forecasting. As a result, the knowledge shared during the scientific engagements was strengthened by the local indigenous knowledge shared during the community engagement.

"I used to believe that farmers use seasonal forecast to make sound decisions when farming. However, I learned in the workshop that it is not the case. They use indigenous knowledge, which has been viable for them. It once seemed obvious to me that seasonal forecast is accurate, yet now it is clear that it is based more on probability. Therefore, it might be much better to combine seasonal forecast and indigenous knowledge. I've also learned a lot about crop models, which is viable for my research", said an intern.

Feedback from farmers on the earlier engagement and how they had benefited from seasonal forecast information during the 2017 engagement were likewise shared. Updated seasonal crop and climate information was also explained in layman's terms. However, a need for standardised communication was highlighted, to enable dissemination of crop-climate seasonal information to farmers through sustainable means. This was accomplished through establishing a clear communication channel (email and mobile contacts) between farmers, extension officers and researchers.

Correspondingly, local university students who actively participated in the workshops, directly benefited through the facilitated engagement in their community of practice and university. For instance, they gained knowledge of local protocols that materialized in community engagements. Furthermore, research skills of student participants were enhanced. The engagements also offered a targeted and efficient platform for knowledge sharing through collaborations with the local Institute for Rural Development (IRD).

"I am going to use some of these presentations to prepare for my test on Research methodology, especially the data collection and analysis techniques", said an honours student at the University of Venda.

Way forward

Establishing links with community offered new perspectives and a critical way forward concerning research dissemination process. This endeavour is currently taking form through a monthly and quarterly emailed newsletter to the extension officer. The newsletters contain seasonal forecast information on climate parameters (mainly rainfall and temperature). The purpose at this stage is to improve the communication process, the definition of useful information and co-sharing local knowledge.

Communication by emailed newsletters is particularly important because it provides a platform for continuous engagement with all the stakeholders, beyond the lifespan of the project, hence offering a chance of sustainability of the initiatives introduced by this project.

The project is expected to host its final workshop with academics and communities in 2018. This would conclude the project administration and support in addition to local engagement of farming communities, academics and extension services mostly.

Participants in group discussions responding to questions on usefulness of seasonal forecasting (top) and students presenting their research during the scientific engagement (bottom)

This experience, amongst a multitude of similar others, is taking a small journey through the co-production of knowledge and skills from research to farming engagement. It is a fruitful scientific activity, in support of developing institutional and community engagements, as it empowers equally the researchers, students and farmers. This is particularly paramount when promoting the sustainability of farming practices to managing the impacts of climate variability in poor and vulnerable communities.

Acknowledgements

Our sincere gratitude to the WRC fo funding project K5/2496/4, all project partners including University of KwaZulu-Natal (UKZN), Agricultural Research Council (ARC), South African Weather Services (SAWS), Council for Scientific and Industrial Research (CSIR), and particularly those making the engagements possible, namely University of Cape Town (UCT), University of Fort Hare (UFH) and University of Venda (UNIVEN).

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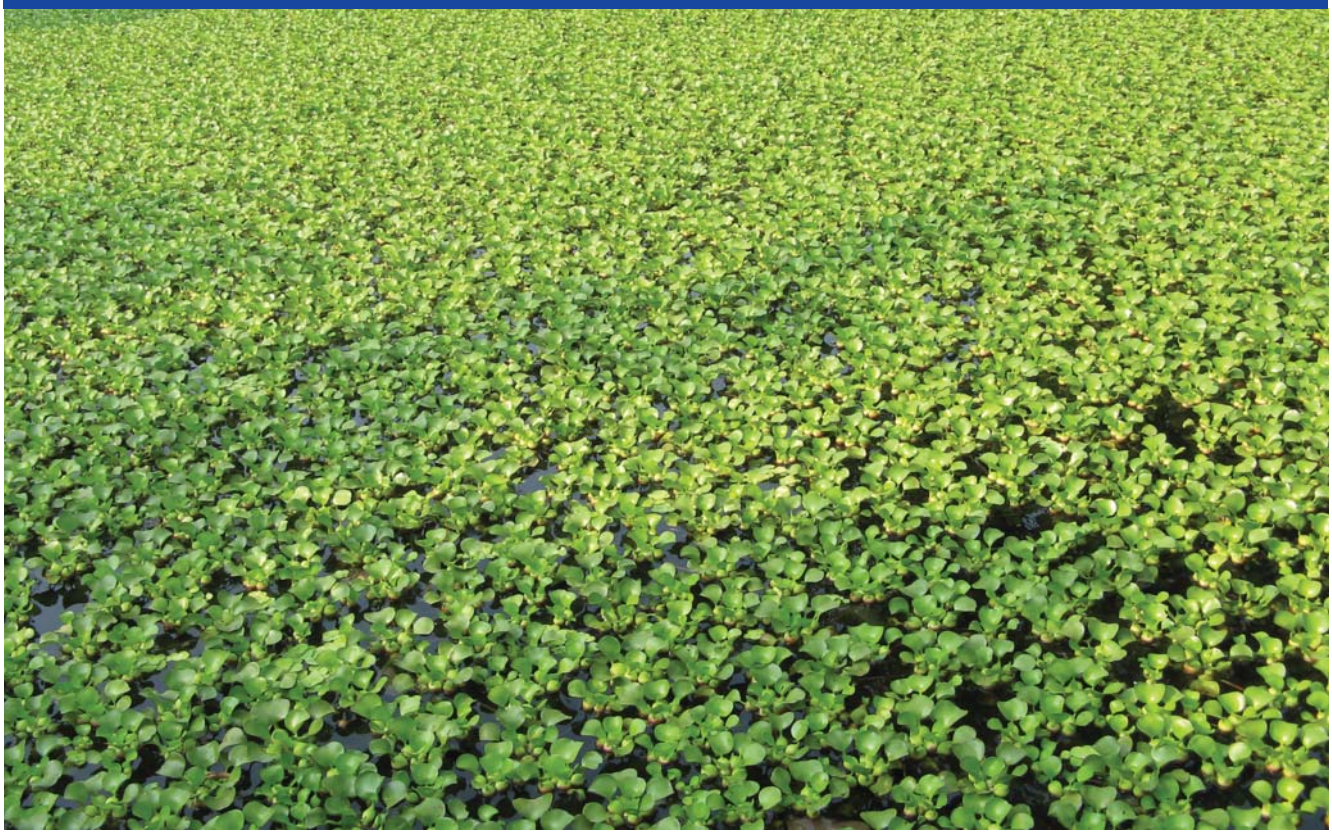
WATER QUALITY

Water hyacinth: Adding value to a noxious weed

Water hyacinth has been dubbed a scourge on South African water systems for decades. But what if this noxious weed held some value?
Article by Ashira Roopnarain, Rosina Makofane and Rasheed Adeleke.



Water hyacinth (***Eichhornia crassipes***) is a perennial, free-floating aquatic weed which is notorious for its rapid reproduction. The plant is indigenous to the Amazon River basin in South America, but is now found in lakes, dams, rivers and swamps in tropical and subtropical countries worldwide. The plant comprises dark green, thick, glossy leaves attached to spongy petioles containing air-filled sacs that enable it to float on water.

Water hyacinth can tolerate a wide range of environmental conditions and successfully out-competes other aquatic plants. Water hyacinth growth is directly correlated to the nutrient concentration in water bodies, especially nitrogen and phosphorus levels. In nutrient-rich water bodies the proliferation rate of the plant can cause various negative effects that are detrimental to aquatic life and human activities. These include blocking light penetration for other submerged aquatic plants, decreasing dissolved oxygen thus affecting water quality, and preventing activities related to navigation, recreation, irrigation and hydropower generation.

Control methods

The negative effects of water hyacinth have motivated research and development activities to manage its proliferation. Several chemical, physical and biological control methods have been tested but none of them provide a permanent solution for the water hyacinth problem.

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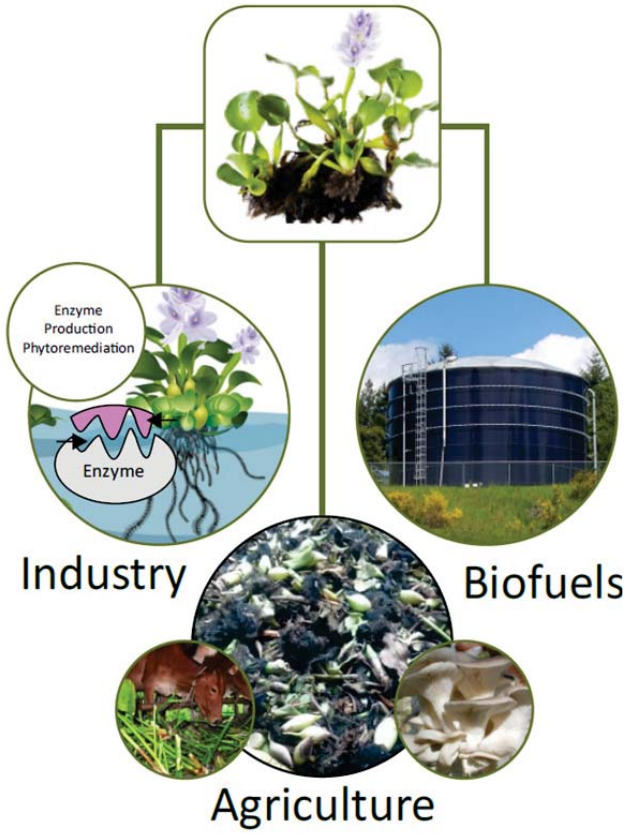

Value-added applications of hyacinth

These strategies also have high labour and cost implications. The complete elimination of water hyacinth from waterways is almost impossible due to the production of hardy seeds by the plant that remain viable for up to 20 years. Of the control methods tested, the physical removal approach is seen as the most efficient. It is environmentally friendly in comparison to chemical approaches and does not require the introduction of exotic species (e.g. weevils) as with biological control methods.

Problems related to the physical removal method are the cost implications and the fact that the removal is usually only temporary. Strategies need to be in place to offset the costs involved in the physical removal of the weed from waterways in order to ensure its economic viability. The removal of water hyacinth plants results in the generation of a sustainable source of organic matter which has numerous applications.

Value-added applications/products of water hyacinth

Industrial uses of water hyacinth

Water hyacinth is composed primarily of water (95%) but it has fibrous tissue with an elevated energy and protein content, hence it can be utilised for numerous applications. One such application is the production of enzymes from water hyacinth residues. These enzymes include cellulases, xylanases and beta glucosidases, which have potential applications in the food, textile and paper industries. The cost of enzyme production is generally prohibitive due to the choice of carbon source used in the process. Water hyacinth is a low-cost carbon source which motivates its utilisation as a substrate in industrial applications such as enzyme production.

Water hyacinth has long been known for its phytoremediation properties. Its function in ecological systems has been likened to that of the kidneys in the human body, i.e. the removal of toxic compounds. However, proper management of the plant is imperative for water hyacinth to retain its advantages as 'nature's kidney'. The phytoremediation properties of water hyacinth have been exploited for the treatment of industrial effluent rich in heavy metals and pigments. The utilisation of the plant in phytoremediation is both eco-friendly and cost-effective.

Applications in agriculture

Agricultural applications of water hyacinth range from compost to animal feed production. Water hyacinth has a low carbon to nitrogen ratio and low lignin content, making it suitable for use as an organic fertilizer. Furthermore, it actively takes up important plant nutrients such as nitrogen, phosphorus and potassium from nutrient-rich waterways which are stored in the leaves and will be released when the organic fertilizer is applied to soil. Water hyacinth derived compost has a high organic matter content which aids in the improvement of soil structure, improving ventilation and facilitating water percolation through the soil.

Water hyacinth has been investigated as a supplementary feed in fish farming. Furthermore, the elevated protein content in the leaves of the plant together with its rapid growth rate has motivated the utilisation of the plant as fodder for farm animals. Studies have also been conducted on the utilisation of water hyacinth in mushroom cultivation.

Biofuels from water hyacinth

Much attention has been drawn to water hyacinth as a potential renewable energy source. The rapid growth of the plant ensures continual availability which is key when selecting a biomass source for sustainable energy production. Water hyacinth has been successfully utilised for biogas, bioethanol, biohydrogen and biobutanol production.

The numerous applications for water hyacinth motivate the need for more research to evaluate the plant from an energy, environmental and engineering perspective. There is definite potential for the conversion of this noxious weed into precious commodities. The Agricultural Research Council is currently undertaking research on the feasibility of using water hyacinth as a feed for anaerobic digestion. This research is funded by the Water Research Commission and is aimed at maximising biogas production from water hyacinth plants. The feasibility of the use of the effluent from the system as an organic fertilizer is also being evaluated.

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Water KIDZ

The wonderful world of freshwater habitats

Water does not only sustain us. It provides a home to some of the world's most interesting creatures.

A dragonfly nymph. The world's rivers support thousands of insects, which provide a source of food for other animals, such as birds and fish.

In addition to being our main source of drinking water our river systems are some of the most species-rich habitats in the world.

There are various freshwater animals that inhabit rivers, wetlands and lakes (or dams in South Africa). Freshwater animals are generally defined as those animals which depend on freshwater habitats for any critical part of their lifecycle.

There are hundreds of thousands of animals that are dependent on freshwater systems, mostly insects. Almost half of the world's fish spend at least part of their lifetime in freshwater. Nearly 4 000 amphibian species (like frogs) can be found in ponds and wetlands. When you add other animals such as molluscs (e.g. snails), crocodiles, hippos and otters to this total, it becomes clear what an important role freshwater systems play in maintaining our world's biodiversity.

It is important to realise that while terrestrial and marine ecosystems have a larger percentage of known species, the relative richness of freshwater ecosystems is higher. This is because these species are restricted to living in a habitat which only covers an estimated 0.8% of the world's surface area.

River systems are also rich in plants species. Reeds and rushes along the shores shelter frogs. Birds and mammals nest and feed in wetland vegetation. In South Africa, we are lucky to also have large animals in some of our water courses, such as otters, crocodiles and hippos.

Plants and algae are particularly important to freshwater ecosystems as they provide oxygen through photosynthesis, and food for animals. In fast streams and rivers many plants have special structures that keep them from being carried away by

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Freshwater systems support up to 14 000 known fish species in the world.

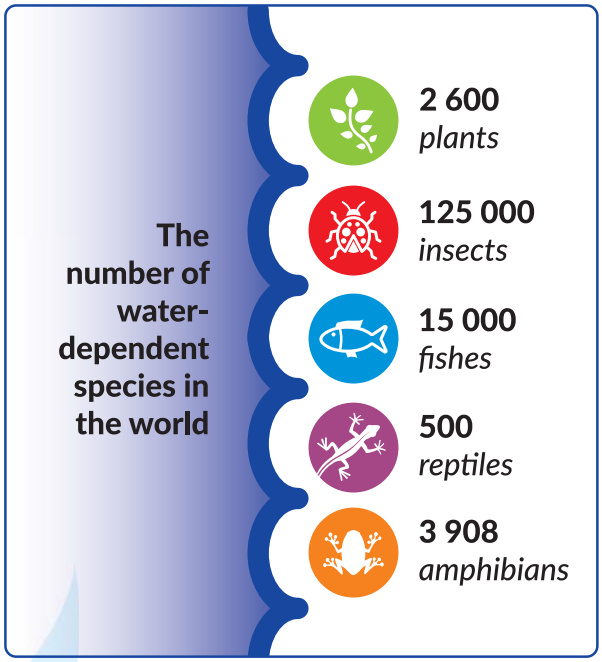
the water. Some aquatic plants have strong roots that keep them anchored securely, while others have stems that bend easily with the movement of the water.

On the other hand, plants such as water lilies float on the surface. Reeds, lilies and other vegetation grow along the shoreline of many freshwater ecosystems.

While South Africa is a dry country we have some special freshwater species. The country has about 300 freshwater fish species. Most of these species are endemic, which means that they are found nowhere else on Earth.

People are dependent on river systems, and not just for their water supply. While about 21% of protein intake in Africa is from freshwater fish, people also make use of freshwater plants for medicine and building material, for example.

Despite their many values, rivers rank among the most degraded ecosystems on the planet. As people we haven't been taking care of their freshwater ecosystems, using and abusing our rivers to the point that many of them don't flow all year round anymore. Other rivers are so degraded that they have little to no life in them.



Source: IUCN

Another threat is invasive alien species. Fish species such as smallmouth, largemouth and spotted bass, all introduced from North America, eat our indigenous fish, and have taken over many of our river systems. Invasive alien trees are also a problem as they shade out our sun-loving species and use excessive volumes of water.

This has not been good for our freshwater plants and animals, with many of these species now threatened with extinction.

We have to start taking care of our river systems and all the creatures that live in them.

Watching the African fish eagle hunt is a majestic sight.

One of South Africa's most endangered riverside creatures is the riverine rabbit. This little bunny is endemic (i.e. found nowhere else) to the semi-arid Great Karoo and parts of the Klein Karoo region of South Africa. The riverine rabbit functions as the flagship species as well as an indicator species for the river ecosystems of the Karoo as its regional extinction in many areas of its former natural distribution range is indicative of the degraded status of the riverbanks along the perennial Karoo rivers. The riverine rabbit is critically endangered and is recognised as one of the most threatened terrestrial mammals in southern Africa.

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WRC SHINES AT BIENNIAL CONFERENCE

As a patron member of the Water Institute of Southern Africa (WISA), the Water Research Commission (WRC) was a prominent participate in the institute's 2018 biennial conference, which took place in Cape Town from 24-27 June 2018.

The central theme of the conference was 'Breaking barriers, Connecting ideas'. The conference, which attracted around 1 500 delegates, sought to address past, existing future water resource challenges by promoting collaboration, cooperation and integration within the water sector.

Senior managers and contracted researchers presented various aspects of the WRC's research, from alternative sanitation technologies, mine-water management, to wastewater beneficiation and programmes aimed at innovation and resilience, to name but a few.

WRC CEO, Dhesigen Naidoo, was also a keynote speaker of the conference. A highlight of the conference was the South-South Dialogue on Water Security: Avoiding Future Water Scarcity and Disasters, which took place on 26 June 2018. The objective of the dialogue was to extract new thinking and paradigms on how we tackle growth with growing water uncertainties.

WRC's Hlengiwe Cele assisting a WISA delegate to download reports at the Commission's exhibition stand.

WRC CEO, Dhesigen Naidoo with Sunita Narain, DG of the Centre for Science and Environment (India), and WRC Executive Manager, Jay Bhagwan.

Grace Metswamere, Letlhogonolo Lemoko, and Sarah Ravhudzulo at the Wader stand.

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11th ICARD | IMWA 2018 Annual Conference
South Africa

11th ICARD | IMWA 2018 Conference

International Conference on Acid Rock Drainage
International Mine Water Association
WISA Mine Water Division

10 – 14 September 2018
CSIR International Convention Centre
Pretoria, South Africa

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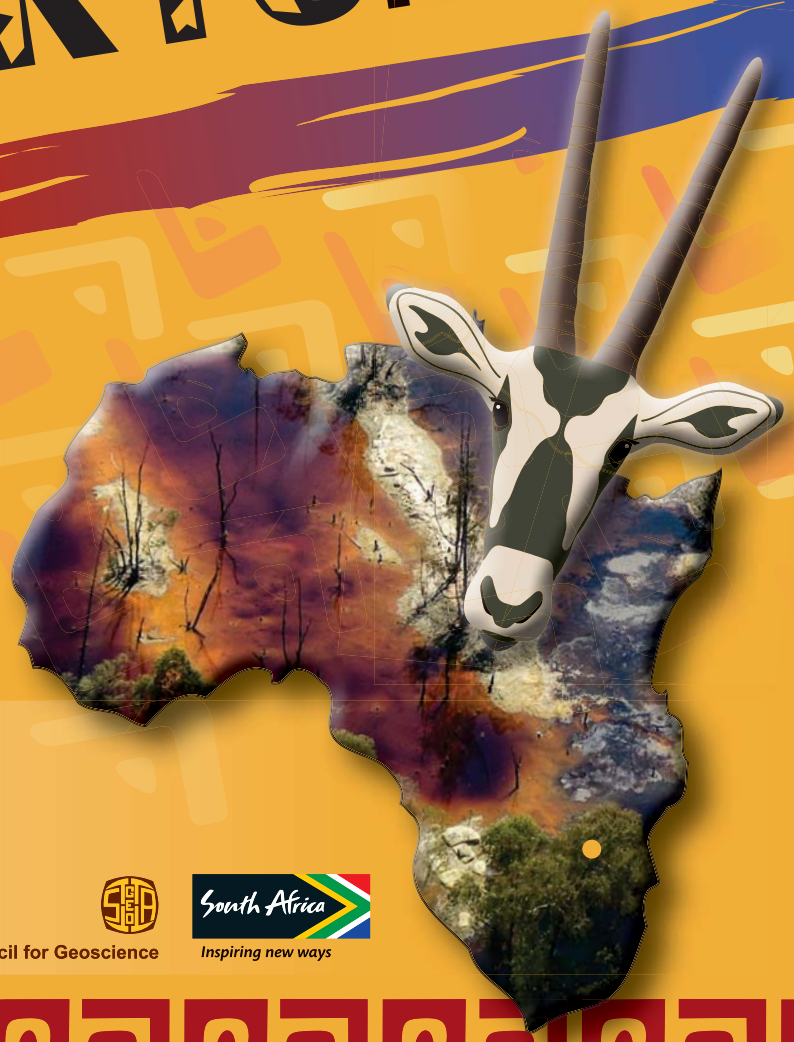

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The Water Research Commission not only endeavours to ensure that its commissioned research remains real and relevant to the country's water scene, but that the knowledge generated from this research contributes positively to uplifting South African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

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

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

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