THE
WATER WHEEL

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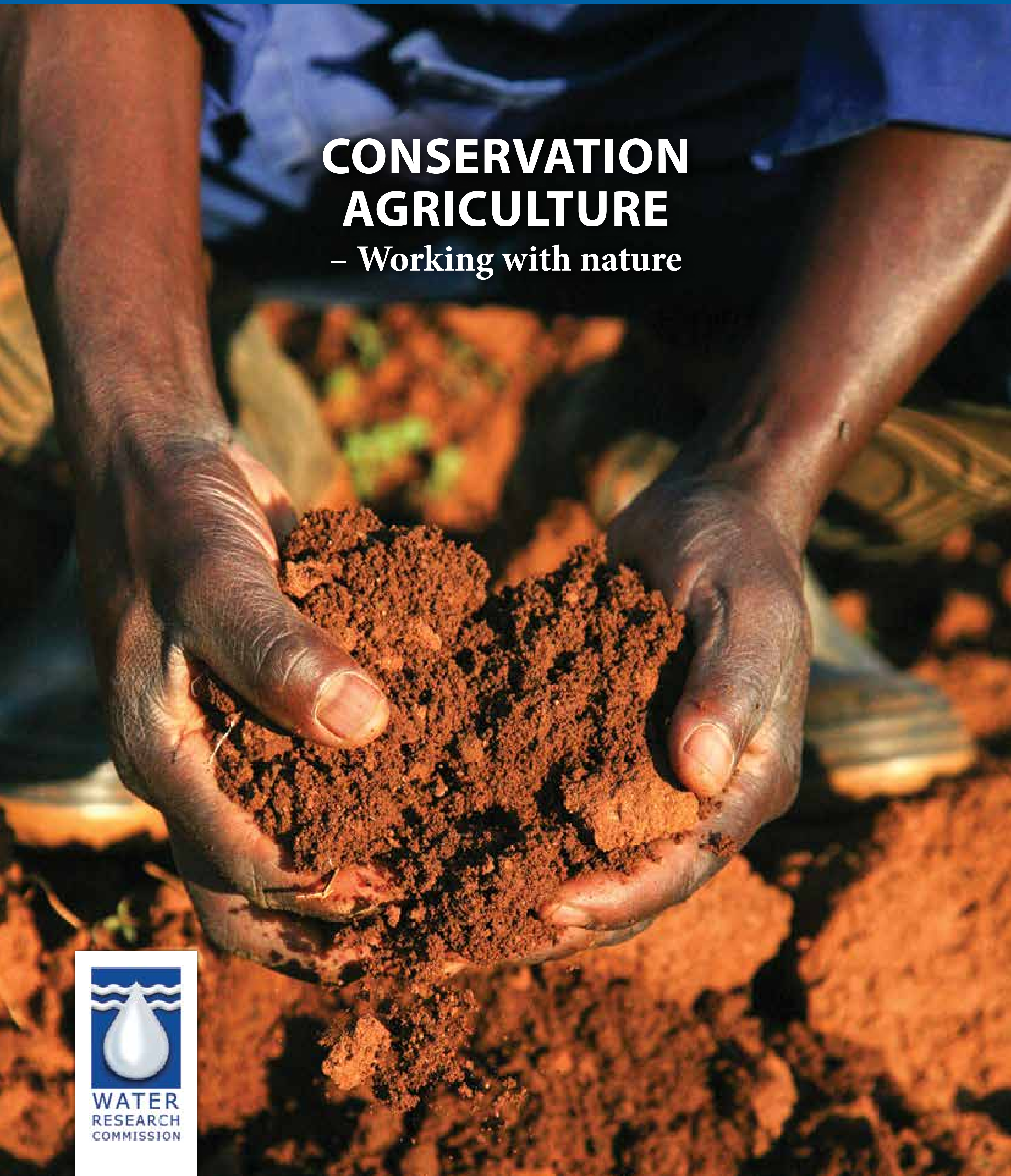

CONSERVATION AGRICULTURE
– Working with nature

WATER RESEARCH COMMISSION

Southern African Society of Aquatic Scientists

SASAQS 2016

26-30 June 2016

Skukuza, Kruger National Park

Dear SASAQS Delegates

Our 2016 congress will be hosted by North West University's Research Unit for Environmental Sciences and Management in the Kruger National Park from 26-30 June 2016.

A panel of international acclaimed researchers will act as keynote speakers with our theme: Aquatic Research, Management and Conservation in a rapid changing world!

This is in the high season school holiday period and therefore we would like to make a special request with you that all registration and accommodation fees will have to be paid by the 1st of March 2016 in order for us to keep the reservation.

We know there are challenges with some of the Academic Institutions and Government Departments and would like to accommodate all of you as far as possible but we will require prepayment as the Society have to pay that over to Sanparks and cannot take the financial risk. The recommendation is that you all make provision for an advance in order to settle your registration and accommodation fees in time. Please note that accommodation cannot be guaranteed in Skukuza.

Please note that purchase orders should also be processed and paid by the 1st of March 2016 to secure your booking, please check the procedure with your financial department to adhere within the timelines. Quotes, Invoices and Statements are available on the online registration system.

- **We can only take reservations for the congress date. (26 June - 30 June) Any pre or post congress bookings should be made directly with Sanparks. www.sanparks.org.**

CONFERENCE SECRETARIAT

Mrs Petrie Vogel - Registration and Administration
Tel: +27 (12) 346 1674, Fax: +27(12) 346 2929
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Abstract deadline: 29 April 2016
Submit abstracts electronically at http://savetcon.conference-services.net/directory.asp

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

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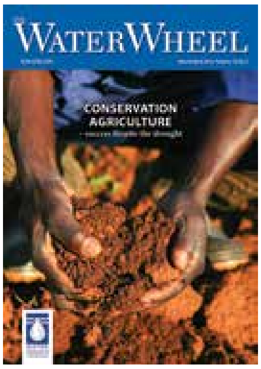


Conservation agriculture is not only producing healthy dividends for South African farmers, but a healthier environment too. See article on page 12. Cover photographer by Pippa Hetherington/Africa Media Online

Fluid Thoughts

WRC CEO, Dhesigen Naidoo

Planning for a new hydro economy

We are at the beginning of 2016 caught in a fearful gridlock of strategic contradictions.

On the one hand we are in one of the tighter economic contractions in recent history, characterised by some of the lowest growth rates in modern times with the general scent of austerity accompanying most national budget policies – around the world. Much of the global economic woes are laid at the doorstep of China's declining growth rate, the lower prediction, from The Conference Board[1] of which is 3.7% in their "Global Economic Outlook 2016" (the IMF forecast is 6.3%[2]). Of course in the same report, the USA is described as "a bright spot in a weak global economy" with a predicted growth rate of 2%.

The general commentary points to an increased Sino-consumption pattern as a core remedy to the global economy. This of course is a vicious circle. China's consumption patterns depend intimately on its earnings from exports. Exports to exactly those countries that can no longer afford these Chinese exports as their own economy is in decline because of lower Sino consumption trends. The chicken is not getting enough nutrition to lay the egg to grow into the next chicken. On both sides of the import/export divide.

Further, the added conundrum is also the primary contradiction. The World Economic Forum cites the failure of adaptation and mitigation measures to global climate change as the number one risk to the global economy in 2016[3]. This supersedes last year's number one risk, namely, the water crisis, and comes on the back of a lukewarm result in COP 21, Paris, in December 2015.

Core to any adaptation and mitigation strategy is a radical shift to lower consumption patterns from local to global levels. Herein lies the fundamental contradiction. If the touted solution of increased Chinese and concomitant global buying patterns as the fundamental remedy to the current economic crisis is realised, then this must mean two steps backward for sustainable development and the global climate change agenda. And yet these conversations occur rampantly in the media as if they have no relationship at all, and sometimes even by the same commentators. If ever we needed innovation and creativity, this is that time.

This conundrum is mirrored in the water sector, and perhaps water can pave the way with an innovative strategy. South Africa's ability to meet the entirety of its national water and sanitation objectives, including the sustainable development goals (SDGs), requires a significant quantum of new investment in both infrastructure and more rigorous operations and maintenance regimes. The traditional model of increased sales to realise sufficient funds for these interventions, aka the global economy, is clearly contrary to the overall objective of sustained and predictable water security. In fact, many of the solutions we have been punting in South Africa, from an ability to deal decisively with leaks and non-revenue water to large-scale adoption of low flush and dry New Sanitation to more efficient irrigation methods and practice to more efficient water use in industry and mining, all point to lower sales volumes. But, this is on the back of an increased recognition of value.

Financial sustainability in the water sector in a sustainable development paradigm rests on three important pillars. The first is water being priced in relation to its value and in line with use efficiency. High efficiency use must be incentivised and low efficiency use must be penalised – at all levels, in all use sectors. The second is that operations and maintenance optimisation must be a legitimate component of the infrastructure budget. The third is an expansion of capability and opportunity to radically increase the size of the water resources team.

It is time to open up the discussion on the sustainability of the model of the state as the sole water service provider. Minister of Water and Sanitation, Nomvula Mokonyane, has been clear that this is not the same as privatisation, and Finance Minister, Pravin Gordhan, in the 2016 budget speech, has opened the doors to innovative models.

We must use them. This is not only about increasing the funding pool for water investments, but can also genuinely increase the size of the South African water team in a manner that guarantees our water security into the future to stimulate and enable the growth we vie for. This water security must be achieved in a manner that ensures a realisation of the constitutional imperative of meeting the basic water and sanitation needs in a reliable and dignified manner for all who call South Africa home.

1 https://www.conference-board.org/data/globaloutlook/
2 International Monetary Fund World Economic Outlook, January 2016
3 World Economic Forum Global Risk Report 2016

University tightens water use

While Gauteng is experiencing one of the driest and hottest summers in years, the University of Pretoria (UP) has to ensure that it adheres to the water restrictions implemented by the City of Tshwane while maintaining one of its biggest assets – its environment.

Fortunately, says Prof Susan Adendorff, Director: Facilities Management, the university has been planning for possible water shortages or water disruptions for quite some time. "Because the infrastructure outside the university has been deteriorating over the past few years, UP has been preparing for possible water shedding for a while.

According to Prof Adendorff, the challenge posed by water shortage is that water, unlike electricity, cannot be generated. "You can use the available water as effectively as possible or you can store it. Those are the only two options you have when it comes to water shortages."

In light thereof the university has initiated an investigation into all the available sources of water on campus for the event of a sudden disruption in the water supply. This entails an investigation into the amount of boreholes on the various campuses, as well as reservoirs such as water tanks on the roofs of certain buildings.

One of the unique water storage facilities of the university is the rainwater harvesting area outside the Mining Study Centre. This area was completed in 2013, and serves as a harvesting garden for rainwater that is used to irrigate the Botanical Garden. It also hosts various water plants. Up to 80 000 litres of water can be harvested and stored here. This facility has a further function because it is often used in research.

Prof Adendorff says all the other lawns and gardens on the campuses are irrigated with borehole water and, where possible, irrigation systems have been adjusted to water the gardens only in the evenings to limit evaporation.

As far as the planting of new plants are concerned, waterwise gardening is implemented by using drought resistant plants. Any new buildings constructed by the University are also built in accordance with waterwise regulations, for instance by utilising grey water where possible.

In addition, a team of consultants have conducted an investigation into the water usage at all the buildings on the campuses and where the water usage was too high, it led to a search for any possible water leaks. These leaks were repaired and this action alone has resulted in big savings.

Diary

Civil Engineering: May 9–10
The South African Institution of Civil Engineering (SAICE) is hosting its annual Civilution Congress at Gallagher Estate, Midrand.
Visit: www.civilutioncongress.com.

Large dams: May 15–20
The 84th Annual Meeting of the International Committee of Large Dams will be held in Sandton, Gauteng. This is the first time since 1994 that this international conference is coming to South Africa.
Visit: www.icold2016.org

Water: May 15–19
The Water Institution of South Africa is hosting its biennial conference at the ICC in Durban with the theme 'Water – the ultimate constraint'.
Enquiries: Jaco Seaman (Conference organiser), Tel: +27 (0)11 805-3537; Email: events@wisa.org.za; Visit: http://www.wisa2016.org.za/

Wastewater technologies: June 13–16
The 13th IWA Leading Edge Conference on Water and Wastewater Technologies will take place in Spain with the theme, 'Evaluating impacts of innovation'.
Visit: http://www.let2016.org/

Water history: June 23–25
The International Conference of the Historical Association of South Africa (HASA) will take place at the Riverside Sun Hotel, Vanderbijlpark, under the theme 'Bridging the disciplinary divide: New routes to understanding the Southern African past?' The conference promises a strong focus on specifically water history. Enquiries: Petra Lawson (conference administrator); Email: conferencepl@gmail.com; Tel: 083 231 6538.

Aquatic science: June 26–30
The annual conference of the Southern African Society of Aquatic Scientists (SASAQS) is taking place in Skukuza, Kruger National Park. Contact Petrie Vogel, Tel: (012) 346 1674, Fax: (012) 346 2929
Email: petrie@savetcon.co.za;
Visit: http://www.riv.co.za/sasaqs/pdf/1st_SASAQS_11Jan2016s.pdf

Geology: August 27 to September 4
South Africa is hosting the 35th International Geological Congress in Cape Town. The event is aimed at, among others, contributing to the advancement of fundamental and applied research in the geological sciences and to provide a space where ideas and information can be exchanged across the geoscience disciplines. Visit: www.35igc.org

World water: October 9–13
The IWA World Water Congress will take place in Brisbane, Australia with the theme 'Shaping our water future'. Visit: http://www.iwa-network.org/event/world-water-congress-exhibition-2016/

Municipal engineering: October 26–28
The annual conference of the Institute of Municipal Engineering of Southern Africa (IMESA) will be held at the East London Convention Centre. The theme is 'Siyaphambili – Engineering for the future'.
Enquiries: Debbie Anderson, Tel: (031) 266-3263; Email: conference@imesa.org.za;
Visit: www.imesa.org.za

Drought leaves 2.5 million in 'crisis' – international agencies

At least 2.5 million are in crisis and require urgent humanitarian assistance to protect livelihoods and household food consumption in southern Africa as a result of current drought conditions.

This is according to a joint statement by the Food and Agriculture Organisation of the United Nations (FAO), Famine Early Warning Systems Network (FEWS NET), the European Commission's Joint Research Centre and the World Food Programme.

Southern Africa is currently in the grips of an intense drought driven by one of the strongest El Niño events of the last 50 years.

Across large swathes of Zimbabwe, Malawi, Zambia, South Africa, Mozambique, Botswana and Madagascar, the current rainfall season has so far been the driest in the last 35 years. Agricultural areas in northern Namibia and southern Angola have also experienced high levels of water deficit.

Much of the southern African sub-region has consequently experienced significant delays in planting and very poor conditions for early crop development and pasture re-growth. In many areas, planting has not been possible due to 30 to 50 day delays in the onset of seasonal rains resulting in widespread crop failure.

Although there has been some relief since mid-January in certain areas, the window of opportunity for the successful planting of crops under rainfed conditions is nearly closed. Even assuming normal rainfall for the remainder of the season, crop-water balance models indicate poor performance of maize over a widespread area.

Seasonal forecasts predict a continuation of below-average rainfall and above-average temperatures across most of the region for the remainder of the growing season. The combination of a poor 2014/15 season, an extremely dry early season (October to December) and forecasts for continuing hot and drier-than-average conditions through mid-2016, suggest a scenario of extensive, regional-scale crop failure.

South Africa has issued a preliminary forecast of maize production for the coming harvest of 7.4 million tons, a drop of 25% from the already poor production levels of last season and 36% below the previous-five-year average.

This drop has increased the region's vulnerability due to the depletion of regional cereal crops and higher-than-average food prices, and has substantially increased food insecurity. FEWS NET estimates that at least 2.5 million people are in crisis on top of the already 14 million food insecure people in the region.

Drought emergencies have been declared in most of South Africa's provinces as well as in Zimbabwe and Lesotho. Water authorities in Botswana, Swaziland, South Africa and Namibia are limiting water usage because of low water levels. Power outages have been occurring in Zambia and Zimbabwe as water levels in the Kariba Dam have become much lower than usual.

While it is too early to provide detailed estimates of the population likely to be food-insecure in 2016-17, it is expected that the population in need of emergency food assistance and livelihood support will increase significantly. Additional assistance will be required to help food-insecure households manage an extended 2016 lean season.

According to the entities, over the coming year humanitarian partners should prepare themselves for food insecurity levels and food insecure population numbers in southern Africa to be at their highest since the 2002/03 food crisis.

SA strengthens water links with India

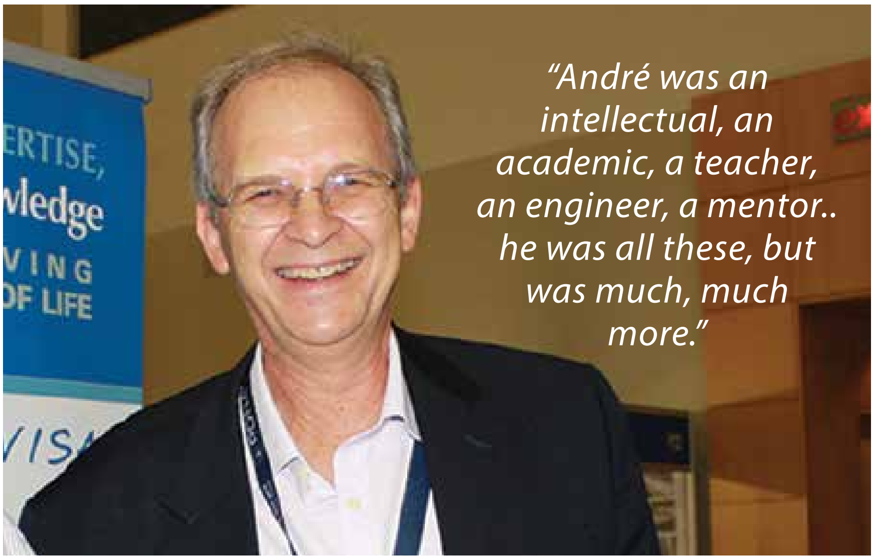
A Water Research Commission (WRC) delegation headed by the CEO, Dhesigen Naidoo, together with officials from the departments of Water and Sanitation and Science and Technology as well as Rand Water formalised a needs-based knowledge partnership for collaborative research, knowledge exchange, dissemination and capacity building with the Centre for Science and Environment (CSE) in Delhi, India.

The aim of the collaboration is to strengthen advocacy campaigns and community engagement and to share lessons in focused research areas of mutual interest. Areas that are being explored include water-sensitive design and planning (rainwater harvesting, decentralised wastewater treatment and faecal sludge management), water–energy issues and climate change, as well as green innovations.

Activities of this partnership will include joint research, workshops, seminars, and conferences, but will also focus on staff exchange initiatives such as short-term visits and training programmes for researchers to help strengthen the capacities of staff from both institutions. In addition to this, the WRC will be the local host and regional hub partner for the various CSE training programmes in Africa.

CSE is a public interest research organisation based in New Delhi (India) and was set up in 1980. It lobbies for and communicates the urgency of development that is both sustainable and equitable. The Centre was a recipient of a prestigious International Stockholm World Water Prize in 2005. CSE's mission is to expand environmental development work focusing on selected countries in Asia and African countries by creating awareness about problems and propose sustainable solutions.

Water sector loses one of its favourite sons



The South African water sector is mourning the loss of one of its favourite sons.

A founding member of Golder Africa and one of its first African Principals, Dr André van Niekerk died on 14 January at the age of 62 following a short battle with cancer.

Dr Van Niekerk served Golder with distinction in many roles ranging from the Engineering Business Unit Leader, Board member of Golder Africa, Zitholele and Global Golder, and recently as a strategic advisor and mentor for the Engineering Business Unit.

Commented colleague, Dr Ralph Heath: "André's biggest technical strength was his clarity of mind. He was able to analyse the most complex water treatment issues and come up with a simple solution. He was a respectful listener, but when he talked we all listened as he invariably had the solution. He was well respected globally and through his expertise Golder designed the two largest mine-water treatment plants in Africa and the first biogas-to-energy from sewage process."

Dr van Niekerk also served the water sector through various other ways. His contributions ranged from pioneering in-stream water quality requirements, global acid rock prevention guidelines, water reuse and desalination strategies, large-scale active mine-water treatment plants, and more. He also worked in collaboration on water-treatment projects throughout the world.

"André was an intellectual, an academic, a teacher, an engineer, a mentor..he was all these, but was much, much more," says Water Research Commission Research Manager, Dr Jo Burgess.

"In a world of cynics, André always held the candle of hope. His heart and his kindness will always be remembered, and his integrity and ethos will live on in the hearts of all who had the privilege of knowing and working with him."

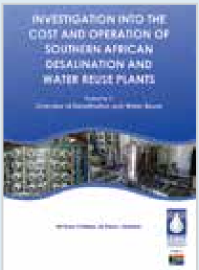
SA groundwater doyen dies

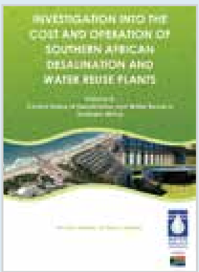
The South African water sector is mourning the loss of one of its 'fathers' of hydrogeology.

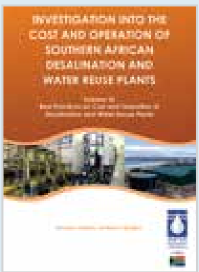
Johannes Roelf Vegter passed away on 6 January at the age of 91. A hydrogeologist, he was one of the Groundwater Division's founding members and was a recipient of the Groundwater Medal. He was widely acknowledged by his peers for his meritorious and outstanding service and dedication to furthering the science and technology of groundwater.

Mr Vegter will be fondly remembered by his family, friends and colleagues. He bequeaths the groundwater community with a wealth of knowledge gained and shared throughout his illustrious career.

New from the WRC







Report No. TT 636/15 to TT 638/15

Investigation into the cost and operation of Southern African desalination and water reuse plants

The aim of this project was to capture real operational and maintenance data (including associated costs) of selected desalination and water reuse plants, as well as to establish a first-order knowledge base for these types of projects in the augmentation of water supply in a southern African context. Volume 1 provides background and insight into desalination and water reuse. Volume II follows with a report on the current status of desalination and water reuse in Southern Africa. Volume III presents descriptions of the selected plants and their main processes, as well as summaries of the capital costs and operations and maintenance costs. The report then provides unit costs and comparisons with the other plants, and finally presents summaries of lessons and best practise in desalination and water use.

Report No. 2113/1/14

Integrated water sector skills intervention map based on a sector skills gap analysis

This project was commissioned by the WRC on behalf of the Department of Water and Sanitation in response to repeated declarations that the water sector in South Africa was lacking (and losing) skills necessary to plan for and maintain the supply of water services to the public. The research project provided a technologically up-do-date method of arriving at the evidence required to take management decisions on the situation described.

Report No. 2181/1/15

Ephemeral wetlands of the Nelson Mandela Bay Metropolitan Area: Classification, biodiversity, and management implications

In order to standardise and formalise the identification, delineation and typing of wetlands, many tools and methods have been developed to assist researchers, managers and practitioners. The research presented in this report was designed to utilise the tools that have been developed nationally and apply them to wetlands in the Nelson Mandela Bay Metropolitan area.

Report No. 2132/1/15

Advanced oxidative water treatment process for water disinfection using an electrohydraulic discharge reactor and TIO_2 immobilised on nano fibres

This project investigated the design and methods for applying electrical energy to single or multiple electrodes. The project also aimed to investigate optimisation of the whole electrohydraulic discharge reactor system, as well as detection and quantification of the free reactive species, both of which have been some of the most challenging tasks in previous WRC-funded projects.

Report No. TT 639/15

MiniSASS data management: Development of an online man-based data portal

MiniSASS, a community river health monitoring tool, marries

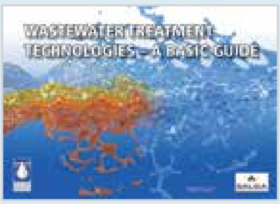
WRC Executive receives international recognition

During the 66th meeting of the International Executive Council of the International Commission on Irrigation and Drainage (ICID), Water Research Commission Executive Manager: Water Utilisation in Agriculture, Dr Gerhard Backeberg, was awarded for his work in the sector.

Specifically, Dr Backeberg was recognised for his contribution as Chair of the ICID Task Force on Financing Water for Agriculture between 2009 and 2013.

The task force was set up to broaden the scope of analysis and to clarify concepts and approaches on financing irrigation, by taking stock of various experiences through a cross-country analysis of policies, strategies, current situations, mechanisms and practise regarding irrigation financing. The task force has helped to gain a better understanding and insight of the required investments in agricultural water, and the beneficiaries of these investments; the presently available financing mechanisms and constraints for maintaining or improving physical irrigation capacity; and the expected changes and innovations for more appropriate financing mechanisms to enable sustainable water use for food production.

community participation and a simple aquatic biomonitoring technique to determine river health. This project was initiated to further develop the miniSASS package as a citizen science health monitoring tool through the development of a dedicated website and tailored database for the universal capture, exploration and sharing of miniSASS data by citizens.



Report No. TT 651/15

Wastewater treatment technologies – A basic guide

Wastewater treatment works (WWTW) are just one of the many uses of water that are required when development takes place. In order to ensure that the development takes place in a manner that will be sustainable the WWTW chosen needs to be a technology type that will be suitable for a particular development and not necessarily the best available technology. The purpose of this guide is to graphically illustrate the journey of sewage from collection, conveyance, treatment and discharge to the environment. The guide includes liquid and sludge components.

Report No. 2246/1/15

The use of GIS and remote sensing techniques to evaluate the impact of land use and land cover change on the hydrology of Luvuvhu River catchment in Limpopo Province

This study was undertaken to evaluate the impact of land cover and land use change on the hydrology of Luvuvhu River catchment. The results of the study will be of significance by way of detecting the cause-effect relationships of human induced changes to the hydrology and water resources in the catchment. The information derived will help prevent the potential for human conflict over diminishing resources and disease outbreaks related to waterborne vectors.

Report No. KV 329/15

Review of the use of Earth observations and remote sensing in water resource management in South Africa

The main aim of this study was to assess the use of Earth observation and remote sensing technologies in the efficient and integrated management of water resources in South Africa and to identify research gaps that constrain the full use of these technologies. The study illustrated the manifold advantages of using Earth observation and remote sensing in managing the country's water resources. It illustrates the current uses and applications as well as the many sources of data that can be exploited. The need for capacity, competencies and infrastructure required to fully utilised the potential of these technologies is discussed.

Report No. 2083/1/15

Empowerment of women through water use security, land use security and knowledge generation for improved household food security and sustainable livelihoods in selected areas of the Eastern Cape

This research set out to quantify the different land, water, infrastructure and knowledge resources at the disposal of rural people in three villages in the Eastern Cape, and documented their agricultural aspirations and challenges. A set of eight intervention strategies was formulated to facilitate multiple parallel avenues of smallholder development, coordinated through a participative watershed development approach and underpinned by reflexive knowledge-networking systems.

To order any of these reports, contact Publications at Tel: (012) 330 0340, Email: orders@wrc.org.za or Visit: www. wrc.org.za to download an electronic copy.

Projects in Progress

Assessing the impact of alien plants on water quality

It has long been known that removing invasive alien vegetation can improve water quantity in a catchment, but does it also influence water quality? This is what conservation ecologists from Stellenbosch University (SU) are trying to find out by taking a closer look at how the quality of river water improves once invasive black wattle is removed.

"The current drought conditions are a stark reminder that water is the most limiting natural resource to development and a sustainable future for South Africa, and that we should take special care of it," notes Dr John Simaika of the SU Department of Conservation Ecology.

He received a grant from the Water Research Commission (WRC) to study how the removal of black wattle (*Acacia mearnsii*) trees impact the surface water quality of rivers. The project is run in collaboration with colleague, Dr Shayne Jacobs, and is being co-funded by the Department of Science and Technology.

Black wattle is ranked as one of the invasive species that have over the years caused the most damage to the distribution of riparian plants and animal life that are found naturally around the rivers of the Cape Floristic Region.

It is well known that the removal of these fast-growing and water-thirsty invasive plants around rivers help to increase water flow and availability. In the process, natural vegetation such as fynbos, gets a chance to regrow, while local insect species such as dragonflies often return to an area. This has been seen in many cases where tracts of invasive plants have been cleared.

"While we know that clearing efforts improve water volume, little is currently known about the effect that these initiatives have on the actual quality of the surface water that passes through these cleared areas," explains Dr Simaika. Good quality water is needed to ensure that the various lifeforms that rely on a river system are able to persist or return once a site has been cleared.

"The project will close a major research gap on the quality of water after clearing, and also about the dynamics behind stream ecosystem recovery," he believes.

Black wattle takes up nitrogen from the atmosphere and then enriches the soils in which these plants grow. This process of nitrogen fixing may boost the invasive plants' ability to outcompete the natural plants around it. Researchers do not yet know what happens to the nitrogen in the soil once the invasive plants are removed.

"We want to find out if it washes into the streams during rain events, if it enters groundwater or does it have a negative effect on stream health," Dr Simaika explains some of the research questions that he hopes to answer. "Cape streams are typically nutrient poor and therefore an increased nitrogen load could potentially have negative knock-on effects on algal growth and even the diversity of bigger insects."

The main aim of the project is to focus on the nitrogen cycling in soils within stands of black wattle and whether clearing efforts have a positive spin-off for the aquatic plants, insects and animals that naturally occur around South African rivers.

Three MSc students are part of the project. Zaid Railoun is investigating the rate of nitrogen fixation by Acacia plants, and how digestible their leaves are to bigger insects that forage on instream leaf litter. Kenwinn Wiener is studying the amount of sediment trapped by the extensive root systems of black wattle and then settles at the river bottom and banks. "It is likely that detritus trapped from black wattle will significantly increase the amount of nutrient in the sediment, says Dr Simaika.

The third student, Jay-Dee Don is studying the water plants and animals that are found around rivers, and what the effect of clearing invasive plants are on the various organisms that serve specific purposes within the water system. This includes algae, filter feeders and predators. "Measuring such functional diversity can be very informative and helps to tell you whether a specific area is healthy or impaired," Dr Simaika explains.

Commented WRC Research Manager, Bonani Madikizela, on the project: "The WRC is very keen on supporting research around the control and management of invasive alien plants. These plants have an extremely negative affect on our limited water resources – a situation that is worsened by drought and climate change."

Researcher, Dr John Simaika, of Stellenbosch University's Department of Conservation Ecology.

One of the team's field experiments.

THE WATER WHEEL

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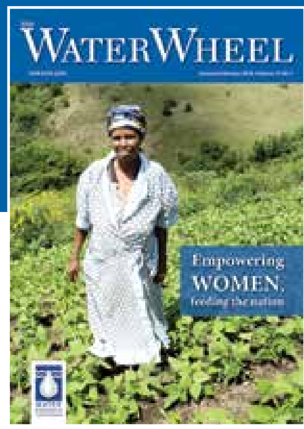

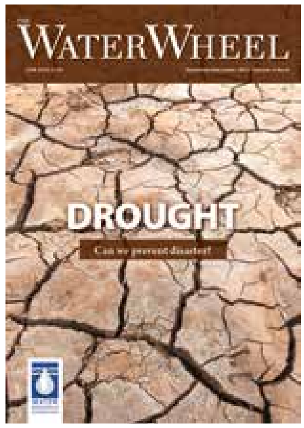

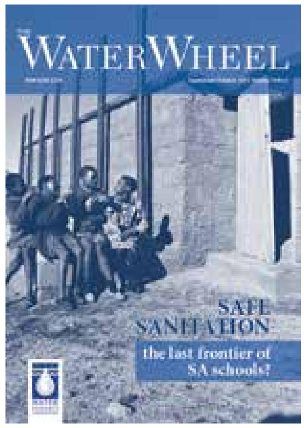

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WATER RESEARCH COMMISSION

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Water and agriculture

Conservation agriculture: Farming for the future

Conservation agriculture is proving well worth South African farmers' investment.

Article by Petro Kotzé.

Traditionally, a farmland is a neat block of upturned soil, divided into clean rows devoid of any vegetation, ready to be sowed with seeds. Though pleasing to behold, the consequences have not always been as pretty. "According to research, we are losing about three tons of topsoil per hectare each year per ton of maize that we produce," says Dr Johann Straus from the Research and Technology Development Services of the Western Cape's Department of Agriculture. A specialist in sustainable cropping systems and conservation agriculture, Dr Strauss is one of a growing group of researchers and farmers calling for more sustainable farming methods.

Zero tillage conservation agriculture

"Conservation agriculture is an alternative way of doing; it entails breaking away from the old way of breaking down earth to plough," explains Dr Strauss. He adds that if he has to sum it up, he would describe it as a sustainable farming method. Yet, perhaps more importantly if conservation agriculture is to become successful: "It is a mind shift."

Conservation agriculture is based on the three principles of minimum soil disturbance, maximum cover and crop diversification. Most available literature would include at least these key elements when discussing conservation agriculture, otherwise known as ZT/CA. The soil is not cultivated, crops are rotated over the years and crop residues are left on the surface.

Because the soil is thus left undisturbed and permanently covered, "conservation agriculture doesn't always look as pretty as conventional agriculture," explains Dr Strauss. Furthermore, no burning takes place and seeding is done directly into previously untilled soil, with specialised seeding equipment designed to plant seeds into undisturbed crop residue and soil.

This calls for an almost complete opposite approach to agriculture when compared to conventional methods. "Seeing as we're trying to not disturb the soil at all, we do not plough anymore," notes Dr Strauss.

The benefits are plentiful. Conservation agriculture allows the soil to recover from degradation that would have taken place due to traditional practices, and increases organic matter in the soil, and biology as a whole. Because the soil is not cultivated with heavy machinery, soil compaction is reduced, which leaves the old root holes to facilitate internal drainage.

The pulverisation of soil aggregates and formation of pans is averted, draft power for planting is reduced and fauna is provided with shelter, winter food and nesting sites. Crop residues on the surface practically eliminate wind and water erosion, reduce soil moisture loss through the mulch effect, and act as a reserve of organically-compounded nutrients as they decompose to humus.

In a nutshell, if you a want to improve the health of your soil, move away from tilling, manage nourishment and pest control with deeper insight work, improve on biodiversity though cultivating more crops and even cover crops in a rotational system, keep soil cover as optimal as possible and pick the fruit of better returns and lower input costs.

The technique has gained traction internationally, particularly in Brazil, one of the first countries to apply it. As is often the case, the movement towards more sustainable and profitable agricultural practices here were driven by necessity. Their entire agricultural industry was threatened by the devastating effects of soil erosion, fuelled by torrential rainstorms common to the southern region. After many unsuccessful attempts, they focused on erosion control through continued cover of the soil. Soil conservation became central to their sustainable farming activities, the central pillar of which is zero tillage.

The movement was spearheaded by farmer Herbert Bartz in southern Brazil, who adopted ZT/CA farming in 1972. Ten years later, efforts to expand cultivation into the very difficult production region of the Cerrados, in Brazil's centre-western savannah (Cerrado biome) were initiated by farmers, researchers, crop consultants and the agro-industry.

Pioneering work was done here by agronomist John Landers. Bartz and Landers are now both widely recognised as forerunners of the movement and key to achieving social, economic and environmental sustainability though ZT/CA. Their work contributed to the reversal of the historically accelerating degradation of soil organic matter and soil structure by abandoning conventional tillage. Adoption of the ZT/CA philosophy and technologies is currently practiced on more than 50% of the annual crop area in Brazil.

In South Africa, the movement started about 35 years ago, though it is still applied in relatively few numbers. For some crops, like rooibos, it's still very much in the beginning phases. For others, like wheat, which is one of the first crops where conservation agriculture was applied and experimented with, the impact has already been astounding.

One of the features of conservation farming is the alternation of crops.

Conservation agriculture in South Africa

In 2013, the Directorate Plant Sciences conducted a survey to assess the adoption and impact of conservation agriculture among wheat producers in the Western Cape. The data was analysed by the Economic Analysis Unit of the Agricultural Research Council (ARC). The information obtained from the survey, along with data from long-term crop rotation trials at Langgewens and Tygerhoek research farms were then processed by the ARC.

At the time of the survey, 166 000 ha of wheat was grown using conservation agriculture methods. The financial benefit to the province from these methods was determined at R341 million since the introduction of conservation agriculture, though that was thought to be very conservative figure.

Farmers (84%) reported an increase in total production, while 94% indicated that total income per ha has increased. It was found to be 16,5% more expensive to fertilise using conventional methods than with conservation agriculture. The average cost to produce three tons of wheat using conventional methods was R4 444/ha, compared to the R2 387/ha using conservation agriculture.

As a result of the application of conservation agriculture, the Western Cape is currently producing nearly double the amount of wheat on less than half of the area previously planted with wheat. Results from the Langgewens long-term crop rotation trial speaks directly to the increase of wheat production within crop rotation systems.

It's tough to argue with the benefits, which is perhaps why the use of conservation agriculture methods among wheat producers in the Western Cape has increased from 5% in 2000 to 60% in 2010, and the idea is slowly taking root more widely, including more types of crops.

"We were approached by rooibos farmers in 2003 for assistance," says Deon Heydenrych, also from the Western Cape Department of Agriculture's Sustainable Resource Management branch. Farmers were reporting that while their parents were able to get five to seven harvests per plant, they were getting less and less, and often only managed four harvests per plant.

Traditionally, rooibos fields were ploughed, and the residue burnt before the plot is left to sterilise in the sun for two years. After those two years during which wind and rain removed a lot of good topsoil the rooibos is planted and during its lifetime weeding is done by ploughing between rows. In most soils continuous ploughing over time creates a plough-pan at the depth of the bottom of the plough disc that hinder water and roots to enter deeper into the soil. Where conservation farming is applied to an old land, the land is first inspected to see if a plough-pan is present. If so a deep tine is used to break it. Soil samples is taken and chemical corrections applied if necessary. Then the whole land is planted with oats by the use of a conservation farming planter. At planting of the rooibos, narrow rows are cleared were the rooibos is to be planted between the oats in double rows like train tracks with an open space before the next two rows are planted. This open space, wide enough for a tractor to drive down is used to build up the soil with cover crops. When the current tea comes to the end of its lifetime, the new rooibos will be planted down this open space and were the old tea was flattened with a knife-roller the build-up of soil with cover crops are starting again.

Where conservation agriculture is applied, the plot only lies for one year between rooibos crops instead of the traditional two and the soil is covered instead of being ploughed/burnt clean and left in the elements. Rooibos is planted in the two 'train track' rows with a broader lane in between planted with cover crops. The first two years this will be natural cover, while years three and four is usually lupine. This is then followed with oats again.

During weed control in the conservation farming rooibos lands a boom sprayer is not used anymore to spray the whole land like in the past with traditional rooibos plantations. A knife-roller is used to break the food channels and flatten grassy weeds and broadleaf weeds are spot sprayed with a rucksack sprayer or handgun sprayers connected to a spray tank pulled by a tractor.

Butch talks about conservation agriculture.

Producers, trade and researchers discuss conservation agriculture.

One of the joys of conservation agriculture is seeing life, like earthworms, return to the soil.

According to Heydenrych their results have been very positive, particularly in terms of the biodiversity that quickly increased. "Things that were not previously there, returned," he says. Earthworms were suddenly found in the soil again, and couch grass and gerbils returned. A solution for the latter was made by erecting poles to attract birds of pretty to the fields to catch the gerbils.

"Sometimes dune mole-rats give us problems. Then you have to think about how to control them without hurting mole snakes." The biggest change, is changing the way that you think, he says. The producer now has to think innovatively about solutions to problems that will still keep the soil as healthy as possible.

Heydenrych says a challenge that they are currently dealing with is weeds that also returned to the fields. "We are looking at chemical and mechanical control, though the latter is not ideal as the goal is to not disturb the soil." They are also looking at using different cover crops, efforts which are hampered by the previous year's below average rainfall coupled with very hot temperatures. "It's still completely a story in development," he says, "but we simply have it make it work."

Though there has not yet been higher yield from the rooibos plots where conservation agriculture is applied, certain costs have declined significantly. "According to Heydenrych, there has been a 50% reduction off fuel cost alone.

This is echoed by Dr Strauss, who says: "There are growing pains, but you have to stick it out. The biggest hurdle is the cost of the machinery. It takes about five years to get the system going and start reaping the benefits, but making the mind-shift is the most difficult."

Surging ahead

"We believe it has to be the accepted method of farming in South Africa," maintains Dr Strauss. Though policies are in the process of being developed, he says that there are still challenges. "We do have the support from the industry, but we need to help them to make the transition." He adds that discounts can perhaps be implemented to help producers carry that financial cost of making the transition, until they see the financial benefits.

More plans include expanding on the cash crops currently produced under conservation agriculture. At the moment, these are mainly canola, grain and legumes. "We'd like to see more diversity of cash crops as well as cover crops. Furthermore, as soon as our cover crops take off, it can be applied as a management resource."

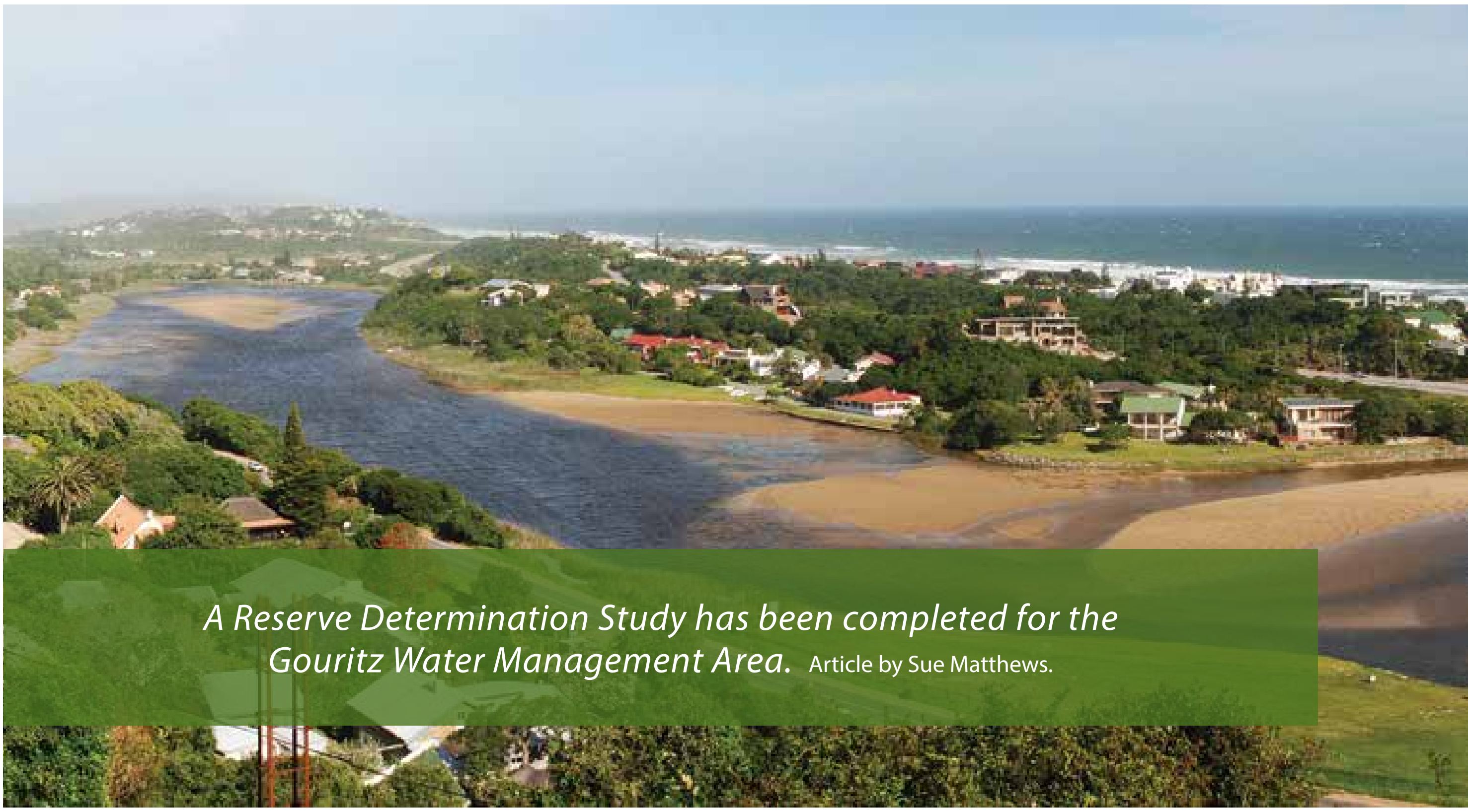
Research is also focusing on developing more low-input agriculture, trials of which are set to start this year. "Though we are spraying considerably less than usual, we are still depending on insecticides. The next step would be to move away from it completely, and we'd like to fine-tune that system," says Dr Strauss.

Heydenrych says he has received phone calls from farmers who say that they do not agree with the new methods, but that they have no other choice. "For me, it became clear very early on that it is about more than merely the implementation. It is about the entire biodiversity, including insect, organism, owls and so forth."

"We cannot afford to lose more of our topsoil," says Dr Strauss. "We have to realise that the old ways of doing things are over."

The environment and water

New study steers integrated management of Gouritz water



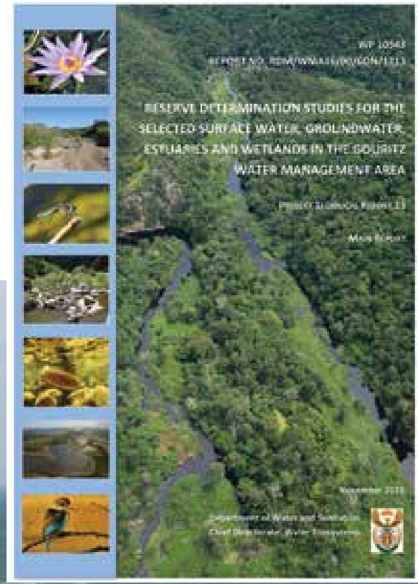
A Reserve Determination Study has been completed for the Gouritz Water Management Area. Article by Sue Matthews.

The Gouritz Water Management Area (WMA), covering an area of approximately 53 000 km^2, was one of 19 WMAs delineated in the 2004 edition of the National Water Resource Strategy, but consolidated into nine in 2012. The Gouritz WMA was merged with the Breede-Overberg WMA to form the Breede-Gouritz WMA, but by then the tender process for the Gouritz Reserve Determination Study had been completed, and project planning was underway. The tender was awarded to a consortium of specialists, with Aldu le Grange of AECOM (formerly BKS) heading up the project management component and Patsy Scherman of Scherman Colloty and Associates the technical component.

The study was motivated largely by the need to determine the Reserve – the quantity and quality of water required to protect aquatic ecosystems and meet basic human needs – before various applications for water licences that had been made to the then Department of Water Affairs (since renamed the Department of Water and Sanitation) could be processed. The 2009 to 2011 drought in the Central Karoo and Southern Cape had highlighted the precarious nature of water supply in the area, and there were concerns that existing and planned development could aggravate the situation, while also threatening the conservation status of priority water resources.

In brief, Reserve determination studies involve an EcoClassification process and an Ecological Water Requirements (EWR) determination. During EcoClassification, the health of the various biophysical components – such as instream or estuarine habitat, hydrology, water quality, and plant and animal groups – is compared to their likely pristine, natural state, known as the reference condition. The causes of change are identified, and a Present Ecological State (PES) is allocated within a range of ecological categories from A (near natural) to F (critically modified). The Ecological Importance and Sensitivity (EIS) is evaluated – or Estuarine Importance scored in the case of estuaries – and the Recommended Ecological Category (REC) is set, taking into account the importance rating, the potential for restoration and the ability to attain it. The REC is designed to maintain the PES if importance is low or moderate, or improve the PES if the importance is high or very high.

The Reserve Determination Study which has been completed for the Gouritz Water Management Area.



Sue Matthews

The EWR Determination component entails assessing the consequences of altered flows, before making recommendations on the volume and duration of high and low flows for each month of the year. Finally, a monitoring programme is designed, incorporating ecological specifications and thresholds of potential concern. Ecological specifications allow predictions made during the study to be tested, while thresholds of potential concern are effectively 'red flags', prompting investigation into the cause of severe change and the need for corrective management action.

Rivers

The main rivers in the WMA are the Gouritz and its major tributaries – the Buffels, Touws, Groot, Gamka, Olifants and Kammanassie rivers – but smaller rivers drain the coastal belt, which experiences year-round rainfall reaching 865 mm per year in places. The river component of the Reserve determination study was conducted by a team of subject specialists headed by Delana Louw of Rivers for Africa, and began with a desktop EcoClassification exercise to describe the status quo with respect to water use, river ecology, water quality problems and ecosystem services. It also included the identification of ecological hotspots, where further investigation would be required if development was being considered.

Based on this information, Ecological Water Requirement (EWR) sites on 10 rivers were selected for more detailed assessments. Half of these – on the Duiwenhoks, Goukou, Doring, Olifants and Kammanassie rivers – were rapid-level assessments, while those on the Gouritz, Gamka, Touws, Buffels and Keurbooms rivers were intermediate-level assessments. All sites were surveyed during two field trips in April and July 2014, the only difference being that the geomorphology component was excluded from the 'rapid' sites. The specialists also relied on existing information from the River Health Programme, Google Earth images and historical aerial photographs, distribution maps of vegetation types and of plant and fish species, and even historical accounts of vegetation by early explorers. However, long-term records of flow and water quality data are most important for increasing confidence in the assessments, and these are not always available because gauging weirs are few and far between – highlighting the importance of maintaining and calibrating those that do exist.

The Touws River EWR site was found to be in the best overall condition, with a PES of B/C, despite the fact that the mean annual runoff is only half what it was in the pristine, natural state. Although the EIS is high and the REC should therefore be set at a B, any improvement in condition would likely require an increase in baseflows and small floods, which is not possible without additional infrastructure or restrictions of allocation. It was therefore recommended that flows be set to maintain the PES.

Estuaries

There are 21 estuaries in the study area, from the Bloukrans in the east to the Duiwenhoks in the west, but 11 of these had already been assessed in previous Reserve determination studies. The specialist team, which was led by Susan Taljaard of the CSIR, re-assessed the 2008 Reserve results for the Keurbooms Estuary. Five other estuaries that were rated low priority due to development pressures and/or protection status – the Hartenbos, Blinde, Piesang, Groot (Wes) and Bloukrans – were subject to a desktop assessment.

Rapid-level assessments were done for the Wilderness and Klein Brak estuaries, while the Gouritz, Goukou and Duivenhoks estuaries were selected for more detailed intermediate-level assessments. In December 2013, field surveys were conducted for these five estuaries, and some additional data was collected for the Keurbooms. Where available, the specialists also drew upon existing information from DWS river inflow gauges and water quality monitoring stations, estuary water level recorders, previous surveys , bi-annual sampling by DAFF fisheries staff, and Coordinated Waterbird Counts, better known as CWAC counts.

More than half of the estuaries in the WMA were found to be in good to excellent health, with those in the best state typically being small estuaries in protected areas, such as the Bloukrans in the Tsitsikamma section of the Garden Route National Park and the Goukamma in the provincial nature reserve of the same name. Small estuaries in urban settings, such as the Hartenbos and Piesang, are in a poor condition, while larger estuaries are generally more resilient as they are well flushed by strong tidal exchange or have a higher absorption capacity through, for example, dilution of pollutants or nutrient uptake by plants. However, larger estuaries tend to be more affected by catchment pressures, development in the floodplain and overfishing.

Wetlands

Wetlands occur at a low density in the dry interior of the Gouritz Water Management Area compared to the coastal belt, but there were nevertheless too many to assess on an individual basis. The Reserve determination – conducted by Mark Rountree of Fluvius Environmental Consulting with input from other specialists and stakeholders – therefore relied upon a desktop-level assessment in which the average PES and EIS for wetlands in each quaternary catchment was determined (although those catchments with less than 0.5% wetlands by area were excluded). The results revealed that where wetlands do occur in the interior they are important for livestock grazing, trapping flood flows and recharging the water table, and they tend to be in better condition on average than coastal wetlands, which are heavily impacted by urban development, agriculture and forestry.

The condition of 33 priority wetlands was also scored in terms of biodiversity, hydrology and physical condition, which gave an indication of the PES. These wetlands were then ranked

Table 1: The results of the Ecological Water Requirements determination for the river sites, expressed as a percentage of the natural Mean Annual Runoff

EWR Site	River	EC	nMAR (MCM)	pMAR (MCM)	Low flows (MCM)	Low flows (%)	High flows (MCM)	High flows (%)	Total flows (MCM)	Total flows (%)
H8DUIW-EWR1	Duiwenhoks River	D	83.7	79.8	14.2	17	8.2	10.2	22.7	27.1
H9GOUK-EWR2	Goukou River	C/D	54.1	46	7.1	13.1	4.3	13.9	11.4	21.0
J1TOUW-EWR3	Touws River	B/C	45.2	22.3	1.15	2.6	11.5	25.6	12.7	28.2
J2GAMK-EWR4	Gamka River	C	85.5	61.7	3.9	4.6	17.4	20.4	21.4	25.0
J1BUFF-EWR5	Buffels River	C	29.3	18.7	1.4	4.7	6.9	23.3	8.2	28.0
J4GOUR-EWR6	Gouritz River	C	543.5	310.4	27.1	5.0	102.5	18.8	129.6	23.8
J1DORI-EWR7	Doring River	C/D	4.5	2.0	0.4	8.5	0.6	14.3	1.03	22.8
K6KEUR-EWR8	Keurbooms River	B/C	49.8	30.5	10.7	21.4	8.7	17.4	19.3	38.8
J3OLIF-EWR9	Olifants River	C	13.8	11.3	0.5	3.9	3.1	22.2	3.6	26.1
J3KAMM-EWR10	Kammanassie River	C/D	20.6	19.6	1.8	8.9	2.8	13.5	4.6	21.0

nMAR: natural Mean Annual Runoff
pMAR: present day Mean Annual Runoff
MCM: million m^3
EC: final Ecological Category for management of the rivers

The Gouritz Estuary (left) end river (right)

according to their threat status, so that highly threatened wetlands with high PES could be identified. Two of these – the Bitou floodplain and the Duiwenhoks unchannelled valley bottom wetland – were selected for rapid field assessments, conducted during December 2014. The information collected was used to verify the desktop data, determine the Ecostatus (PES, EIS and REC) and recommend management actions aimed at halting or reversing degradation.

On a broader scale, nine Wetland Resource Units (WRUs) – areas with similar wetland types and processes – were delineated for the WMA, and ecological specifications for the management of wetlands within these WRUs recommended.

Groundwater

Groundwater is the dominant water resource in the drier inland region of the Gouritz WMA, becoming even more important during droughts, when dams dry up. The specialists – Koos Vivier and Reuben Grobler of Exigo – delineated groundwater resource units (GRUs) in the WMA and then conducted a desktop, rapid-level Reserve determination for all 130 quaternary catchments. The results indicated that 28 of these catchments are potentially stressed, and were used to identify priority areas for further investigation in a field survey. Almost 100 boreholes and springs were surveyed, and information on groundwater levels, utilisation and quality collected.

Using this information, these 28 catchments were modelled in more detail as part of an intermediate-level Reserve determination. The results showed that – if the Reserve requirements are to be met – eight of the catchments would potentially have a groundwater deficit under normal rainfall conditions, increasing to 22 during droughts. The team therefore recommended that the general authorisations in all 28 catchments be reviewed and reduced to sustainable levels, which may be zero in some cases.

Further groundwater development is still possible in about 70% of the catchments, although alien vegetation could significantly reduce this potential.

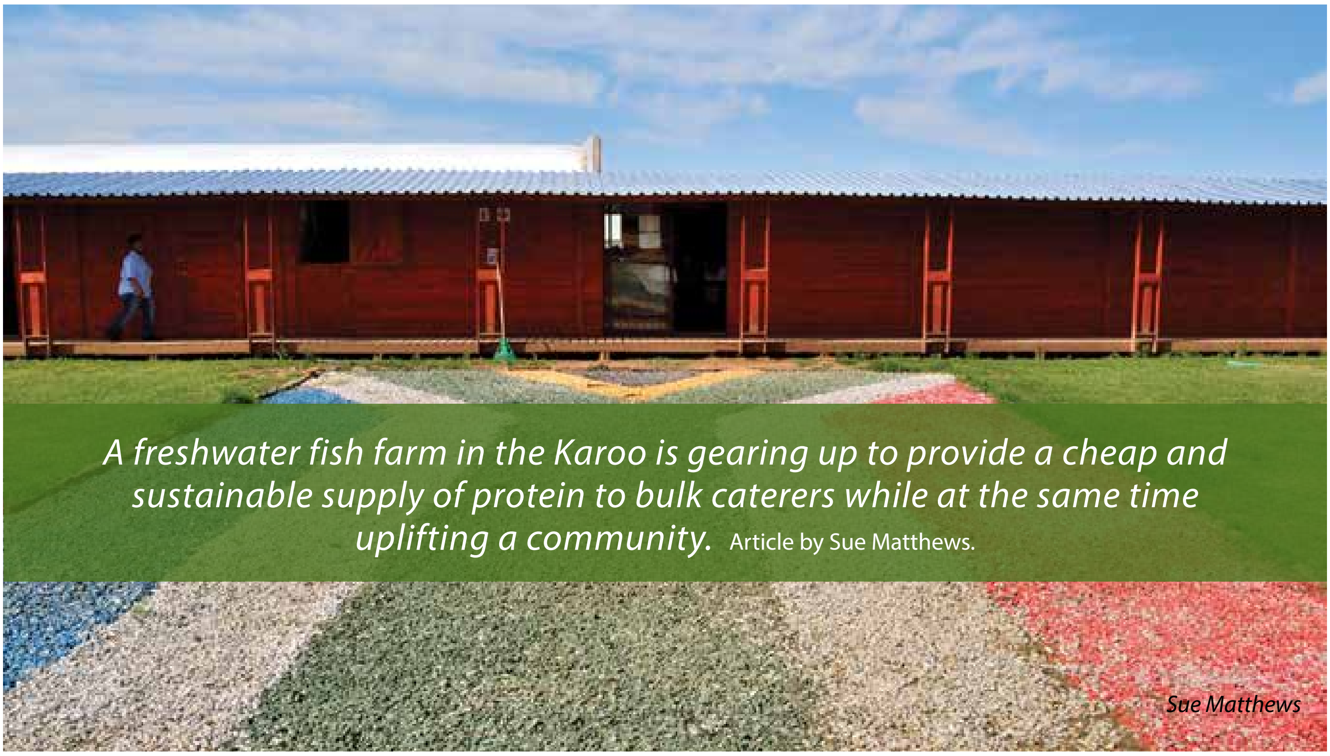
The Gouritz Reserve Determination Study included an economic overview, which showed tourism to be the dominant sector in the coastal area of the Garden Route, replaced by agriculture in most other areas. Likewise, the value of ecosystem services mostly related to tourism, recreation and aesthetics, since few communities are dependent on rivers and estuaries for any subsistence needs. The Basic Human Needs Reserve for each quaternary catchment was also determined, based on the assumption that 1% of the population was dependent on rivers or streams as the primary water supply. This was in accordance with data from Census 2011, which revealed that on average only 0.2% of the resident population relied on local rivers of streams, while the highest dependency rate was 1.5%.

The findings of the Gouritz Reserve Determination Study will now feed into a two-year project to determine the water resource classes and resource quality objectives for water resources in the entire Breede-Gouritz WMA, in line with the requirements of the Water Resources Classification System, gazetted in September 2010.

In terms of the WRCS, water resources are categorised into one of three specific management classes depending on their ecological condition and their level of use in meeting social and economic needs, while resource quality objectives describe the conditions that should be met to maintain the resource in the management class to which it has been assigned, with its associated protection level. The aim is to strike a balance between the utilisation and protection of water resources, in keeping with the principle of sustainable development.

Aquaculture

Farming with fish – Community finds new hope through aquaculture project



Sue Matthews

A freshwater fish farm in the Karoo is gearing up to provide a cheap and sustainable supply of protein to bulk caterers while at the same time uplifting a community. Article by Sue Matthews.

Like many bold enterprises, it started as a hobby, became an ambitious plan, and then evolved into a workable scheme as ideas gelled, lessons were learned and hurdles overcome.

"My husband and a friend started pottering around on our Graaff Reinet smallholding, converting pig sties into fish tanks," explains Blue Karoo Trust project manager, Liesl de la Harpe. "We began raising tilapia with the idea of selling some to local shops, but farmers started approaching us looking for something to occupy the women living on their farms. At that stage we were envisaging fish grown in cages in farm dams and reservoirs, but then we found out that the Total Allowable Catch for pilchard had dropped by 80% since 2004, which meant the gap was wide open for an alternative processed fish. That changed everything, because it would need more people, intensive aquaculture systems and proper processing facilities."

And so the idea was spawned for the Camdeboo Satellite Aquaculture Project, which they presented to the Eastern Cape Development Corporation in 2008. The intention back then was to launch a two-year pilot phase in 2009, followed by a scaling-up period between 2011 and 2015 to establish 50 satellite farms, using recirculating aquaculture systems in greenhouse tunnels. The pitch paid off, in that the ECDC contributed R780 000 towards business plan development, an environmental impact assessment and a market acceptance survey – the results of which prompted a species switch from tilapia to catfish.

"Catfish scored only a few percentage points below pilchards, which were used as a control in the survey," says Liesl. "From a farming point of view, catfish is a no-brainer! It gets to a kilogram in six months, whereas tilapia takes 12 months to reach its marketable size of 450 grams."

This is the African sharptooth catfish *Clarias gariepinus*, which has a native range extending over much of the African continent bar the northern and southern extremes. Also known as barbel, it is considered an alien species in the Western and Eastern Cape provinces, but has already become widely established there as naturalised populations. It has also invaded parts of Asia, South America and Europe after being introduced for aquaculture. Being a hardy fish that can tolerate high turbidity and low oxygen levels – and eats almost anything – it is easy to raise, even in unsophisticated systems. Global aquaculture production for the species currently exceeds 200 000 t.

In South Africa, a few catfish-farming ventures have tried to make a go of it since the late 1980s, but none became commercially viable. This was attributed largely to a lack of market research and product development – aquaculture production increased rapidly, before a customer base was secured – but the high cost of artificial feed also played a role. A second growth spurt starting in 2000 was nipped in the bud when a strengthening Rand stymied plans to export the fish to Thailand.

At the Camdeboo Satellite Aquaculture Project, they're determined not to make the same mistakes, and have put considerable effort into getting the basics right. *Clarias gariepinus* is an ugly fish with a PR problem, thanks to its eel-like appearance, whiskery barbels and bottom-feeding habits in natural environments. In whole form, it is unlikely to be chosen if displayed on ice next to trout, yellowtail or other more attractive offerings at the supermarket's fish counter – although in most countries where it is cultured it is primarily sold fresh. Even filleted, its 'bloody' flesh makes it somewhat unappealing, so the focus has been to develop a processed product that the market will accept.

"The R&D side of things has been a long journey," says Liesl. "We initially set out to prove we could develop a canned freshwater fish to rival pilchard, so we started out doing it with tomato sauce in small cans, and later moved to large cans. Now we're packaging the fish separately in 2 kg retort pouches, and working with Crown National for a number of different sauce options. Because catfish flesh is quite bland, it takes on the taste of whatever sauce you put it with. So a cook on an oil rig, for example, could buy the fish and ten different sauces, make a variety of meals, and the crew would never guess it's the same fish!"

The product – marketed under the brand name Karoo Catch – is to be targeted specifically at caterers in remote areas, schools, hospitals, prisons, military bases and other operations making use of bulk-feeding schemes.

The farm already has a contract to supply 10 tonnes per month to its first customer, and has letters of intent from others. While feed is indeed expensive – making up 70% of the farm's running costs – it is now being made by Montego, which is based in Graaff Reinet. The cost is partly offset by the farm supplying Montego with heads and tails discarded during processing for use in pet food, but the fish feed contains pricey chicken meal and fish meal. During 2016, researchers from the aquaculture division at Stellenbosch University will be investigating cheaper sources of protein, such as maggot meal or blood meal, with co-funding from THRIP – the Technology and Human Resources for Industry Programme of the Department of Trade and Industry (DTI).

African sharptooth catfish, Clarias gariepinus.

Production manager, Philip Steenkamp, in a grow-out tunnel housing some 25 t of fish.

Aquaculture trainees wait for water to drain during filter cleaning.

The study forms part of a broader THRIP-funded research project headed by Suné Henning from the Department of Food Science and Technology at Cape Peninsula University of Technology (CPUT). Her students will be focusing on product development in the short term, as well as environmental aspects influencing the quality and nutritional value of the fish. They have already gained a valuable understanding of some of the issues to address, because the catfish farm currently has its fish processed in the greater Cape Town area – partly on CPUT's Bellville campus! Blue Karoo Trust used some of its funding to develop a pre-processing line in the Department of Food Science and Technology's pilot plant, where the fish is filleted and minced before being sent to a company in Stellenbosch for packaging and sterilising in retort pouches.

This approach has been useful in ironing out problems and developing the necessary quality control and food safety systems, but transporting the fish to Cape Town in refrigerated trucks is costly. A processing factory will therefore be built on site in Graaff Reinet during 2016, using a R5.4 million grant from DTI's Employment Creation Fund. The processing factory is a key component of Commercial Phase 1, which upon completion would also include 10 aquaculture production tunnels, a hatchery, and training facilities for both farming and processing.

By the end of 2015 the farm had four tunnels in operation – three for production and one for training – as well as the hatchery and a suite of classrooms. Funding contributions to date that have made this possible include a R23.5 million loan made available by the Development Bank of Southern Africa through its Green Fund, a R10 million contribution from the Department of Agriculture, Forestry and Fisheries, R2.7 million from the Industrial Development Corporation, R1.43 million from the Eastern Cape Job Stimulus Fund, and R200 000 from the Cacadu District Municipality, in which the Camdeboo Municipality lies.

The training and job creation aspects of the project are particularly important given that, according to the 2011 census, some 36% of the population aged 20 and older in the Camdeboo Municipality has either no schooling or not gone beyond primary school, and the unemployment rate stands at 30%. Liesl points out that because so many people in the area live on grants, many families lack a role model for being employed, which means there's a limited understanding of what is expected of them in the workplace.

"It's been a massive learning curve on all fronts, but we now have a training programme that works," she says. "We start off with basic adult education, life skills and work skills, during which the trainees receive a stipend, and that's increased for the second year, when they do a learnership. As part of that we run a competition over six months in the training tunnel, allowing them to practise and make their mistakes, and they're mentored as needed. The learnership culminates with an NQF Level 1 qualification, at which stage staff are fully equipped to run the system, and eligible for an employment contract. There are now about 110 people who are either in training or recently qualified, but we'll need 190 people on site for the 10 tunnels planned for Commercial Phase 1."

The farming operation is overseen by technical partner Leslie Ter Morshuizen, who runs an aquaculture training and consulting service in Grahamstown. He spends a week every month at the farm, and has a production manager as well as a hatchery and training manager on site. He explains that the stocking density in the grow-out tanks at harvest time is approximately 400 fish per cubic metre of water, and that optimal growth rates are achieved with a water temperature of 28°C. Since heating is required during the winter months to maintain this temperature, solar panels are being installed to reduce dependency on the Eskom supply, and hence lower production costs.

Back at his home base, he is working on a project with Rhodes University to improve water recycling efficiency and wastewater treatment. The farm relies mainly on borehole water, although it is connected to the municipal water supply too, and water quality in the recirculating aquaculture systems must be kept at acceptable levels for the fish to thrive. Water therefore passes through a mechanical filter to remove faeces, and then through a biological filter where nitrogen-fixing bacteria convert potentially toxic ammonia to nitrates, but some water is discharged when the filters are rinsed.

"We lose between 15 000 and 25 000 ℓ of water per day, which currently flows into a marshy area where it evaporates or seeps into the ground. We're planning to pump that water to what we're calling a wastewater repair system, where we'll remove all the organic material, use it as a fertiliser for crops, and return the cleaned water to the fish."

Based largely on the integrated algal pond system that the Institute of Environmental Biotechnology at Rhodes University developed with Water Research Commission funding, its efficacy for aquaculture wastes needs to be properly assessed.

There is also scope for aquaponics – the combination of aquaculture with hydroponics in a recirculating system. The excretory products of fish provide the nutrients for direct uptake by plants, which cleans the water for the fish. Leslie constructed his own tilapia-based aquaponics tunnel in Grahamstown in 2012 and grew herbs and vegetables such as basil, rocket, lettuce and cucumbers, selling both fish and greens on a small scale. He would now like to install a system at the catfish farm as a demonstration unit, budget-permitting.

And what of the early aspirations for satellite aquaculture farms, dotted around the Karoo? There's still a hope that the dream might become a reality at some stage in the future, but for now that's been put on the backburner as a possible Phase 2.

"From a farming point of view, catfish is a no-brainer! It gets to a kilogram in six months, whereas tilapia takes 12 months to reach its marketable size of 450 grams."

The catfish farm makes use of recirculating aquaculture systems in greenhouse tunnels.

Domestic wastewater treatment

Wastewater treatment – Tackling a wicked problem through dialogue and action research

At the heart of the wicked problem of dysfunctional wastewater treatment works (WWTW) is a set of complex political tensions between the constitutional right of local government to provide and earn income from water services, including WWTWs, the threats that dysfunctional WWTWs pose to water users and water resources, and the urgent question of who should, can and will take responsibility for dealing with those threats. In this article, Victor Munnik and Tally Palmer present a current attempt to address this issue through a series of action research dialogues.

Pollution from South Africa's WWTW has been a national priority concern for some years now. Dysfunctional WWTW threaten the provision of drinking water, the safety of people living downstream from WWTW and using water directly, as well as the health of aquatic ecosystems. To date, most interventions have focused on training and capacity building, emergency interventions and inspections. They have not addressed the political questions that constitute the dynamic of dysfunctional works.

In 2015, a Water Research Commission (WRC) project tackled this problem with a combination of political ecology, action research, social learning and complexity approaches (see box on political ecology). Our research question was: "Can dialogue, social learning in a community of practice formed from diverse stakeholders, practical co-operation and a better understanding of the position of WWTWs frontline staff as well as the responsible municipalities, lead to improvement in Green Drop scores and performance?"

The research was specifically framed in terms of the Green Drop incentive scheme, which originated in 2008. Some of the research team members had gained experience of this approach in the Rietspruit Catchment Forum (part of the Upper Vaal) in 2011 when a working group of the Rietspruit forum engaged with the Department of Water and Sanitation (DWS) and staff of the three Emfuleni WWTW. It was found that the Green Drop approach provided space for collaboration and developing trust between catchment forum members, the department, and WWTW staff, when elaborated into a seven step *Green Drop Support Campaign*.

In 2014, the Crocodile (East) Catchment Management Forum agreed to form the Crocodile Green Drop Support Campaign as a forum working group, in response to a proposal by the Rhodes University project team emanating from information gathered in interviews with stakeholders in the Rhodes University THRIP project: An Integrated Water Quality Management Process (IWQMP) for the Crocodile River Catchment.

In earlier research on the Crocodile River undertaken in 2011 and 2012, dysfunctional WWTW had been identified by stakeholders in the IWQMP project as a top priority among water quality issues. The research team became concerned that the wastewater treatment works' performance could be masking other water quality problems – such as increasing salinity from mines – which over the long term may turn out to be more serious.

Also, water users were asking why they should comply with stricter standards if government itself did not comply with the basics? The project was based on a theory of change, namely that as a result of a Green Drop support campaign:

- WWTW would achieve a higher profile locally, in public and with the municipality (councillors and officials). This would prevent the current practice of reallocating WWTW budgets to other priorities midyear, and inappropriate and inadequate procurement practices;
- Civil society would adopt a supportive attitude towards WWTW, on the basis of an in-depth understanding of their context and functioning. Staff responsible for WWTW would not be under general attack by civil society and other catchment stakeholders; instead efforts would be focused on identifying the bottlenecks in achieving a better green drop score, within the Green Drop programme.
- While there was clear support from national and regional DWS, and a focus by the Inkomati Usuthu Catchment Management Agency (IUCMA), the working group with broad stakeholder support needed to orient the support into productive channels, to avoid providing perverse incentives to municipalities.

The first Dialogue took place in January 2014, with the seventh taking place in February 2015. Attendance grew with each meeting and most relevant stakeholders were drawn in. This included TSB Sugar, the White River Irrigation Board, manganese mines and industries, municipal WWTW staff from the four local municipalities (Mbombela, Umjindi, Nkomazi and Emakhazeni), the IUCMA water quality team, DWS Green Drop national and regional staff, members of the Crocodile Forum including its chairperson, the South Kaap Farmers Association, university researchers, as well as senior managers from two out of the four targeted municipalities.

In the first meeting the CGDSC working group agreed on the following approach:

1. Understand each individual WWTW and its challenges. Understand Green Drop requirements in relation to the individual works.
2. Know and support the frontline staff.
3. Collective empowerment at process controller's level so that they can support each other.
4. Develop healthy challenges between municipalities
5. Understand the dynamics in the municipalities and get ward councillors on board
6. Work with the willing, attract the unwilling, look for sticks for the unwilling – in Berg River, farmers were affected economically and made a strong lobby group. Patience with local government may run out. Media can be used as a stick (Name and Shame).
7. Use tools from regulations, and pressure from central government
8. Approach rapid response unit for financial needs
9. Encourage industry and civil society to adopt a neighbouring wastewater treatment works

"The main problem was identified as a disconnect between the WWTW frontline staff and local government's top triangle: municipal manager, technical manager, finance manager."

Discovering drivers of WWTW dysfunctionality

The project created a safe space (including anonymity in dialogue minutes) in which to discuss the real obstacles to Green Drop improvements. The main problem was identified as a disconnect between the WWTW frontline staff and local government's top triangle: municipal manager, technical manager, finance manager.

Staff would be given responsibility for Green Drop performance, then not get budget or support, then do badly, and then be held responsible for the results by top management. This was very frustrating. It also mirrored the experience in the Upper Vaal, where the core finding was that the municipality did not take proper care of their WWTW and their staff.

This insight provided a trigger for growing solidarity and understanding between WWTW frontline staff and civil society counterparts who until then had taken a generally accusatory attitude. It was also important to recognise the dynamic inside local government. A municipal manager, who joined the dialogues later, made a frank contribution in which he explained that municipal managers are overworked ("our in-trays are overflowing"), and that the politicians they answer to have far more interest in interventions that are visible to their constituents, such as health clinics, roads and street lights, than in WWTW.

The Crocodile River, whose water quality has been affected by dysfunctional wastewater treatment.

Interventions by national departments

The working group then decided to explore what help could be offered by national departments. In co-operation with Association for Water and Rural Development (AWARD), the Rhodes team undertook a number of interviews with national government departments which revealed the following institutional and political landscape:

- Treasury is reluctant to intervene. Since its focus is on money flows, the quality of the effluent and other technical parameters are not visible to these officials. However, they have taken a keen interest in Green Drop developments, from a 'value for money' perspective.
- The Department of Co-operative Governance and Traditional Authorities (COGTA) has undertaken a Back to Basics programme, which holds the promise to motivate better performance of wastewater treatment works. However, it was noticeable in interviews with Municipal Infrastructure Support Agency (MISA), a supporting agency within COGTA that interventions in municipalities can only happen when welcomed by the municipalities.
- DWS arguably has the most responsibility and opportunity to intervene. In theory, the Green Drop scheme does not replace day-to-day compliance monitoring, and could itself trigger pre-directives, and court action (against poorest non-performing municipalities). In practice, this is limited by the number of officials on the ground, and the fact that Green Drop competes with other tasks on their agenda. DWS officials pointed out that a number of directives have been issued against municipalities, and have produced results. In addition, DWS has embarked on a Municipal Services Strategic Assessment (MuSSA) programme, in which municipalities self-report in a number of risk areas, including wastewater treatment.

The overriding picture that emerged from interviews is that all the national departments are bound by the constitutional autonomy of local government, which is, firstly, an equal sphere of government and, secondly, has the right (or is designed) to earn income from providing water and electricity services, which it defends jealously.

While the dialogues were in progress, the project team was also able to achieve practical outcomes. TSB, the sugar corporation and neighbour of Nkomazi municipalities, donated land and expertise to enable Nkomazi to refurbish one of their wastewater treatment works.

Staff from the Green Drop Unit came through from Pretoria on several occasions to explain Green Drop requirements and clear up questions. This was very well received as it was directly empowering to WWTW staff. The IUCMA compiled, as a result of its regular inspections in the area, a comprehensive report on WWTW, which provided an authorative baseline from which to question current practices and push for improvements.

The Crocodile dialogues proved, again, that the majority of frontline staff at WWTW are keen to do their work properly, but need better support from local government to do so, in terms of routine procurement, maintenance and expansion of works, and staff provision. In particular, they need local government officials to be responsive to their needs before and during Green Drop inspections. The new emphasis of SALGA in supporting the Green Drop as part of SALGA's contribution to the implementation of the NWRS2 could make a major contribution here.

There is a substantial interest in civil society (or catchment citizens, other water users) to participate in finding solutions for this problem. Participants in the Croc GDSC attended 7 dialogues to grapple with the problem. Local participants have extensive local and technical knowledge.

Political and racial tensions are still present. They need to be addressed through careful facilitation. However, participants showed that they had the resources to deal with this, and develop trust relationships across class, racial and political lines.

There are many opportunities and programmes for technical and capacity building support for the operation of WWTW, but they do not address the political problems.

Conclusions

The fact remains that ongoing risk and degradation is also the business of other actors in the water sector. There is a constellation of interests and mandates around dysfunctional WWTW – although they are not currently all connected and working together. At the moment, local government is uniquely privileged in this constellation, although not capable and motivated to deal with the consequences of its neglect of WWTW.

A first potential policy response is to question whether local governments are capable of taking responsibility for WWTW, and that the responsibility should be moved to other actors, such as water boards. This has, in fact, happened in Bushbuckridge and, on a temporary basis, in the Upper Vaal.

Researchers were warned that such a trajectory would invite stiff resistance from organised local government, although the possibility of outsourcing the operation and maintenance (with some profit for local government built in) already exists. The broader political problem is whether local government has more responsibilities than it has a budget and capacity.

A second response is to sharpen the possibilities for intervention, and make that a concerted and coordinated effort by national government. A third is a more long-term building of citizens' power via catchment management agencies (and catchment forums), to hold local government to account, and also to support them.

These trajectories all rely on increasing public awareness and pressure on this issue. It requires raising the visibility of the WWTW issue by making the consequences clear through new and synthesised research focusing on the following:

1. Diarrhoea is a leading cause of child death between the ages of one and five. Contaminated drinking water is an important cause of diarrhoea. Water in river stretches immediately following dysfunctional WWTW is dangerous to users, who are the constituents of local government.
2. The impact of eutrophication on ecosystems is serious. Repeated oxygen depletion events, for example, lead to the impoverishment of ecosystem function and integrity, also reducing the ability of the river to self-purify.
3. Economic impacts include the threats to health in terms of costs to the public purse and to suffering families, to livelihoods, and threats to the marketing of contaminated products nationally and internationally.

This article is based on work done in WRC project K5/1098, Engaging a Complex Problem through a Community of Practice Approach: Improvement of dysfunctional WWWTW through a multi-stakeholder Green Drop Support Campaign, and Development and Implementation of An Integrated Water Quality Management Process (IWQMP) for the Crocodile River Catchment, a Rhodes University Institute for Water Research Technology and Human Resources for Industry (THRIP) project.

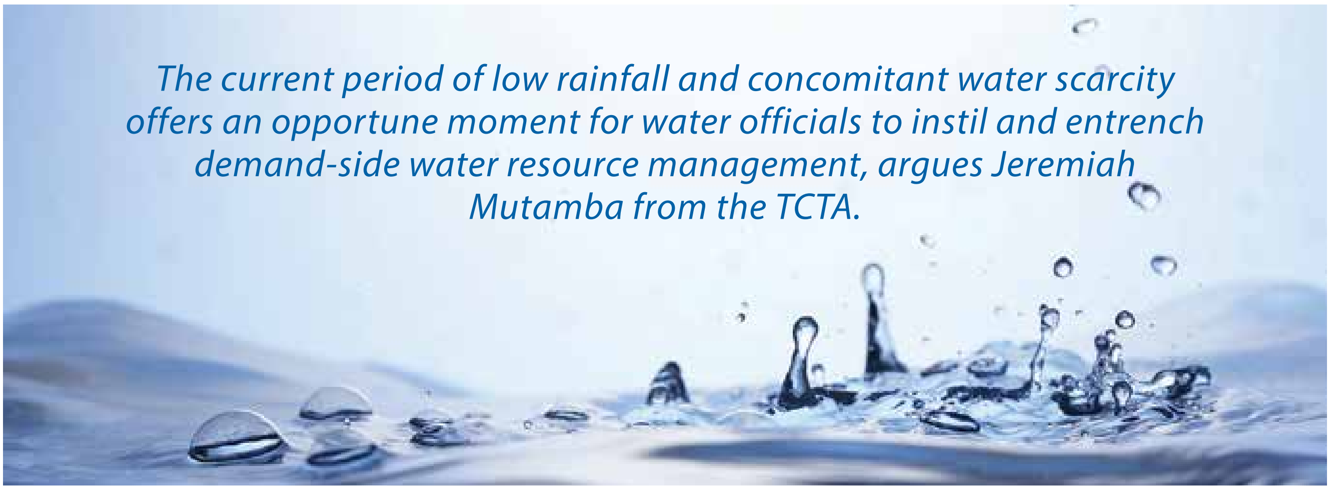
Using political ecology and cognitive justice approaches to address complexity

There is growing recognition, both in South Africa and internationally, that social science is necessary to deal with complex problems in the water sector. This project used, as a core analytic, the multi-disciplinary approach of political ecology, which brings together ecology (understanding the science of environmental dynamics), political economy (issues of power and money) as well as the politics of knowledge and representation, within an expansive social learning approach. Cultural Historical Activity Theory (CHAT) has proven to be accessible to natural scientists and students in a multidisciplinary setting.

Demand side management

An opportune time to promote demand-side water management

The current period of low rainfall and concomitant water scarcity offers an opportune moment for water officials to instil and entrench demand-side water resource management, argues Jeremiah Mutamba from the TCTA.



Introduction

Traditionally, water resources management practitioners more easily opted for supply-oriented management practices to address water challenges. This practice persists despite it being acknowledged and widely held that integrated water resources management (IWRM) consists of both supply-side and demand-side management strategies.

It is, however, becoming increasingly clear that supply-side solutions are becoming more and more expensive as the easily accessible options have been fully developed, and new options are becoming difficult to find. Under these conditions, demand-side water management options become more attractive and easy to sell and can significantly assist in addressing local and national water challenges. The trouble is that water utilities and sector specialists have not succeeded much beyond theory to sell to the public and their counterparts the concepts of water conservation and demand management – to the effect that demand-side strategies have lagged behind in application.

Water resources management and demand-side strategies

Water management experts, managers and water utilities all advocate for integrated approaches to water resources management. All concur to the approach, with very few, if any, dissenting voices.

The IWRM paradigm consist of two distinct yet equally important parts, supply-side management strategies and demand-side management strategies. For more effective outcomes, the two strategy groups should be used conjunctively. However, in practice, the historic tendency has been to emphasise supply-oriented management and investment strategies.

This approach is also widely evident in South Africa, with great efforts expended on designing and construction of greenfields water supply infrastructure (for example, dams, transfer schemes and associated infrastructure) as solutions to meet growing water requirements. As a result, water management utilities have been on the receiving end, being criticised for predominantly focusing on supply-side strategies and for believing that water demand increases will be met by concomitant supply increases.

This practice has proliferated despite the fact that new freshwater resources are finite and dwindling, with the few remaining being even more difficult and expensive to develop. For South Africa, in particular, the Department of Water Affairs (now Department of Water and Sanitation), acknowledges that the majority of available resources have been allocated, and, particularly, most of the viable dam sites have been developed.

Interestingly and positively, demand-side water management strategies and approaches are now widely accepted as sound water management policy. In his 2000 article in Water International Volume 25 No 1, Peter Gleick succinctly captures this paradigm shift in the quote below:

"A reliance on physical solutions continues to dominate traditional planning approaches, but these solutions are facing increasing opposition. At the same time new methods are being developed to meet demands of growing populations

without requiring major new construction or new large-scale water transfers from one region to another. More and more water suppliers and planning agencies are beginning to shift their focus and explore efficiency improvements, implement options for managing demand, and reallocate water among users to reduce projected gaps and meet future needs".

However, more than 15 years after this key pronouncement by Gleick, beyond theoretical policy changes, the level of implementation and uptake of demand-side approaches still remain low in most countries, including South Africa. Yet water security concern has catapulted to the front as a strategic global business risk over the same period.

As such, there is an urgent need to redirect water management thinking and practice towards the yet to be fully explored demand-side management. To effectively understand the disparity between belief and practice, the central question that needs to be asked and addressed is: why have demand-oriented strategies not been the favoured options by water management practitioners?

To highlight the extent to which demand-side management options have not been favoured the literature point out that, globally, about 33% of water provided in the urban drinking water distribution system is not accounted for – quite a significant amount that can bring relief either in quantum or financially. In attempting to address this question, the notion is advanced that, for South Africa, water shortages currently being experienced present an opportune moment to promote demand-side water management strategies.

Demand-side water management

Demand-side water management strategies refer to measures designed to improve water services through inducing changes at points of use. These strategies are predicated on successful increase in end-use efficiency and reduction of waste – ensuring that users can achieve the same or more with less.

A number of options are available to effect the required changes. These water use changes include: managing and, where practicable, eliminating water leaks; behavioural changes in water use patterns; improved awareness of water-wise water use in communities; adjustment of per capita water allocation to optimal levels in new designs; introduction of effluent fees to curb water consumption and pollution; introduction of water efficient technologies; and promotion of industrial recycling and reuse.

Other demand-side strategies include carefully-managed water rationing and restrictions as well as introduction of subsidies to incentivise adoption of water efficient technologies. The later options are more appropriate in industrial and agricultural sectors.

Application of demand-side water management

It is essential to highlight that the major challenges that water managers and practitioners encounter do not relate to knowledge (or lack thereof) of options to apply. Rather, the key challenges and struggles relate to application (or implementation) and uptake of some of the proposed demand-side water management strategies. This is particularly alarming because, globally and in South Africa in particular, water is regarded as a basic necessity and even an implied basic human right.

As a basic necessity, instituting measures that stretch a limited resource to ensure broader and sustainable access and supply should clearly be commendable and, without doubt, readily embraced by all. However, in practice, a number of reasons have militated against easy adoption and widespread implementation of demand-side water management options. Two interlinked reasons include:

- Consideration of water, by the general society, as a God-given natural resource.
- Limited knowledge of the fact that water is finite scarce resource.

"The level of implementation and uptake of demand-side approaches still remain low in most countries, including South Africa."

In addition, water demand-oriented projects are, by their nature, not generally grand in size and are naturally not among the most attractive to implement. As such, they are generally not accorded the highest priority and preference by both professionals and leadership. These reasons for low water demand management strategies uptake and application have the following implications:

a. Continued business as usual practices among consumers despite resource scarcity – resulting in no real impact on water consumption rates and total consumption. Should society fully comprehend that water is a limited and scarce resource, the attitude, behaviour and approach to water utilisation by society should drastically improve for the better. Notably, it requires that the general fear of conflating technically-proven water scarcity with service delivery crisis be overcome to allow for society to clearly comprehend the need to be water-wise even during periods of normal rainfalls.
b. Limited commitment and concomitant low appetite by leadership to drive what may be perceived as extreme measures to curb water wastage. The use of economic strategies (especially pricing strategies) comes to mind here. Wasteful water use is largely associated with low water prices

– themselves grounded in the often unchallenged belief that water is a free good. Further, influenced by the fact that water is a basic necessity, practitioners generally refrain from applying certain demand curtailing measures as they are considered unpopular. It is critical that practitioners avoid confusing society's claim to have a right to water with a view that they have a right to unlimited water – as factually water resources are limited. It needs to be instilled in our minds that unmanaged right to unlimited water leads to no water at all at some point in future.

c. In a growing democracy – in a nation coming from a history of racial segregation – it is difficult to disconnect basic service offering from the varying and often complex forms of political nuances. Given this and that a majority of South Africans lacked access to water prior to the new democratic government ushered into power in 1994, the natural and logical approach is to drive service provision (provide access for the first time) to those previously denied access to the precious resource. Notwithstanding this, however, in a space were the resource is limited and scarce, the drive to offer water services (a supply-side imperative) needs to be shrewdly integrated with demand-side strategies to ensure sustained provision of the essential resource.

Why it is opportune to promote demand-side strategies

A number of compelling reasons motivate for the current drought period to be an opportune moment to advocate and roll-out demand-oriented water management strategies – not only as short-term drought-linked interventions, but rather as a part of permanent and long-term solutions to a country with a well-documented history and record of water resources scarcity. Three compelling reasons for this perspective standout.

These reasons include, that:

a. Beyond the current dry spell, South Africa urgently needs to improve on its water use efficiency. Rated as the 30th driest country globally and with estimated average system water losses of about 37% (losses can be as high as 70%), the country definitely requires to be water frugal. This view is further emphasised by extant research with accompanying publications – attesting to both facts that the country does not have an abundance of the precious resource and that the current water use patterns are not sustainable.

b. Notwithstanding the complexity and current low uptake of demand-side strategies, the fact that supply-oriented options have been exposed as vulnerable by the current drought points to a need by the general public, guided by water practitioners and experts, to seriously consider elevating demand-side water management strategies. To practitioners this offers the best chance to emphasize the complementarity of supply-side and demand-side water management solutions. I emphasize complementarity to underscore the essence of an integrated approach in practice. During this period of drought-induced water shortages, water scarcity moves from the theory domain (as pronounced by researchers' publications) to the real domain. For water practitioners, it moves from the abstract to the real – here it is kind of phenomenon. Everyone is practically experiencing the lack of water. The fact that some communities scrambled for interventionist water supplies drive home the reality of the resource scarcity. This makes it a lot easier to explain to society why demand-side strategies are critical and required now.
However, what is even more critical is the need to emphasise that the current water challenges (heightened by drought) are not only limited to the drought problem – which is ephemeral – but that in the broader scheme of things, the country is naturally physically water scarce, with a number of critical users competing for the same resource.

c. Because everyone is attentive during crisis periods, the gospel of demand-side water management has the best of opportunities to be granted unfettered attention by all and sundry during this drought crisis. In line with this thinking, over the past few months, media has been abuzz with suggestions and 'how to" propositions to manage water demand to reduce consumption. It can be clearly observed that the timing would be most appropriate, and all it needs is developing appropriately crafted solutions with accompanying actions to roll-out demand-focused water management. It is important to highlight that this period is most appropriate as there is the least amount of stakeholder dissonance on the matter than any other period – stakeholders from all persuasions will be singing from the same sheet.

Conclusions

In conclusion, notwithstanding the bad effects of drought, water practitioners should take advantage of the drought period to promote the often difficult to sell demand-side water management. The time is most opportune as stakeholder opposition is expected to be minimal, stakeholder attention on the subject will be at its highest, and the vulnerability of supply-side options will be maximum to easily convince society of the need for a balanced approach.

References available on request

Drought mitigation

Analysing South Africa's water management options mitigating drought

Dr Emmanuel Mwendera from the Agricultural Research Council - Institute for Soil, Climate and Water provides his views on mitigation strategies against South Africa's present drought conditions.

Introduction

South Africa is a semi-arid to arid country with a highly variable climate and highly constrained freshwater resources which are affected by weather extremes imposed by climate variability and change. Drought is one of the main constraints for crop and livestock production in South Africa. The socio-economic impacts of droughts tend to be severe in regions with an annual rainfall of less than 500 mm, hence, the annual average rainfall of approximately 450 mm makes South Africa prone to recurrent droughts. Indeed, the drought which is currently devastating parts of the country is a recurrent characteristic feature of South Africa's highly variable climate and weather extremes.

Various researchers have examined the occurrences and management of drought in South Africa. This article reviews the available options for mitigating drought through management of water resources in South Africa. It looks at various water resource management measures with emphasis on water storage.

Definition of drought

A drought can be defined as "a decrease of water availability to substantially below the normal condition for a certain place and time", typically associated with a period of below-average rainfall. Drought is unlike other natural hazards (such as floods) in that there is often no well-defined start and end. There are four basic categories of drought, namely meteorological drought, agricultural drought, hydrological drought and socio-economic drought.

Figure 1 shows the interrelationships between initial meteorological drought, followed by the cascade of successive agricultural, hydrological, and socio-economic forms of drought. The sequence of drought occurrence and impacts for the most commonly accepted drought types is presented in Figure 2.

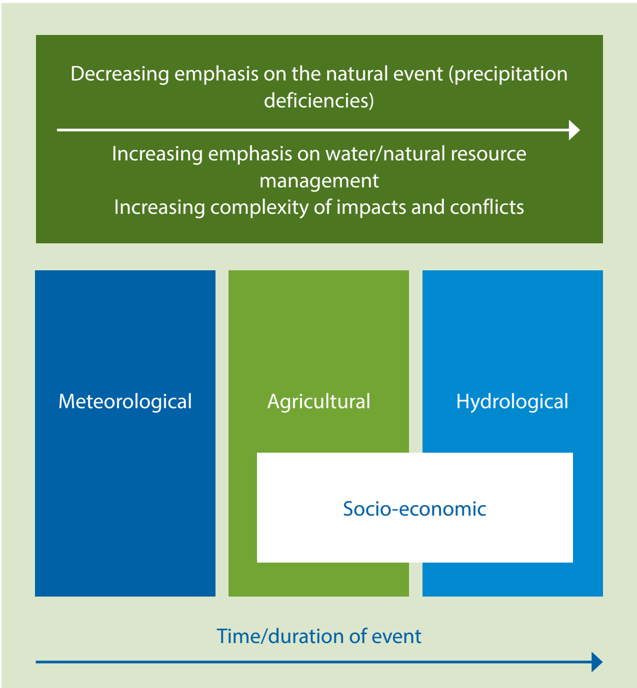


Figure 1: Interrelationships between different forms of drought (Adapted from: National Drought Mitigation Centre, 2006)

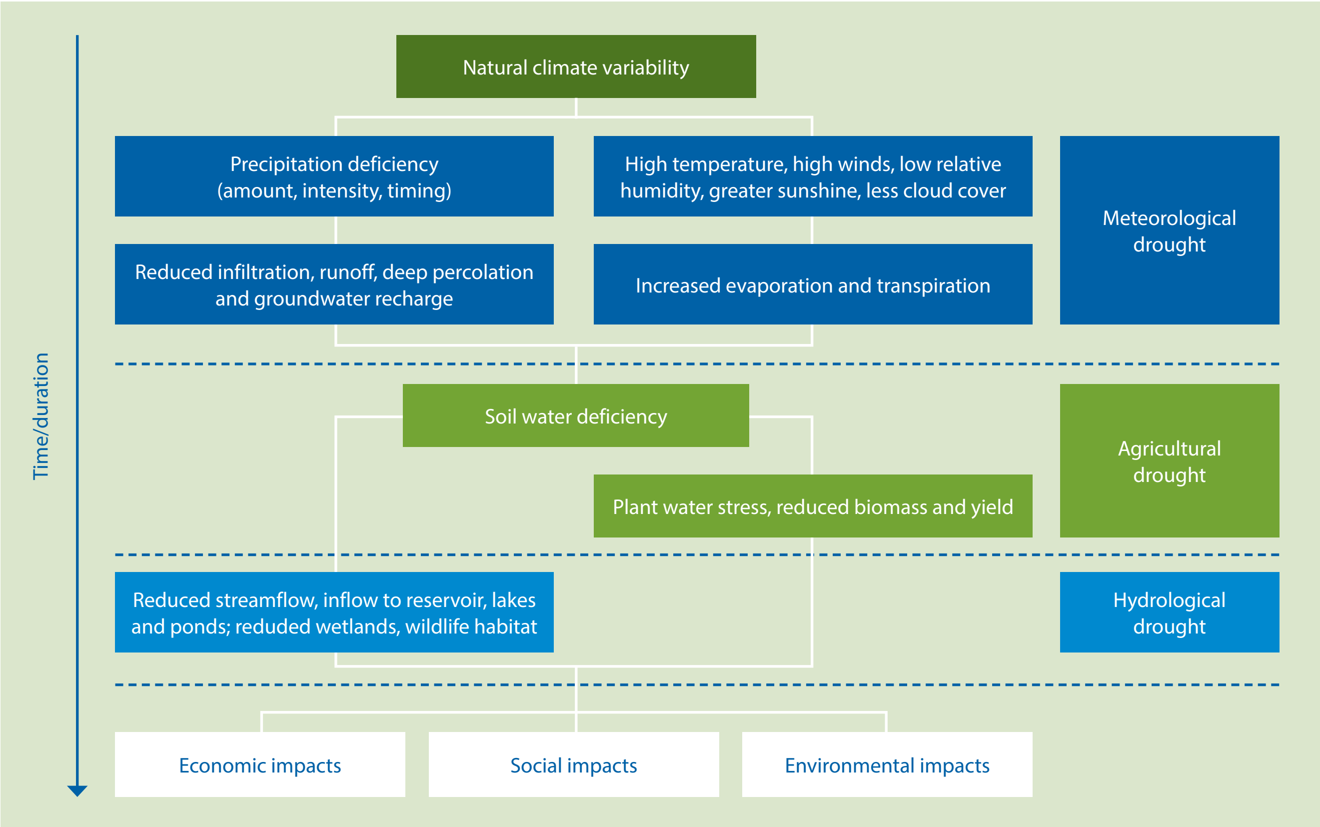


Figure 2: Sequence of drought occurrence and impacts. (Adapted from: National Drought Mitigation Centre, 2006)

Figure 2 also shows the economic, social and environmental impacts which are independent of the time scale, indicating that such impacts can occur at any stage during a drought. Figures 1 and 2 illustrate that all droughts actually originate from the initial deficiency in precipitation, which is known as meteorological drought. The other forms of drought and the resulting impacts cascade through time from the initial deficiency.

Droughts in South Africa

The climate of South Africa exhibits variability in global and hemispheric circulation patterns at intra-seasonal (of the order of one or two months) and inter-annual (year-to-year) time scales. El Niño-Southern Oscillation (ENSO) is recognised as the leading mode of inter-annual variability in the tropics and is driven by variations in sea-surface temperatures (SSTs) in the equatorial Pacific Ocean. There is a link between ENSO and southern Africa's rainfall such that warm ENSO events (El Niño) are commonly associated with below-average summer rainfall over much of southern Africa and cold events (La Niña) are typified by above-average rainfall in this region. It has been observed that summer droughts in southern Africa tend to occur under El Niño conditions.

Water management practices for mitigating drought

Since the primary concern of drought is water shortage, most of the drought mitigation and adaptation activities are aimed at reducing the effect of water shortage through measures that are taken before, during and after drought. The activities comprise a wide range of measures to reduce societal vulnerability that are not necessary linked to water resources.

In addition to planning, effective water resource management in drought prone areas hinges on the institutional and legal set-up established for addressing the interrelated issues of water conservation and planning for drought. Because of the close relationship between water resources and drought, drought management is an essential element of national water resources policy and strategies.

It is argued that drought response problems are water management problems. Hence, from the water resources perspective, a proactive approach to drought is equivalent to strategic planning of water resources management for drought preparation and mitigation. Such planning consists of two categories of measures, both planned in advance:

- long-term actions, oriented to reduce the vulnerability of water-supply systems to drought, i.e. to improve the reliability of each system to meet future demands under drought conditions by a set of appropriate structural and institutional measures; and

- short-term actions, which try to face a particular drought event within the existing framework of infrastructures and management policies.

The overriding objective of the long-term actions is adjustment to drought conditions, even under normal situations, as a proactive and preparatory measure. This includes, for instance, the increase of water storage capacity, the adoption of water saving technology, the recharge of groundwater, etc.

Depending on the severity of drought, long-term actions may or may not eliminate completely the risks associated with it. They are supplemented by short-term measures which correspond to the actions taken during what is called a drought contingency plan. The plan is implemented during drought but the shift to it is usually gradual, reflecting the progressive onset of drought.

An effective water resources plan is one that has an optimal combination of both long and short-term measures.
The measures that can be included in each of the above two categories for alleviating drought impacts can also be grouped into three main types or sub-categories:

- water-supply oriented measures;
- water-demand oriented measures; and
- drought impact minimisation measures.

The measures related to supply management aim at increasing the available water supplies, whereas those pertaining to demand management aim at improving the efficient use of the available resources. These two categories of measures aim to reduce the risk of water shortage due to a drought event, while the third category is oriented to minimize the environmental, economic and social impacts of drought. In practice, the measures are actually interrelated and, at times, even overlapping; but such interrelationships are necessary in order for the plan to achieve its goals. Table 1 gives various drought mitigation measures related to water resources.

Table 1: Drought mitigation measures related to water resources.

Category	Short term	Long term
Supply management	- Mixing fresh and low quality waters - Exploiting high-cost waters - Over-drafting aquifers - Diverting water from given uses - Decreasing transport and distribution losses - Adjust legal and institutional framework	- Increase water collection and storage opportunities (reservoirs) - Desalination of brackish and saline water - Treatment and reuse of wastewater - Water transfers - Artificial precipitation - Locate potential new resources - Groundwater recharge - Adjust legal and institutional framework
Demand management	- Restricting agricultural uses (rationing, subjecting certain crops to stress) - Restricting municipal uses (eg. lawn irrigation) - Review operations of reservoirs - Water metering and pricing - Water rationing - Education and awareness creation - Provide permits to exploit additional resources - Provide drilling equipment - Adjust legal and institutional framework - Negotiate transfer between sectors	- Adopting supplementary and deficit irrigation - Water-saving irrigation techniques (drip, sprinkler, etc.) - Incentives to invest in water saving technology - Water recycling - Dual distribution networks for drinking water supply - Inventory private wells and negotiate their public use - Assess vulnerability and advise water users - Adjust legal and institutional framework
Impact minimisation	- Temporary reallocation of water resources (on the basis of assigned use priority) - Restrict uses - Emergency supplies - Public aid to compensate loss of revenue - Tax relief (reduction or delay of payment deadline) - Rehabilitation programmes - Resolving conflicts - Implement set-aside regulations	- Development of early warning system - Reallocation of water resources on the basis of water quality requirements - Use of drought resistant plants - Development of a drought contingency plan - Mitigation of economic and social impacts through voluntary insurance, pricing and economic incentives - Education activities for improving preparedness to drought - Elaborate set-aside regulations

(Source: Bazza, 2002)

Efficient irrigation techniques, such as drip irrigation, can be effective in combating drought in arid and semi-arid areas. Improved access to water for irrigation or supplemental irrigation can prolong the growing period, avoid false starts, and reduce the risk of impacts from dry spells, both for large-scale as well as smallholder farmers.

Water storage

Currently, agriculture in South Africa is predominantly rainfed. According to FAO estimates of 2012, only about 13% of total cropland is equipped for irrigation, of which an estimated 95% is actually irrigated, and agricultural water withdrawals amount to just 15% of total renewable water resources. The country's rainfall and river flows are variable, erratic and seasonal; droughts occur frequently and agricultural yields are often constrained by insufficient water. Under these circumstances, even relatively small volumes of water storage can, by safeguarding domestic supplies and supporting crops and/or livestock during dry periods, significantly increase agricultural and economic productivity and enhance people's well-being.

Water storage is often associated with large dams mainly because of their considerable financial requirements, as well as the political opportunities that they represent. There is ample evidence of the broad links between high storage capacity constituted by many large dams and increased agricultural productivity and economic growth.

Generally, water storage provides a mechanism for dealing with drought which, if planned and managed correctly, increases water security, agricultural productivity and climate change/variability adaptive capacity. Building dams with large storage capacity is one of the strategies governments use to match water demand with stored supply, and for security against the risk of drought.

Water storage capacity

One of the indicators of water resources deployment is the water storage capacity, which is the amount of water stored in reservoirs per capita. Improved water resource management and water storage capacity make the economy more resilient to external shocks, such as rainfall variability and drought, and thus provide a stable and sustainable base for increased food and industrial productivity and production to maintain economic growth and development.

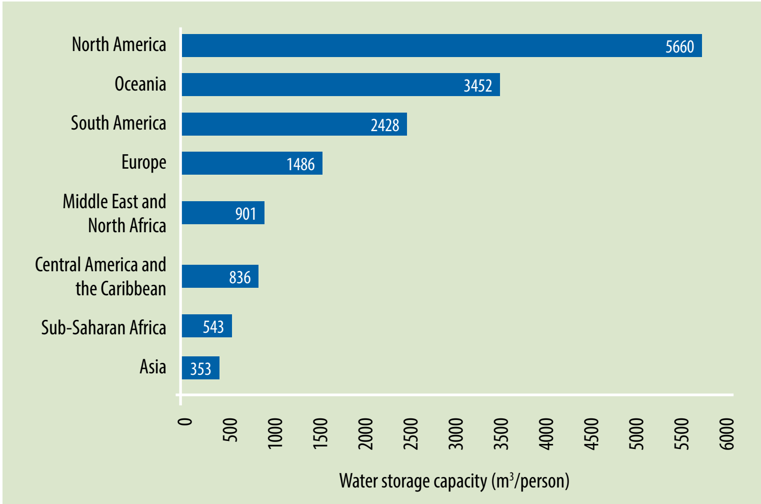


Figure 3: Water storage capacity in m³/person by continent (Source: White, 2005)

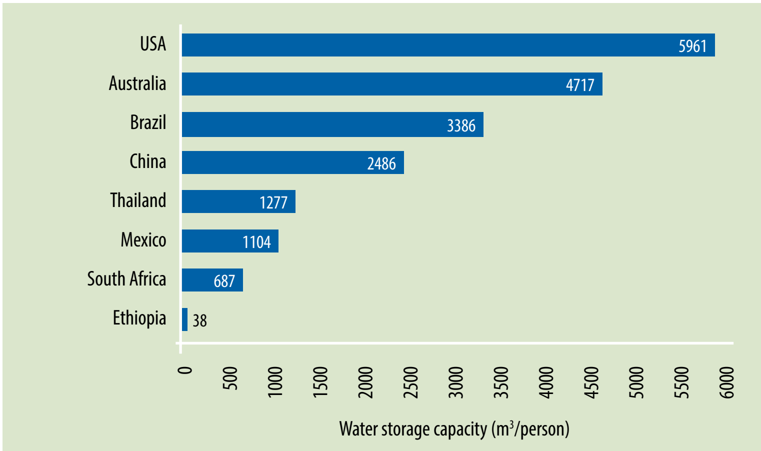


Figure 4: Water storage capacity in m³/person in selected countries, 2003 (Source: Grey and Sadoff, 2006b)

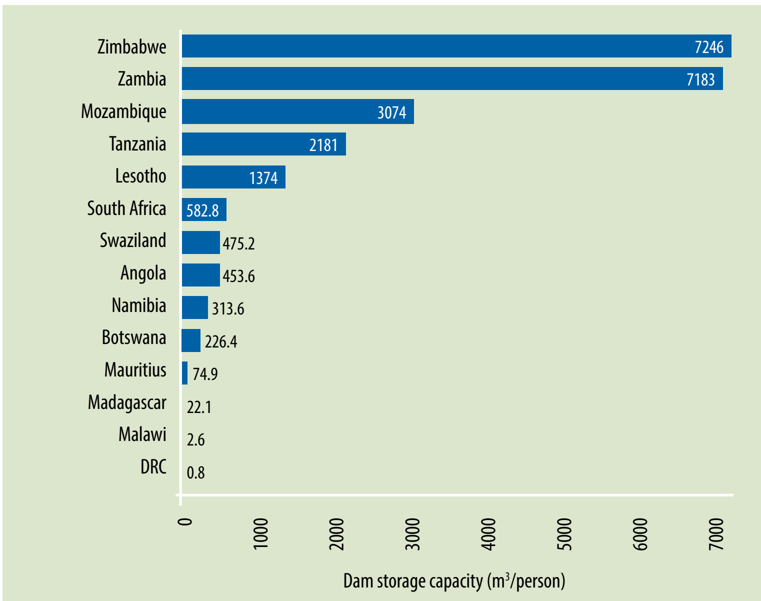


Figure 5: Water storage capacity in m³/person in SADC countries for period of 2008-2012 (Source: FAO, 2015)

Despite the region's vulnerability to frequent droughts and floods, sub-Saharan Africa and Asia have the least-developed water storage infrastructure needed to manage the variability of rainfall and drought (Figure 3).

When compared with other nations on the globe, South Africa has very low water storage capacity (Figure 4).

The average water storage capacity in South Africa is the ninth lowest within the southern African region (Figure 5).

Within the country, the Free State Province has the largest water storage capacity of 5 669.6 m³/capita while Gauteng Province has the lowest water storage capacity of 8.7 m³/capita (Figure 6).

Available water per capita

The indicator 'water resources per capita' is frequently used to show the mismatch between freshwater resources – a renewable but finite resource – and population, and a sense of the level of competition. It indicates a risk of scarcity when a population and its needs are high when compared with the availability of water. A country is said to be rich in water when it has more than 1 700 m³/inhabitant/year, while a water scarce country is below 1 000 m³ (and becomes extremely water scarce when below 500 m³/inhabitant/year).

Figure 7 shows that water availability in South Africa has been declining steadily from 1 329 m³/capita in 1988-1992 to 980 m³/capita in 2008-2012. The projection is that South Africa will remain a water scarce country with water availability of less than 1 000 m³/capita by the end of the 2013-2017 period.

Figure 7 also shows that water storage capacity declined steadily from 776 m³/capita in 1988-1992 to 582 m³/capita in 2008-2012.

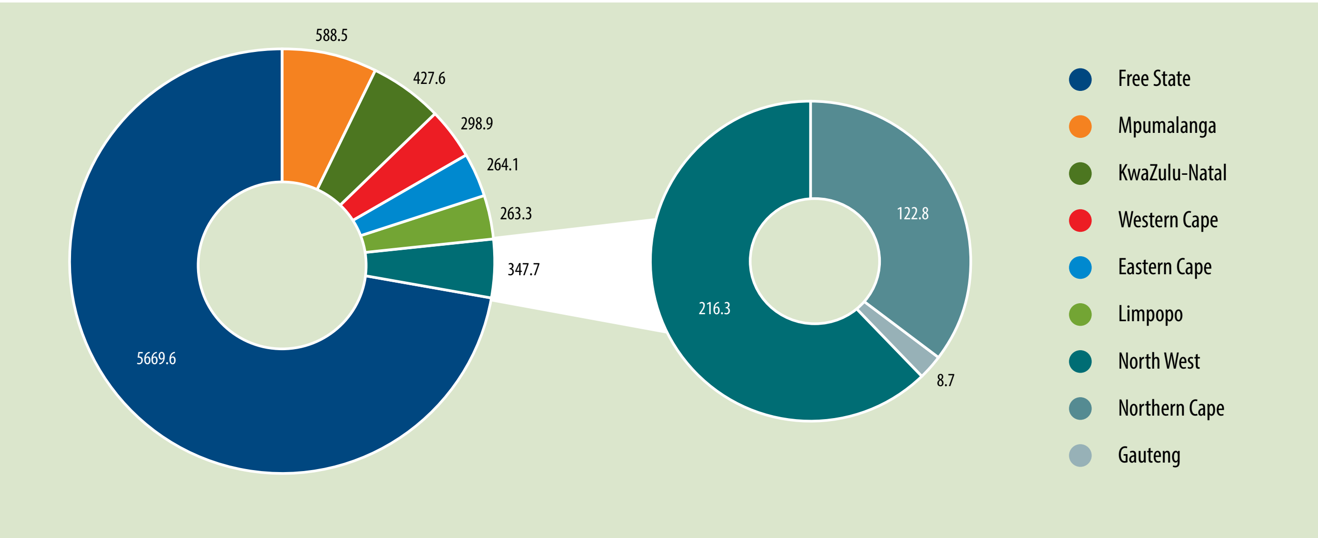


Figure 6: Water storage capacity in m³/person by province in South Africa in 2015 (Data source: DWS, 2015; Statistics South Africa, 2015)

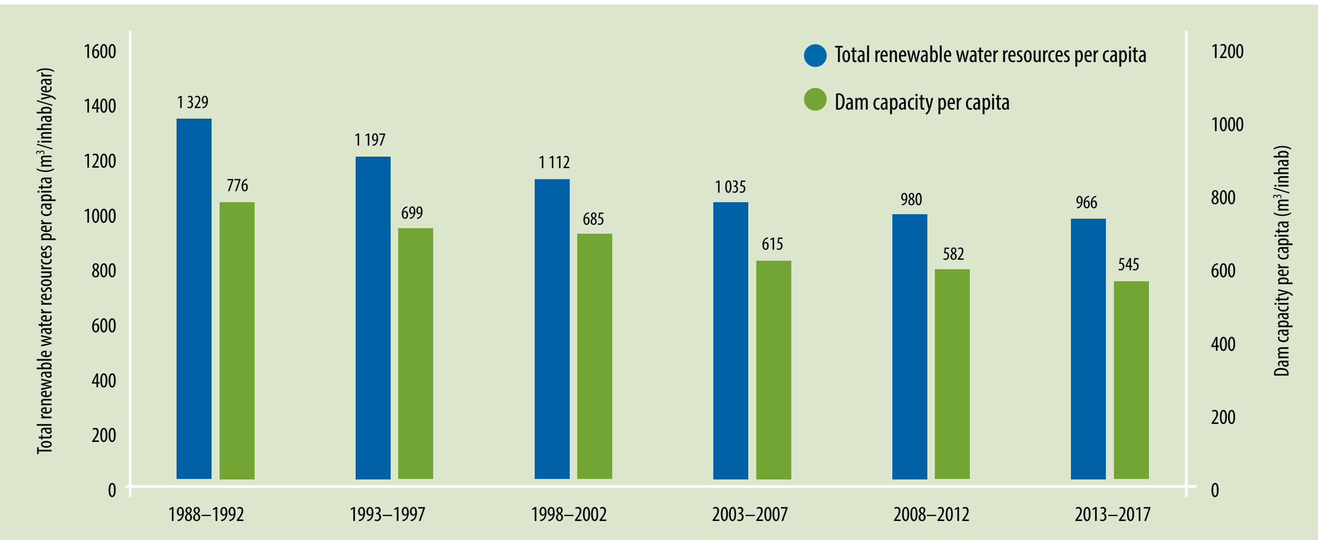


Figure 7: Trend of available water and total storage capacity in South Africa (Source: FAO, 2015)

Water storage options

There are various water storage options for mitigation climate drought. The water storage options include natural wetlands, soil moisture, groundwater, ponds and tanks, and reservoirs. The various storage options and summarised in Table 2.

Natural wetlands, such as lakes, swamps and other wetland types have provided water for agriculture for millennia both directly as sources of surface water and shallow groundwater, and indirectly through soil moisture. Wetlands span the surface/subsurface interface and provide water in many different ways and as a result of their important role in the provision of water, wetlands are increasingly perceived as natural storage infrastructure.

Soils store huge amounts of water. However, such volumes vary from place to place and are quickly depleted through evapotranspiration. Today, there are various in situ rainwater management techniques that enhance infiltration and water retention in the soil profile.

These rainwater harvesting techniques are part of soil and water conservation measures which include deep tillage, reduced tillage, zero tillage and various types of planting basin. The effectiveness of different measures depends a lot on soil characteristics and, particularly, on water holding capacity.

"Water storage, in all its forms, has an important role to play in poverty reduction, sustainable development and adaptation to climate change."

Water stored beneath the soil surface, groundwater, has the advantage of little or no evaporation and total volumes are often much greater than annual recharge. The amount of water that can be abstracted from groundwater body

Table 2: Water storage options

Storage option	Benefits	Risks
Natural wetlands	• Water storage is provided as an ecosystem service without the need for costly infrastructure; • Water purification; • Regulation of water flows; • Attenuating floods and droughts; • Sediment & nutrient retention and export.	• Excessive utilisation of water in natural wetlands may undermine other ecosystem services.
In-field rainwater harvesting	• Generally, low-cost options that can be implemented by individual farmers and communities.	• Limited storage, will not provide water for more than a few days without rain; • Farmers with small land holdings may be reluctant to give up some land to serve as donor areas.
Groundwater	• Evaporation losses are low or non-existent; • Multiple year storage that is largely decoupled from seasonal variability.	• Requires detailed hydrogeological information to locate wells and estimate yields; • Depending on the geology of the aquifer, the water may contain toxic chemicals (e.g., arsenic).
Ponds and tanks	• Low cost options implementable by communities and non-governmental organizations (NGOs).	• High evaporation losses; • Risk of contamination from surface runoff and livestock; • Risk of siltation; • May provide breeding habitat for disease vectors.
Reservoirs	• Large volume of water which can be used for multiple purposes; • It enables production of electricity; • Can offer protection from floods.	• Requires substantial capital investment; • Displacement of large number of people; • Significant environmental and social impacts arising from changes in river flows; • May provide breeding habitat for disease vectors.

(Source: McCartney and Smakhtin, 2010; SANBI, 2011; Wang et al., 2012; Mussá et al., 2015)

is a function of the characteristics of the aquifer. Groundwater reservoirs can be increased by pumping surface water directly into an aquifer (using injection wells) and/or enhancing infiltration by spreading water in infiltration basins.

Ponds and tanks are often linked with rainwater harvesting and store relatively small volumes of water. Ponds and tanks fill either by surface runoff from a roof or surface catchment or through groundwater and differ from reservoirs by the absence of a dam. While tanks are often covered, ponds are usually shallow, with a relatively large surface area, so that often a significant proportion of the water is lost through evaporation.

Reservoirs are water impounded behind small and large dams constructed across streams and rivers. Small dams store relatively small amounts of water and often empty every year. Large dams (often rock-filled or concrete) store millions, sometimes billions of cubic meters of water. The water may be used for multiple purposes and they are sometimes used for flood control and power generation. Some large reservoirs provide storage that is greater than the mean annual runoff and thus provide multi-year carryover of water.

"Most of the drought mitigation and adaptation activities are aimed at reducing the effect of water shortage through measures that are taken before, during and after drought."

Conclusion

Water storage infrastructure is an indispensable tool for mitigation of, and adaptation to, drought and climate change. The review shows that South Africa needs to improve on storage capacity as the country is water scarce.

Apart from large storage reservoirs, there isa need for smaller scale storage which offers the benefit of more local control and less externalities in terms of submerged area.

Improved water control may also be achieved through methods that focus on the control of evaporation, such as conservation farming, drip irrigation, furrowing and levelling of fields.

These methods have also tended to be the most economical and affordable for resource-poor farmers. Water storage can also contribute to power generation and providing water supply for domestic, commercial and industrial uses.

Hence, water storage, in all its forms, has an important role to play in poverty reduction, sustainable development and adaptation to climate change. By providing a buffer, water storage reduces risk and offsets some of the potential negative impacts of droughts, thereby reducing the vulnerability of people. Water storage can, thus, enhance both water security and agricultural productivity.

It is important to treat water conservation (and storage) as a way of life and not just something that has to be done when we are forced to.

References available on request

Industrial water use

Three cheers for water savings in the soft drink industry

A recently completed study for the Water Research Commission (WRC) illustrates how far the South African soft drink industry has come in terms of water conservation.

Article compiled by Lani van Vuuren.

The WRC project, completed last year by the Pollution Research Group at the University of KwaZulu-Natal, involved a survey of the South African soft drink industry in order to obtain an overview of operations, specific water use, specific effluent volume and the extent to which best practice is being implemented.

The survey forms one of several National Industrial Water and Wastewater Surveys (NATSURV) currently being undertaken with funding by the Water Research Commission (WRC). The surveys follow on the original NATSURVs undertaken in the Eighties.

The original NATSURVs measured the water use and effluent generation in a range of industries aimed at identifying areas in which industrial water use and effluent management could be improved. The new round of NATSURVs are revisiting these industry and are intended to provide a latter day comparison to determine whether improvements have been made in the area of industrial water management.

With regards to the soft drink industry there have been quite a number of changes to the sector since the original survey was conducted in 1987. This includes new legislation, new markets, social attitudes and change in ownership as well as the use of updated technology, the manufacture of new products and the variety of packaging materials available.

State of the soft drink industry

The global consumption of soft drinks has increased from 1 171 million Megalitres in 2011 to 1 974 million Megalitres in 2014. Compared with the compilation of the market in 1987, today's soft drink industry includes a variety of 'new' products, such as bottled water, energy and sports drinks, although carbonated drinks still remain the main revenue for soft drink manufacturers.

The South African soft drink industry produces in region of 3 700 Megalitres per year (based on 2012 figures). This is more than double the volume recorded in 1987.

Water is used in various quantities in the following soft drink manufacturing processes:

- Storage of concentrate/raw product
- Water treatment
- Sugar dissolving
- Blending
- Carbonation/pasteurisation
- Filling and packaging
- Bottle forming
- Bottle washing/rinsing
- Cleaning-in-place

The production processes followed by a soft drink company depends on the product being manufactured and the type of packaging to be used.

How much water does the South African soft drink industry use?

The study calculated the specific water intake (SWI) of participating companies. The SWI refers to the litres of water used per litre of production.

The average SWI was calculated as 1.6 ℓ for carbonated soft drinks. This is far lower than the target of 2.3 ℓ set out in the 1987 survey. The average water use was calculated at 170 000 kl/year while the average production was calculated at 120 000 kl/year.

Only one bottled water company responded to the survey with an average water use of between 1.2 ℓ and 1.5 ℓ.

Where information was supplied, those companies undertaking bottle and crate washing were highlighted as these operations resulted in a higher water consumption.

The SWI for fruit drink manufacturers ranges from a low of 1 ℓ to a high of 4.5 ℓ per litre of production. Fruit companies that process fruit on-site (rather than manufacture from concentrate) have a higher water consumption, on average.

Comparison between the 1987 and 2014 results show that, on average, the water used by the soft drink sector has increased approximately two-fold in South Africa, however, there is a much larger range in water consumption than previously reported.

On the other hand, production volumes have increased four-fold, even though the number of soft drink companies in South Africa has reduced overall.

It therefore appears that, while the soft drink sector is consuming more water, this water is being used more efficiently than in the past. With regards to best practice, a comparison of SWI to benchmark figures shows that the South African companies are operating at a lower SWI. This indicates that the majority of companies are aware of the need to optimise water use.

The increase in efficiency in the use of water is attributed to the following:

- Installation of sub-metering
- Leak prevention programmes
- Optimisation of clean-in-place
- Recovery and reuse of filter water from water treatment
- Optimising water use on the conveyors
- Investigating the use of rainwater harvesting

In addition, the move away from returnable bottles to plastic bottles also impact on water use, as it reduces the need for bottle washing.

With regards to effluent, the soft drink sector discharges, on average, 120 000 kl/year of effluent. The reported COD range is higher in the 2014 survey than in the 1987 survey. This is most likely as a result of the lower SWI, which can result in a more concentrated pollution load.

Good management practices

It is clear from the study that the implementation of best management practices and the awareness of good water and wastewater management practices is not equal throughout the soft drink sector, and further work is required to raise awareness and assist companies in identifying opportunities for water use reduction.

The study ends with a section on good management practices which can assist companies in saving even more water. These include aspects such as maintenance, training and awareness.

For example, a maintenance programme that gives priority to the repair of water leaks is key to an effective water management programme. In many cases leaks either go unnoticed or are ignored as they have not been quantified.

Further, it is important to make staff aware of the cost of water, not only in terms of monetary value, but also the environmental value due to the limited water resources in the country.

Washing of equipment and factory floors is important in the soft drink industry, but some options can be implemented to save water in this area. These include the use of flow restrictors on hoses to ensure an optimum spray flow, the installation of automatic shut off triggers on hoses to prevent them being left running, making use of high pressure systems where possible to limit the volume of water used, and to make use of dry cleaning methods and squeegees before using a hose.

To order the report, *NATSURV 3: Water and wastewater management in the soft drink industry (Edition 2)* (WRC **Report No. TT 640/15**) contact Publications at Tel: (012) 330-0340; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free digital copy.

Definition of soft drinks

Soft drinks can be described as sweetened, water-based beverages (usually balanced with the addition of an aid), which can be carbonated, flavoured or coloured, and which often contain an amount of fruit juice, fruit pulp or other natural ingredients. Soft drinks come in two forms, namely ready-to-drink and concentrated (i.e. made-to-dilute) forms. Bottled water is also included in this definition and can be still, carbonated, plain or flavoured.

The increasing use of plastic bottles rather than reusable glass has led to significant water savings in the soft drink industry.

Indigenous crops

Sowing the seeds of knowledge on underutilised crops

As South Africa's agricultural sector continues to battle the aftermath of current drought conditions, researchers at the University of KwaZulu-Natal's School of Agriculture, Earth and Environmental Sciences are growing valuable knowledge on the water use and production of drought tolerant traditional crops as a viable alternative to currently grown, more popular variants.

Article by Tafadzwa Mabhaudhi and Albert T Modi.

South Africa, like much of sub-Saharan Africa, is currently going through a severe drought due to El Niño. The phenomenon causes changes to seasonal weather conditions. For South Africa, this often translates to below average rainfall and drought.

The United Nations reports that about 30 million people in sub-Saharan Africa face hunger due to the ongoing drought. In South Africa, the government has declared five provinces disaster areas. South Africa will have to import between four and six millions tons of maize to meet the gap caused by low yields due to the prevailing drought. This will have a negative effect on food prices and access to food in poor households.

Subsistence farmers in rural areas are most vulnerable as they lack resilience. There is a need to reconsider the potential of currently cultivated major crops to continue to provide food security, especially in marginal agricultural production areas.

In pursuit of such an alternative, the Water Research Commission of South Africa (WRC) has been systematically funding research aimed at identifying drought tolerant underutilised indigenous and traditional crops. Underutilised indigenous and traditional crops are those crops that are either indigenous to or have been "indigenised" in South Africa.

Indigenous crops are those that have their centre of diversity in South Africa while indigenised crops are those who, although their centres of diversity lie outside of South Africa, have been domesticated in South Africa over hundreds of years, thus making them traditional crops. Plant breeders generally refer to the crops as landraces and they play an important role as sources of genetic material for crop improvement and biodiversity.

Previously, these crops played a major role in contributing to food security for the majority of rural people. However, the promotion of exotic major crops has caused the decline in cultivation of indigenous crops. These crops are well–adapted to local growing conditions, which are often marginal and harsh, thus offering sustainable food production.

Given the challenges of climate change and that South Africa is largely an arid land with only about 3% of it being fertile, it is imperative that the our research efforts should include underutilised indigenous and traditional crops.

Examples of such crops include *Amaranthus spp* , wild mustard (*Brassica spp*), sweet potatoes (*Ipomoea batata*), wild melon (*Curcubita spp*), taro (*Colocasia esculenta*), Bambara groundnut (*Vigna subterranea*), cowpea (*Vigna unguiculata*), maize landraces (*Zea mays*), millets [*Eleusine coracana* (pearl millet), *Panicum miliaceum* (proso millet), *Pennisetum glaucum* (pearl millet), *Setaria italic* (foxtail millet)] and sorghum (*Sorghum bicolor*).

The University Of KwaZulu-Natal's Prof Albert Modi and his research team have been funded by the WRC to work on these crops with the current project focusing on cereals and legumes (Project No. K5/2274).

Cereal crops, and maize in particular, are an important staple crop in South Africa and the region. However, major cereal crops such maize, wheat and rice are not drought tolerant. For example, maize has high water requirement whilst wheat, barley and rice suffer high yield losses and crop failure during drought periods.

Climate change projections show decreases in yields of wheat (-22%), maize (-5%) and rice (-2%) due to increases in drought and temperatures. On the other hand, cereal crops, such as sorghum and millets, which are indigenous to sub Saharan Africa are drought tolerant and have potential to produce reasonable yields in areas where major cereal crops may fail.

This makes them very good alternatives for cultivation in low rainfall areas and during drought periods. In addition, climate change projections suggest that yields of sorghum and millets will increase, albeit slightly. However, a lack of information regarding basic aspects of their production still results in these crops being underutilised.

Similarly, research has shown that underutilised indigenous and traditional legumes such as bambara groundnut may be more drought tolerant compared to major legumes such as dry bean (*Phaseolus spp*) and groundnut (*Arachis hypogea*). Climate change modelling for Bambara groundnut showed an expansion inland in areas suitable for production and yield increases high yields for all provinces in the intermediate future (2046-2065).

The expansion in area suitable for production is attributed to certain areas becoming drier and temperatures increasing. This augers well for Bambara groundnut production into the future. Ongoing research has also confirmed that intercropping drought tolerant underutilised cereals and legumes can be productive and also contribute to improving resilience of cropping systems. In addition to being drought tolerant, underutilised indigenous and traditional crops are also nutrient dense and could thus contribute to dietary diversity in poor rural areas.

While research is still ongoing, there is a need to start promoting the uptake of underutilised indigenous and traditional crops in marginal agricultural production. Some challenges to this though are that seed for most of these crops is not readily available on the market.

The few farmers who still cultivate these crops rely on farmer saved or recycled seeds, which are often of inferior quality. However, as much as that is a challenge, it also creates an opportunity for developing farmer-driven seed systems for these crops. In this way, the farmers who have conserved these crops would be empowered and recognised for their contribution.

As the frequency of drought is expected to increase due to climate change, our hope may very well lay in tapping into our past.

Growing knowledge and people

Dean and Head of the UKZN School of Agricultural, Earth and Environmental Sciences, Prof Albert Modi, is not only growing valuable knowledge on South Africa's underutilised indigenous and traditional crops, he is also mentoring a new generation of agricultural researchers and farmers. Prof Modi, seen in the photograph (left) with UKZN Honorary Research Fellow, Tafadzwa Mabhaudhi, was one of the recipients of the WRC Knowledge Tree Awards in 2015 in the category, Human Capacity Development. Prof Modi trained 15 Masters and PhD students while working on two WRC projects and published numerous papers on the ensuing research. He has also gone on to receive a UKZN Distinguished Teacher Award in the same year. This is a remarkable achievement, especially since Prof Modi is only the second Dean to achieve this honour. He was nominated by his students. Prof Modi is a crop scientist and champion of sustainable agriculture, and of the value of indigenous knowledge in informing scientific research. He has successfully led a number of research projects and was pivotal in the establishment of the Ezemvelo Farmers Organisation, which focused on the small-scale production of amadumbe for supply in commercial retail chains. This project, the first of its kind in South Africa, has facilitated a sustainable model for community farming.

Water research and development

Finding the right chemistry to grow water science in South Africa

The Water Research Commission (WRC) has completed the first ever comprehensive survey of the state of water research in South Africa.

Lani van Vuuren highlights the most pertinent results.

Guy Stubbs

In the last 500 years, science has emerged as a central and transformative force that continues to reshape our everyday life. Science does not only help us to understand the world we are living in, it also teaches us how to adapt and thrive in that world.

Science is also an important basis for sound decision-making in many sectors of society. International science and technology cooperation and exchange also play a critical role in narrowing knowledge, information, and technology gaps between countries and societies.

In South Africa, targeted water-related research and resulting scientific discoveries have played a significant role in reducing uncertainties and improving the management of this scarce natural resource. Our improved scientific understanding has also formed the foundation for practical applications that have enhanced the prosperity and security of South African society.

In today's world of threatening climate change and increasing water scarcity, research on water resources has taken on greater importance than ever before.

But how well are we doing in terms of research and innovation? Monitoring and evaluating the various facets of the scientific enterprise is a necessary and integral part of science policy. Rising costs of research and development, coupled with disciplinary claims for financial resources require intelligent allocation of resources, which presuppose knowledge of the activities and performance of the innovation system.

While the National Research and Development Survey and Experimental Development, undertaken annually by the Department of Science and Technology, provides valuable information on various research and development expenditures in various fields, water research is not part of the report's classification schemes.

Thus, for the first time, the WRC has undertaken a study to determine the state of water research in South Africa. The investigation provides an overview of the investment for water-related research and development (R&D). The study will also provide a benchmark for future assessments.

The study reports on the following pertinent indicators:

- Research and development expenditures for water
- Bibliometrics of water research in South Africa as seen in the international context
- Patent analysis of water inventions
- Human resources for water research

What is being spent on water research in South Africa?

Water-related R&D spend amounted to R240-million in 2014, up from about R50-million in 2000. Despite this progressive increase in expenditure, the total amount translates into a minute percentage of gross domestic product (GDP), only 0.0069%.

Established in 1971 to, among others, promote the coordination, cooperation and communication in the area of water R&D, the WRC remains the main funder of water-related research in South Africa. In 2014, the WRC was funding 65% of all water-related research, followed by the CSIR (16%), Mintek (9%) and the National Research Foundation (8%).

Water patent analysis

Patents play an increasingly important role in innovation and economic performance as they are useful indicators of inventive activity and a country's capacity for innovation. There is an increasing trend among policy-makers, researchers, innovation analysts and technocrats to rely on patent statistics for this reason.

The patents most often utilised internationally for this type of analyses are those granted by the US Patent and Trademark Office (USPTO) even though most countries have their own patent authorities.

The last two years exhibit an increase in the number of patents awarded to South Africans, and it appears that the long-term decline in the South African share has been stabilised. A definite highlight is the granting of 160 patents to South African inventors in 2013 – an all-time high.

In general, however, South Africa gets very few patents in the USPTO compared to, for example, companies such as IBM, which are granted more than 3 000 patents a year. Of all the patents granted to South African inventors between 2000 and 2014, only 46 patents were related to water. This translates to around three patents a year.

Human resources in water R&D

An important set of indicators monitoring the science, technology and innovation space are those classified under human resources in science and technology. Attracting, developing and retaining talent in science and technology is a priority of the water science community.

Capacity building in science is critical to meet the demand for scientific advance, and to improve science-based decision-making and problem-solving. In South Africa, transforming the water science sphere to include more individuals from historically disadvantaged communities is another focus area.

One way of assessing capacity building in the water research sector is by considering the production of Masters and PhD degrees by the higher education system. These indicators provide information about the supply of researchers, in particular scientific disciplines and specialities, and the academic institutions producing these researchers and specialities.

With this information important gaps in a research field can be identified; research can be stimulated in neglected areas; networking and collaboration between researchers can be encouraged; while facilitating informed decision-making and strategic management.

The study indicates that between 2000 and 2014, the number of relevant PhDs awarded annually in the water science sector ranged from 14 to 32. The number of water-related PhDs produced in South Africa thus remains small, and indicates an apparent lack of focus on water research in South Africa. Researchers and PhD candidates are distributed across the country.

Bibliometric analysis

Publishing one's work in a scientific journal is an integral part of being a scientist. Journal articles act as a permanent record of what has been discovered, when and by whom. It shows the quality of the scientist's work – through the peer review system other experts have rated it as valid, significant and original.

Since communication in science is realised through publications, they are considered an extremely suitable source of data to investigate the growth rates of science. Bibliometric analysis, the quantitative study of the research system, is based mainly on publication indicators.

According to the WRC study, South African researchers have been producing around 60 water-related publications per year since 1981. During the 2000s this number increased to around 100 publications per year. By 2014, the number jumped to 200 publications.

While a number of factors have contributed to this growth, increases in research funding and emphasis on publishing by funding institutions, such as the WRC, were undoubtedly of critical importance.

It is significant to note that South Africa ranks 19th in the world in the field of water research (the only African country among the top 20). This compares to the country's world ranking of 33rd in the world for the total number of publications in all fields.

It is the expressed hope that the outcomes of this study will go a long way towards guiding research and innovation policy in South Africa.

To obtain a copy of the publication, *The state of water research in South Africa 2015* (**Report No. SP 92/15**) contact Publications at Tel: (012) 330-0340; Email: orders@wrc.org.za; or download a copy at www.wrc.org.za

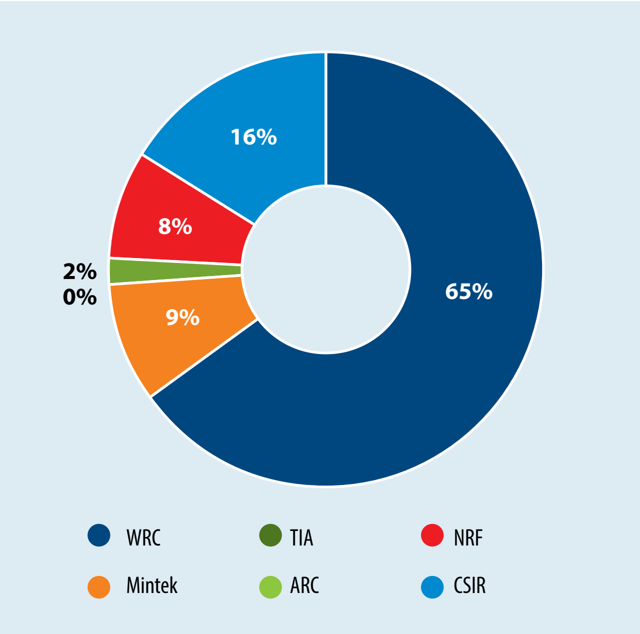


Figure 1: Funders of water research (2014).

Water KIDZ

DIRT AT PLAY – kids get a closer look at rare South African peatland

Those who opted to get their feet wet could enter the wetland for a closer look.

On Saturday, 30 January 2016, over 120 children, accompanied by parents, youth group leaders, students and other volunteers, descended on the Colbyn Wetland in Pretoria to learn about wetlands and their role in sustaining our lives and livelihoods.

This annual event, held to mark World Wetlands Day, was co-hosted by the Water Research Commission (WRC) and Agricultural Research Council (ARC), in association with the Friends of Colbyn Valley, Centre for Wetland Research and Training (WetResT), Botanical Society of South Africa, South African Wetland Society, International Mire Conservation Group and Aquila Business Consulting, in the City of Tshwane's Colbyn Wetland Nature Reserve.

2 February marks the anniversary of the adoption, in 1971, of the Convention on Wetlands (also known as the Ramsar Convention) in the Iranian city of Ramsar, and is celebrated across the globe as World Wetlands Day. The theme for World Wetlands Day 2016 is 'Wetlands for our Future – Sustainable Livelihoods', which aims to involve and inspire the youth in protecting wetlands for the future of our planet and its people.

Educational activities on offer at the Colbyn Wetland were aimed at children between the ages of 6 and 13, and included an early morning bird walk to spot some of the almost 150 bird species that can be found in the greater nature reserve, and 'Wetlands 101', led by local specialists Prof George Bredenkamp and Dr Piet-Louis Grundling.

This introduction to wetland science included a 'wetland awareness walk', which demonstrated the different wetland zones by looking at various soil and vegetation markers, and the construction of a simple wetland model to illustrate basic principles of wetland structure and function. Held annually since 2014, the event has been attracting ever larger numbers of children, with the 2016 turnout being the largest yet. Each year has also seen new collaborations formed with partner organisations.

A feature of this year's event was the assistance of a number of student volunteers from various institutions, including the Tshwane University of Technology's Department of Environmental, Water and Earth Sciences, and the University of

Venda's Department of Soil Science. In addition, the NGO SOAPkidz supported the attendance of children from two of the city's children's homes.

The Colbyn Wetland includes areas of peatland, a relatively rare occurrence in South African wetlands. The wetland is vulnerable to a number of impacts due to its urban location, but remains a valuable biodiversity and water resource, as well as offering the residents of Pretoria a unique educational and recreational site.

In recent years the Colbyn Wetland has received much attention in the press due to concerns over the proposed development of a park-and-ride facility on its border, and most recently was the subject of public outcry when it was suggested that it may form part of a decision by the City of Tshwane to auction off certain areas of municipal land. However, it has since been clarified that this applies only to a small section of land south of Stanza Bopape Street and located outside of the wetland and nature reserve.

The involvement of the WRC in wetland conservation and education initiatives such as the above reflects the value of these ecosystems in providing essential natural infrastructure for managing the country's water resources. Wetlands provide significant economic, social and cultural benefits.

They are important for primary products such as pastures, support recreational and tourism activities and are also important sites for biodiversity. Wetlands help to reduce the impacts of storm damage and flooding, maintain good water quality in rivers, recharge groundwater and store carbon.

Wetland ecology is one of the focus areas identified by the ARC for strategic research, as wetlands provide vital ecological goods and services relating to agriculture and water resources. The aim of the ARC's Natural Resource Management programme is to promote research to secure national biodiversity, the integrity of ecosystems and the efficient use of agricultural natural resources for agricultural production.

The Water Science programme at the ARC-Institute for Soil, Climate and Water (ARC-ISCW) engages in multi-disciplinary wetland research projects led by Dr Althea Grundling (Senior Researcher: Wetlands).

The importance of protecting South Africa's rare peatlands

Peat forms when low-energy flows and permanent water-logging enable partially-decomposed plant material to accumulate. Active accumulation of peat depends on a slow rate of decay in oxygen-deprived (anaerobic) conditions.

Peatlands anywhere in South Africa are a relatively rare discovery – only about 10% of our wetlands contain peat. And, once discovered, peat is often exploited as a resource, mined to use as a potting medium, fuel source, adsorbent or filter material. Flow through a peatland is often diverted or channelled and the peat is left high and dry, catches fire, and, after millennia of flow accumulation, is gone.
Yet the Colbyn peatland persists, tucked away under a dense bed of reeds.

Occupying just over a hectare, the peat layer in Colbyn has been estimated to be about 7 000 years old, and is 2.4 m thick at its deepest point. The total volume of peat in Colbyn amounts to about 15 000 m^3.

The best part of playing with peat is getting dirty!

The reedbed has made a remarkable recovery following some good rains.

Dr Piet-Louis Grundling explaining the workings of a wetland with the use of a wetland model.

Schools, plumbing graduates benefit from new water innovation

Twenty Johannesburg schools are benefiting from an innovative new technology that is set to help them identify leaks and save water.

The Aquatrip is a new technology that was selected for testing by the Water Technologies Demonstration Programme (WADER) – a joint programme of the Department of Science and Technology (DST) and the Water Research Commission (WRC). WADER, in partnership with the South African Local Government Association (SALGA), put out a call for innovative water and sanitation technologies and solutions that will contribute to improving water conservation, efficient use, cost-effectiveness and efficient management of water and waste in the municipal environment.

The AquaTrip device, which functions in a similar way to an electricity trip switch, identifies unknown leaks and plumbing failures, including, taps left running, leaking toilets and urinals, leaking or failed appliances, and cracked pipes or leaking fittings. The device also identifies and prevents all inadvertent or accidental over-use. For example, forgetting the hosepipe on when refilling the pool, not turning off the garden sprinkler, or having the hoze nozzle pop off in the sun.

According to WADER Manager, Dr Manjusha Sunil, the Aquatrip technology could assist the end consumer to manage their water in a sustainable manner. This will also assist municipalities in reducing their non-revenue water.

Johannesburg Water helped to identify 20 schools where the technology is now being tested on a pilot scale. An exciting part of the initiative is the fact that six plumbing graduates from South West Gauteng College have been brought into the project and are now being trained on the installation of the device. They will be involved in the plumbing work at the various sites.

Going forward, SALGA would continue collaborating with WADER to explore innovative technological solutions that are informed by science and practical application. Lastly, and more importantly SALGA pledges to act as an enabler and facilitator for technology demonstration sites. In a statement the association said it looked forward to a festival of ideas from all South Africans in taking the water sector to greater heights.