THE
WATER WHEEL

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Biodiversity, human health under the spotlight at Phongolo

WATER RESEARCH COMMISSION

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A multiyear study has highlighted the environmental and human health risks to the Lower Phongolo River system. See article on p. 14.

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.
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Fluid Thoughts


WRC CEO, Dhesigen Naidoo

Sanitation – a global revolution is afoot

More than a thousand delegates from sixty one countries converged in Chennai, India in the third week of February to discuss the global sanitation challenge.

This was the 4th international conference on Faecal Sludge Management – known as FSM4. In her opening keynote address, Minister of Water and Sanitation, Nomvula Mokonyane, was clear – the economic and social arguments were stronger than ever for a huge investment injection into safe sanitation globally, but, perhaps our strongest driver is the quest to expand the frontiers of dignity. The SDG (sustainable development goal) target for sanitation is an ambitious one, and was the subject of much discussion and anxiety for delegates from around the world. Global universal sustainable access to safe sanitation by 2030 is without doubt an immense challenge.

The experiences of various countries, including South Africa and India, served as important case studies not only for their triumphs, but perhaps more importantly for the learnings from the various interventions that were not as successful. It was also clear that many countries have plans to meet the SDG targets well before the 2030 timeframe. Perhaps one of the more ambitious is India's target in the context of the Swachh Bharat or the 'Clean India' campaign. This is led directly from the office of the Prime Minister. The target is to end open defecation and achieve universal access to improved sanitation by 2 October 2019. This is the date of the 150th birthday of Mahatma Ghandi. The progress reports presented at the conference by the secretaries of the various national and state ministries indicated a rate of progress that is very encouraging. South Africa's own trajectory also indicates a sustainable achievement of the target well before 2030.

South Africa featured prominently at FSM4 through the national ministry's efforts on the policy and the roll-out of the bucket eradication campaign; the WRC, led by Executive Manager, Jay Bhagwan, and the sanitation research management team, with its global leading work on sanitation innovations; and the City of eThekwini, in partnership with the University of KwaZulu-Natal, as one of the world leading city's demonstration on the ground, the foundation of a new sanitation platform for the world. The key of course is the treatment of the waste that will eventually decide the level of sustainability. This was the focus of the majority of the conference sessions. The presentations and workshops ranged from smarter business models for removal of faecal sludge to cutting edge technologies for faecal waste beneficiation. The latter ranged from the classic solutions of fertilizer production to biogas harvesting and even biofuels production. All of which turns the conversation from 'waste to wealth' – a slogan that has been adopted in many environments already.

It was also gratifying to get global acknowledgement for the leading work that is happening on the African continent, both in the domain of creating new solutions as well as being the test-bed of preference for many of the new technology platforms and business models. The road is a combination of daunting and incredibly exciting as we explore the pathway to accelerate the access to safe sanitation and higher health security for all the world's people; but we are approaching it in a manner that is catalytic for waste beneficiation and resource recovery that may well turn the blight of poor sanitation of the past, into a vibrant pillar of development tomorrow.

It is important to acknowledge the contributions of the Bill and Melinda Gates Foundation. The foundation has catalysed the global dialogue on the back of the 'reinvent the toilet' campaign, and through the hard work of the likes of Doulaye Kone, Brain Arbogast, and their team, helped to glue together the various initiatives around the world into the powerful global force that was witnesses in Chennai.

Minister of Water and Sanitation, Nomvula Mokonyane, delivering the keynote address at the 4th Faecal Sludge Management Conference in Chennai, India.

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University presents first learning programme in water governance skills

A group of 25 municipal officials and educators from Technical Vocational Education and Training (TVET) colleges in the Western Cape attended the first Water Governance for Water Leaders learning programme at Stellenbosch University (SU) in February.

The programme, presented by the SU Water Institute (SUWI) in partnership with its School of Public Leadership (SPL), was developed specifically for municipal councillors and officials by the SPL's Prof Erwin Schwella in collaboration with several experts in the water sector.

According to Prof Schwella, the course connects the fields of leadership development, practices in water governance and leadership innovation in public water utilities and institutions by way of comparative and relevant case studies. The course, which is registered with SU and holds nine credits on level eight of the National Qualifications Framework, took place from 6 to 10 February 2017.

Municipal officials from Hessequa, George, Knysna, Swellendam and the City of Cape Town attended, as well as educators and officials from Boland College, South Cape College, Northlink College and representatives from various non-governmental organisations and small to medium-sized enterprises (SMEs) operating in the water sector. A representative of the policy and regulation division of the Department of Water and Sanitation attended as an observer.

During the course, partipicants had to complete a class-based group project and an examination at the end of the programme. Participants also have to submit an individual assignment by the end of February, after which the successful candidates will receive a Certificate of Competence.

Manuel Jackson, project-manager at SUWI, says apart from the learning programme they are also developing an occupational qualification in wastewater treatment in partnership with EWSETA under the framework of the Quality Council for Trades and Occupations.

"TVET Colleges can play a pivotal role in building capacity in the water sector and specifically in a critically important area such as waste water treatment," he adds.

The next learning programme will take place from 8 to 12 May 2017 at the Saldanha Municipality. For information about upcoming workshops and short courses, contact Katherine Morris at kmorris@sun.ac.za or Tel: (021) 808 9453.

Water Diary

Large rivers
April 18-21
The Third International Conference on the Status and Future of the World's Large Rivers will be held in New Delhi, India. Topics to be covered include hydrology, hydraulics and water quality; sediment transport and river morphology; ecology and restoration; and integrated river management.
Visit: http://worldslargerivers.bku.ac.at

Water sustainability
May 7-10
The Water Institute of Southern Africa (WISA) is hosting a Water Sustainability Forum with the theme 'From scarce to sufficient', aimed at turning current water challenges into opportunities.
Visit: www.wisa.org.za

Water history
June 15-17
The conference of the International Water History Association will be held in Grand Rapids, Michigan, USA. The conference is co-hosted by the Western Michigan University.
Visit: www.iwha.net

Hydrology
July 10-14
The annual conference of the International Association of Hydrological Science will be held in Port Elizabeth. Visit www.iahs.info

Catchment management
October 9-11
The International Water Association in association with WISA is hosting a specialist conference on watershed and river basin management at Skukuza camp, Kruger National Park.
Visit: www.rbm2017.com

Groundwater
October 14-18
The Groundwater Division of the Geological Society of South Africa will be hosting its Biennial Conference at Spier Hotel, outside Stellenbosch with the theme 'Change, challenge, opportunity'.
Contact: Deidre Cloete;
Email: deidre@iafrica.com;
Visit: www.gwd.org.za

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News

New CEO for premier research institution

From 1 February the CSIR has a new CEO.

Dr Thulani Dlamini is no stranger to the CSIR. He first joined the organisation in 2005 as head of the CSIR National Laser Centre. In 2008 he was appointed to the position of Group Executive for Research and Development, a position he held until 2011. Dr Dlamini then left the CSIR to join Sasol as the Executive Manager: Research and Development and later the Vice-President for Strategic Research and Technology.

Dr Dlamini holds a PhD in Chemistry from the University of the Witwatersrand and a Masters in Business Leadership from the University of South Africa. He is a member of the Academy of Science of South Africa and has served on numerous Boards, including those of the Sasol Pension Fund, Automotive Industry Development Centre, Sasol Technology UK and the Netherlands.

"I am excited about my return to the CSIR to take forward the excellent work of my predecessors," noted Dr Dlamini. "I look forward to working with our partners and the brilliant minds in the organisation. The CSIR is well positioned to have an impact beyond the South African border, and it is my hope that together with our global partners we can deliver on the mandate of the CSIR to use science, engineering and technology to advance society and industry."

CSIR Board Chairperson, Thokozani Majozi, said that by appointing such a thought leader in science, the CSIR was poised for greater success ahead. "The Board is excited about Dr Dlamini [re]joining the CSIR, and we have full confidence in his leadership and management skills. He is indeed the ideal incumbent to usher the CSIR into a new phase."

Drought fears turn to flood fears as dams fill fast

Following a week's rain in February the Department of Water and Sanitation (DWS) warned communities located in the floodplain area of the Vaal and Bloemhof dams to vacate as they were exposed to possible flooding.

The Vaal Dam was expected to reach 100% full for the first time in many years, followed by Bloemhof Dam located downstream in the North West province. The sluices of both dams were due to be opened to reduce pressure on the dam walls.

South Africa experienced torrential rains towards the end of February following tropical storm Dineo. The system caused widespread rain showers over eastern Mpumalanga and Limpopo, in particular. When the storm dissipated tropical conditions caused widespread rain over much of the country.

Flash flooding was experienced at the Augrabies Falls, in the Northern Cape, while in the North West all provincial dams reached full capacity, with the exception of the Molatedi and Klein Marico dams.

In KwaZulu-Natal, DWS was closely monitoring Mearns Dam whose water storage level had risen to over 120%. While no casualties had been reported at the time of writing, the department warned people living in the dam catchment to relocate immediately. Despite the full capacity of the Mearns Dam, average storage in the Umgeni storage system remained at a low 54%.

The Marico, Crocodile (West), Vaal, Vals, Wilge (Free State), Caledon, Upper Olifants, and Thukela rivers were all flowing strongly, and dams were all filling up. The DWS warned that care should be taken downstream of dams and on the floodplains of all rivers in the central and northern provinces.

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Science Minister wins international award

Minister of Science & Technology, Naledi Pandor, has been chosen by the American Association for the Advancement of Science (AAAS) to receive the 2016 Award for Science Diplomacy.

The minister was honoured by AAAS not only for integrating science in policymaking in South Africa, but also for her advocacy for young scientists and women scientists by supporting initiatives that encourage international collaboration for both groups.

"Science not only enables us to more decisively respond to major societal challenges," Pandor said, "but also plays a critical part in helping to foster international partnership, friendship and solidarity." She explained that the role of science diplomacy is more important than ever, and said she is humbled and honoured to receive this award.

"Under her leadership, South Africa has made numerous contributions to building science structures in organisations such as the African Union and the Southern African Development Community, to strengthening the science granting councils of other African countries, and to expanding the role of the Global Research Council," noted Tom Wang, AAAS' Chief International Officer.

NGO reacts to coal mine threat in strategic water resource

Non-governmental organisations have reacted vehemently to the news that Minister of Environmental Affairs, Edna Molewa, approved an application for coal-mining to go ahead in the Mabola Protected Environment – less than three years after the area gained protected status.

Along with four other wetland areas in Mpumalanga, the 8 772-ha Mabola Protected Environment was declared on 22 January 2014. It is a strategic water source area, generating critical water supplies for agricultural, industrial and human use.

"The Protected Areas Act recognises that there are areas that play such an important role in safeguarding the country's ecological services that they require safeguarding at all costs," noted Dr Morné du Plessis, CEO of WWF South Africa (WWF-SA). "That an incompatible activity such as coal-mining has been given the go-ahead is a worrying turn of events that does not bode well for other protected areas."

"Coal-mining in strategic water source areas is not only contrary to sound scientific advice, but also to basic common sense. These are areas of high biodiversity which are critical for water generation and future economic growth. WWF will leave no stone unturned to ensure that the best interests of society are pursued," Dr du Plessis added.

WWF-SA reported that it has a copy of the letter indicating that Molewa authorised the application in August 2016 for an Indian company, Atha-Africa Ventures (Pty) Ltd, to develop an underground mine in the Mabola area. She is a co-signatory with the Minister of Mineral Resources, who signed off on the application in November last year. In terms of the law, both signatures are required for mining to go ahead.

However, at the time of writing there had been no public announcement on the decision. "We are increasingly aware of the trend of diminishing transparency in decisions related to mining activities in general. This is fast becoming a significant concern of short-sighted decision-making that has the consequence of short-changing society," concluded du Plessis.

Consultancy grows its groundwater capabilities

JG Afrika, a leading multi-disiciplinary engineering and environmental consultancy, has grown its groundwater division by acquiring Geowater IQ, a specialist in the field of geohydrology, water-resource management, research and other related disciplines.

Paul Olivier, MD of JG Afrika, says the acquisition of the 100% black-owned consultancy comes at a time when the management of South Africa's scarce water resources and the upgrading of related infrastructure have been placed at the top of the agenda.

This intense focus on water infrastructure is mirrored by the recent appointment of JG Afrika as the geohydrologist professional for a large water and sanitation project for schools in rural areas that is being driven by the KwaZulu-Natal Department of Public Works.

This contract, awarded to JG Afrika by the firm Ramgoolam complements the company's already extensive portfolio of successful water-related initiatives.

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Global

New test for waterways finds crazy list of pollutants

A new way to test for a wide range of micropollutants in waterways has already turned up a nightmarish cocktail of contaminants.

"Water quality monitoring is conventionally done by narrowly investigating one or a few contaminants at a time. We aimed to develop an analytical method that would be as broad as possible," explained Damian Helbling, assistant professor of civil and environmental engineering at Cornell University. The work appears in the journal, *Environmental Science: Water Research & Technology.*

"We demonstrate that our approach can more than double the amount of information that would otherwise be obtained from more conventional methods," Helbling noted, "This has important implications for risk characterisation and exposure assessment."

The new technique—using high-resolution mass spectrometry—assessed 18 water samples collected from New York state waterways. A total of 112 so-called micropollutants were found in at least one of the samples—chemicals including pharmaceuticals, pesticides, and personal care products. Helbling said that eight of the chemicals were found in every sample and dozens more were found in most samples. Helbling and graduate student Amy Pochodylo refer to their approach as 'suspect screening.' The spectrometer analysed the chemical composition of the water samples and the researchers compared the resulting data with a large list of 1 100 'suspect chemicals' by employing a nimble data-mining algorithm.

The unmasked contaminants read like a soup recipe concocted in a pharmacist's nightmare, as they found anticonvulsants (levetiracetam), antihistamines (fexofenadine), and muscle relaxants (carisoprodol, metaxalone, and methocarbamol)— all chemicals that have rarely been reported as water contaminants and some of which are being reported for the first time. Prominent chemicals found in New York's waterways include triclosan, an anti-bacterial agent found in liquid hand soaps and toothpaste; the anaesthetic and heart medicine lidocaine; diethyl-phthalate, a component of plastics; and the herbicide atrazine.

In all of the 18 waterways, researchers detected atenolol acid (a high-blood-pressure medication component); 5-methyl-1H-benzotriazole (a corrosion inhibitor found in dishwasher detergent); caffeine; the insect repellant DEET; gabapentin (an epilepsy medication); metformin (a medication that controls blood sugar); saccharin and sucralose (Splenda).

Citing how this new technique represents a broad range of chemical structures unlikely to be found using conventional means, noted Helbling, "These results are not only interesting from a novelty perspective, but demonstrate the breadth of chemical coverage that our suspect screening affords."

To access the original paper, Visit: http://pubs.rsc.org/en/Content/ArticleLanding/2017/EW/C6EW00248J#!divAbstract

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Language a barrier to flow of scientific knowledge

Language is still a major barrier to the transfer of scientific knowledge even though English is increasingly used as the global language of science, a study has found.

The research, published in the journal *PLOS Biology*, highlights a practical problem that scientists in many parts of the world have long struggled with. Its authors took a close look at scientific documents on biodiversity conservation published in 2014. The documents – more than 75 000 in total – were written in 16 different languages.

For every ten documents, roughly six were in English and three in other languages. The number suggests that English remains a leading language within scientific communities. But the results also underline the fact that a great deal of research is still conducted in languages other than English, and that they end up having little visibility.

That is particularly true for universities and research centres in several African countries that do not use English as their primary language.

"I have long been interested in how language barriers could affect science in general," noted Tatsuya Amano, lead researcher on the study. "However, this problem has rarely been tackled by scientific communities so far."

Native English speakers tend to assume that all important knowledge is available and can be communicated in English, according to Amano. On the other hand, he noted, non-native English speakers tend to think that conducting research in English is the first priority, and often they end up ignoring non-English language science. "Ignoring such non-English knowledge can cause biases in our understanding of study systems," the researchers wrote in their paper.

To access the original article, Visit: http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.2000933

Water has another phase we did not know about

Scientists have discovered that there are two types of liquid water – not just one as previously thought.

This new peculiarity adds to the growing list of strange phenomena in what we imagine is a simple substance. The discovery could have implications for making and using nanoparticles as well as in understanding how proteins fold into their working space in the body or misfold to cause diseases such as Alzheimer's.

Writing in the international *Journal of Nanotechnology*, Oxford University's Laura Maestro and her colleagues in Italy, Mexico, Spain and the USA, explain how the physical and chemical properties of water have been studied for more than a century and revealed some odd behaviour not seen in other substances. For instance, when water freezes it expands. By contrast, almost every other known substance contracts when it is cooled. Water also exists as a solid, liquid and gas within a very small temperature range (100 °C) whereas the melting and boiling points of most other compounds span a much greater range.

Many of water's bizarre properties are due to the molecule's ability to form short-lived connections with each other known as hydrogen bonds. There is a residual positive charge on the hydrogen atoms in the V-shaped water molecule either or both of which can form such bonds with the negative electrons the oxygen atom at the point of the V. This makes fleeting networks in water possible that are frozen in place when the liquid solidifies. The bonds are so short-lived that they do not endow the liquid with any structure or memory.

The team has looked closely at several physical properties of water, such as its dielectric constant or the proton-spin lattice relaxation (the process by which the magnetic moments of the hydrogen atoms in water can lose energy having been excited to a higher level). They have found that these phenomena seem to flip between two particular characters at around 50 °C, give or take 10 °C. The effect is that thermal expansion, speed of sound and other phenomena switch between two different states at this crossover temperature.

These two states could have important implications for studying and using nanoparticles where the character of water at the molecule level becomes important for the thermal and optical properties of such particles. Gold and silver nanoparticles are used in nanomedicine for diagnostics and as antibacterial agents, for instance.

Moreover, the preliminary findings suggest that the structure of liquid water can strongly influence the stability of proteins and how they are denatured at the crossover temperature, which may well have implications for understanding protein processing in the food industry but also in understanding how disease arises when proteins misfold.

Source: sciencedaily.com

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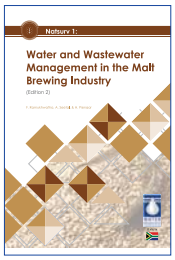
New WRC reports



NATSURV 1: Water and wastewater management in the malt brewing industry (Edition 2)

Since the publication of the first edition of Natsurv 1 in 1986, the number of breweries in South Africa has increased from eight to more than 150, as have production volumes. Previously, most breweries were locally-owned; however, current ownership is both national and multi-national for the large breweries, whilst the medium-, small and craft/micro-breweries tend to be locally owned. Water consumption estimates range from 4 to 8 ℓ/ℓ beer produced, but may be higher in the case of small breweries, generally owing to inefficient water management processes and systems. Water is used for beer production and also for cleaning, sanitation, heating and cooling processes. The study has shown that, for a number of different industrial sectors, there are common technologies available and applicable to reduce resources use and impacts (such as energy and water consumption) and wastewater generation. Many of these technologies would be applicable to breweries in general.

Report No. TT 676/16

Water use and crop parameters of pastures for livestock grazing management

Sustainable pasture production requires optimal nutrient, water and defoliation management practices in order to attain good yield and forage quality. The basic understanding of the water requirements and drivers of irrigated pasture production systems are essential for the development of sound water management strategies. Pasture systems, however are highly complex, involving interactions between crop growth, soil and plant nutrient dynamics, and livestock and pasture management systems. This project focused on mixed pastures which either included the subtropical kikuyu pasture over-sown with a temperate grass, or a temperate grass mixed with a temperate legume. The two most important legume species evaluated in this project included lucerne and white clover.

Report No. 2173/1/16

Improving weather radar estimates of rainfall using a high density

Advancing radar rainfall estimates in South Africa is extremely important as the South African Weather Service (SAWS) upgraded its network of radars between 2009 and 2012 for millions of rands. The initial objective of this study was to calibrate this radar network to improve the accuracy and reliability of the data measured by these radars. Due to unavailability of SAWS radar network for research, the North-West University purchased and installed its own Parsivel disdrometer radar called NWU Lekwena weather radar in Potchefstroom in August 2014. Preliminary (1 year) results from this radar have highlighted the need to customise radars from overseas for the South African climatic conditions. After the calibration and customisation, results from this radar were compared to the newly installed rainfall network, and the results were highly correlated. The combination of the ongoing rainfall monitoring from the rain gauge network and rainfall measurement from the radar has greatly improved rainfall estimates in the area covered by this radar.

Report No. 2062/1/16

Fate and behaviour of engineered nanoparticles in simulated wastewater and their effect on microorganisms

Despite the numerous advantages of nanotechnology and nanomaterials applied in a variety of study fields ranging from catalysis and water treatment materials, to environmental remediation and biomedicine, concerns have been raised for the human health and the environment. Nanomaterials, especially zinc oxide and silver, are increasingly being applied in consumer products. It is expected that such products will be on the increase. As such, substances from these nanomaterials might increasingly be released into wastewater processes, where the knowledge of their fate and ecotoxicological effects on the microbial population of wastewater systems is still lacking. The focus of this project was on the investigation of the potential impact of ENMs on wastewater treatment plants, using laboratory scale activated sludge based wastewater treatment systems.

Report No. KV 350/16

Modelling impacts of climate change on selected South African crop farming systems

The agricultural sector is physically and economically vulnerable to climate change. In most regions of South Africa, the availability of water is the most limiting factor for agricultural production. Any change in rainfall attributes could have wide-ranging implications for commercial and subsistence food and fibre production, as well as for the GDP, employment and foreign exchange earnings. Climate change is superimposed upon all existing agricultural stressors and is anticipated to exacerbate these issues, and in combination with low adaptive capacity, the South African agriculture sector through the value chain is highly vulnerable to effects of climate change and the associated increase in climate variability. There has been limited research on climate change and related impacts on livelihood and the natural resources in some African countries. However, evidence from global climate models developed thus far suggests that the agricultural sector in the Southern African region is highly sensitive to future climate shifts and increased climate variability.

Report No. 1882/1/16

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Smallholder irrigation entrepreneurial development pathways and livelihoods in two districts in Limpopo Province

In South Africa, unemployment and poverty are closely associated and the rural areas are nodes of both unemployment and chronic poverty. Agriculture makes an important contribution to food security at a household level, particularly for the poorest households. Agriculture is also seen as one of the key strategic opportunities for employment and rural development but smallholder farmers face formidable challenges. It is well-established that a poorly-functioning rural economy with undeveloped infrastructure, weak market linkages and poor agricultural support services isolate rural households from the mainstream economy and from important agricultural value-chains. Weak and conflicted land institutions add uncertainty and limit transactional opportunities. Enhancement of entrepreneurship is seen as key to growth in a free-market economic system including in the agricultural sector. Entrepreneurship in the South African informal sector is by and large, small-scale entrepreneurship, and largely synonymous with self-employment. Two categories of informal enterprise have been identified, namely survivalist enterprises and micro- or growth enterprises. Whilst survivalist enterprises are motivated by necessity (a push factor), generate limited income and rarely go beyond self-employment, micro-enterprises tend to be more motivated by opportunity (a pull factor) and offer the best potential to grow, create employment and bring about economic development.

Report No. 2179/1/16

Using membrane distillation crystallisation for the treatment of hypersaline mining and industrial wastewater

Membrane Distillation Crystallisation (MDC) offers a sustainable wastewater treatment process, particularly when using excess heat from peripheral processes to produce pure water as well as salt(s) products, thereby converting a waste material into a product of value that can be reused, recycled or sold to offset water treatment costs. MDC is also attractive because it requires lower operating temperatures (40-60°C) than evaporative crystallisation, enabling the efficient use of waste heat or renewable energy. This project investigated the applicability of MDC for the treatment of industrial wastewater with a specific focus on the treatment of mine water, and the impact that the presence of antiscalants had on the MDC process. Aqueous thermodynamic modelling using two different brines showed that the propensity for crystallisation increases with an increase with water recovery in the MDC process; this is directly linked to the increase in the supersaturation and consequently the driving force for crystallisation as a result of the removal of permeate water from the brine.

Report No. 2223/1/16

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No hidden figures: Success stories can help girls' STEM careers

What makes a young girl believe she is less intelligent and capable than a boy? And what happens when those children face the "hard" subjects like science, technology, engineering and mathematics (STEM). United Nations Women Executive Director, Phumzile Mlambo-Ngcuka, weighed in on society's role to promote gender equality in science on the International Day of Women and Girls in Science, celebrated on 11 February.

A recent study showed that by the age of six, girls were already less likely than boys to describe their own gender as 'brilliant', and less likely to join an activity labelled for 'very, very smart' kids.

Research tells us repeatedly that girls and boys are strongly influenced in the development of their thinking and sense of themselves by narratives and stereotypes that start to be learnt at home and continue at school and through life, reinforced by the images and the roles they see in advertising, in films, book and news stories.

So, how do we change this, and what should girls learn now that sets them up to thrive in a transformed labour market of the future? The answer is not simply more and better STEM subject teaching. They must also learn that girls have an equal place in that future. This isn't a given. A major and underestimated obstacle for girls in STEM is the stereotype that has been created and perpetuated that boys are better at these subjects and careers.

Not only do we have to ensure that children enter and stay in education, we must equally pay close attention to what they are learning. The changing future of jobs means that fields of study for children now in school should include equipping them for 'new collar' jobs in the Fourth Industrial Evolution. Jobs that do not exist today may be common within the next 20 years, in the green economy, or areas such as robotics, artificial intelligence, biotechnology and genomics.

The media plays a powerful role in biases, with the power through effective storytelling to reinforce negative perceptions and norms or to set the record straight and create new role models. ***Hidden Figures***, Margo Lee Shetterly's book, that tells the untold story of the black women mathematics who helped win the space race, has been released as a film and bring recognition to those who were doubly invisible at NASA – as women and as black women. Making accomplished women scientists visible is important for the accuracy of news and history. It is also an essential part of building further scientific success.

Census data in the United States shows that women comprise 39% of chemists and material scientists, and 28% of environmental scientists and geoscientists. These are not the equal proportions that we ultimately want – but they are far higher levels of success in science than fiction tells us. Alarmingly, best-selling movies have tended to significant underrepresent the facts. A 2015 global study, supported by UN Women, showed that, of the onscreen characters with an identifiable STEM job, only 12% were women. This tells us that women are still hidden figures in science, and it has a chilling effect on girls' ambitions.

According to a 2016 Girl-guiding survey, fewer than one in ten girls aged 7 to 10 in the UK said they would choose a career as an engineer or scientist. Un-learning this bias and changing the stereotypes is not a simple matter, yet it is essential if we are to see boys and girls able to compete on a more equal footing for the jobs of the future. This goes hand in hand with the practical programmes that teach immediately relevant skills.

UN Women is working with partners around the world to close the gender digital gap. For example, in Moldova, GirlsGoIT teaches girls digital, IT and entrepreneurial skills and specifically promotes positive role models through video. Similarly, in Kenya and South Africa, Mozilla Clubs for women and girls teach basic coding and digital literacy skills in safe spaces.

We need to deliberately and urgently un-stereotype the ecosystems in which children play, learn and grow up. Across the world, in schools, at home, in the workplace and through the stories we tell – we all need to reflect and enable a world where girls can thrive in science, so that their success becomes as probable as they are capable.

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THE WATER WHEEL

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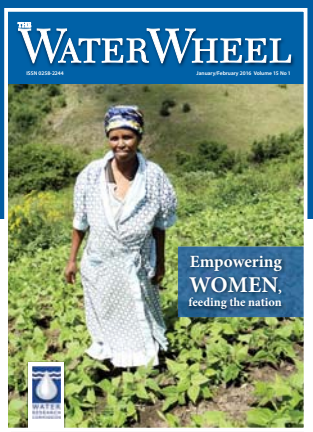

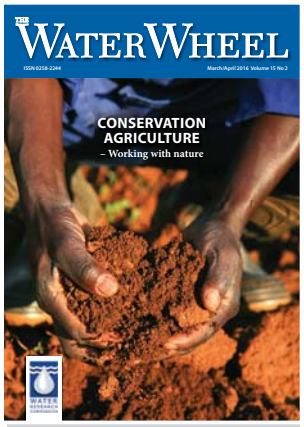

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Water and the environment

One of South Africa's potential breadbaskets at risk, study shows

An extensive transdisciplinary study report – compiled by a team of natural and social scientists – confirms that the Lower Phongolo River and floodplain, in the north-eastern corner of South Africa, are struggling to maintain their socio-ecological system function. The implications are not just regional, as this fertile area has been described as potentially the breadbasket of South Africa.

Article by Kim Trollip.

The findings based on the risk model developed for this study indicate a potential for reduced biodiversity and reduced ability of this system to be sustainably utilised. "In our conclusion we actually modelled a reduced flow of 50% and clearly showed the increase in risk associated with flow and flood reductions," explains project leader and ecologist Prof Nico Smit of North-West University (NWU).

Farmers, fishermen and women, fish vendors and the community living in the area depend upon the abundance of the floodplain known as the Makhathini Flats. This region has the potential to produce food in quantities to make a significant impact on South African and international markets, according to a Department of Agriculture development plan for the region. The area is strategically placed, in close proximity to several ports. Job opportunities in different sectors of our economy that are linked to Makhathini Flats projects include agriculture, tourism, freight and logistics, maritime, automotive, rail and manufacturing. But the plans for the area will remain tenuous if the issue of ecosystem integrity is not addressed.

Impact of organic pollutants on human health

The Phongolo system falls within South Africa's Dichlorodiphenyltrichloroethane or DDT malaria control region. The WRC study therefore also determined and evaluated the bioaccumulation and biomagnification of DDT and other relevant organic pollutants and potential impacts thereof on the river and floodplain, as well as the associated risk to the local communities.

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Masters student, Jurgen de Swardt, Prof Rialet Pieters of NWU and Honours student Melissa Hannam taking sediment and water samples from the Phongolo River.

The study set out to conduct the first integrated regional scale risk assessment of the Pongolo system since the construction of the Pongolapoort Dam in the 1970s. Its aim was to:

- Establish and evaluate threats to the ecosystem;
- Carry out an ecological integrity state assessment;
- Use fish as indicators of ecological health;
- Determine and evaluate the presence of relevant organic pollutants and potential impacts thereof on the system and the associated risk thereof to the local communities;
- Provide data to conservation authorities to aid in the management of conservation areas; and
- Evaluate the economic, ecological and cultural implications associated with the use of fish as an ecosystem service.

Study leaders Profs Smit and Victor Wepener, also of NWU, concluded that despite the containment of DDT use through indoor residual spraying, high levels of the pesticide still enters the aquatic environment of the Phongolo River and floodplains. "All five species of fish and all four species of frogs studied showed high concentrations of DDT in their tissues. However, health assessments of these organisms did not reveal any adverse effect to their health. This supports a previous WRC-funded study by our team on tigerfish in Kruger National Park where high levels of DDT also did not affect their health.

"Our study showed that local communities make extensive use of fish from the Phongolo system as a source of protein (consuming fish on average twice a week). The risk assessment of the consumption of DDT contaminated fish by the local communities showed that a definite health risk does exist due to the eating of the fish, however, there are no epidemiological studies to support. This needs to be studied further, preferably through a health assessment of the local community focussing on this aspect."

Proposed interventions

The model used in the study showed that the ecosystem services provided by the Phongolo floodplain have undergone significant changes. The study strongly proposes management interventions and monitoring in future.

The intricate interlinkages between biota and the physical environment form the framework for humanity's interaction and survival. Many of the poorest and most disadvantaged in this world are critically dependent for their sustenance and health on their immediate environments and ecology. Short-term

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Researchers and students at the field lab at Ndumo Game Reserve.

exploitation, whether from necessity or personal gain, often depletes and degrades the sustaining environment beyond the capacity of that environment to maintain the functions for the future. Where such a tension occurs, it is imperative to measure the stresses so that the situation can be described and information for mitigation and conservation provided.

One of the major outcomes of this project is the importance of Ndumo Game Reserve (NGR) as a refugia for aquatic biodiversity of the lower Phongolo system, thus an important management intervention should be reducing the threat of human encroachment into the reserve and thereby maintaining its essential role as supplier of ecosystem infrastructure to upstream communities. Ndumo was proclaimed a game reserve in 1924 with the primary objective of strict protection of its biodiversity. Today, the NGR is a RAMSAR site because of its unique wetlands.

Surrounding the NGR are communal areas that are heavily dependent on resources from the floodplain. However, the environmental sustainability of the floodplain has been questioned over time. Following an earlier ecological study of the floodplain system it was suggested that the ecosystem infrastructure of the Phongolo floodplain is maintained through controlled flood releases that were introduced to simulate the flood regime prior to the construction of the Pongolapoort Dam. The controlled flood releases were required to mimic the annual inundation of the floodplain. Although there are proper protocols for water releases these appear to be ignored and are therefore not in accord with ecological needs. The environmental flow requirements to maintain the physical and chemical structure, biodiversity, ecosystem processes and functions in the Lower Phongolo River and floodplain may therefore not be met.

Since the construction of the dam, there had, until now, been no major ecological studies that have monitored the floodplain wetlands of the Phongolo River. Very little was therefore known about the current ecological state as well as functioning and structure of the floodplain as a whole.

This new and comprehensive study allows scientists to recommend the implementation of an appropriate, long-term monitoring system to observe and track water quality, flow, diversity, aquatic health and levels of organic pesticides among others. The study leaders note with concern that, of the four original, active Department of Water and Sanitation (DWS) monitoring sites in the lower Phongolo, only the one below the Pongolapoort Dam is currently operational.

Maintaining a sustainable balance between use of resources and protection

The risk of not implementing the interventions outlined in the study was modelled according to several scenarios. In the conclusion, the researchers used the Relative Risk Model (RRM) to establish and evaluate threats to the Lower Phongolo River and floodplain ecosystem. They tested different scenarios if management practices change. One of these actually modelled the risk that should the population pressure in NGR increase to that experienced upstream, i.e. outside the game reserve, the risk to the birds, fish and subsistence fisheries endpoints would all increase to moderate risk states. This scenario would therefore remove any refuge function that the reserve provided for specifically fish and birds. Furthermore under this scenario there is a high risk that the sustainable balance between use of resources and protection would not be possible. Monitoring and management would be imperative under such a scenario.

Looking ahead, an in-depth study into the connectivity between the river and associated floodplain pans is necessary, in order to determine the ecological flow requirements to sustain the function and structure of the pans. "Fortunately we (NWU- Water Research Group) in collaboration with KU Leuven and the University of Antwerp, with funding from the Flemish Inter-university Council Team programme, are currently studying this," adds Prof Smit.

PhD student, Lizaan de Necker, collecting invertebrates as part of the study.

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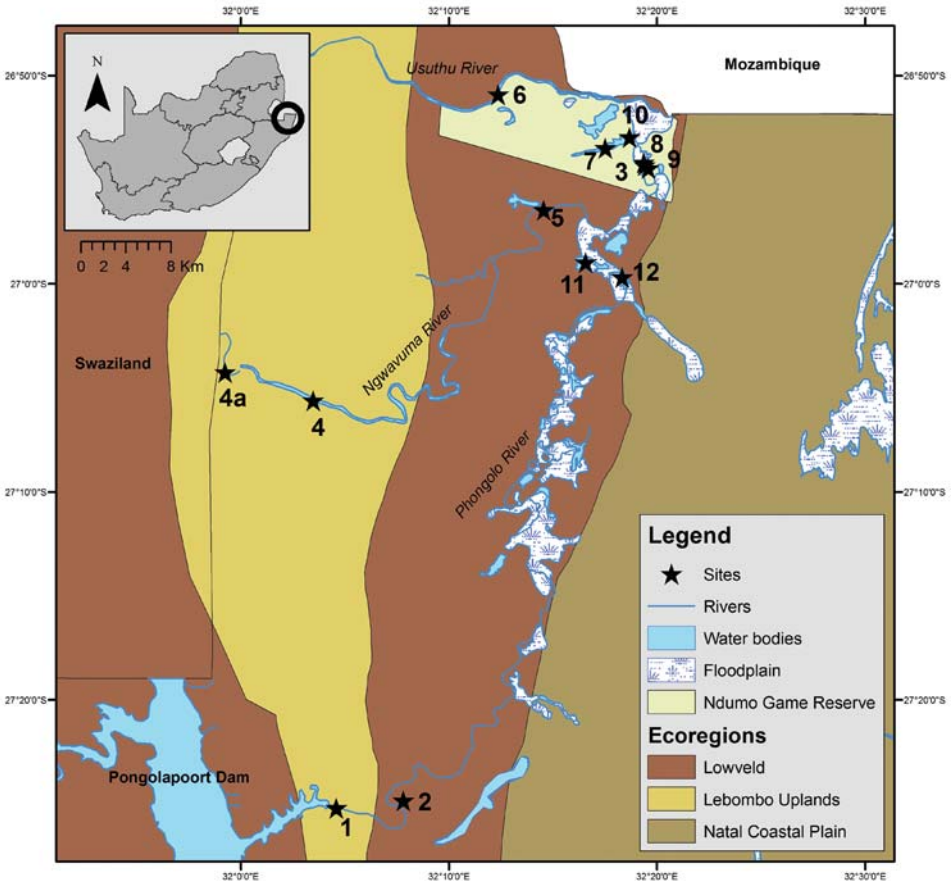

The Pongolapoort Dam supplies irrigation water for sugarcane and cotton plantations in the adjacent floodplain, the Makhathini Flats. The floodplain of approximately 10 000 ha increases to 13 000 ha at full inundation. The flats extend to the confluence of the Pongolo and Usutu Rivers in Ndumo Game Reserve (NGR) up to the border with Mozambique.

"All five species of fish and all four species of frogs studied showed high concentrations of DDT in their tissues. However health assessments of these organisms did not reveal any adverse effect to their health."

What can be done in the meantime?

The study leaders urge Ezemvelo KZN Wildlife, the Department of Environmental Affairs and DWS to consider using the Relative Risk Methodology that was developed during this project as a management tool. The RRM provides an innovative way to contribute to the determination of water resource protection measures and associated objectives as required by the National Water Act (Act 108 of 1998).

In addition, the high levels of DDT detected in all the fish species tested pose a potential serious health risk to the local community. The RRM further showed that an increase in current DDT levels will increase human health risks. Based on these findings it is imperative that the continued use of DDT in this area should be re-assessed, as well as the current health status of the people of this region should be investigated.

Finally, the role of floods in maintaining ecosystem processes in the floodplain pans will increase the certainty associated with the risk predictions. It therefore remains essential that fundamental research be conducted and supported financially in order to provide the necessary data that address these processes.

To order the report, *Socio-ecological system management of the lower Phongolo River and floodplain using relative risk methodology* (**Report No. 2185/1/16**), contact Publications at Tel: (012) 761 9300, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.

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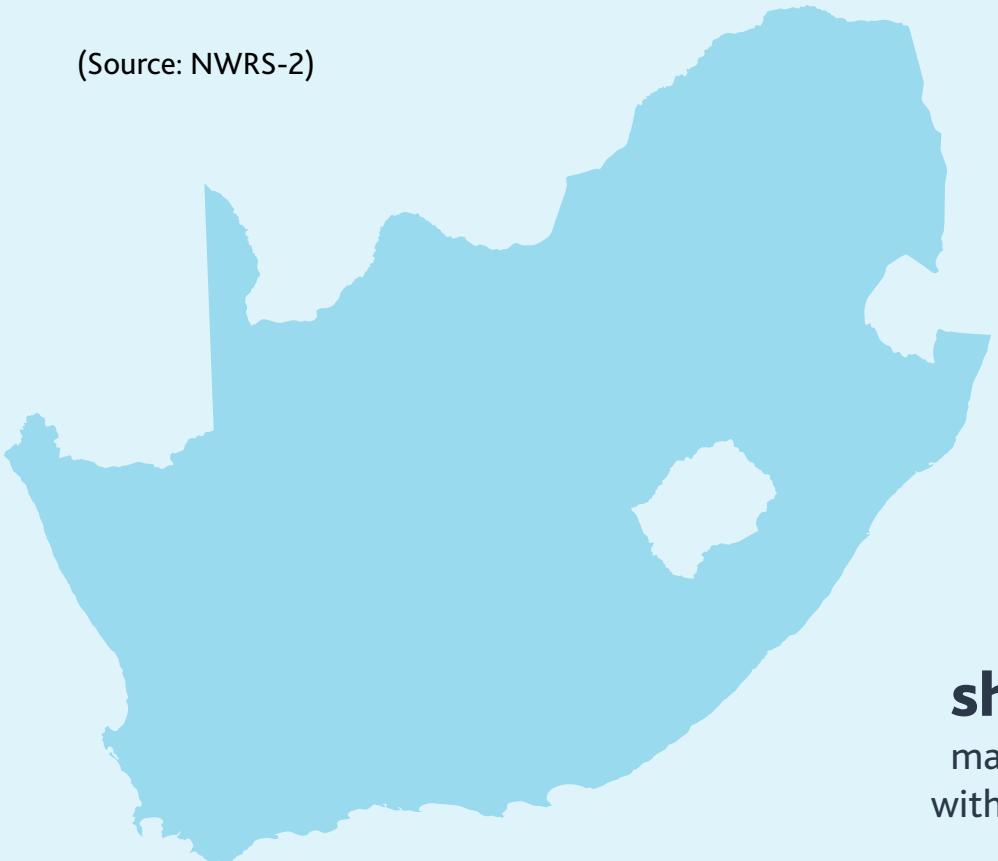
WATER BY NUMBERS:

South Africa's water – a precious resource

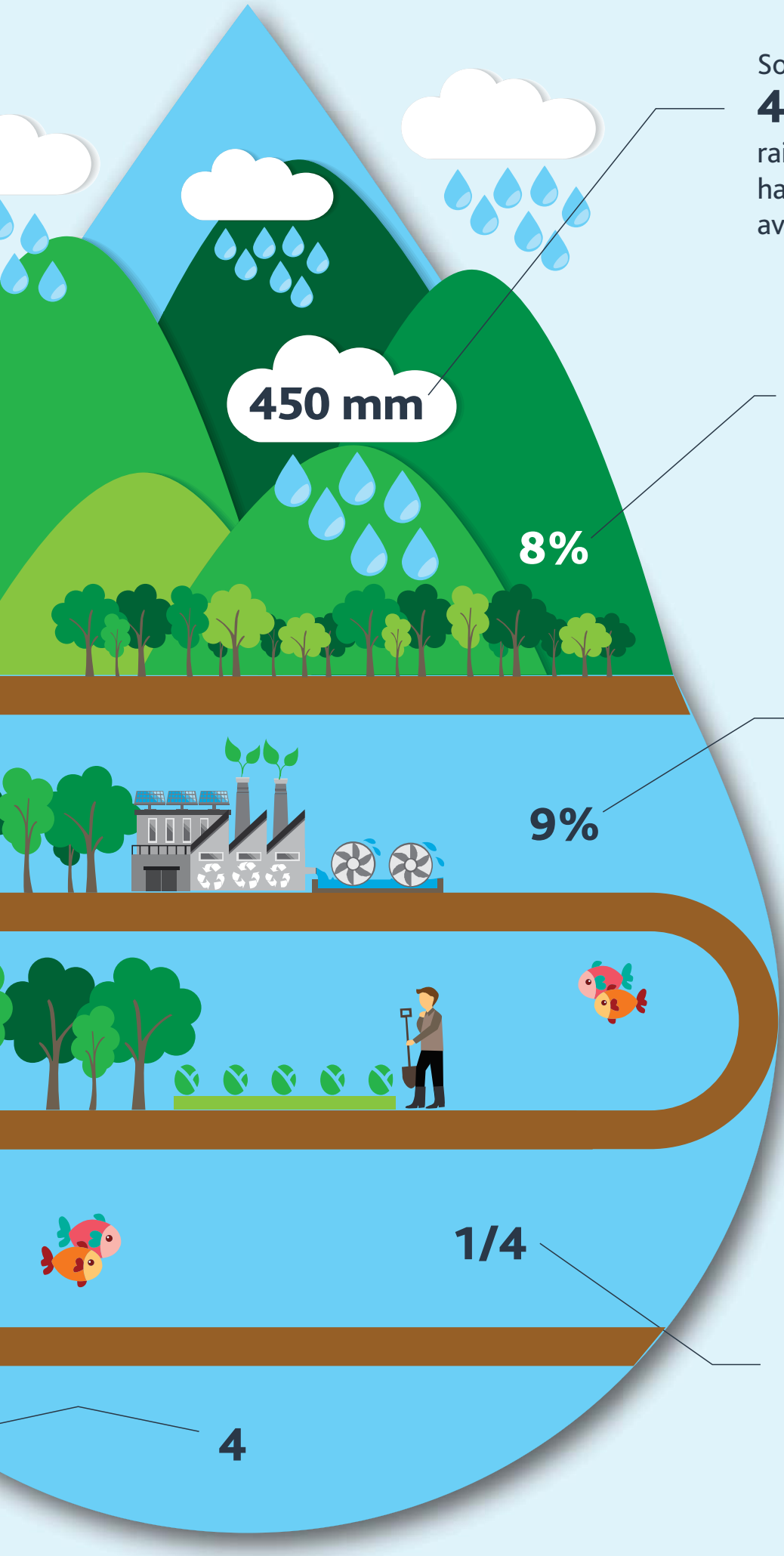
Who uses what?

- **67%** Irrigation
- **18%** Urban
- **04%** Rural
- **05%** Mining
- **03%** Power generation
- **02%** Afforestation
- **01%** Transfer out

(Source: NWRS-2)



South Africa
shares four
major river systems
with other countries.



South Africa only receives
450 mm
rain a year – about
half of the world
average of 860 mm a year.

8%
of South Africa's
land area provides
50% of our runoff

Of all the rain that
falls, only
9% reached
our rivers.

South Africa's
biggest river system
is the Orange,
which conveys a
¼ of the country's surface
water and is 2 000 km long.

Mine-water management

Reading the land – new atlas set to improve decision-making around mining and water

The Water Research Commission-funded South African Mine Water Atlas will be a vital decision-making tool in assessing the impact of mining on water resources.

Article by Sue Matthews.

Headlines about acid mine drainage (AMD) have hammered home the threat posed by disused gold and coal mines to water resources on the Witwatersrand, but how much do we know about the risks associated with current and future mining activity?

After peaking in the 1970s, gold production by South Africa remained in the top spot in the world rankings until 2006, but now only manages 12th place. Today, however, the country is the world leader in the production of platinum, chromite ore, manganese, vermiculite and ilmenite, and is also among the five largest producers of palladium, zirconium, vanadium, fluorospar, rutile and gem-quality diamonds. In addition, it falls within the top 12 for coal, cobalt, iron ore, nickel and silicon production.

Although mining is generally derided as environmentally destructive and polluting, the industry contributed R286 billion towards South Africa's Gross Domestic Product in 2015 – representing 7.1% of overall GDP – and provided jobs for 457 698 people. There is still considerable scope for growth in some sectors, highlighting the need to plan new ventures with care, while existing operations clearly have to be managed to minimise their impact.

"We didn't have a good idea of what the risks were in the different areas though," says Dr Jo Burgess, WRC Research Manager for the portfolios Sustainable and Integrated Industrial Water Management, and Mine Water Treatment and Management. "You might, for example, have a high number of mines in an area where the rainfall is so low or the evaporation rate is so high that there's no real AMD risk, even though you'd presumed there would be. Or the opposite – you might have an area that is dry and looks good for mining, but the groundwater is vulnerable and the minerals would generate acid, which means the risk of AMD is higher than it first looks."

"So in 2014, the WRC put out a call for proposals to produce a Mine Water Atlas that covered the whole country, and Golder Associates was subsequently awarded the contract. We asked them to map environmental vulnerability and mining activity for each of the Water Management Areas, and then to overlay that with a risk assessment of ecological status."

The approach used was based on the understanding that the environmental conditions resulting from mining is controlled largely by the type of mineral deposit, the geology of the host rock, and the particular mining method. This 'geo-environmental risk' was then considered against the vulnerability of the receiving water resource to come up with a 'mine water threat' rating, which is colour-coded on the maps – red depicting areas at highest threat.

"A key aspect is that there are two reasons why areas are red," explains Dr Burgess. "We've got areas that are red because they're already badly damaged, and we shouldn't damage them any further or we're going to face a catastrophe at a local level.

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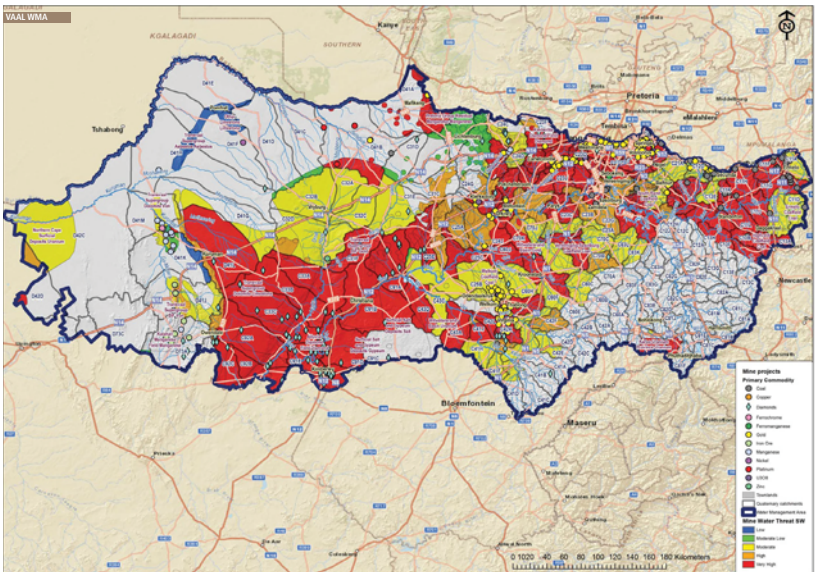

The mine-water threat to surface waters in the Vaal MWA takes into account the mineral risk rating, the associated or likely mining activity, and the vulnerability of the receiving water resource. Surface waters with a very high mine-water threat, shown in red, are those that are either in a very degraded state and need remedial intervention, or alternatively in a healthy state and require protection for human use or biodiversity conservation.

But we've also put in red areas where the ecological status is currently very good, such as headwaters in rivers that are important resources for humans or for biodiversity. Those are areas that really can't take any damage, because the downstream impacts would be so great and so significant."

The threat to both surface water and groundwater resources is addressed in the Atlas, using different criteria. While surface waters are assessed in terms of present ecological state and water quality, groundwater resources are scored according to aquifer type and yield, regional and local secondary structures such as folds, dykes and quartz veins, as well as borehole yield and groundwater quality. And since the impact on aquifer systems depends on the type of mining activity, the groundwater vulnerability rating differentiates between surface mining – in the upper 100 m of the ground – and deeper underground mining, where water is mainly confined to 'fractures' in the rock.

A detailed explanation of the methodology used to arrive at the final mine water threat ratings is provided in the opening pages of the Atlas, after which each of the country's nine water management areas (WMA's) is covered in its own section. These include an introduction with an overview on the WMA and mining that occurs there as well as profiles on mineralogy, surface water and groundwater, followed by a set of thematic maps showing the various components of the assessment, namely:

- Mining and mineral resources
- Mineral risk rating
- Mine activity risk rating
- Groundwater vulnerability – surface mining
- Groundwater vulnerability – underground mining
- Surface water threat
- Mine water threat groundwater – open cast
- Mine water threat groundwater – underground
- Mine water threat surface water.

For many of us, the term 'atlas' brings to mind one of our school geography textbooks, crammed with detailed maps depicting every part of the planet, or perhaps the kind of road-map booklet that has been rendered largely redundant by dashboard GPS navigation devices or smartphone apps. With its many colourful and informative maps, the *Mine Water Atlas* certainly has much in common with these publications, and it will indeed be available in printed form – obtainable upon request at no charge, as for other WRC publications – and also as a .pdf that can be freely downloaded from the WRC website.

But it is so much more than that. It will be distributed too as a fully interactive digital database of spatial information for GIS users, while an online web map portal will allow the less technically inclined to browse the datasets, select layers, zoom in and out, and perform basic attribute queries at the click of a mouse.

"We're also printing the maps as A0 posters, so that people needing technical detail on particular WMAs can put them up on the wall," says Dr Burgess. She stresses, however, that the Atlas does not in any way replace the need for site-specific specialist studies in determining the risk, impact assessment or specific mitigation strategies associated with mining and water management.

"It will help us prioritise how we invest in mitigation and remediation activity for sites that have already been damaged though," she says. "It can also provide a guideline for new mining activity. For example, banks can use it if they're approached for capital for a new mining venture. They can look at the Atlas, and if it's in one of the areas flagged as red, it doesn't tell them they absolutely can't mine there, but it does tell them it's going to be really expensive because their liabilities are going to be high!"

To order the *South African Mine Water Atlas* (**Report No. TT 670/16**) contact Publications at tel: (012) 671-9300; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.

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Disaster management

Flirting with (natural) disaster – Recent floods highlight need for adequate forecasting

The trip home from work turned into a frightening ordeal for scores of commuters in the eastern parts of the Greater Johannesburg Area on 9 November, when flash flooding following a thunderstorm changed major roads into raging torrents. Some cars were washed off embankments or completely submerged, prompting heroic behaviour and human-chain rescue efforts by members of the public. The Jukskei River burst its banks in Alexander, destroying shacks in an informal settlement and sweeping away their owners' meagre belongings, while underground parking areas at OR Tambo International Airport were inundated with water, causing severe damage to some cars. At least seven people died as a result of the natural disaster.

The South African Weather Service (SAWS) had issued a watch for severe thunderstorms at 14:15 for the southern parts of Gauteng, and at 16:33 this was escalated to a warning for heavy downpours and small hail for the Midvaal area. Less than an hour later, at 17:23, this warning was extended to the City of Johannesburg and Ekurhuleni too, but by the time the general public would have been alerted – via radio broadcasts, social media or weather app notifications – the flooding was probably already being experienced.

SAWS does make use of an early warning system for conditions likely to result in flash floods, known as the South African Flash Flood Guidance system. Updated on an hourly basis, it uses rainfall estimates from weather radars and satellites, together with rain-gauge data collected over the past 24 hours and hydrological modelling of soil moisture conditions, to calculate how much rain would likely result in flooding for 5366 small catchments averaging 50 – 100 km^2 in the country's main metropolitan areas, as well as the coastal strip between Cape Town and Port Elizabeth.
Unfortunately, the calculations assume natural stream channels, so they are less accurate for the concrete canals and highly

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modified river sections typical of urban environments. Besides, much of the flooding on 9 November was caused by the deluge of water being funnelled down roads and trapped by high embankments and barrier walls.

The day after the flooding, the national roads agency, SANRAL, issued a press release noting that the Gauteng freeway network had been designed to withstand one in 20-year floods when it was constructed 40 years ago, but the landscape had changed considerably since then. The reduced infiltration – and hence increased runoff – associated with the hardened surfaces of built-up areas, combined with inadequate or possibly blocked stormwater systems in some places, meant that roads in low-lying areas were prone to flooding. The following day, SAWS tweeted that OR Tambo International Airport had measured 79.4 mm of rain over one hour during the storm, making it a one in 200-year event. Until then, the highest rainfall in the long-term record for this site had been 65 mm, and that was over a 24-hour period!

The South African Flash Flood Guidance (SAFFG) system was first implemented by SAWS in 2010, and in 2015 a Water Research Commission (WRC) funded project to improve certain aspects of it was completed (Poolman et al., **WRC Report No. 2068/1/15**). During the project, some calibration errors in the soil-moisture modelling component were detected that resulted in underestimation of potential flooding in Gauteng, but these were subsequently addressed with the developers of the system – the Hydrologic Research Centre in San Diego, USA.

Another aspect that was resolved within the project was the system's poor performance in simulating flash floods in the Western Cape. Most of the province's rain falls in winter from stratiform clouds, which are low-level horizontal clouds covering a large area, as opposed to the towering thermal columns of convective clouds, typically associated with thunderstorms. Since rainfall estimates from satellites rely heavily on cloud-top temperature measurement, however, they tend to be more accurate for clouds with high tops. The Western Cape's stratiform rainfall was being seriously underestimated, so a new algorithm was developed, which entailed combining satellite convective rainfall estimates with stratiform rainfall forecasts from the UK Met Office Unified Model operated by SAWS. This succeeded in producing more realistic simulations of flash flood potential in the province.

Likewise, rainfall for the area surrounding Port Elizabeth was found to be significantly underestimated, but in this case the problem was due to estimates from radar rather than satellites. Weather radar systems are useful for tracking thunderstorms and tornadoes, so SAWS upgraded the network between 2009 and 2012 with the purchase of 10 new S-band radars (using a 10 cm wavelength), as well as two X-band radars (3 cm wavelength), which are more sensitive but have a limited range, for use at the OR Tambo and Cape Town international airports. Some of the old C-band radars (5 cm wavelength) are still in operation too, but these are prone to interference from radio local area networks (RLAN) being operated in the vicinity. In Port Elizabeth, filters had been deployed to reduce this interference, but had resulted in such inaccurate rainfall estimates that their use in the SAFFG system had to be discontinued.

As part of the project, a procedure was also developed to increase the predictive capability of the SAFFG system beyond the current 1 – 6 hour nowcast to a 12 – 18 hour forecast, allowing for more response time. In addition, workshops were organised with municipal and provincial disaster management officials so that their needs in terms of flash flood warnings could be identified.

The learning that took place during the WRC project has benefited areas within South Africa that fall outside the domain of the SAFFG system, as well as our SADC partners. This is because a similar system – the Southern African Regional Flash Flood Guidance (SARFFG) system – has been implemented by the World Meteorological Organisation in accordance with a resolution taken at its 15th WMO Congress in 2007 to develop a flash flood guidance system with global coverage. In February 2009, the WMO signed a Memorandum of Understanding with USAID's Office of Foreign Disaster Assistance (OFDA), the National Ocean and Atmospheric Administration (NOAA), which operates the US Weather Service, and the Hydrologic Research Centre to turn the resolution into reality. There are now a dozen FFG systems up and running or in the process of implementation, covering 52 countries around the world.

Facebook

On 9 November 2016, commuters in the afternoon rush hour were caught off-guard by flash flooding following a thunderstorm.

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"By the time the general public would have been alerted – via radio broadcasts, social media or weather app notifications – the flooding was probably already being experienced."

In contrast to the SAFFG, the SARFFG covers the whole of South Africa plus eight other countries, and only updates every six hours for catchments of approximately 200 km^2, using rainfall estimates derived from satellites but not radars, which the other countries generally lack. The SAWS head office in Pretoria, designated by the WHO as the Regional Specialised Meteorological Centre (RSMC-Pretoria), is responsible for running the SARFFG modelling system on its computers, and hosts the web interface that makes the products available to weather forecasters throughout the region.

Before the SARFFG was operational, however, RSMC-Pretoria was playing a leading role in another WMO initiative – the Severe Weather Forecast Demonstration Project (SWFDP). This global project actually originated in Southern Africa in 2006, but there are now also SWFDPs for Eastern Africa, Southeast Asia, Central Asia, the Bay of Bengal and the South Pacific. The aim is to improve the ability of developing countries' national meteorological services to forecast severe weather events and coordinate with disaster management agencies and the media for enhanced delivery of early warnings.

The Southern African SWFDP began with the participation of only five countries – Botswana, Madagascar, Mozambique, Tanzania and Zimbabwe – but with RSMC-Pretoria acting as the principal regional centre and RSMC-La Reunion providing support on tropical cyclone forecasting. Based on the successful one-year demonstration phase, however, the Meteorological Association of Southern Africa requested that the SWFDP be rolled out to the entire region, so it was subsequently expanded to include the 15 SADC member countries and Comoros.

Most of these countries do not have the capacity or resources to run weather forecast models, so the SWFDP relies on a 'Cascading Forecast Process'. A number of global centres, namely the UK Met Office, NOAA's National Centres for Environmental Prediction (NCEP), and the European Centre for Medium-Range

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Weather Forecasts (ECMWF), provide specialised forecast products to RSMC-Pretoria, which in turn disseminates them to the national meteorological services via a dedicated link on the SAWS website. In addition, RSMC-Pretoria provides products from its satellite nowcasting system and from the Unified Models run by SAWS over the SADC domain, as well as daily interpretation and guidance on severe weather for the next five days, focussing on heavy rains, strong winds, rough seas and extreme temperatures. The various national meteorological services assess the information and issue country-specific warnings as necessary.

Recognising that SARFFG and SWFDP have many common features and objectives, a USAID-funded twinning project has been underway since 2015 to link the two early warning systems. The intention is to integrate them into an enhanced, more streamlined system that will improve the accuracy, lead time, communication and dissemination of early warnings about extreme hydrometeorological hazards to communities.

The project has a strong capacity-building component, consolidating the frequent training activities for forecasters that have been hosted by RSMC-Pretoria for the SARFFG and SWFDP. It also strives to ensure that disaster management agencies and NGOs in the emergency preparedness and response arena receive appropriate information and training, based on needs clearly defined by them. And a particular emphasis is being placed on 'reaching the last mile' – making sure accurate warnings reach the affected population with sufficient lead time, in a format that can be easily understood and acted upon.

The nine participating countries are each expected to prepare a 'Roadmap' document detailing how the project objectives will be met and outlining deliverables, work plans, timelines and organisational structures. They must also compile a Concept of Operations document that spells out everything necessary for a fully functional end-to-end system covering all components of the forecast-warning-response chain.

In an overview of the project published in the international journal ***Water*** in June 2016, the authors – Robert Jubach of the Hydrologic Research Centre and Sezin Tokar of USAID-OFDA – point out that failure of one component will lead to failure of the entire system.

"State-of-the-art technology and a perfect forecast will not save lives if the populations at risk are not informed in a timely manner, or do not have plans and policies in place in advance to reduce impacts," they write. "Well-prepared communities remain vulnerable to these hazards if they do not have access to and understand information that provides the lead time needed to take necessary actions."

"In addition, close coordination must occur between all sectors and between national and local governments for systems to function properly, with clear lines of roles and responsibilities, to avoid confusion and chaos during disasters."

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Water resource management

Promoting sustainable economic development in water-constrained catchments

A current research project, funded by the Water Research Commission (WRC) and the Western Cape Provincial Department of Economic Development and Tourism, is driving solutions for integrated water resource and economic development planning in the water-constrained Saldanha Bay and the Berg River catchments. The study is being carried out by GreenCape in partnership with the University of Cape Town's African Climate Development Initiative.

Article by Claire Pengelly and Helen Seyler.

There is increasing recognition that the combined effects of climate change, population growth and continued urbanisation are exerting pressure on limited water resources. By 2012, approximately half of the major South African supply schemes were already in a water balance deficit, requiring new water resources interventions to meet projected future demands.

According to the Department of Water and Sanitation (DWS), 55% of smaller schemes supplying settlement areas or towns are currently or will be in a water balance deficit within the next ten years. At the same time, economic growth remains vital for alleviating poverty, hence the large national drive to stimulate growth.

Therefore, growth is required in spite of significant water resource constraints. However, the DWS has been careful to point out that whilst water is essential to development, its availability is not a driver to, nor constraint on, development. This position of DWS is based on the view that as much water can be made available as is required (via desalination for example).

Yet, in the case of a catchment where all readily available water is allocated (referred to as a "constrained catchment"), future development requires additional water resources, either through the development of new resources or the reallocation from other users in the catchment. Both of these approaches come at a cost: new infrastructure for water resource development will need to be paid for by the state or by the water users through increased water tariffs; reallocation from other users implies curtailment of existing use resulting in trading-off some sectors or areas against others.

Given the possible constraint of water on development, or the cost of supplying water to support development, the allocation of water should be towards those water users or developments that maximise the socio-economic benefits for the water used. Furthermore, in constrained catchments there may simply not be "enough for all, forever" and allocation decisions between competing uses or development options may need to be taken.

Decision-makers need to understand: what is the socio-economic impact of diverting more water towards agriculture in

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a bid to promote food security? Conversely, what is the impact on the food processing industry and on food security, of a decision to promote more economically lucrative uses of water than agriculture?

In a perfect water market, market forces would dictate the allocation of water resources between competing users. However, water is identified as a basic human right in the South African Constitution, and is institutionally allocated and priced. Therefore, allocation decisions should be made with the understanding of the socio-economic-environmental costs and benefits of each use of water, and the trade-offs that these decisions imply.

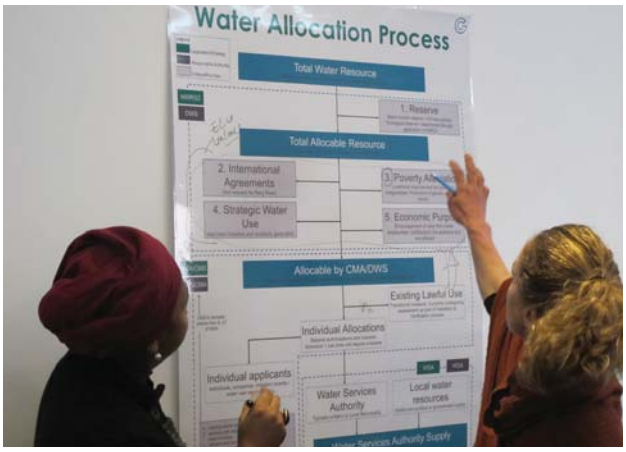
Whilst the discussion above is theoretically relevant to many catchments within South Africa, it is particularly pertinent for the Berg River catchment and the development future of Saldanha Bay. The West Coast District Municipality is supplied by water from the Western Cape Water Supply System (WCWSS), via the Berg River and Misverstand Dam and, in turn, supplies water to Saldanha Bay Local Municipality.

The West Coast District Municipality estimated system yield is 582 million m^3/a while current allocations total 609 million m^3/a. The municipality is a minor downstream user of the WCWSS, which also supplies the City of Cape Town, yet they are already using more than their allocation from the WCWSS by 6 million m^3/a.

At the same time, an ambitious development future is being planned for Saldanha Bay. An Industrial Development Zone (IDZ) is being created in Saldanha that will service the offshore oil and gas sector and is included as one of the 18 Strategic Infrastructure Projects in the National Infrastructure Plan. In addition to the IDZ, Saldanha is attracting interest from a number of investors that could cumulatively invest R72 billion and add 10 500 jobs to the local economy.

Additional water supply resources, which can be either locally developed (such as a desalination plant) or allocated from the WCWSS (through reallocation or as an outcome of the current validation and verification process that may discover that the system is not in deficit), have been investigated for Saldanha's planned development.

Both options have been pursued by the West Coast District Municipality. The desalination plant is not supported by DWS and the municipality does not have the funding to finance the plant. The municipality has applied for additional water from the WCWSS, yet as noted above, there is currently no water available for allocation. Additionally, at the regional catchment level, allocations from the WCWSS must weigh up the potentially competing demands of industrial development in Saldanha verses agriculture in the Middle and Upper Berg, verses domestic and industrial supply to the Cape Town metropolitan.
The municipality has not yet received a response from DWS on their water use license application, so in the short term, the planned investment in the Saldanha Bay area is at risk due to water supply shortages. Indeed the municipality has been unable to confirm future water supplies for several planned projects potentially leading to disinvestment.



Claire Pengelly

Infrastructure development in Saldanha Bay for the industrial development zone .

Raymond Siebrits

Model of the water allocation process being discussed with stakeholders.

A series of engagements (ranging from one-on-one interviews to workshops) with decision-makers in economic development and water resources planning spheres of government revealed that the current planning systems do not take the socio-economic considerations of water allocation into account. Decision-makers reflected a series of challenges including; a misalignment in planning approaches between water resources and economic development; a lack of feedback between water requirements and economic developments; a lack of consideration of the economic productivity or of the socio-economic benefit of various water uses in decisions over what development to promote for Saldanha and the Berg River Catchment; and a first come, first served approach to provision of water services to developments. It is therefore not possible, within current panning systems, to implement the integrated water and economic development planning approach motivated above, in which the socio-economic-environmental costs and benefits of each use of water, and the trade-offs that development decisions.

In response to the challenges reflected by decision-makers in Saldanha and the Berg River catchment, GreenCape, initiated the research project. The project has the ultimate aim of better integrating water resources and economic development planning, and aims to promote allocation decisions that take the full socio-economic cost-benefit of water use and water infrastructure into account, through the development of

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necessary "tools" that illustrate alternative decision-making approaches.

The tools under development include:

1. A multi-criteria decision analysis of development applications for Saldanha Bay, weighing them against the local jobs generated, their water requirements, their fit with local skills and the environmental impact.
2. A regional catchment-scale hydro-economic model to quantify socio-economic impacts or trade-offs between water allocations, which is based on two interlinked models:
   - A water requirements projection tool enabling decision-makers to spatially view various scenarios for future regional growth and climate change, assessing the impact on water requirements
   - An assessment of the socio-economic value of water, largely focused on the economic value of water generated as an input into production, and the jobs that are indirectly created by the businesses that use water for their processes.

Parallel research into governance processes aims to ensure that the tools are optimally integrated into existing systems, and hence make positive change to the way decisions are currently made.

The development of the multi-criteria decision analysis tool for development applications for Saldanha Bay revealed insights on how the local municipalities views development applications. The municipality identifies the quantity of potable water required by a proposed development as the most important criterion for consideration, where the less water required the better. Furthermore it is concerned about in-migration impacts of the development in the area, and would like to prioritise developments based on the likelihood that most of the jobs generated will be absorbed by the local community.

In applying the tool these criteria, along with others, result in the IDZ being scored as an average development, despite the importance of this initiative to provincial and national government. This highlights how regional strategic objectives may not always be in alignment with a local authorities' priorities and constraints, and how this can impact on the viability of a development of this nature.

In calculating the water requirements of the various sectors in the catchment, agricultural irrigation requirements were estimated using bottom-up calculations, based on field sizes, crop water demands, and crop type amongst other factors. The estimations reveal that while most of the water is used by urban users (the City of Cape Town is by far the largest user), agricultural water use is predominantly consumed in the production of wine grapes. Yet, when analyzing water as an input into a farms' production, initial results indicate that the marginal economic value of irrigation water for wine grapes is lower than other crops modelled in the region.

This implies that there may be more "productive" uses for water currently irrigating wine grapes. However, when considering the impact that wine grape production has on jobs, the picture becomes more complicated due to its support of the agri-processing industry. Early estimates reveal that close to ten times as many jobs are created in the agri-processing sector in comparison to primary agriculture for the same quantity of water. The study aims to understand these linkages and the potential trade-offs in water allocation decisions in greater depth.

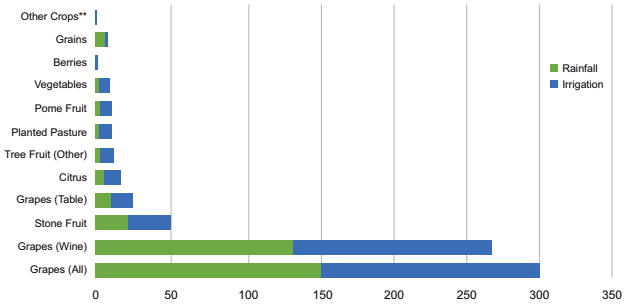

Figure: Total crop water requirements (million m³ per year), split by rainfall and irrigation requirements.

The research to date has highlighted several lessons. GreenCape's project has a strong emphasis on implementation, creating change, and co-production with decision-makers. To meet this aim, those specific decision-makers need to be involved in each step of the process, to ensure the tools under development are on track, and meeting requirements. This is challenging for all, largely due to the time requirements involved. There is a broad range of criteria that decision-makers consider for making decisions and it is not possible to incorporate all criteria into the tools at this stage.

The priorities of decision-makers can also shift based on political or external factors, and the decision-makers themselves change with successors perhaps not as interested in changing the status quo. There may be technical barriers to the use of the most appropriate tool where capacity building is necessary. Tensions can arise when what is deemed the most theoretically robust tool or solution, particularly from the perspective of academic and research rigour, doesn't match the tool that is practical or feasible for a decision-maker to implement, and to ensure research products are defensible yet implementable this tension cannot be avoided and needs to be addressed. This tension is exacerbated by data constraints experienced by the researchers; it is not possible to model the system in the most theoretically correct manner due to the lack of data or its inconsistency.

Although the research is based on the case study of Saldanha Bay and the Berg River catchment, it has relevance to other constrained-catchments. Development of the tools is coming to an end, and during this year the tools will be tested by stakeholders and the research team will promote their implementation. The final WRC report will be ready at the end of this year.

Acknowledgements: Appreciation is noted for the members of the research team whose on-going work is cited in its preliminary format in this article: Marthinus van der Walt, Jacob Muller, Megan Cole, Nick Fordyce, Hugo van Zyl, James Kinghorn. And furthermore for the support and guidance from the following project team members: Prof Mark New, Prof Theo Stewart, Dr Jane Turpie, Anton Cartwright, Dr Julian Smit, and Dr Nadine Methner.

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Urban water management

Shifting to urban sensitive water design – One Water

Urban planning has adopted liveability as its new catch phrase, and is seeking to create an urban landscape where residents get to enjoy green open spaces, trees that keep the concrete jungle cool, and water systems that are resilient to drought and disruptions. For the water industry this has meant a shift in the way services are delivered, from an approach that traditionally aimed to avoid the bad impacts of nature (flooding) and humans (sewage), to one where the services we provide add more value – designing water systems that are sensitive to the urban needs – urban sensitive water design.

Article by Pierre Mukheibir.

For the land use and urban planning sector, this has meant thinking about how to incorporate water as a complementary component to the urban landscape, by viewing all forms of water in the urban landscape as essential to a healthy urban environment and potential resources, and not as problems to get rid of – ***net positive infrastructure***.

To move in this direction, specific attention will need to be placed on the interplay between the different kinds of factors that affect successful collaboration and integration between urban and water planners. Some that 'push' for change through present day needs (drivers), such as the impending infrastructure capacity and resource constraints, the need to reduce flooding and nutrient discharge to waterways through sewer overflows.

Others that 'pull' or attract change through fresh aspirations (visions of the future) for liveable urban environments, with new water systems that mimic and work with nature and provide potentially lower economic costs to society while ensuring resilience to climate change and mitigate the heat island effect, improve green open space and improve health outcomes. And still others that act as 'weights' or barriers for change (challenges), that prevent the institutional changes and collaboration required. Foremost of these is the inertia associated with the dominant paradigm of centralised and siloed systems. This is evident in funding and institutional arrangements and in training that often favours non-integrated infrastructure and management.

The management of urban water systems is often fragmented, with the design, construction and operation of the various elements carried out in isolation from one another. Short-term solutions are selected with little consideration for the long-term impacts on the entire urban water system. More specifically, the conventional approach to planning for urban water management is typically associated with the following issues:

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(Source: Pathways to One Water. A guide to institutional innovation)

The six key elements that contribute poitively to a One Water paradigm

Fragmentation – An overall systems approach to urban water infrastructure and resources is still missing. The various elements of the urban water system are often planned and operated in isolation. Such a fragmented approach can result in technical choices that are based on the benefits to an individual part of the system, but may neglect the impacts caused elsewhere, such as flooding, pollution, and heat island effects, to mention a few.

Short-term solutions – Water management tends to focus on today's problems, opting for short-term, politically expedient solutions despite the risk that the implemented measures are not cost effective or sustainable in the long term. Collaboration between institutions and levels of government can offer an opportunity for risk sharing and longer term planning, beyond the political election cycles and budgets.

Lack of flexibility – Conventional urban infrastructure and management tends to be inflexible to changing circumstances. Planning for water management has tended to address problems through large investments in a limited range of long-established technologies. Water supply, wastewater treatment and stormwater drainage systems are constructed to match fixed capacities and when these are exceeded, problems occur. Likewise, the management of these systems becomes dysfunctional when faced, for example, with increasing climate variability and rapidly growing urban demand. Incremental planning and implementation that accommodate changing circumstances can provide the flexibility needed.

Research led by the Institute for Sustainable Futures (University of Technology Sydney) synthesised common themes from twenty seven case studies in Australia and the USA that can transition organisations to work towards urban sensitive water design, or a One Water approach:

Strong leadership and vision from senior officials are key to driving a One Water approach. At a political level, public funds must be made available to incentivise the transition to One Water management. At the institutional level, executives and boards must drive implementation of One Water strategies and address institutional capacity requirements.

Institutional coordination to proactively pursue long-term, mutually-beneficial relationships with a broad range of agencies, including the private sector. This will foster the collaboration and data-sharing needed for development projects to be aligned with the One Water strategy and implemented in a coordinated manner. This coordination should be driven at both the state and city levels.

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Changing organisational culture to incorporate the One Water approach into everyday practices and thinking. It is useful to identify what One Water "success" would look like in an organisation, set the measurable indicators, and then work backwards to identify the steps necessary to build professional capacity. Getting buy-in from senior level executives is equally important so that they "walk the walk" and support One Water initiatives.

Transparent stakeholder engagement that involves both the private and public sectors is key to confirm the vision and support the implementation of the strategy. This could include dedicated public involvement and staff education; customer awareness, satisfaction, and values surveys; and online public engagement tools. This fosters worthwhile conversation with customers, stakeholders and policy makers, which avoids confusion and can often aid acceptance of required rate increases, fees, or costs.

Considering the full economic impacts of the One Water management approach in urban planning decision-making and investment would ensure that financial, environmental, and social costs and benefits are included in the analysis. Making the financial argument has been raised as a challenge to innovation, however, a number of strategies have been deployed to ensure that the business case stacks up. In some examples, public capital funding was allocated to key bulk infrastructure schemes to create an enabling infrastructural environment, which encouraged the private sector to invest in decentralized infrastructure.

New pathways for cost-effective revenue generation should be explored, as they provide multiple benefits to customers and could cross-subsidise the creation of liveability benefits. Stormwater improvements can be funded through separate stormwater utilities or segregated funding mechanisms. Subsidies for on-site treatment and use could be an incentive for decentralised systems, which relieves the need for expensive network upgrades.

Enabling legislation and regulations are needed that encourage integrated water management, and that are consistent across government agencies respectively. Local government leadership has been demonstrated through the enactment of ordinances or guidelines to encourage or require One Water approaches. A streamlined permitting process (e.g., for non-potable recycling) makes the compliance processes for design, construction and operation of these schemes more attractive to operators and owners.

By moving to a situation where water services are designed and managed to meet the express needs of the urban form and its residents, directly ensures that liveable cities become a reality. The One Water approach endeavours to integrate the planning and management of water supply, wastewater and stormwater systems in a way that minimises the impact on the environment and maximises the contribution to social and economic vitality.

To support planners and policy makers, the research team produced a Guide for transitioning to a One Water approach, which provides a range of enabling actions (and illustrative examples) required to begin a successful transition to urban sensitive water design.

To access the guide, visit http://www.werf.org/c/KnowledgeAreas/IntegratedInstitutionsinfo.aspx

The outcomes of this project were made possible with the financial and technical assistance of Water Environment Research Foundation, Water Research Foundation and Water Research Australia, and the researchers of the Institute for Sustainable Futures (UTS), ForEvaSolutions, and the Centre for Neighbourhood Technologies. This article first appeared in Future Water (http://www.futurewater.com.au/).

Wetlands and disaster management

Exaggerating the value of wetlands for natural disaster mitigation is a risky business

As climate change increases the frequency and severity and heightens the risks of many natural hazards, the role of wetlands in disaster risk reduction is gaining prominence. Wetlands can reduce the impacts of natural hazards. In the aftermath of hurricanes, floods or tsunamis, they often play an important role in getting communities back on their feet, write Matthew McCartney and Max Finlayson.

Evidence shows that wetlands mitigate some natural disasters and lower the risks for people: first, by reducing the immediate physical impacts and second, by helping people survive and recover in the aftermath.

Controlled flooding of floodplain wetlands has long been used as a management strategy to protect the city of Lincoln, in the UK. The flood protection role of the That Luang wetland in Vientiane, Laos, has been estimated to be worth US$2.8-million per year. Coastal wetlands have been shown to reduce the damaging effects of hurricanes on coastal communities in the USA.

Several global agreements, such as the Paris Agreement, Sendai Framework on Disaster Risk Reduction, and the Sustainable Development Goals, recognise the vital role that sustainable management of wetlands can play in mitigating the risks of natural disasters. Wise management of wetlands is thus an urgent imperative that merits all the attention it can get, but sweeping statements about their universal value to mitigate disaster can do more harm than good.

The reality is that differences between wetland types translate into very different outcomes. Wetlands are not a cure-all for natural disasters, and overstating their benefits could hinder rather than help.

Wetlands' effects on water flows and storm surges depend on many factors, including other land features, which vary widely across locations. They are dynamic, meaning that their role may change over time – mitigating disasters on some occasions, while on others contributing to the natural processes that enhances risk. Mangroves are a good example.

Do mangroves save lives?

Some mangroves, especially the larger and more examples found around the coast of Sri Lanka, are widely believed to moderate the devastating impacts of storm surges and tsunamis – a major threat to low-lying coastal areas – by slowing water flows and reducing the energy of waves. Some have called them "bioshields", but there is little tangible evidence to suggest that, in the face of large disasters, these wetlands significantly reduce human death tolls.

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After the Indian Ocean tsunami of 2004, for example, studies showed that some areas suffering the least damage had been sheltered from direct exposure to the open sea by bays, lagoons and estuaries. This, rather than the mangroves themselves, was the most significant factor determining the extent of damage and loss of life.

Mangroves clearly have a role to play in mitigating hazards. But it also pays to consider alternatives, although often these are not without their own limitations.

In areas of high population density, such as along parts of the Japanese coast, sea walls and embankments may be a better investment. Where population is lower, advance warning systems, based on sensors at sea to detect tsunamis and effective communication systems to alert people to move to higher ground or purpose built shelters, may be more effective. Such a system, administered by the National Disaster Warning Centre, has been established along the Andaman coast of Thailand.

"Wetlands' effects on water flows and storm surges depend on many factors, including other land features, which vary widely across locations."

A mixed picture of inland floods

In contrast, wetlands do play a critical role in attenuating inland floods. Plenty of research has shown that floodplains can significantly reduce the flooding of cities and towns by providing space for inundation and storage of water upstream.

In the Netherlands, this recognition has led to the commendable Room for the River initiative, which protect urban centres by reversing many centuries of dyke building and reconnecting rivers to their floodplains to allow them to fill and store flood waters.

There is less clarity about other types of wetlands to mitigate flooding. For example, research conducted by the International Water Management Institute in southern Africa's Zambezi River basin has shown that upland wetlands tend to promote rather than reduce flood flows.

In northern England, some £500-million has been spent over the past decade on blocking drains to rehabilitate upland peat wetlands, partly to reduce downstream flooding. But there is little evidence that this measure has attenuated flooding. In fact, some research suggests that it may actually have increased the magnitude of the largest, most damaging, floods by raising groundwater levels and reducing the space for water storage. Many wetlands are also believed to play an important role in mitigating drought impacts, and this is undoubtedly true in some cases. Tanzania's Mara River wetlands, for example, help communities cope with drought, because the soils remain moist much longer than in surrounding areas, thus providing a place to grow food.

Another widely help assumption about wetlands is that they sustain river flows during droughts, thereby providing a useful service for downstream water users. However, according to a comprehensive review of scientific studies, two-thirds of the projects concluded that, by promoting evaporation, wetlands tend to reduce downstream river flows during dry periods.

A false sense of security

Advocating for wetlands alone is a simplistic approach to the reduction of natural disaster risks, and can create a false sense of security, potentially leading to policies that are ineffective or even dangerous, jeopardising people's lives and livelihoods. But the opposite error of undervaluing wetlands and their many benefits can have equally tragic consequences, especially where resources are not available to construct other defences.

Investing in wetlands makes sense, when it is based on a sound case that takes into account their multiple benefits in relation to disaster risk reduction. Decision-makers must closely examine the evidence behind positive claims about risk reduction before drawing conclusions and implementing policies. In going forward, planners should view wetlands as just one component of a plan to reduce disaster risks.

In many cases, the best bet will involve a mix of wetland conservation with infrastructure development and other options, such as early warning systems, disaster relief and contingency planning, together with smart planning, aimed at minimising people's exposure to natural hazards.

This builds on the benefit that wetlands can provide, and avoids the dangers of over-generalising by using a more tailored approach for specific conditions of a given location, designed on the basis of rigorous science.

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Managing our wetlands for sustained water security

The Water Research Commission's (WRC's) Wetlands Day celebrations took on an educational quality this year. The Commission, in partnership with the departments of Water and Sanitation, Environmental Affairs, Agriculture, Forestry and Fishing as well as the South African National Biodiversity Institute and the Tshwane Metro hosted a wetlands workshop along with a training course on the identification of wetlands plants. The latter was held using the popular WRC publication, ***Easy Identification of South African Wetland Plants*** (**Report No. TT 479/10**). The workshop showcased some of the WRC's research in the field of wetlands. The Commission has spent over R60-million in wetland-related research over the last 15 years. Latter research has focused on established improved decision support systems around wetlands management.

Training workshop participants hard at work at identifying wetland plants.

The WRC's Wetlands Day celebration included a field trip.

Wetlands Day participants pose for a group photograph.

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DEEPLY ROOTED IN SOUTH AFRICA WATER SOCIETY

www.wrc.org.za

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

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

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

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