THE
WATER WHEEL

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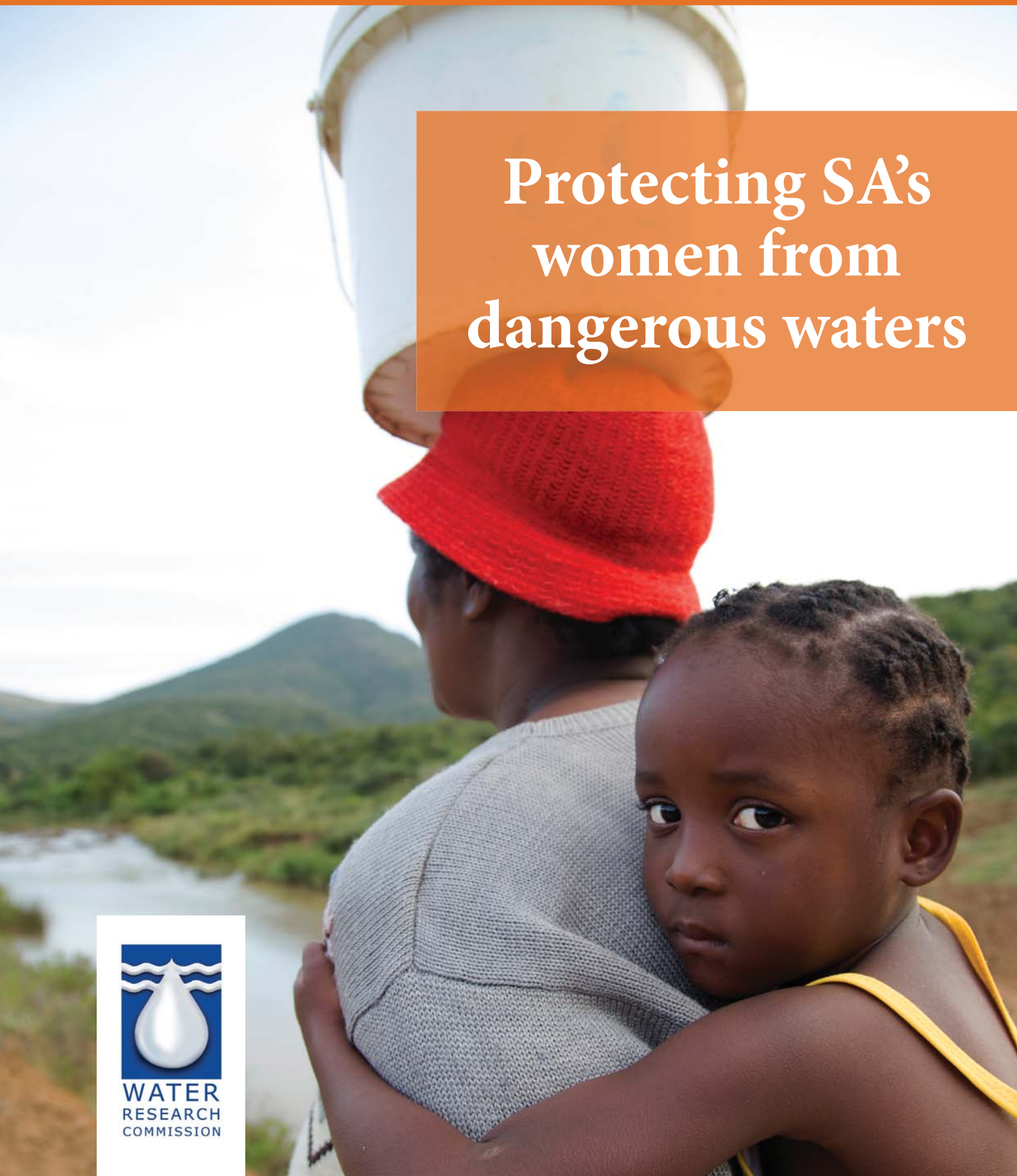

Protecting SA's women from dangerous waters

WATER RESEARCH COMMISSION

17th WaterNet/WARFSA/GWP-SA Symposium on

Integrated Water Resources Management: Water Security, Sustainability and Development in Eastern and Southern Africa

Jointly convened with the International Association of Hydrological Sciences (IAHS) and the University of Botswana

Gaborone International Convention Centre (GICC)
Botswana
26th – 28th October 2016

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WARFSA-II
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There is increasing awareness about the dangers of schistosomiasis, particularly to women in South Africa. See article on p. 14. Cover photograph courtesy Håvard Holme.

Fluid Thoughts


WRC CEO, Dhesigen Naidoo

Reflections on World Water Week 2016

At first glance the setting for World Water Week 2016 (WWW2016), the annual gathering in Stockholm, Sweden, of thought leaders, policy makers, advocacy groups and academics to deliberate on the global water scarcity and poor quality challenges, is paradoxical.

Stockholm comprises 14 islands set in pristine Lake Malaren just before it meets the Baltic with some of the best water services in the world. But the half-life of the paradox rapidly diminishes as Mayor, Karin Wanngard, reminds us, that while you can now virtually drink the water directly from the lake outside the City Hall, 19th century Stockholm was an unhealthy place – a city that was not sewered and had no piped water. This resembles many cities around the world in the throes of the 21st century challenges of rapid inadequately planned for urbanisation, with poor infrastructure and inadequate services.

Cities like Stockholm and Singapore demonstrate what is possible with a converged vision, political will, smart planning, prudent investment and innovative implementation with an ethos of continuous improvement. These are two examples of places in the world that have demonstrated that a combination of knowledge based decision-making, sound infrastructure, pools of skilled talent with active pipelines and water wise behaviors by all citizens – individual and corporate can and did achieve water security, perhaps even water prosperity.

But we do not have the century that it took for Stockholm or the 50 years it took for Singapore to reach their states of water prosperity. This is why WWW2016 was an incredibly important bus stop and consolidation point to tie together the strings of the various global dialogues and initiatives with a view to creating a stronger rope to pull in the resources, and other commitments to set us on a sounder course to sustainable development.

The keystone of the global water and sanitation narrative is the 2015 Heads of State adopted United Nations Sustainable Development Goals (SDG) suite, and in particular SDG 6 which seeks to have access to safe water and improved sanitation for all people everywhere in the world by 2030.

While the Millennium Development Goal (MDG) scorecard is a mixed one, there have been sufficient achievements globally to usher the SDGs into the realm of possibility. Such an ambitious agenda has the potential to fundamentally improve the quality of life for all the world's population to a never before achieved level of global development. What is therefore needed is a series of catalytic actions to propel the SDGs from the outer rim of possibility to the mainstream of probability.
One of the important accelerators that was further crystallised in WWW2016 was the United Nations Secretary General's High Level Panel on Water (HLPW). The group of 10 Heads of State, which includes South Africa have been tasked to develop solutions for an enabling environment to achieve the SDG 6 by 2030.

My own reflections of the week-long gathering that enjoyed the participation of more than 3 000 delegates from around the world rests on three points.

The first is one of great encouragement. The 2016 Stockholm Water Prize Laureate was Prof Joan Rose, the world renowned authority on water quality from the USA and the winners of the Stockholm Junior Water Prize was a team of three schoolgirls from Thailand who presented an amazingly rich biomimicry project.

The picture of the four Laureates together spelled hope for the future. Not only was it an acknowledgement of the power of women in science, it also provided an assurance of leadership into the future with a stalwart from the developed world symbolically handing over the baton of tomorrow's water science leadership to three remarkable girls from the developing world.

The second was an anxiety. The water community, while preaching integration and the removal of silos, continues to be quite insular in its approach. WWW2016 demonstrated an important recognition of the imminent competition for skills and resources between the different SDG teams in pursuit of the 17 individual goals. While water is both a connector and an enabler to achieve and empower the complete SDG suite, the water and sanitation community of practice has to reach out to the other sectors in a more deliberate and meaningful way, while becoming prominent players in facilitating the pursuit of the related SDGs.

Africa was prominent in its participation in WWW2016, and South Africa quite pivotal with the WRC being a strategic partner and Minister of Water and Sanitation, Nomvula Mokonyane, being a prominent voice of the Global South in many of the key debates.

"The water and sanitation community of practice has to reach out to the other sectors in a more deliberate and meaningful way."

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The water and sanitation revolution we want to realise will only come about on the back of innovative new disruptive solutions. We need to abandon the notion of incremental improvements if our targets are to be met in a mere 15 years.

The third point of reflection is, in fact, an offer. The world needs a greenfields site to experiment at scale with these new water and sanitation solutions and technologies. Africa can and should be that global laboratory to finetune and demonstrate the suite of revolutionary water and sanitation services and practices for the 21st century.

In that spirit, we must invite the world to partner us in this great African laboratory to define the new parameters for Global Water Prosperity in the 21st Century.

Stockholm Water Prize winner, Prof Joan Rose, and the three Junior Water Prize winners from Thailand.

Water Diary

Water Law
Various dates
The South African Institution of Civil Engineering is hosting a series of workshops by water law expert, Hubert Thompson. The workshops will be held in Durban on 20-21 September, in Cape Town on 27-28 September and in Midrand on 20-21 October. *Contact Tel: (011) 805-5947; Email: dawn@saice.org.za.*

Hydrological sciences
September 14-16
The 18th biennial symposium of SANCIAHS will be held at the University of KwaZulu-Natal, in Durban. The theme for this year's symposium is 'Characterising hydrological uncertainty in a changing world: Transferring theory to practice'. *Contact: Scott Sinclair, Tel: (031) 260-1151 or Visit: http://cwrr.ukzn.ac.za/sanciahs/sanciahs-2016*

Young science professionals
October 6-7
The Young Scientists' Conference will be held at Birchwood Hotel with the theme 'Human Rights'. Enquiries: Edith Shikumo; *Tel: (012) 349-6614; Email: edith@assaf.org.za*

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

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

Mine-water management
November 9-10
The Water Institute of Southern Africa's Mine Water Division is holding its annual symposium with the theme 'Management options for mine-water'. *Email: chair@wisa-mwd.org or Visit: www.wisa-mwd.org*

Water history
June 15-17, 2017
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*

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WE HAVE MOVED

Water Research Commission New Offices

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WRC moves to new location

After nearly 28 years at the same premises the Water Research Commission (WRC) has found a new home. On 1 September the WRC took up its new residence at Lynnwood Bridge office park at 4 Daventry Road, Lynnwood Manor.

The WRC has moved into floors two and three of the A-grade Bloukrans office building, part of the Lynnwood Bridge mixed-use commercial precinct. It is located next to the Kaaimans building, in close proximity to the City Lodge Hotel Lynnwood.

Combined, the Kaaimans and Bloukrans buildings offer a combined 12 000 m^3, with a shared podium, parking basement, visitor parking and security site. Each building comprises six storeys, served by five basement levels and a central atrium. The WRC shares its building with other major tenants such as radio station Groot FM, Stratus Computers, and Atterbury Property. Consulting engineering firm, Aurecon, is located in the Kaaimans building.

The five-star Green Star building offers the WRC closer proximity to other science entities, such as the CSIR, Department of Science and Technology and the University of Pretoria. The precinct's strong appeal also benefits from its access just off the N1 highway at Lynnwood Road. The offices are well served by public transport, including the Gautrain bus service.

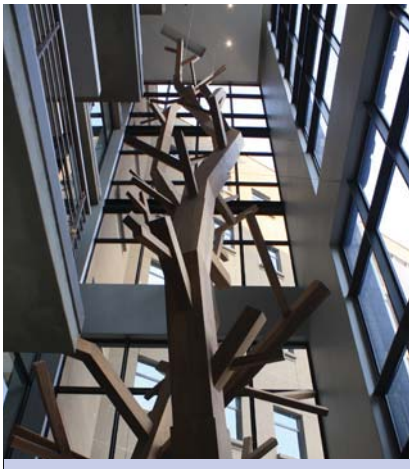
The building has been thoughtfully constructed with lots of smart, green tactics incorporated. They include rainwater harvesting which collect, store, treat and use large quantities of rain from the building's roof and surrounding paving, to be used for tasks such as toilet flushing. The building's façade controls heat from the sun entering the building through full-height glazing, yet let in plenty of light. Instead of water-cooled chiller, it uses air-cooled ones. The buildings are also designed for lots of fresh air and efficient lighting, occupancy sensors, and have a fine-tuned building management system.

There is plenty of place for nature at these building that feature roof gardens, timber decking, cobbles and landscaped shrubs chosen to keep watering to a minimum. And, the tower also offer benefits for people striving to keep their own environmental footprint light, with 35 prime designated parking bays for hybrid vehicles and motorcycles and secure storage for 40 bicycles, with added benefit of changing facilities and lockers.

The new offices offer various spaces for interaction.

The freshly stocked resource centre.

WRC Receptionist, Shirley Maheso, greets visitors at the new entrance.



The building features several nature-inspired design features.

WRC awarded international prize from Monaco

On 30 June 2016, the Water Research Commission (WRC) was awarded the 2016 Water Award by the Foundation of the HSH Prince Albert II of Monaco.

The Commission received the award for its contribution towards a better understanding of the environment as well as its work in South Africa in the field of water resource management, water supply and sanitation.

The Foundation was established by Prince Albert in 2006 and is dedicated to environmental protection, sustainable development, with a particular focus on climate change, biodiversity and water.

WRC CEO, Dhesigen Naidoo, who received the award on behalf of the WRC said: "I knew about the Foundation from afar but this award was a complete surprise. The Foundation is a very interesting space, and one of the powerful things about the Monaco Foundation, it is one of the few in this domain around the world that isn't recognised as having a corporatised agenda, so it's a genuinely neutral voice pushing the climate change and the green agenda in the world that is really well respected. This recognition helps our organisation to be able to get our own messages out around the importance of research and innovation to make a fundamental change to the lives of people and the planet."

Addressing his figures of how 663 million people do not have access to safe water and one-ninth of the world goes hungry every day, Naidoo added, "The way societies are structured, there's such a distance between those who don't have and those who do have that there's a convenience, you can turn the other way.

"Poor folk have the smallest voice everywhere and don't have to be listened to. Interestingly, the green agenda turns that on its head. The green agenda says that your climate change future depends on how you organise these interventions around the poorest folk of the world. Because if you're not providing an energy solution to poor folk, than they have to destroy the forests to survive, they have to increase carbon emissions by burning off wood for power. The interventions of the poor actually organise itself around a much broader equation for all of this and maybe this will turn the tide.

Global science community calls for harvesting of local knowledge to aid development

Integrating local knowledge into research could expedite solutions to global challenges such as disease, poverty and climate change.

This is according to experts attending the EuroScience Open Forum 2016 (ESOF 2016), held in Manchester, in the United Kingdom, in July.

The biennial event served up an array of topics which attracted robust discussion. Department of Science and Technology (DST) Deputy Director-General, Imraan Patel (who is also a member of the Water Research Commission Board) participated in a panel discussion contemplating the question: Can science, technology and innovation help eradicate poverty and secure development? Other panel members included Sir Peter Gluckman (Chief Science Advisor to the Prime Minister of New Zealand), and Robert-Jan Smits, Director-General for Research and Innovation at the European Commission.

Gluckman pointed out that the decisive defeat of global challenges required the concerted integration of local and scientific knowledge, adding that it was time for the world to recognise that there were different kinds of science and scientific expertise, and that all of them should be used together towards development and problem-solving.

South Africa is increasingly offering support mechanisms, investing in indigenous knowledge systems (such as programmes covering African traditional medicines, cosmeceuticals and nutraceuticals). Patel was adamant that science, technology and innovation could and should play a central role in development globally. However, he highlighted the importance of international partnerships, saying that these were crucial if the sustainable development goals were to be achieved.

Source: DST

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67 boreholes to bring relief

Operation Hydrate and Awqaf South Africa, supported by the Department of Water and Sanitation and the Mandela Foundation have pledged to drill at least 67 boreholes in drought-stricken areas over the coming months.

The initiative was announced as part of Mandela Month celebrations in July. The organisation and its partners were aiming to drill as many as 95 boreholes.

An amount of R7-million has been set aside for the drilling of 67 boreholes. A further 28 boreholes are expected to be drilled later this year at a cost of R3-million.

The four organisations said they are all committed to continue assisting communities in need of water. "The drought is far from over, and these boreholes will go a long way towards providing much needed water to the communities," the organisations said in a joint statement.

Water and Sanitation Minister, Nomvula Mokonyane, said the department will continue to do its part, as well as support humanitarian initiatives that espouse and reflect the values that Madiba stood for. "This is a long-term and sustainable initiative to show what can be achieved when the private and public sectors work together to make a difference in the lives of others."

Source: SAnews.gov.za

Freshwater science doyenne wins WWF Living Planet Award

International river flow expert, Dr Jackie King, was awarded WWF South Africa's prestigious Living Planet Award at its annual conference earlier this year. The award is given to exceptional individuals in South Africa who inspire people to live in harmony with nature. As a leading aquatic ecologist in South Africa, Dr King was praised for "inspiring several generations of scientists, planners and legislators in South Africa and around the world."

Over the past four decades, she has been part of and led scientific teams working on the river flow management of many of the world's major river systems, among them the Nile, Mekong, Indus and Okavango.

Dr King was recognised for her leading role in ensuring that aquatic ecological research led to the sustainable development and management of river systems and, in particular, her innovative and practical approaches that gave effect to improved water management in the real world.

Water and science consultancy wins top science award

Twenty-five years of pioneering scientific work, coupled with successfully growing a start-up business into a highly respected consultancy, have been acknowledged with a prestigious award for Cape Town earth sciences company Umvoto Africa.

At the 18th annual National Science and Technology Forum awards (NSTF-South32), held on 30 June in Gauteng, Umvoto won the category 'Research leading to innovation through an SMME'. NSTF is a multi-stakeholder non-profit forum in South Africa that promotes science and technology through collaboration.

These national awards recognise, celebrate and reward excellence in science, engineering, technology and innovation in South Africa. The awards were presented by Minister of Science and Technology, Naledi Pandor, who is also the event patron.

Umvoto researches and develops sustainable geoscientific and technological solutions to address resource, environmental, social and economic concerns. It consults in integrated water resource management, contamination and remediation studies, education and training, process facilitation and ecological risk management studies. In the research and development arena, Umvoto's processes rely on inventive application of aerial and satellite remote-sensing, geographic information systems and space-geodesy for hydrogeological exploration and mapping.

In the photograph Umvoto founder and MD, Rowena Hay (centre), is receiving the award from Minister of Science and Technology, Naledi Pandor (left) and Agnes Peter, Group Executive, Agency and National Advertising, Independent Newspapers.

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Global

New drought management handbook now available

The Integrated Drought Management Programme (IDMP), which is co-sponsored by the World Meteorological Organisation (WMO), the Global Water Partnership (GWP) and some 30 other partners, has officially released the *Handbook of drought indicators and indices.*

"The handbook addresses the needs of practitioners and policymakers," notes Robert Stefanski, Chief: Agricultural Meteorology Division at WMO. "It is based on available literature and draws findings from relevant works wherever possible. The purpose of the handbook is to present some of the most commonly used drought indicators and indices that are being applied across drought-prone regions."

The goal is to advance monitoring, early-warning and information-delivery systems in support of risk-based drought management policies and preparedness plans. These concepts and indicators and indices are outlined in the handbook, which is considered a living document that will evolve and integrate new indicators and indices as they come to light and are applied in the future.

The handbook is aimed at those who want to generate indicators and indices themselves, as well as for those who simply want to obtain and use products that are generated elsewhere. It is intended for use by general drought practitioners such as meteorological/ hydrological services and ministries, resource managers and other decision-makers.

"The handbook aims to serve as a starting point, showing which indicators and indices are available and being put into practice around the world", said Frederik Pischke, GWP's Senior Programme Officer for International Climate and Hydrology. "In addition, the handbook has been designed with drought risk management processes in mind. However, this publication does not aim to recommend a 'best' set of indicators and indices. The choice of indicators and indices is based on the specific characteristics of droughts most closely associated with the impacts of concern to the stakeholders."

To download the handbook, Visit: http://www.droughtmanagement.info/literature/GWP_Handbook_of_Drought_Indicators_and_Indices_2016.pdf

Dirty to drinkable – novel hybrid nanomaterials transforms water

Graphene oxide has been hailed as a veritable wonder material; when incorporated into nanocellulose foam, the lab-created substance is light, strong and flexible, conducting heat and electricity quickly and efficiently.

Now, a team of engineers at Washington University in St. Louis, USA, has found a way to use graphene oxide sheets to transform dirty water into drinking water, and it could be a global game-changer.

"We hope that for countries where there is ample sunlight, such as India, you'll be able to take some dirty water, evaporate it using our material, and collect fresh water," said Srikanth Singamaneni, associate professor of mechanical engineering and materials science at the School of Engineering & Applied Science.

The new approach combines bacteria-produced cellulose and graphene oxide to form a bi-layered biofoam. A paper detailing the research is available online in Advanced Materials.

"The process is extremely simple," Singamaneni said. "The beauty is that the nanoscale cellulose fiber network produced by bacteria has the ability to move the water from the bulk to the evaporative surface while minimising the heat coming down, and the entire thing is produced in one shot.

The new biofoam is extremely light and inexpensive to make, making it a viable tool for water purification and desalination. "Cellulose can be produced on a massive scale," Singamaneni said,

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"and graphene oxide is extremely cheap -- people can produce tons, truly tons, of it. Both materials going into this are highly scalable. So one can imagine making huge sheets of the biofoam."

"The properties of this foam material that we synthesised has characteristics that enhances solar energy harvesting. Thus, it is more effective in cleaning up water," noted Pratim Biswas, the Lucy and Stanley Lopata Professor and chair of the Department of Energy, Environmental and Chemical Engineering.

"The synthesis process also allows addition of other nanostructured materials to the foam that will increase the rate of destruction of the bacteria and other contaminants, and make it safe to drink. We will also explore other applications for these novel structures."

To access the original article, Visit: http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1521-4095

US launches comprehensive system for forecasting water resources

The National Oceanic and Atmospheric Administration (NOAA) has reported launching a comprehensive system for forecasting water resources.

WRF-Hydro, a powerful NCAR-based computer model, is the first US wide operational system to provide continuous predictions of water levels and potential flooding in rivers and streams from coast to coast. NOAA's new Office of Water Prediction selected it last year as the core of the agency's new National Water Model.

"WRF-Hydro gives us a continuous picture of all of the waterways in the contiguous United States," said NCAR scientist David Gochis, who helped lead its development. "By generating detailed forecast guidance that is hours to weeks ahead, it will help officials make more informed decisions about reservoir levels and river navigation, as well as alerting them to dangerous events like flash floods."

WRF-Hydro (WRF stands for Weather Research and Forecasting) is part of a major Office of Water Prediction initiative to bolster US capabilities in predicting and managing water resources.

By teaming with NCAR and the research community, NOAA's National Water Centre is developing a new national water intelligence capability, enabling better impacts-based forecasts for management and decision-making.

Unlike past streamflow models, which provided forecasts every few hours and only for specific points along major river systems, WRF-Hydro provides continuous forecasts of millions of points along rivers, streams, and their tributaries across the contiguous US.

To accomplish this, it simulates the entire hydrologic system — including snowpack, soil moisture, local ponded water, and evapotranspiration — and rapidly generates output on some of the nation's most powerful supercomputers.

WRF-Hydro was developed in collaboration with NOAA and university and agency scientists through the Consortium of Universities for the Advancement of Hydrologic Science, the US Geological Survey, Israel Hydrologic Service, and Baron Advanced Meteorological Services.

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New WRC reports

Report No. 2026/1/15 (Volume 1), 2026/2/16 (Volume 2) and TT 655/15 (Volume 3)

Development of technical and financial norms and standards for drainage of irrigated lands

There are numerous benefits, both economic and environmental, of well designed and constructed surface and sub-surface drainage systems in irrigated agricultural lands. The need arose in South Africa to research the technical and financial aspects of drainage systems to ensure that current practices were technically sound as well as being financially feasible. Thus this project was initiated. As a result of thorough research three comprehensive volumes were produced. The manual provides a comprehensive text on the subject of both the technical and financial aspects of surface and sub- surface drainage and will benefit engineering technicians in the country's provincial agricultural departments; financial and technical advisors at co-operatives and agri-businesses who offer financial and technical advice to farmers; banks who offer financial assistance to farmers; technical personnel at engineering consultancies; and students in the field of agricultural or bio-resources engineering. In addition, examples are presented in the text which illustrate application of the underlying scientific and economic principles which are unique to the field of drainage.

Report No. 2269/1/16 (Technical report) and 2269/2/16 (Implementation manual)

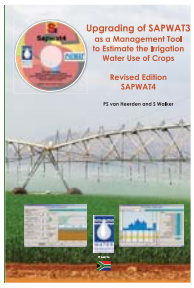
The design of a National Wetland Monitoring Programme

Wetlands are complex and dynamic ecosystems that provide indispensable services to the people and the environment of South Africa. In order to protect and manage the remaining wetlands of the country, assessment, monitoring and reporting on the state of wetlands is crucial. The South African Department of Water and Sanitation conceptualised a National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) in the early 1990s. Although a number of monitoring programmes have been implemented under the NAEMP, a wetlands monitoring programme has yet to be established. With this need in mind the WRC issued a directed call for a project entitled the design of a National Wetland Monitoring Programme (NWMP) following a phased approach. The phases were: Firstly, conducting a situation analysis regarding the complexities of monitoring wetland health or integrity and developing a framework that can serve as the basis for phases 2 and 3; Secondly, designing a monitoring programme and developing an implementation plan; and thirdly, pilot testing.

Report No. 2138/1/16

An investigation into the presence of free living amoebae and amoeba resistant bacteria in drinking water distribution systems of healthcare institutions in Johannesburg, South Africa

Free living amoebae (FLA) are ubiquitous in natural and man-made water systems. Certain FLA are known human pathogens and carriers of amoeba resistant bacteria (ARB) known to cause serious, potentially fatal infectious diseases. Members of the genera Legionella, Mycobacterium, Vibrio, Staphylococcus, Pseudomonas and others are known ARB often implicated in nosocomial infections. The importance of drinking water quality supplied to and distributed through public healthcare facilities, with special reference to FLA and certain ARB, had not been studied prior to this project. The study attempted to provide a general overview of the presence of these organisms within water distribution systems of three public healthcare institutions in Johannesburg and also briefly highlight the potential human health risk implications.



Report No. TT 662/16

Tool to estimate the irrigation water use of crops: Revised edition – SAPWAT 4

SAPWAT 4 is an improved version of SAPWAT 3, the program that is extensively applied in South Africa and internationally and was developed to establish a decision-making procedure for the estimation of crop irrigation requirements by irrigation engineers, planners, agriculturalists, administrators, teachers and students. The development of the current SAPWAT 4 program, as in the case of SAPWAT3, is based on the FAO published Irrigation and Drainage Report No. 56, ***Crop evapotranspiration: Guidelines for computing crop water requirements***. This intuitive and comprehensive document is highly acclaimed and has become accepted internationally.

Report No. KV 354/15

A revised Adopt-a-River programme: Stakeholder input on the institutional and financial frameworks with a focus on an implementation strategy

This document builds on the Adopt-a-River (AaR) review and redesign document prepared by the project team and summarises the outcomes of a two-day stakeholder workshop held at the WRC offices in Pretoria in November 2015 to discuss the revision of the AaR programme. The primary aim of the workshop was to understand and re-vision the AaR Programme, to redefine the key objectives and strategy (including re-vision of the institutional/governance framework as well as developing a funding framework and potential business case) towards developing a revised and sustainable AaR Programme.

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Report No. 2382/1/16
Strategic assessment and mapping of opportunities for water desalination and water use optimisation of concentrated solar power generation in South Africa
Renewable energy projects, including concentrated solar power (CSP), are being increasingly developed in South Africa while the country attempts to minimise its reliance on fossil fuel-based power production. CSP plants use a thermal power generation process which requires a steam cycle; the steam is required to be condensed, and this requires cooling. Sites need to be chosen that have a suitable combination of cost of energy and cost of water to maximise the energy cost efficiency of CSP plants while still minimising water consumption.

New range of tools to reduce mining impact on wetlands
By virtue of their positions in the landscape and relationship to drainage networks, wetlands are frequently impacted by coal-mining activities, especially opencast methods. The impacts are on-going, since coal is a strategic resource and will continue to be mined to support the country's development. However, regulatory authorities and the public now have an improved understanding of the range of economic, social, ecological and hydrological costs of wetland loss and degradation. The rules of the game have changed, with regulators increasingly insisting that mines avoid, minimise and mitigate their impacts on wetlands, and internalise the true costs of wetland loss into their balance sheets. Many mining proposals entailing large-scale wetland loss have encountered delays in licence approvals, unrealistic rehabilitation commitments and unwelcome public and media attention. As a result, the coal mining sector has realised that it needs to proactively and systematically address the business risk posed by its impact on wetlands. One of the key project aims was to improve the knowledge and use of appropriate spatial information to guide mining companies and regulators in their planning and decision-making. This is a set of publications to guide both mining companies and regulators with regard to high risk wetlands and associated landscapes. It identifies key wetland landscapes in the grassland biome of Mpumalanga that are particularly important or irreplaceable in terms of biodiversity, water resource management and ecosystem services. There is a users' guide to the Atlas and a DVD that contains this High Risk Wetlands Atlas itself, the required software to use it, and the underlying spatial data for those who use their own GIS systems.

The full set of publications comprises: *Wetland rehabilitation in mining landscapes: An introductory guide* (**Report No. TT 658/16**); *High risk wetlands atlas: Reference guide to the Mpumalanga Mining Decision Support Tool* (**Report No. TT 659/16**); *Mpumalanga Mining Decision Support Tool* (available as a DVD inside TT 659/16); *Wetland offsets: A best practice guide for South Africa* (**Report No. TT 660/16**); *A review of depressional wetlands (pans) in South Africa* (**Report No. 2230/1/16**) and *Assessment of the ecological integrity of the Zaalklapspruit wetland in Mpumalanga (South Africa) before and after rehabilitation: The Grootspruit case study* (**Report No. 2230/2/16**).

The Water Research Commission has relocated!

From 1 September 2016 the WRC will be based at its new offices at Bloukrans Building, Lynnwood Bridge Office Park, 4 Daventry Street, Lynnwood Manor. You can still contact our Publications team at Tel: (012) 330-0340; Email: **orders@wrc.org.za** or Visit: **www.wrc.org.za**. Please note that since the bulk of the WRC's reports are now stored off site pre-ordering is essential.

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Water and health

Dangers in our water – Fighting the scourge of bilharzia

The waterborne parasitic disease schistosomiasis is not being taken seriously as a public health issue in South Africa, despite a growing body of evidence that it increases susceptibility to HIV infection and raises the risk of cancer.

Sue Matthews reports.

Håvard Holme

When schistosomiasis – commonly known as bilharzia after its discoverer, Dr Theodor Bilharz – first came to the attention of South Africa's medical professionals, it was thought to affect mainly boys. After initially being recorded in 1863 in Port Elizabeth, numerous case reports until the turn of the century (when the disease disappeared from the south-eastern Cape) indicated that it was primarily boys between the ages of 3 and 16 who were infected with the parasitic blood fluke ***Schistosoma haematobium*** – a species of trematode flatworm – after swimming in local waterbodies.

The most common symptom was haematuria, the medical term for blood in the urine, but colloquially referred to as 'redwater' at the time. This often stopped by the age of 20 because men rarely swam, reducing the chance of further infection, although it was recognised even then that the parasite probably persisted in the body. Girls and women were thought to be seldom affected because their contact with waterbodies was more limited.

In 1899, however, 48 years after Bilharz had discovered the worm in the veins of an Egyptian man during an autopsy, ***The Lancet*** published a paper entitled 'A case of bilharzia of the vagina', describing a prominent warty mass. This was the first report of schistosomiasis in the genitals of a woman – perhaps not so

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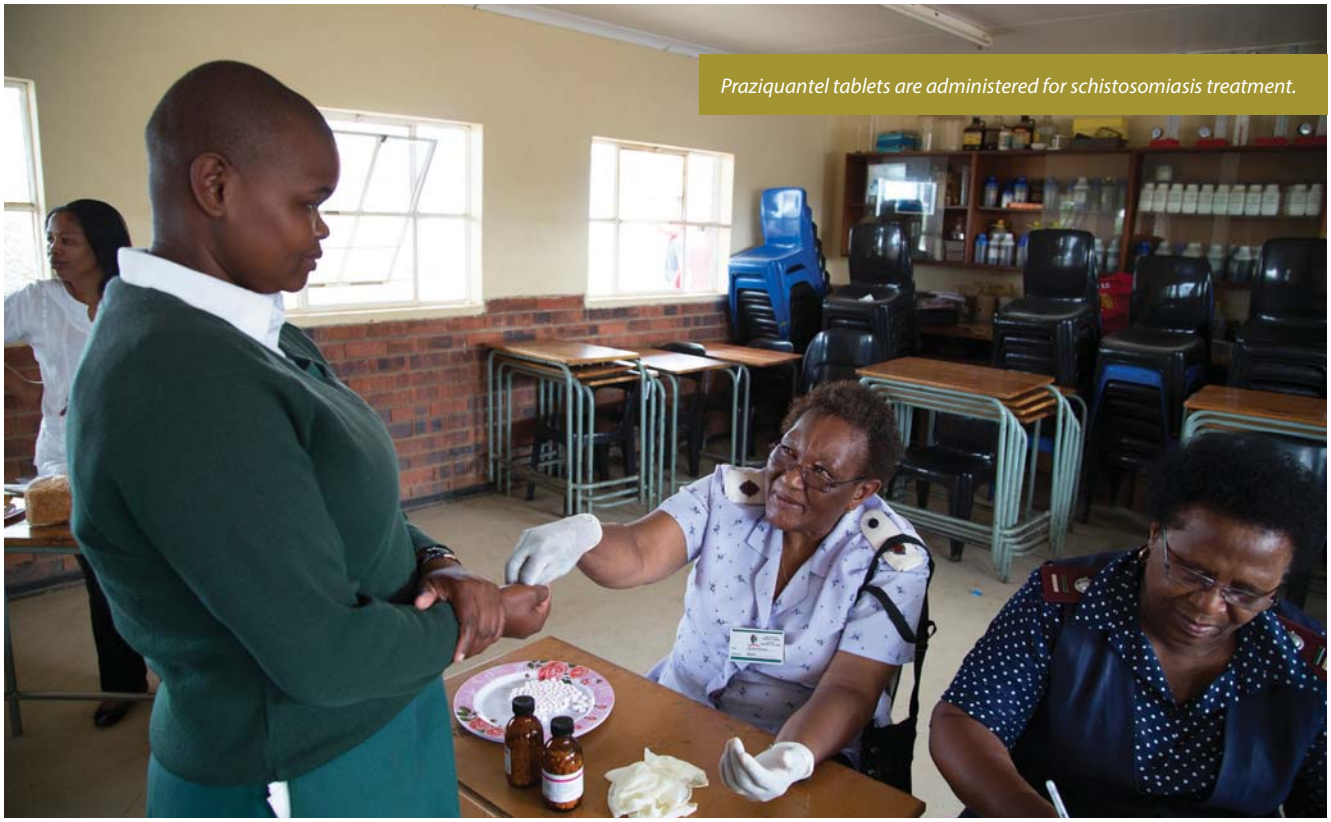

Praziquantel tablets are administered for schistosomiasis treatment.

Håvard Holme

coincidentally an Egyptian woman, given that evidence of the disease has since been detected in Egyptian mummies dating back 5 000 years!

Today, female genital schistosomiasis is known to affect all parts of the internal and external female genitalia. Adult worms in the surrounding veins and venules lay copious quantities of eggs, many of which become lodged in tissues of the bladder, ovaries, fallopian tubes, uterine cervix, vagina and vulva. There they cause lesions, bleeding and painful inflammation, as well as a variety of secondary effects. For example, alteration of tissues in the fallopian tubes has been linked to infertility and life-threatening ectopic pregnancies, while lesions in the vagina and cervix increase susceptibility to HIV infection. The disease is also associated with an elevated risk of bladder cancer, and possibly cervical cancer too.

With the growing understanding that ***Schistosoma haematobium*** infection affects both the urinary and genital tracts (in men, eggs are commonly found in the seminal vesicles and prostate), the name of the disease has been changed in recent years from urinary schistosomiasis to urogenital schistosomiasis. The parasite occurs primarily in Africa and the Middle East, although since 2013 there has been an outbreak in Corsica, which infected visiting tourists from other nationalities. By contrast, five other species of ***Schistosoma*** cause intestinal schistosomiasis in various parts of the world, but only one of these, ***Schistosoma mansoni***, occurs in South Africa and is more limited in distribution.

Schistosoma eggs may travel beyond the target organs to other parts of the body and become trapped in the brain, spinal cord, pancreas, kidneys, liver or lungs, leading to neurological symptoms, high blood pressure, kidney failure, liver damage and other serious complications. The mortality rate due to schistosomiasis is unknown because the cause of death is often linked to these complications, but has been estimated at more than 200 000 deaths per year.

Many people are not even aware they have been infected by the parasite, however, because they either have no symptoms or develop a fever, cough, swollen glands, aches and pains, or a general feeling of malaise and fatigue that they put down to the flu, their living conditions or some other illness. It may take years before a sudden deterioration in health prompts them to seek medical attention. One young woman in the United States had seemed perfectly healthy until she had a seizure due to ***Schistosoma*** eggs in her brain, four years after spending a semester in Ghana, where she had swum in a river on just one occasion!

In the case of female genital schistosomiasis, patients presenting at clinics with pelvic pain, abnormal discharge or genital itching are often given antibiotics for sexually transmitted chlamydia, gonorrhoea or trichomoniasis before the possibility of cervical lesions due to schistosomiasis is considered, while lesions on the vulva may be confused with genital warts caused by the Human Papilloma Virus. Many girls and women might be too embarrassed to seek treatment, but others are simply misdiagnosed. Even those that are given a gynaecological exam are at risk of unnecessary referral for cervical cancer treatment.

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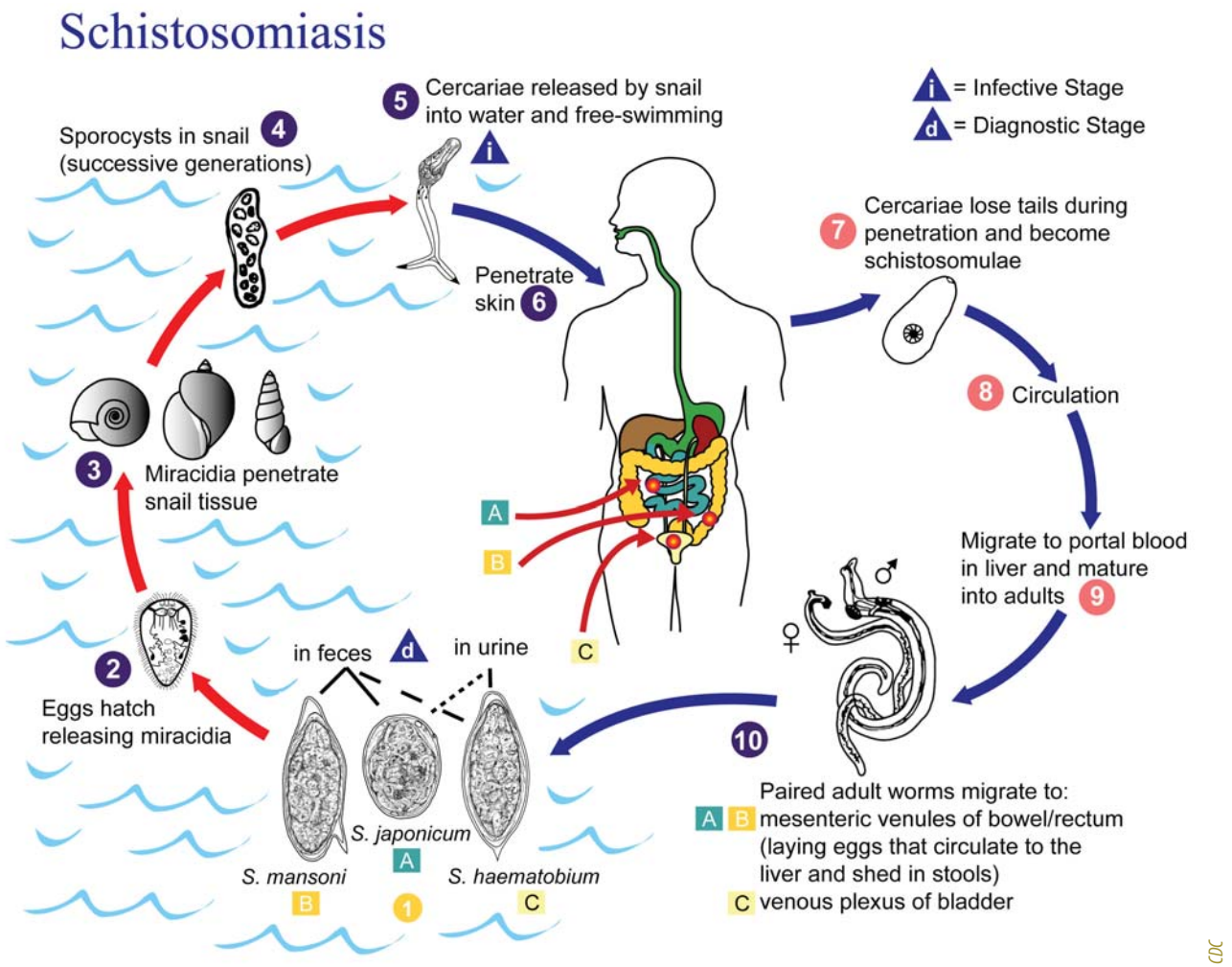

People may contract schistosomiasis after wading, swimming, bathing or washing in contaminated water. Parasite larvae that have been shed from the intermediate host snails penetrate the skin and then develop into adult flatworms inside the body, where they form mating pairs. Some of the eggs produced are excreted in urine and faeces, and hatch if deposited in freshwater. These larvae enter the intermediate host snails to continue the cycle.

"The mortality rate due to schistosomiasis has been estimated at more than 200 000 deaths per year."

In 2014, in an effort to increase knowledge of female genital schistosomiasis and improve its diagnosis, an expert group of medical researchers and clinicians published a comprehensive 'atlas' of the disease's manifestations in the lower genital tract in the open-access, online journal ***PLoS Neglected Tropical Diseases***. More recently, the World Heath Organisation (WHO) has published a more user-friendly 'pocket atlas' for distribution to clinical heath-care professionals. This is essentially an illustrated guide to schistosomiasis lesions on the cervix and vaginal wall, using photocolposcopic images captured during gynaecological exams of consenting patients in Malawi, Madagascar and South Africa. The lesions are divided into four types – grainy sandy patches, homogenous yellow sandy patches, abnormal blood vessels or rubbery papules – all of which can be identified during visual inspection with the naked eye or a colposcope.

The pocket atlas was launched in May at the South African Congress for Gynaecologists and Obstetricians, and is being widely distributed as both a hard copy and PDF. The booklet was compiled with the assistance of a number of clinicians and researchers working in southern Africa, with staff from the University of KwaZulu-Natal's medical faculty playing a leading role. The university has long been the main academic centre for schistosomiasis research in South Africa, focussing on the freshwater snails that serve as the intermediate hosts of the parasites, as well as the disease itself. Two members of its Discipline of Public Health Medicine – Dr Eyrun Kjetland and Prof Myra Taylor – founded and currently co-lead the international research group BRIGHT, an acronym for 'Bilharzia Research Improving Global Health Today'.

BRIGHT is a collaboration of eight partner institutions in South Africa and Europe, and was specifically set up to study female genital schistosomiasis. Work began in the Ugu District in southern KwaZulu-Natal in 2009. Urine sample collection from approximately a thousand girls of 10-12 years of age from 18 rural primary schools revealed that 32% had ***Schistosoma haematobium*** eggs in their urine. During interviews, many of these girls reported symptoms such as stinking, bloody

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discharge, ulcers, tumours and a burning sensation in their genitals.

Subsequently, BRIGHT researchers have extended their reach to more than 40 schools in three districts, collecting urine, stool and blood samples, conducting confidential interviews and physical examinations, offering counselling and group discussions, and taking part in information sessions and parents' meetings. Working with nurses from the three district health departments, more than 175 000 learners were treated between 2011 and 2014.

The recommended treatment for all forms of schistosomiasis is a single dose of 40 mg/kg of praziquantel. This kills the adult worms, but is probably not sufficient to eliminate all eggs. Furthermore, while it may resolve or provide some relief from urogenital lesions, especially in children, advanced cases in adult women are resistant to treatment.

The WHO therefore recommends regular treatment from an early age to prevent schistosomiasis from progressing to genital damage and other complications. In high-transmission areas, praziquantel should be administered every year to entire communities or routinely in health facilities.

At the 2001 World Health Assembly, a resolution urging countries to start tackling worms – specifically ***Schistosoma*** species and soil-transmitted helminths – was endorsed by all WHO Member States, including South Africa. The 'Global Target', against which each country's progress would be measured, was for at least 75% of all school-aged children at risk of illness from schistosomiasis or soil-transmitted helminths to be regularly treated by the year 2010. In order to reach that goal, a 'sub-goal' was set, stating that all health services in endemic areas should be stocked with the drugs to treat these infections.

By the time 2010 came around, however, it was clear that the Global Target had not been met, and in May 2012 a new resolution was adopted at the 65th World Health Assembly. This calls on countries endemic for schistosomiasis to intensify control interventions and ensure the provision of essential medicines, amongst other matters.

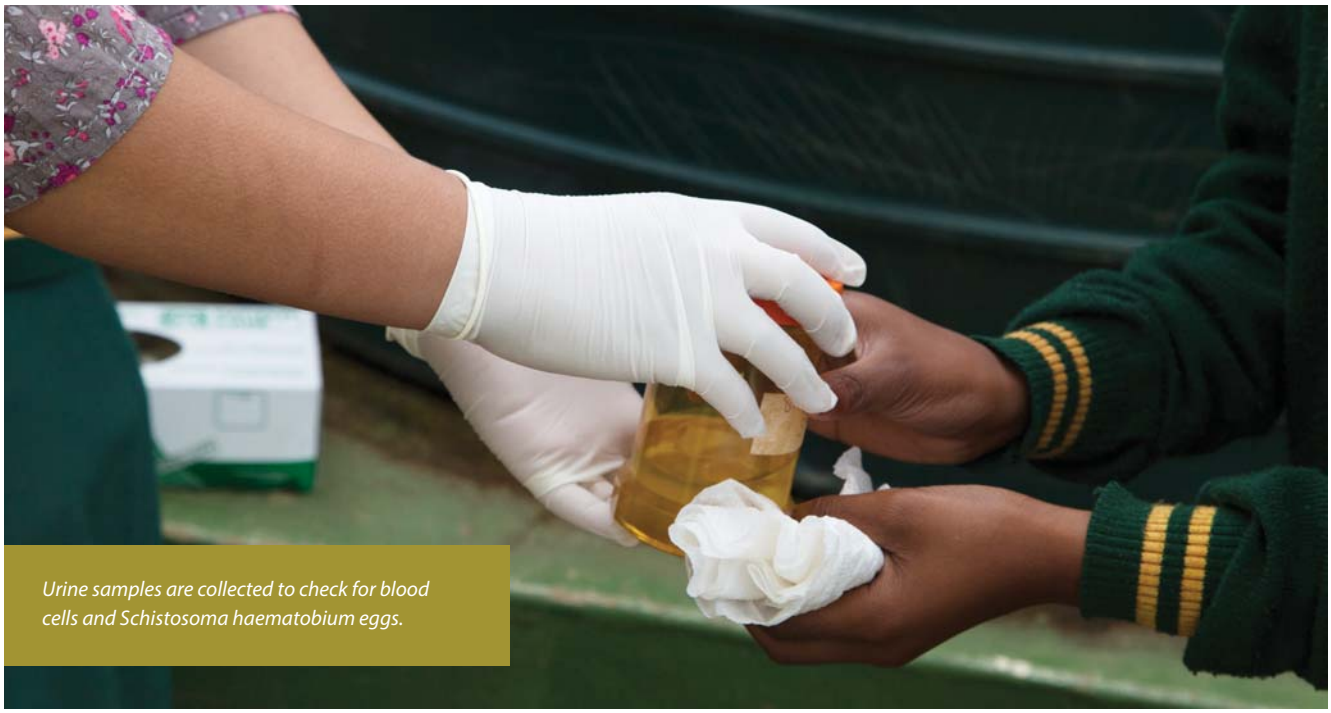
But in a paper published recently in the ***South African Journal of Science***, entitled 'A review of the control of schistosomiasis in South Africa', Taylor, Kjetland and co-authors from the University of KwaZulu-Natal lament the lack of progress in this regard, given that more than 4 million people are estimated to be infected with the disease in this country.

"In South Africa, only Bayer's Biltricide® (praziquantel) is available for the treatment of schistosomiasis. The Department of Health purchases praziquantel for schistosomiasis at a cost of US$4.49 per tablet, making mass treatment programmes unaffordable and almost impossible to run in South Africa. Praziquantel is not even fully stocked in local clinics at the moment as it is too expensive."

"Contrary to the current practice in South Africa, other countries accept WHO-accredited generic praziquantel. These simple,

Dr Eyrun Kjetland hands out consent forms during a BRIGHT school visit

Håvard Holme



Urine samples are collected to check for blood cells and Schistosoma haematobium eggs.

Håvard Holme

effective, cheap and commercially available generics are of excellent quality, have been on the market for more than 20 years and have been used widely in schistosomiasis control programmes."

The authors note that, as a Schedule 4 drug, praziquantel must currently be dispensed by a professional nurse. They encourage the relevant authorities to consider rescheduling this drug, which does not have serious side effects, and also to take urgent action towards registering the generic forms of praziquantel. They conclude by pointing out that a well-structured schistosomiasis control programme has the potential to contribute to a reduction in the prevalence of HIV amongst young women.

Since the publication of the paper, the government has launched the National School Deworming Programme, which will be rolled out annually to Grade R to 7 learners in quintile 1 to 3 schools – the poorest schools in the country. However, this will target only soil-transmitted helminths, namely roundworm, whipworm and hookworm, which can be treated with mebendazole. This is registered as a Schedule 1 drug, which anybody can access over the counter. The WHO has donated seven million mebendazole tablets for the South African programme.

Fast-tracking the registration of praziquantel generics that are already widely used in schistosomiasis control programmes elsewhere in the world would pave the way for further assistance. Since 2007, Merck has donated 340 million of its generic tablet to the WHO, with over 74 million patients, mainly school children, treated to date. In 2015 alone, more than 100 million tablets were distributed across 23 African countries. The intention is to increase this donation to 250 million tablets per year, corresponding to the number of people believed to be infected with schistosomiasis worldwide. The pharmaceutical giant hopes to advance the WHO's goal of eliminating the disease, and to this end it launched the Global Schistosomiasis Alliance with other partners in December 2014.

"Many people are not even aware they have been infected by the parasite."

The WHO Female Genital Schistosomiasis Pocket Atlas is an illustrated guide to the lesions that would be visible during a gynaecological exam.

Håvard Holme

Of course, mass treatment campaigns are only one means of addressing schistosomiasis. In the past, before safe drug therapy was available, control of the intermediate snail hosts via molluscicides and/or habitat modification was an important part of the WHO-recommended strategy. Although these methods had negative environmental impacts and were labour-intensive, the World Health Assembly's 2012 resolution stimulated debate as to whether snail control should again be promoted.

There is general agreement, though, that multi-faceted, integrated control programmes are needed, incorporating education and awareness-raising to encourage avoidance of infested waters, and – of course – safe water supply and sanitation for all.

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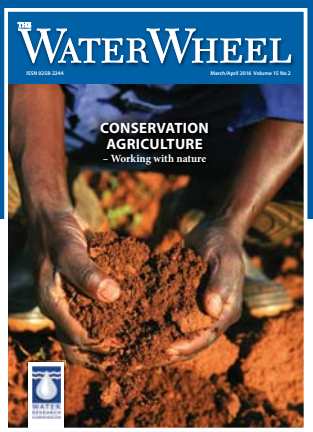

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Capacity development

Have our provincial aquatic scientists become critically endangered?

Conservation agencies play a vital role in the conservation management of natural terrestrial and aquatic resources at a provincial level. What is the role of aquatic scientists and technicians in this important task, and do we face a capacity crisis at present?

Article by Dean Impson.

South Africa is a country blessed with extraordinary levels of biodiversity (ranked third in the world) and is the only country to have one of the world's six floral kingdoms (Cape Floral) contained entirely within its borders. There are also a wide variety of inland aquatic ecosystems present, including seven of the world's freshwater eco-regions; namely the Cape Fold, Karoo, Western Orange, Amatolo-Winterberg highlands, Drakensberg-Maluti highlands, Southern Temperate Highveld and Zambesian Lowveld.

These ecoregions are characterised by a wide range of river ecosystem types and wetland groups. The national Atlas of freshwater ecosystem priority areas (FEPA) produced in 2011, identified 223 river ecosystem types in South Africa as well as 133 wetland groups. Housed within these ecosystems are an amazing diversity of aquatic animals and plants that are dependent on ecologically healthy inland waters for their survival. Many animal and plant species are restricted to certain aquatic eco-regions, and these reach their highest level of endemicity within the Cape Fold Eco-region. According to an excellent analysis of this area by Drs Ferdy de Moor and Jenny Day, an incredible 92% of some aquatic insect groups (e.g. Plecoptera), 86% of freshwater fishes, 86% of hydrophilic vascular plants and 69% of frogs are found nowhere else.

However, unlike many other nations that are rich in biodiversity (e.g. Brazil, Indonesia), South Africa is not blessed with abundant water resources. This is highlighted in the 2016 WWF-SA report, ***Water: Facts and Futures. Rethinking South Africa's Water Future***. For example, South's Africa's average rainfall of 490 mm/year is half the world's average and is highly seasonal and variable. The average rate of evapotranspiration is very high – almost three times the value of our average rainfall, at 1 800 mm.

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South Africa's unique wildlife associated with its aquatic ecosystems are being threatened by the lack of provincial conservation personnel to look after them.

Only one agency comes close to the minimum number of staff required, while two provinces have half the suggested minimum requirement and other provinces have few or no aquatic staff.

Many rivers are over-abstracted for agriculture, and several naturally perennial rivers are now seasonal. In fact, approximately 98% of our surface runoff is already allocated to users. The little water that is left in rivers is frequently in a poor state due to the effects of poor land-use practices and malfunctioning wastewater treatment plants.

Over half of South African rivers are classed as threatened, with 26% regarded as critically endangered, i.e. largely unable to perform essential ecological services. The condition of wetlands is even worse. Wetland ecosystems comprise only 2.4% of our land-surface area, and yet they perform vital ecological services to society. Here, a shocking 48% of wetlands are regarded as critically endangered.

Many of these wetlands have lost most of their capacity to generate and purify waters and assist with flood attenuation services. The effects of habitat degradation are compounded by the impacts of invasive alien species in catchment areas, in riparian zones, in rivers, and in or adjacent to wetlands. Alien plants are water thirsty and cause wetland and river bank degradation. The loss of water through alien plants is severe (estimated at 1.44 billion m^3/year) and is a major threat to South Africa's water security.

This is fortunately being addressed countrywide by the massive alien plant clearing efforts of the Working for Water section of the Department of Environmental Affairs' (DEA's) Natural Resource Management Programmes. Invasive alien fishes also have severe impacts on inland waters, including water quality impairment (e.g. carp) and loss of biodiversity through predation and competition (e.g. bass and trout). The impacts of alien fishes are most severely felt in the Cape Fold Ecoregion and are the prime reason why the majority of endemic fishes there are threatened.

Given this backdrop, it would make sense for South Africa to make the management of aquatic ecosystems a national priority, with a strong regional aquatic capacity in conservation agencies. But is this the case?

Role of aquatic scientists and technicians in provincial conservation agencies

Rivers and wetlands that provide high-quality ecological services (provision of abundant uncontaminated water, flood attenuation, fisheries, biodiversity, eco-tourism) are generally those that are in a good to excellent ecological condition. Every province in South Africa is very dependent on such ecosystems for water security, but all are also water stressed (especially at present with the ongoing droughts).

Hence this vital ecological infrastructure needs to be effectively managed at provincial level by appropriate agencies and appropriate staff experienced in the management of rivers and wetlands.

The ecological management of rivers and wetlands is primarily the responsibility of the DEA and its provincial departments and agencies. It is true that the Department of Water and Sanitation (DWS) also plays an important role here through its Resource Protection section, but their mandate differs from that of the DEA.

So what then is the role of an aquatic section in a provincial conservation agency? The functions of this group include the following:

- Monitoring aquatic biodiversity, focusing on threatened species. Most aquatic sections have a particular focus on FEPA's, including Critical Biodiversity Areas for fish that have been identified in the national Atlas.
- Monitoring the ecological condition of rivers and wetlands using nationally approved indices (e.g. those development for the River Eco-status Monitoring Programme). This should be done in conjunction with the Resource Protection section of DWS. The choice of monitoring sites on rivers and wetlands should include rehabilitated areas where Working for Water and Working for Wetlands have been active.
- Land-use advice for proposed developments near rivers and wetlands (e.g. proposed dams, fish farming, housing developments) that trigger Listed Activities.
- Provide scientific input to the conservation management section of the agency. This section manages the Protected Area network, which in many provinces is a vital source area for water provision (consider the Hottentots Holland Nature Reserve, managed by CapeNature that provides arguably most of the run-off to Theewaterskloof Dam and the Ukhathlamba-Drakensberg Park, managed by Ezemvelo Wildlife that provides southern KwaZulu-Natal with most of its water). It has been estimated that 8% of our land-surface (generally declared mountain catchments) provide 50% of South Africa's water.
- Recommendations regarding regulatory requirements e.g. permits to stock fish, permits to start fish farms, permits to use Alien Invasive Species.

- Identify research needs for inland waters and their biodiversity
- Guidance regarding conservation planning, as this has to include aquatic priorities for planning.
- Provide scientific information, based on monitoring work and expertise, to assist in the compilation of National Biodiversity Assessment reports, Alien Species Management reports, and State of River reports, amongst others.
- Advice to the public regarding aquatic issues. Many queries are about angling and associated issues as angling is a very popular outdoor activity in South Africa. Furthermore, inland fisheries play a vital role in recreation as well for subsistence purposes. The Department of Agriculture, Forestry and Fisheries (DAFF) is the logical department to drive the fisheries mandate, but currently has not yet developed inland fisheries capacity.
- Network with other stakeholders involved in inland water management in terms of scientific information exchange (scientific agencies e.g. CSIR; funders e.g. Water Research Commission (WRC), WWF-SA, EWT; government agencies e.g. DWS, DAFF, South African National Parks; water user associations e.g. catchment management agencies and public groups such as the angling sectors).
- Ensure that aquatic science is integrated into conservation work by using readily available scientific products (WRC reports, scientific literature), platforms (annual South Africa Society of Aquatic Scientists conference) and networks (e.g. with South African Institute for Aquatic Biodiversity).
- Synthesise information from the ever-growing body of scientific evidence in support of evidence-based decision making
- Scan the 'knowledge horizon' to alert their agencies of emerging threats and opportunities
- Solicit, steer and conduct relevant research to provide the necessary evidence base for evolving social-ecological issues

From the above, it seems obvious that provincial conservation agencies needs a competent aquatic section. So then what should a minimum capacity be at such an agency?

Proposed capacity for an aquatic component at a provincial conservation agency

In determining such a capacity one needs to give consideration to the work that is needed, to what is currently working at a regional level and the availability of funding. There needs to be a distinction between coastal and inland provinces as the former's waters include estuaries as inland waters and these require an additional skill set for appropriate management.

The capacity suggested in the table below is based on presentations on this subject given by the author to the Freshwater Ecosystem Network (FEN) which the South African National Biodiversity Institute has established. This is a grouping of aquatic scientists in South Africa that work on inland waters and meet annually as the FEN. They comprise consultants, research scientists as well as aquatic scientists at provincial conservation agencies and DWS. The capacity in the table below is regarded as a minimum requirement, not an optimum requirement.

Provincial group	Section leader	Scientists (MSc, PhD)	Technical support	Total
Coastal province	Assistant Director (Aquatic)	Fish scientist Wetland scientist River scientist Estuarine scientist	3 staff with BSc or diplomas	8
Inland province	Assistant Director (Aquatic)	Fish scientist Wetland scientist River scientist	2 staff	6

Provincial-based aquatic staff play an important role in safeguarding the headwaters of South Africa.

If the capacity suggestion in the table is correct, the minimum capacity is 8 per coastal province and 6 per inland province in terms of dedicated staff. Obviously aquatic teams would benefit from the ready availability of field ranger staff when conducting field work.

Current capacity in the provinces in the conservation / environmental agencies

Provincial conservation agencies (aquatic staff) were consulted about current capacity and the table below is understood to be correct at the time of writing this article. The table suggests that we may have a crisis in terms of aquatic capacity in the provincial conservation agencies as only one agency (Mpumalanga Parks Board) comes close to meeting to what is suggested as a minimum requirement for aquatic capacity.

Two other provinces have half the suggested minimum requirement (CapeNature, Ezemvelo KZN Wildife) while other provinces have very few aquatic staff or no dedicated staff.

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Province and provincial body	Section leader (Aquatic)	Scientists (MSc, PhD)	Technical support	Total and suggested minimum in brackets
Mpumalanga Mpumalanga Parks Board	0	4	1	5 (6)
KZN Ezemvelo KZN Wildlife	0	3	1	4 (8)
W. Cape CapeNature	1	2	1	4 (8)
Gauteng Dept. Agricultural and Rural Development	0	1	1	2 (6)
Limpopo Dept. Economic Development, Environment and Tourism	0	1	1	2 (6)
Free State Dept. Economic Development, Tourism and Environ. Affairs	0	2	0	2 (6)
N Cape Dept. Environmental Affairs and Nature Conservation	0	1	0	1 (8)
North West Dept. Econ. Devel., Environ., Conservation and Tourism	0	1	0	1 (6)
E. Cape Dept. Economic Development and Environmental Affairs	0	0	0	0 (8)

Dean Impson

Aquatic staff play a key role in conservation status assessments of threatened fishes such as the Clanwilliam redfin, a Vulnerable species.

A dire situation that requires attention

Given the current capacity constraints, two main questions arise for the way forward. How will the minimum aquatic capacity be funded and where will the funding for increased capacity come from? The latter is an over-riding question in government these days as the Treasury Department strives to substantially reduce government expenditure to meet its budget goals.

Given the value of ecological infrastructure that generates and provides water in our water stressed country, a strong argument can be made for dedicated funding in the form of a water levy to sustain organisations that manage major water source areas. Although costs vary between regions and user groups, South Africans pay for water that is used in a variety of ways. Therefore, it seems sensible that a small proportion of this charge per water management area could be in the form of a catchment management levy that is ring-fenced and allocated to management of ecological water infrastructure.

This levy could then be used to ensure that inland water ecological infrastructure is maintained in an excellent health by keeping catchments clear of alien plants, ensuring that wetlands and riparian zones are not degraded, ensuring the implementation of environmental flow releases from dams and effectively monitoring and reporting on the health of key rivers and wetlands.

In closing, this article should not be seen as a criticism of government or any government department. The aim is to make readers aware of the need for aquatic capacity in conservation agencies at provincial level and what form the capacity could take to meet operational requirements. The author has worked as an aquatic scientist at a conservation agency for nearly 25 years and welcomes comment on the article and alternative suggestions to addressing what is viewed by the national Freshwater Ecosystem Network as a growing problem that requires national attention.

Dean Impson

Aquatic staff are needed to guide and undertake fish survey work.

Industrial water treatment

Novel treatment solutions turns industrial wastewater into commodity

A novel industrial wastewater treatment technology developed with funding from the Water Research Commission (WRC) is offering South African industries a more sustainable solution for wastewater treatment.

Article by Sue Matthews.

When Ernest Shackleton and his polar exploration team were forced to abandon their ship in Antarctica in 1915, their survival hinged on two special properties of ice. Firstly, ice is unique in that it is less dense in its solid state than in its liquid state, which means it floats on water – so the stranded men were able to camp on drifting ice floes for over five months.

Secondly, as seawater freezes, the salt ions are rejected from the ice crystal lattice and become trapped in pockets of brine, before slowly leaching out into the seawater below under the effect of gravity. This natural tendency to reject impurities means sea ice that is several years old can be melted and used for drinking water – a key factor in keeping Shackleton's team alive until their rescue.

These special properties of ice are exploited in a new wastewater treatment technology based on research conducted at the University of Cape Town's Department of Chemical Engineering. Under the leadership of Prof Alison Lewis, the research team embarked on their journey of scientific discovery in much the same spirit of exploration that Shackleton showed a century ago – and at times needed a pinch of his perseverance!

In a TEDx talk presented in Cape Town in 2011, appropriately titled 'Be bold and mighty forces will come to your aid', Prof Lewis explained the nature of their research. "Imagine if we could deconstruct contaminated waters and form pure, usable water that we could put back into the water cycle, as well as take the contaminants and recover them in the form of something useful, like pure salts," she said.

"This concept of deconstructing contaminated water into useful products is what we've been doing in our lab. Basically, we're using a process called eutectic freeze crystallisation, which involves cooling the contaminated solution down to freezing point, so the water crystallises out as ice and the contaminants crystallise out as pure, usable salts."

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Prof Alison Lewis, founder and Director of the Crystallisation and Precipitation Research Unit in the Department of Chemical Engineering at the University of Cape Town.

The contaminated waters being used in the research are hypersaline brines originating from mining operations, power stations and petrochemical refineries. Wastewater treatment for these sectors typically involves sequential membrane filtration incorporating, for example, ultrafiltration as a pre-treatment step followed by reverse osmosis. This produces water clean enough to re-use in the plant or release into the environment, but the contaminants are in the process concentrated into a highly saline brine.

One way of reducing the volume of such brines is to discharge them into evaporation ponds, but these require a large area of land set aside for the purpose, and risk contaminating groundwater if not properly lined. Alternatively, the brines can be passed through an evaporative crystallisation plant, which uses heat to transform them into a purified distillate and a dry salt waste. The disadvantages of this approach are the high energy costs for heating and the mixed composition of the salt waste, which necessitates either additional treatment or disposal in a landfill.

The beauty of EFC is that the energy required to separate the water as ice (involving a phase change from liquid to solid) is significantly less than that required to separate it by evaporation (liquid to gas). What's more, individual salts can be recovered, because each has its own unique temperature at which it will crystallise out in that particular mixture.

In one set of experiments, for example, the research team recovered calcium sulphate and sodium sulphate form a brine that had been produced by a reverse osmosis plant treating coal-mining wastewater. Calcium sulphate is more commonly known as gypsum, the material from which ceiling boards, drywall and plaster are made, but it is also used as a fertiliser in agriculture and as a filler in dentistry and orthopaedic surgery. Sodium sulphate is a key ingredient of soaps and detergents, but it is used in the production of paper, glass, textiles and a variety of other materials too.

The potential to sell these and other more valuable salts, combined with the operating-cost savings associated with the lower energy demand, should prove to be a major incentive in the adoption of this technology, although – being so new – the initial capital costs will still be very expensive.

Fortunately, two local stakeholder groups were willing to make the investment required to scale up the lab-based research into a real-world treatment facility. The Coaltech Research Association – made up of coal-mining and -processing companies as well as various research organisations, including the WRC – contracted Prentec to design and build a full-scale demonstration plant at the Optimum Colliery near Middelburg, which became operational in May last year.

In April of this year, Eskom commissioned a pilot plant, which was designed and built by Proxa, at its Research and Innovation Centre at Rosherville. The intention is to test whether the technology will be suitable for recycling water used in the electricity-generation process, and also for treating acid mine drainage so that it can be used at power stations. Eskom consumed almost 300 billion litres of water last year, but EFC could provide a way of reducing its water footprint while at the same time addressing one of South Africa's most pressing environmental problems.

"Students and staff from the Crystallisation and Precipitation Research Unit went up for the commissioning and spent a week on the plant," says Prof Lewis. "Our involvement there is to be kind of an academic sounding board – we were involved in trouble-shooting and problem-solving in getting the plant up and running, but also in identifying other issues for which we need to consider developing new research projects."

"For now, we're still busy with a big WRC project that started in 2013 and runs until the end of 2017, and we're doing that in collaboration with Eskom. We have our own research questions aimed at increasing our understanding of particular aspects so we can feed that back into the design, but the engineers at the pilot plant are also generating new questions. All the questions are a complex interaction between physical and chemical processes – and, of course, what happens at small scale and large scale are often quite different!"

The WRC has been supporting the team's research on EFC since it began in 2007. The initial project to establish fundamental principles used synthetic wastewaters typical of the effluents produced by major South African industries, but the follow-on project used real wastewaters from the coal-mining and platinum industries. Experiments were conducted to investigate aspects such as the effects of impurities, and the influence of operating temperature on yield and purity of the final products.

"Eutectic freeze crystallisation, which involves cooling the contaminated solution down to freezing point, so the water crystallises out as ice and the contaminants crystallise out as pure, usable salts."

The main aim of the current project is to develop tools that would allow EFC to be run in continuous mode. All the experiments for the two previous projects were run in batch mode, and even the Eskom pilot plant is designed to operate on a 20 day cycle. But batch processes often produce inconsistent quality, and they would in any case be unsuitable for industrial concerns that generate large volumes of waste on an ongoing basis.

As part of the project, a lab-scale continuous EFC plant was therefore designed, constructed and brought into operation at UCT. Although its capacity is only two litres, it is already proving its worth in a range of experiments. For example, it is being used to study ice scale formation and how this is affected by scraper speed, and also to investigate whether anti-scalants have an effect on the thermodynamics and crystallisation kinetics of both ice and salt.

In industrial processes, anti-scalants are often added to cooling waters and reverse osmosis feed-streams to prevent scaling of heat exchangers and membrane fouling, so the research aims to determine whether a pre-treatment step to remove them would be necessary. Initial work on phosphonate-based anti-scalants has shown that these have no effect on the solubility of sodium sulphate, nor on the freezing point depression of ice.

Of course, most of the experiments are conducted by students, working under Prof Lewis's supervision. To date, the three WRC projects, along with various industry-funded projects, have provided hands-on training for 6 PhD and 8 MSc students, as well as about 40 undergraduates. The WRC has been so impressed with the progress achieved that it bestowed the 2015 Knowledge Tree Award for 'new products and services for economic development' on Prof Lewis and her team.

"Eutectic freeze crystallisation is regarded as one of the WRC's flagship technologies," says Dr Jo Burgess, WRC Research Manager for mine water treatment and management. "We're proud to be associated with the progression of a technology from lab to full scale."

Prof Lewis points out that work on EFC started overseas in the

Prof Alison Lewis (far left) and some of her postgraduate students at the commissioning of the eutectic freeze crystallisation pilot plant at Eskom's Research and Innovation Centre in April.

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Eskom's eutectic freeze crystallisation pilot plant, designed and built by PROXA at a cost of R8.3 million, is capable of treating 40 000 litres of water every 20-day cycle.

1950s, and over the years a number of researchers showed that it was technically feasible, but the concept was not pursued because freezing was considered too expensive. The vastly improved efficiency of modern-day compressors has now made it more commercially viable, but at the time she and her team began their own EFC research, the only other group working in the field was at the Technical University of Delft in the Netherlands.

"Our main contribution has been multi-component and complex hypersaline brines from mining operations, but there are lots of other potential applications, such as wastewater from the textile, paper and pulp, agriculture and food-processing industries, as well as fracking brines. We just happened to focus on mining because it was so relevant," she says.

"Eutectic freeze crystallization is regarded as one of the WRC's flagship technologies. We're proud to be associated with the progression of a technology from lab to full scale."

Asked whether EFC would be a suitable treatment technology for use on its own, she explains that for relatively dilute wastewaters, including most acid mine drainage brines, it is still more economical to use reverse osmosis to concentrate the stream before treating it with EFC.

"Otherwise, you'd make masses and masses of ice, and there are cheaper ways to separate water!"

Award winning scientist

Prof Alison Lewis was announced the winner of the Distinguished Woman Scientist: Research and Innovation Award at the Department of Science and Technology's 2016 Women in Science awards ceremony, held in Johannesburg in August. This is the second time she has been honoured in the awards, having been named Distinguished Woman Scientist in Physical and Engineering Science in 2012. In the same year she was given the National Research Foundation President's 'Champion of Transformation in Research' Award for her active involvement in training, fostering and mentoring black and female students.

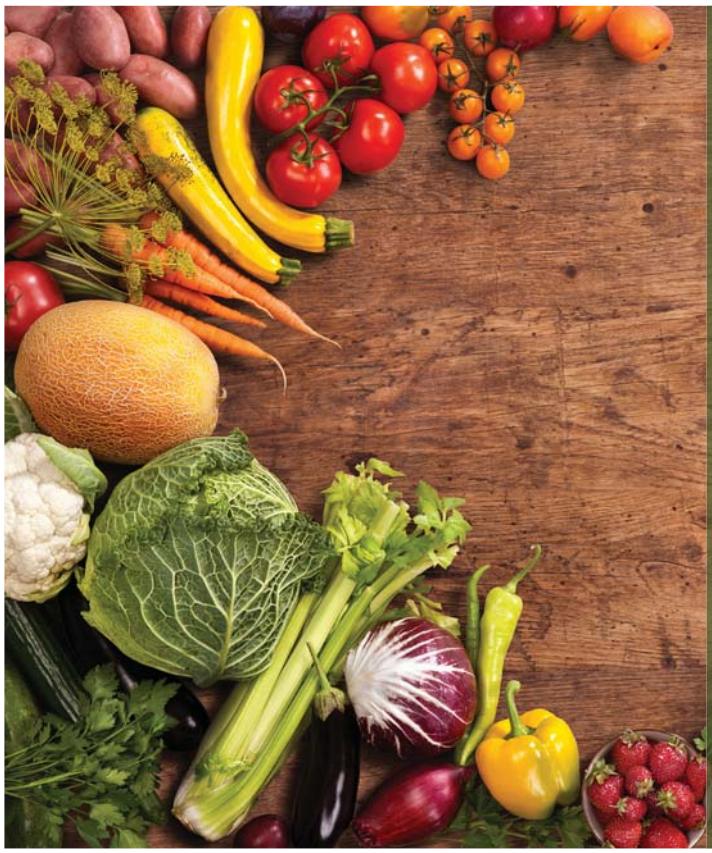
Prof Lewis is the founder and Director of the Crystallisation and Precipitation Research Unit in the Department of Chemical Engineering at the University of Cape Town. She was appointed as a professor in 2007 and – following a two and a half year stint as Head of department – has since June 2015 served as the first female Dean of UCT's Faculty of Engineering and the Built Environment.

Prof Lewis recently co-authored a book, ***Industrial Crystallization: Fundamentals and Applications***, which has been published by Cambridge University Press.

To watch more on Prof Alison Lewis and her work, click here

Water and nutrition

Sowing seeds of knowledge



The University of Pretoria recently conducted a research project, commissioned and funded by the Water Research Commission (WRC), to understand what people in rural households in South Africa grow and eat. The project aimed to identify ways in which rain-fed and irrigated crop production can be strengthened to improve nutrition.

Article by Karen Grobler.

Half of South Africa's population – some 27 million people – live below the global poverty line. Government grants are often the only means of survival in poor rural communities. However, the grants fall far short of being able to cover the basic cost of nutritious food.

The experience of hunger is related to many different forms of deprivation. There is widespread 'hidden hunger', in the form of micronutrient deficiencies, growing rates of overweight and obesity and – perhaps most concerning – stunting and overweight tendencies among small children.

Taking a holistic view

This study of consumption and production patterns investigated how crop production can lead to better nutrition by improving dietary diversity. This unique transdisciplinary study was conducted in four of South Africa's poorest rural communities – Ingquza Hill (Eastern Cape), Jozini (KwaZulu-Natal), Maruleng (Limpopo) and Ratlou (North West).

Qualitative and quantitative data were collected between October 2013 and November 2015 through focus group discussions, key informant interviews and a two-round panel survey to cover both the summer and winter seasons at each site.

The food security situation of the households was assessed using anthropometry (height, weight and arm circumference measurements) of children between 24 and 59 months and their female caregivers, food consumption frequencies and the diversity of their diets.

Findings on nutrition

The researchers found that most households were food insecure. There was inadequate food available to meet the requirements of a diversified diet. Roughly one in four households reported experiencing hunger for most months of the year, but most households cited January as a difficult month.

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The researchers found high levels of hidden hunger, overweight among adult women and children, and stunting in children. Of concern was the number of young children who were both stunted and overweight.

Findings regarding consumption

Access to a diversified diet was problematic for households in these communities. They had a starch-based diet – consisting mostly of maize and bread – that lacked fruit and vegetables. Most households were able to buy enough maize meal for daily consumption, but their diets lacked diversity, and contained far too little, or no fruit and vegetables.

This was worse in winter when even fewer fresh fruits and vegetables grew and water was in short supply. Participants reported that drought and climate change had reduced their opportunities for diversifying production and that wild foods were also not available.

Contrary to expectation, the study found that an encouraging number of households supplemented their diets through crop production in the areas where such production was possible – Ingquza Hill, Jozini and Maruleng. The study also found an encouraging number of households engaging in crop production on farmland, home gardens or school and community gardens, despite low access to agricultural input, support and supplemental irrigation.

Nutritional benefits of crop production

Producing fruit and vegetables allowed households to eat a more diverse diet and helped household members maintain a healthy body mass index. The income from farmland production and irrigated agriculture also allowed people to buy vegetables and fruit but, more importantly, meat, eggs, fish, milk, roots and tubers.

After studying the consumption and crop production patterns of the households, the researchers were able to determine what could be done to improve their diets and overall nutrition. Many crops can be grown to improve nutrition in these communities. But very few crops will yield food in winter. Irrigation offers the potential of increasing the amount and variety of fresh produce, as well as the period of availability.

The data was used to identify which crops could improve the dietary diversity and nutrition of the households. The agronomic conditions in the four sites were examined and crops that could grow in these areas were identified. The prioritised list of crops were presented to the communities for validation through a workshop held at each site.

Foods that were found by the study to be culturally acceptable and that could grow in these communities included:

Dark, green leafy vegetables	Swiss chard, broccoli, the leaves of beetroot, cowpeas, beans, pumpkins and sweet potatoes, as well as African leafy vegetables such as blackjack, cat's whiskers, amaranth, lamb quarters, nettle, nightshade and sow thistle.
Other vegetables	Cabbage, cauliflower, cucumber, eggplant, gem squash, calabash or other squash, green beans, green pepper, lettuce, peas, onion and zucchini (baby marrow).
Orange-fleshed vegetables	Beetroot, carrots, dark orange pumpkin, butternut or squash, orange-flesh sweet potato and tomato.
Legumes	Bambara groundnuts, cowpeas, dhal, dry beans and groundnut (peanuts).
Roots and tubers	Amadumbe, potato and sweet potato.
Orange-coloured fruit	Citrus fruit, mango, papaya, pineapple, spanspek (cantaloupe) and watermelon or maketaan.
Other fruit	Avocado, banana, figs, loquat and marula.

Main recommendations from the study

Increased production is required of nutrient–dense crops.

As many of the crops will require supplemental irrigation, water harvesting and irrigation systems are recommended to reduce drudgery, especially for women. The provision of boreholes and piped water are essential in drier areas.

Research is urgently needed to investigate the impact of climate change on growing patterns to advise on adaptations to production techniques, irrigation practices, production timing and the potential for the development of early- and late-maturing crops to extend the growing season and make food available for longer periods.

Biofortification of crops is needed to increase the nutrient density of multiple micronutrients, especially in dual crops such as beetroot or where the nutrient water productivity of more than one nutrient could be enhanced (such as vitamin A, iron and zinc in carrots). Dual crops are crops where more than one part of the plant is nutrient-dense such as the leaves, roots, fruit or seeds.

South Africans' overreliance on maize has led to a situation of hidden hunger.

Many challenges

A number of fruit and vegetable crops can be produced in these communities. However, very few crops produce edible food in winter. In the higher rainfall areas of Ingquza Hill, Jozini and Maruleng, some of the recommended crops can be produced under rain-fed conditions when normal weather conditions prevail.

Communities reported that this is not possible in drought conditions. Most crops that will produce nutritious fresh vegetables in winter require irrigation. Access to irrigation is essential to overcome these constraints, extend the range of crops possible, extend the growing season, reduce the risk of crop failure and improve yields.

Communities face different constraints where irrigation is concerned. In all the communities, there is potential to enhance household and smallholder irrigation. In some cases the obstacles are technical.

In the arid Ratlou site, water is simply not available.
In Maruleng, a partly functioning irrigation system needs repair and maintenance to serve a wider community, so the problem is financial.

In Jozini, the vast potential of the irrigation scheme is crippled by conflicting commercial interests, managerial incompetence and stakeholder inequality.

In Ingquza Hill, highly productive, rain-fed terrace farming of staples and livestock has shrunk to small, fenced home gardens. These rely on rainfall or arduous manual irrigation. Although there is abundant river water, the rugged topography could demand expensive investments to use it.

For many small producers and home gardeners, agricultural inputs and extension services are inaccessible or simply inappropriate. But there is a will and energy to adapt farming to changing conditions. An example would be doing this by planting local and more drought-resistant crops.

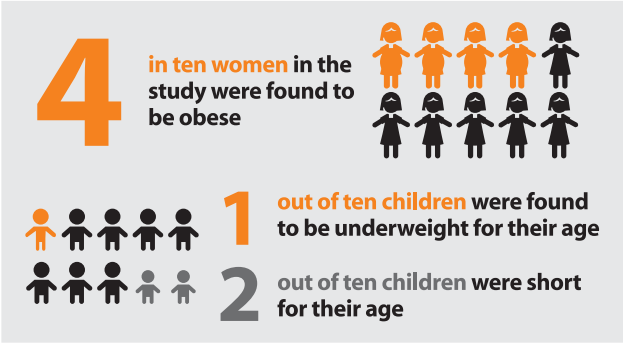
Community involvement

Translators presented the findings in the relevant local languages to maximise the communities' understanding of the issues at hand. In general the response to the research was positive – community members appreciated that researchers took the time and effort to communicate their results.

Communities were well aware of the unhealthy nature of modern, store-bought foods. The most common objection from the communities was that a diverse diet was not affordable, despite suggestions in the data to the contrary.

Lack of water was the major reason cited by communities about why this was the case. The researchers' information was based on long-standing agronomic data, suggesting that growing conditions have changed drastically over the past few decades. This idea was corroborated by community members, who said that many crops that could be grown in the past no longer grew due to a lack of water or a changing climate.

Communities asked the researchers to focus on water use and adaptive farming methods that could help them cope with climate change.



The way forward

For all the assembled data to amount to meaningful change, it needed to be provided to communities in a way that was relevant to them. The researchers' recommendations were based on what is possible to grow in their areas, while ensuring that the recommended crops met die nutritional needs of the communities. Their goal was to find the most nutritious crops that required the least water. Striking such a balance is key to ensuring that poor rural communities are able to sustain themselves in the long term.

Recommendations were usually based on one or more specific nutrient that the crop could provide. Several species were recommended as multi-purpose crops, as in the case of cowpea, a traditional crop that could provide grains and leafy greens, as well as animal feed.

The University of Pretoria's Institute for Food Nutrition and Wellbeing (IFNuW) created a series of posters and brochures in partnership with the communities. Community leaders and agricultural officers would then spread the information to improve their people's knowledge of nutrition and their farming ability. By making better farming and dietary choices, researchers hope that the nutrition of these communities will improve.

An easy-to-use app has been developed that provides information to communities about the crops that will thrive in their areas. Gathered data are also used to craft recommendations for policymakers, as well as to inform the new South African Food Security Information System.

To download the SmartGrow app visited the IFNuW website, http://www.up.ac.za/institute-for-food-nutrition-and-well-being

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Climate change

What Africa's drought responses teach us about climate change hotspots

The world may still argue about whether or not climate change is for real. But in vast expanses of arid southern Africa, the daily struggle to cope with a changed climate is well underway. The lessons being learnt here on a small scale could prove vital in the fight for human survival, writes Gina Ziervogel.

The impact of drought has been felt acutely this season over southern Africa, as El Niño hit hard. Perhaps this is what we might expect under future climate change conditions and so we had better learn how to prepare for it: more frequent years that record less rainfall than usual, along with the associated crippling impact on livelihoods and the economy.

This is particularly the case in semi-arid regions of Africa and Asia. These climate change hotspots are highly dynamic systems that already experience harsh climates, adverse environmental change and a relative lack of natural resources. People here are often further marginalised by high levels of poverty, inequality and rapidly changing socio-economic, governance and development contexts.

This requires an effective response. In northern Namibia and eastern Botswana, research is already underway into what's currently working and not working in relation to managing climate impacts. A major regional project is seeking ways to reduce vulnerability and develop longer-term climate adaptation responses.

Minimising vulnerability

The Adaptation at Scale in Semi-Arid Regions (ASSAR) project aims to redress the lack of information about the best ways to minimise vulnerability and develop adaptation responses. In addition, it aims to produce future-focused and societally-relevant knowledge of pathways to well-being.

One of the initial steps has been to undertake vulnerability and risk assessment workshops. The case study sites are in northern Namibia's Omusati region and eastern Botswana's Bobonong district. These workshops differ from many vulnerability assessments that often focus either on the village scale or on a resource-based sector.

The workshops bring together people from all walks of life. These include village leaders, non-governmental organisations

and government officials, among others. This group is called the Knowledge Group. Issues and hazards of most concern are identified through prior interviews and then refined by this group. During a two-day workshop, the Knowledge Group unpacks how the most important issues impact different livelihood groups in the area and the best responses.

During workshops in Botswana last year, and in Namibia earlier this year, drought was found to be one of the three most important issues facing both regions. One of the exercises was to develop an impact chain to assess possible positive and the negative future impact of drought.

Groups mapped how drought affects the biophysical system – farming, water and natural resources, for example – and then how this will further impact on families' lives, economic activities and broader political and institutional environments.

How drought affects Namibia

In Namibia, the indirect impact of drought on livelihoods that were identified included:

- Reduced crop yields from crop failure leading to loss of income and inadequate food supply in households. This has an impact on health.
- Reductions in water available to wildlife, leading to loss of wildlife. This affects the number of tourists and earnings from tourism.
- Reduced fodder production, heat stress and outbreaks of diseases affecting livestock health and mortality rates. This reduced milk and meat production leads to loss of income.
- Livestock mortality had an impact on cultural practices. The death of livestock often leads to loss of status, prestige and participation in social networks. Livestock deaths limit the ability of people to participate in social and cultural events, such as wedding ceremonies.

All of the above lead to lower household incomes, which increases hunger. Malnutrition of school children leads to poor health and an increased number of school dropouts. Limited household food availability can also increase participation in risky behaviour, such as theft and transactional sex in exchange for food or cash. This then leads to an overall increase in household social conflicts.

Impact of drought in Botswana

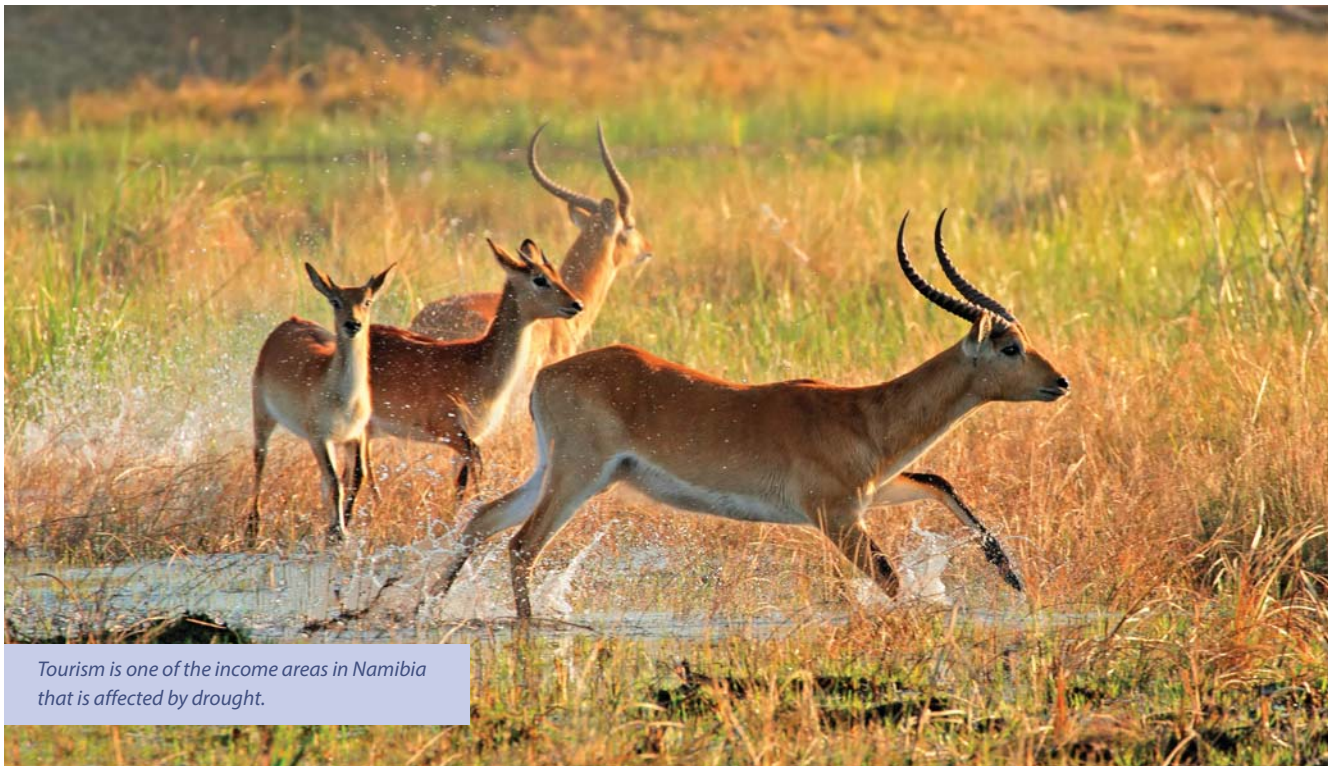
In Botswana, there were some similarities and some additional points that were raised related to the impact of drought: Rainfall patterns had not been consistent for the past 15 years and the frequency and impact of drought had increased.

Arable farmers, livestock keepers and phane (mopane worm) harvesters are most vulnerable to drought because a lack of water increases the likelihood that their crops will fail, animals will die and mopane worms will be in short supply.

Livestock farmers in the area are highly vulnerable to drought because they are not able to migrate with their animals in search of water. Those who have migrated have experienced livestock theft when they move closer to the border.

Traders were thought to be moderately affected to drought because some items are scarcer in a drought, but also because households have less income to spend.

Youth are particularly sensitive to drought. In some cases, youth who take out loans for an agriculture business cannot pay them back during a drought, resulting in further hardship. In some families, the assistance of youth is not needed in the fields or to harvest phone during drought, and so they are unoccupied and get into trouble.



Tourism is one of the income areas in Namibia that is affected by drought.

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Livestock farmers in Botswana are severely affected by drought.

Unfortunately with climate change, drought is likely to become more frequent. It is critical to assess the viability of scaling up successful local solutions as well as identifying new solutions

When there is drought, the elderly have to use their old age grant for food instead of other vital supplies and services. This is made worse by their limited physical fitness.

The associated lack of food and income can have far reaching social consequences. These include people adopting risky behaviours, including drug and alcohol abuse, truancy, criminal activities, theft and corruption that lead to family breakdowns.

Solutions from local communities

One of the strengths of the workshops is that they help the Knowledge Group to identify solutions they think could be strengthened or implemented at the local or district level. So in Namibia, there was a discussion about promoting food banks to address food insecurity at the community level. As part of this, each household is encouraged to contribute 20 litres of mahangu (millet) that is stored by the traditional authority and used in time of distress.

In Botswana, a number of strategies were mentioned, such as irrigation using underground water, leaving phane worms on the ground to allow them to reproduce for the next season and using water harvesting more. There was also support for moving away from dependency on government projects.

In Namibia, regional actors talked about the impact of drought on their activities. Water in northern Namibia is transferred from Angola, first through an open canal and then through a piped reticulation system. When there is a drought there is greater demand for water, and people land up damaging the canal when getting water for their livestock. This reduces both the overall amount of water and reduces the water pressure.

The decrease in water pressure reduces the reliability of water supply for the villages at the end of the pipeline. During droughts people move even further afield with their livestock for grazing and so require water in these far off areas too. These additional challenges not only compromise the water-supply system, but lead to increased maintenance and operational costs.

To help meet the water-supply demands, the Omusati Directorate of Rural Water and Sanitation requests resources from the national level to drill more boreholes, particularly in remote areas. NamWater also has plans to improve the quality and extent of pipes in the area over the coming five years.

The Department of Planning, in the Regional Council, is central to managing drought, even though this might not be obvious at first. It helps with sanitation, which is particularly important during disease outbreaks that commonly occur during drought. It also tankers water into villages when supply is low.

One of the department's responsibilities is for constructing clinics, hospitals and schools. Illustrating how drought can impact on these services, the director explained that the construction of a school in the region has been put on hold for two months in 2016 as there was not enough water for the building process. Examples like this show how education and other services can be impacted by drought directly.

It is clear that drought is already affecting many parts of the system in semi-arid regions. Unfortunately with climate change, drought is likely to become more frequent. It is critical to assess the viability of scaling up successful local solutions as well as identifying new solutions.

Importantly, this needs to be done by including local stakeholders, as well as local government and non-governmental organisations and connecting them to international funding organisations.

- Gina Ziervogel is an Associate Professor in the Department of Environmental and Geographical Science and African Climate and Development Initiative Research Chair at the University of Cape Town. Article republished with the kind permission from The Conversation. Visit, www.theconversation.com

Drought management

Drought – Nature's lessons in overdrive in Kruger National Park

While South Africa's beleaguered farmers have their eyes on the sky, eagerly awaiting the onset of summer rainfall, the researchers of the Kruger National Park have their ears on the ground, closely monitoring drought conditions that have unfolded in sections of the country's largest nature reserve.

Lani van Vuuren visited the park.

Since hippos are not able to move to far away from deep water resources in search of food, they are particularly vulnerable to drought.

All photographs by Lani van Vuuren

"Besides a scarcity of rain, high temperatures have resulted in a lack of fodder for the animals in the Kruger National Park. Both artificial dams and natural and man-made pans have been reduced to mud, while large-scale deaths occurred among animals, such as buffalo and baboons."While this scene sounds eerily familiar, it is actually a (loosely translated from Afrikaans) exert from the Kruger National Park's Annual Report of 1991/92.

Drought has always been a natural part of the Kruger National Park and runs like a golden thread throughout its 90-year history. While the park's climate can be described as semi-arid (average annual rainfall for the park is only around 550 mm) this can vary considerably from year to year, and multi-year oscillations have been observed that vary from above average rainfall years (with increased likelihood of floods) to below average rainfall years (with increased likelihood of droughts).

Every 20 years or so a really severe drought comes along, and these were experienced in the Kruger National Park in the thirties, sixties, early eighties and again in 1991/92. So it came as little surprise to park management when the latest super El Niño made its appearance in 2015 and brought with it hot and dry conditions. During the 2015/16 rainy season areas such as Skukuza only received 190 mm, compared to an annual average of 550 mm. The lack of water has been compounded by some of the warmest days on record being experienced in December, January and March.

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The park has a good working relationship with its upstream neighbours, which means that even during dry times, water is being let through to serve the Kruger National Park at the bottom end of the river catchments.

Each mega-drought has brought increased knowledge about this natural phenomenon in the Kruger National Park, and how best to manage it. "Due to the infrequent nature of such intense droughts, we still have many knowledge gaps," notes Dr Izak Smit, Kruger National Park Science Manager: Systems Ecology, GIS and Remote Sensing. "Now is the time for us to gain as much knowledge as we can so as to prepare better for the future."

As a result research efforts have been intensified in the Kruger National Park to gather as much data as possible during this drought period. For the park's younger researchers especially, many of whom were in primary school during the previous drought, this is an opportunity to contribute significantly to the knowledge pool.

Each drought has been managed differently, depending on the information park management had at the time. During the earliest drought, in the thirties, animal populations were relatively low compared to today, and the park was unfenced, so animals were free to migrate out of the park to water and better grazing. During the early years the drought was largely left to take its course with only a few boreholes being drilled to provide mainly the tourist camps with water.

When fencing of the borders of the Kruger National Park started in earnest in 1957 this left managers with a conundrum. The park's main water resources, the Sabie, Olifants, Luvuvhu, Letaba and Crocodile rivers were starting to show the effects of development and industry upstream. As a result managers implemented an artificial water programme, aimed at boosting water supply in the park through dams, windmills and enlargement of natural pans.

While this seemed to temporarily relieve the situation it also had detrimental effects – since game could now move freely across the breadth of the park (since they had water points all along the way) the grazing disappeared faster. Large herds of animals such as zebra, also pushed out rarer species such as roan antelope. Once grazing is gone animals die of starvation rather than thirst.

Following intensive studies in the eighties and nineties to better understand the natural systems within the Kruger National Park the artificial water policy was adapted. A new management policy, based on strategic adaptive management principles, was adopted whereby nature has been allowed to return to its natural variability.

About half of the artificial water points (mostly away from tourist roads) have since been closed. What this means in the current drought, explains Danie Pienaar, Kruger National Park Head: Scientific Services, is that pockets of grazing have been left in between points where water is available. Stronger animals, which can trek between these grazing areas, will survive, while weaker, diseased animals will perish. It is an unfortunate law of nature – that only the strongest will survive, and a sight that is not always a 'nice to see' for tourists visiting the country's most popular national park. However, game viewing currently is excellent due to the lack of vegetation and daily sightings of the Big Five are a regular occurrence.

Unfortunately, nature has a habit of sometimes throwing curve balls at humans' plans. Late rains experienced in some sections of the Kruger National Park during March may have fed water sources and provided access to some of these grazing sanctuaries too early. So Pienaar and his team are monitoring the situation closely. Conditions are expected to worsen until the onset of the rainy season in November. Due to existing water supply infrastructure potable water supplies to camps and staff quarters have not been affected by drought conditions.

Animal populations are the highest they have ever been in park history. Densities of rhino, elephant, hippo and buffalo, for example, are much higher than they were during the previous drought. Mortalities of hippo and buffalo have already started to occur (rhino and elephant tend to withstand drought conditions longer). Smaller grass-eating species, such as impala, have also been affected. Of course, while some animals are negatively affected by the drought, others are thriving, such as lions, leopards and vultures, which now have an abundance of food. The drought is also not occurring at the same intensity across the park, with the central section being worse off than the far north and south-west.

Park management are also keeping a close eye on natural-occurring diseases such as anthrax, which tend to spike during droughts. During the previous drought buffalo numbers dropped from 30 000 to 14 000 when the drought was followed by an outbreak of anthrax. In the meantime, however, their numbers have swelled again to around 48 000, which tells researchers that recovery in game numbers is not only possible but an eventuality.

Each mega-drought has brought increased knowledge about this natural phenomenon in the Kruger National Park, and how best to manage it.

Since hippos are not able to move to far away from deep water resources in search of food, they are particularly vulnerable to drought. Current hippo numbers are around 8 000 and may be an artificially high density. "Before the establishment of the Kruger Park humans were part of the ecological system. They stayed near permanent water and hunting hippo especially in dry times would have been easy. The many earthen dams that were built also facilitated an unnatural increase in hippo numbers" notes Pienaar. "Too many concentrated hippo creates water quality problems and disease risks in certain water bodies and we had to selectively reduce hippo numbers at some of these places" he explains further. "

A significant feature of the current drought is that the Kruger National Park's main rivers are still flowing thanks to the implementation of the Ecological Reserve, an element of the National Water Act (Act no 36 of 1998), which determines that water of a certain quantity and quality must be made available by law to sustain the natural ecosystem. This is a far cry from the dry rivers encountered in the Kruger National Park in 1991/92 when hundreds of animals such as crocodiles were left to die in significant numbers due to a lack of water. This despite the fact that the current drought is in some areas of the Park more extreme than previous droughts in terms of the lack of rainfall, record summer temperatures and low humidity experienced.

The fact that the Park's perennial rivers are still flowing is extremely important, as large game, in particular, tend to congregate around these rivers during drought conditions, when semi-permanent water resources dry up. As Dr Eddie Riddell, Manager: Water Resources at the Park points out, the perennial rivers also play a key role in supporting terrestrial ecosystem processes.

"We have been able to keep the rivers flowing, and our initial analysis shows that flows in all our perennial rivers have been in the majority of cases better than in the previous two significant droughts. This is a result of improved cross-sectoral management of water resources, through restrictions and to some extent the reliance on water resources infrastructure such as dams," explains Dr Riddell.

The latter particularly refers to dams such as Inyaka Dam, located in the Marite River, a tributary of the Sabie. "We have come to rely on Inyaka Dam, particularly at the end of the low flow/dry season in most years to augment supply in the Sabie river. Flows in the Sabie are much better than they were during the previous droughts as a result," explains Dr Riddell.

The park has a good working relationship with its upstream neighbours, which means that even during dry times, water is being let through to serve the Kruger National Park at the bottom end of the river catchments.

"When it comes to what we call operational water management we have direct communication with the Catchment Management Agency or Provincial Operations offices of the Department of Water and Sanitation, with their respective river or infrastructure managers," explains Dr Riddell. "Furthermore, this interaction usually includes the Irrigation Boards or Water User

Leaf eaters are less impacted by the drought than grass eating species.

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Despite the drought, water is still flowing in the Kruger National Park's main river systems.

Associations (irrigated agriculture) as well as the Water Boards (bulk water supply), as well as our neighbours in Mozambique responsible for water management in the rivers there. Through regular meetings of operational committees tricky decisions in terms of water allocations from dams and restrictions on users have led to a fully transparent and accountable water management process."

A significant feature of the current drought is that the Kruger National Park's main rivers are still flowing thanks to the implementation of the Ecological Reserve.

Using what modern technology has to offer, the Kruger National Park's water managers have become quite reliant on social media such as Whatsapp for real-time group communication and decision-making to track flows in the catchments. Moreover, the use of modern technology such as hydrological models links to decision support systems and climate forecasting systems greatly assist in the stakeholder management process of water resources.

It is uncertain when the current drought will be broken. The El Niño started weakening in May, and sometimes (but not always) this climate phenomenon is followed by a La Niña. El Niño and La Niña are opposite phases of atmosphere-ocean interplay over the tropical Pacific, collectively referred to as the El Niño/ Southern Oscillation (ENSO). They have opposite effects on weather and climate in different parts of the world. Areas which receive below average rainfall during an El Niño (such as South Africa) tend to receive above average rainfall during a La Niña and vice versa.

Some experts are predicting that the dry El Niño conditions will be replaced by wet La Niña conditions in the third quarter of the year. However, according to the World Meteorological Organisation, such an El Niña is likely to be weak and not expected to match the intensity of the past El Niño which was one of the strongest on record.

"If we do get to a situation of a La Niña, then we can expect significant flooding, and this is the forecast for mid-summer," notes Dr Riddell. "The Kruger National Park recognises that floods are also a natural part of the river system processes, and the ecosystem requires them in order to maintain that natural variability in the system by moving sediment and creating new habitats in the river system, for example. Nevertheless, if the rains are significant over the past two very dry years, we will be expecting significant sediment delivery into the rivers from upstream, as the catchments have been quite denuded. This is something we will be keeping an eye on."

A view from Nkumbe lookout near Skukuza illustrates the lack of grazing currently being experienced in the Kruger National Park.

International water resources

Some observations on the water resources development and management transition in Israel

Earlier this year, the South African government signed an agreement with Israel to cooperate on national priority issues such as water and the current drought. Eberhard Braune, an Associate Professor at the University of the Western Cape, shares some thoughts on what lessons can be learnt from the way in which this Middle Eastern country manages its water resources.

Water supply and sanitation in Israel are intricately linked to the historical development of the country. Through its geographic and political situation, Israel cannot rely on external sources of water. Because of the limited size of the country and a policy of unlimited Jewish immigration, the country's land and water resources have had to be developed optimally.

The vision of 'turning the desert into a cultivated land' had to be put into practice. The Terra satellite image of the Middle East in Figure 1 shows the lush, green vegetation along the Mediterranean coast and surrounding the Sea of Galilee in northern Israel and stands in marked contrast to the arid landscape all around. More than 240 million trees have already been planted and even the barren hills of the northern Negev are now dotted with a string of miniature oases of greenery.

Figure 1: Terra satellite image of the Middle East –Jan. 2003 (MODIS Rapid Response Team, NASA/GSFC)

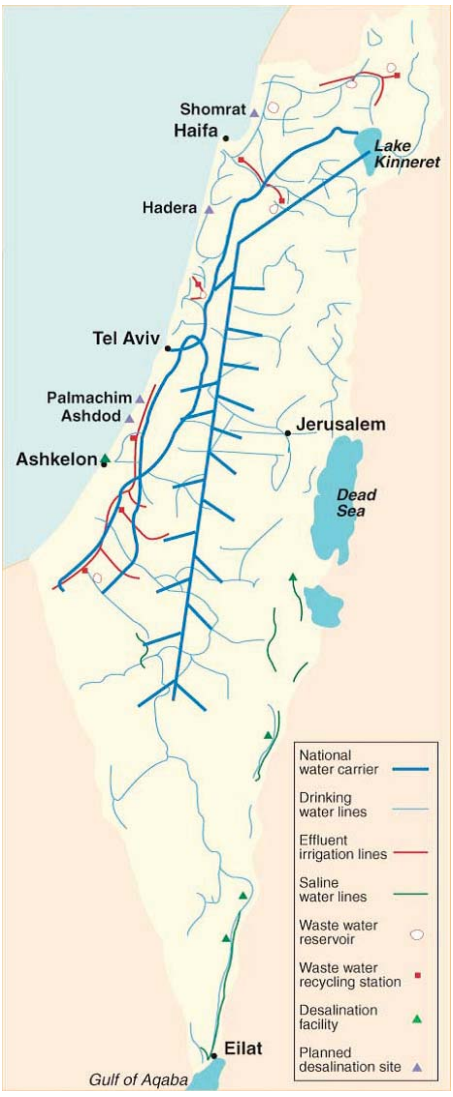

Figure 2: Water supply in Israel (Noah ESS, 2016)

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Awareness of water scarcity has prompted a host of innovative solutions. The supply philosophy is the three-reservoir system, a national conjunctive use scheme from the three main reservoirs, i.e. Lake Kinneret (the Sea of Galilee), the Coastal Aquifer and the Mountain Aquifer. The National Water Carrier functions not only as the main supplier of water, but also as an outlet for surplus water from the north in winter and early spring, as well as a source of recharge to the underground aquifers in the coastal region (Figure 2 and Table 1).

The long-term average quantity of replenishable water from major water resources amounts to about 1 800 million m^3/year (see Table 1). The more recent estimate, however, is less than 1 300 million m^3/year, related to declining average rainfall, possibly as a result of climate change.

About 80% of the water resources are located in the North of the country and only 20% in the South. The National Water Carrier (Figure 2), commissioned in 1964, carries water from the Sea of Galilee to the highly populated coastal region and the northern Negev desert through channels, pipes and tunnels.

Table 1: Long-term potential of renewable water

Resource	(million m^3/year)
The Coastal Aquifer	320
The Mountain Aquifer	370
Lake Kinneret (Surface water)	700
Additional regional resources	410
Total Average	1 800

Source: Jewish Virtual Library

The continued expected growth of the urban sector and of the agricultural sector (only with treated wastewater) can be observed from Table 2.

artificially-induced rainfall - cloud seeding; and desalination. The supply philosophy has changed to a five reservoir system, now including treated wastewater and desalinated water.

Aspects of water resources management in Israel

Water policy

In 1959, a comprehensive water law was passed, making water resources public property and regulating water resources exploitation and allocation, as well as pollution prevention and water conservation. Water is a public resource and municipal and regional water corporations have been established to manage water supply to different consumers. Water corporations purchase their entitlements from the central water company (Mekorot) and are legally responsible for their delivery to end users. Entitlements are granted in perpetuity, but conditional upon beneficial use.

Aquifers, a common pool resource, are managed very tightly. All groundwater schemes and single boreholes need a license and this license must be reviewed every year. Recommendations made by the Hydrological Service are based on the state of the aquifer, protection of all users and future plans for the area.

There is now a strong emphasis that water is a commodity. Initial subsidization had to do with the history of the country. The poorest immigrants settled furthest away from any development and could not be punished by giving them more expensive water. They had to be able to compete in the agricultural market and therefore they had to be subsidized. Already in 1977 the feeling in the Water Authority was that the consumer should be subsidized through the end product and not through water and power. This has happened and was a major driver for the water conservation thrust in the agricultural sector and the shift to high-value crops for the export market. Tariffs for the industry and agriculture sectors are planned to gradually increase, until they reflect the full cost of water and subsidies (currently funded by the domestic sector) can be removed.

Table 2: Water consumption per economic sector

Year	Urban	Industry			Agriculture				Supply to regional neighbors	Nature and Landscape		Unforeseeable	Total consumption
	(1) + (4) °	(1)	(2)	Tot.	(1)	(2)	(3)	Tot.		Fresh water	Tolal	(2)	(3)
1977													1500
2010	764	90	30	120	500	144	400	1044	143	10	60	0	2131
2020	902	95	30	125	490	120	528	1138	143	50	95	70	2672
2050	1482	108	30	138	450	100	900	1450	143	50	80	278	3571

By about 1980 Israel had reached the potential of their conventional water resources. Successive years of drought from 1998–2002 and again in 2008 had dramatically lowered water levels in all of the main reservoirs. 1998–1999 was the worst drought year in Israel for the past 100 years. After drawing on nearly all of its readily available water resources and promoting vigorous conservation programs, Israel has embarked on a national mission to stretch existing sources by developing non-conventional water sources, while promoting conservation. These efforts have focused on the following: reclaimed wastewater effluents; intercepted runoff and artificial recharge;

Recent water reforms, aimed to raise efficiency levels, stress holistic water management at a local level and make cooperation between national policy makers, local water utilities and end users, like farmers, essential. They have also required the change from using municipalities as local water managers to creating local water utilities that have the capacity to do holistic management.

The serious and persistent drought of the last decade and the resulting crises experienced by the Israeli water system has highlighted the need for strategic targets and the development

of a long term master plan addressing water infrastructure in general, and the water sector in particular. The establishment of a 'National Planning Council' is now seen of great importance (State of Israel, 2012). The planned establishment of a national infrastructure coordination committee (water, gas, transportation, electricity) emphasizes the strategic nature of the water infrastructure.

Water infrastructure

The national water system constitutes a strategic infrastructure in Israel, and a crucial factor in its development and the realization of its national goals.

The state-owned National Water Company (Mekorot) is responsible for bulk water supply through the National Water Carrier. Mekorot supplies 70% of Israel's entire water supply and 80% of its drinking water. It supplies water to about 4,800 intermediary water providers, including municipalities, regional associations, agricultural settlements and industrial consumers. It also operates 31 desalination plants. The company's eight wastewater treatment plants, including the Dan Regional Wastewater Treatment Plant, treat 40% of all Israel's wastewater. Its nine reclamation plants enable 70% of the treated effluent to be reused for agriculture.

A new National Water System is being developed since 2009 with several east-west arteries relying on pumping, complementing and partly substituting the north-south National Water Carrier, which relies on gravity (Figure 2). The new pipelines are connecting the five new desalination plants along the coast with water users. When completed, most drinking water supplied to Israel's residents would come from desalinated seawater. This is in line with the climate change mitigation policy of deployment of a water network seeking to mitigate differences within and between areas.

Water Conservation and Water Use Efficiency

Public water conservation campaigns coupled with technical and economic measures are being applied to reduce consumption and to increase awareness of water scarcity in all sectors. In agriculture, the wide scale adoption of low volume irrigation systems (e.g. from furrow to drip and micro-sprinklers and increasingly to greenhouses) and automation has increased the average efficiency to 90% as compared to 64% for furrow irrigation. As a result, the average requirement of water per unit of land area has decreased from 8,700 m^3/ha in 1975 to the current application rate of 5,500 m^3/ha. At the same time agricultural output has increased twelve fold, while total water consumption by the sector has remained almost constant.

Marginal areas also need development of marginal water supplies e.g. brackish water in the Negev desert accessed with deep boreholes (500m to a maximum of 1200m). Under conditions of minimum and poor quality water use, every effort must be made to reduce the build-up of salts in the soil. The most innovative but costly solution has been a channel filled with just enough soil for production, which is replaced whenever measurement indicate a loss in capacity, e.g. once a year. Such higher production costs are only economically justifiable with high value crops, largely for export (olives, water melon, salmon and wine).

By now 75% of wastewater is treated and later re-used, mainly for agriculture. Treated wastewater is also for industry, gardening, etc. Replacing the use of freshwater with treated wastewater helps to address inter-annual and inter-seasonal variability and to build resilience to climate change. Tariffs vary among treatment facilities. The payment they receive for each cubic meter is significantly higher in summer than winter.

In the domestic and urban sectors, conservation efforts focus on improvements in efficiency, resource management, repair, control and monitoring of municipal water systems. The slogan "Don't waste a drop" is known in every home in Israel. Parks have been placed under a conservation regime, including planting of drought-resistant plants and watering at night. A major concern is that urban distribution networks have not been upgraded in the last 20 years and that up to 40% water losses are occurring in water distribution networks. Under the umbrella of a strong R&D focus, various companies have introduced major technology advances like statistical analysis of existing pipe flow data to detect deviations, airborne leak detection and closing of pinhole leaks without requiring pipeline shutdown and excavation. In a city-wide project (Jerusalem) presently underway, every segment of pipe network is monitored to detect the smallest of leaks and respond with preventative maintenance.

Treated wastewater

Increasing quantities of sewage water have been finding their way into the environment, endangering groundwater and other sources of fresh water. The pressing need to find alternate sources of water, together with the critical condition of the environment, led the Water Commission to develop the Shafdan plant in 1969, a large-scale project for treating approximately 130 million cubic meters of wastewater per year for reuse in agriculture. About 110 million cubic meters of this purified water is transported annually via a separate pipeline called the 'Third Negev Pipeline' to the western Negev for use in irrigation. Thanks to the high degree of purification of the treated water, it can be used for all crops without risk to health.

However, wastewater from other cities and towns remained largely untreated. In 1970 there was a cholera outbreak because of illegal irrigation of salad with untreated wastewater. This gave rise to major investments in wastewater treatment under the National Sewerage Plan, which emphasised the reuse of treated wastewater. Smaller-scale plants all over the country provide treated sewage water for irrigation of fields located a short distance from the source of the effluent. In many cases treatment is minimal, and use of the treated water is restricted to crops such as cotton in summer. Small projects of this type are reported to be highly cost-effective. It is expected that most of the water allocated for agriculture will eventually consist of purified effluents, so that quality fresh water can eventually be shifted from agricultural to domestic uses.

Artificial groundwater recharge

Artificial groundwater recharge is practiced extensively in Israel, using flood water, potable water from the National Water Carrier and treated wastewater. Artificial recharge has increased groundwater levels in the Coastal Aquifer and counteracted further seawater intrusion. Groundwater recharge from flood water is done by collecting runoff from winter rains in a drainage basin and directing it into recharge ponds. The groundwater is then pumped during summer through wells around the

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recharge ponds. About 40–50% more water than the average natural recharge is pumped from the aquifer in order to create a temporary hydrological depression and space for artificial recharge the following winter. The largest recharge plant in Israel is the Menashe plant in the Northern coastal plain, capturing about 12 million m^3 in an average year from a drainage basin of 189 km^2.

Desalination
Seawater and brackish water are expected to provide a third of total water demand in Israel by 2020. At present, desalination already accounts for 80% of drinking water in Israel and also across the border in Jordan. There are three large Reverse Osmosis plants along the Mediterranean, one of them the biggest in the world, all developed in last 10 years.

In 1997, the first reverse osmosis desalination plant in Israel was commissioned in Eilat. In 2002, facing the serious drought situation, the government approved the construction of large seawater desalination plants along the Mediterranean coast. These installations were to supply 305 million m3/year of desalinated water by 2010 and 500 million m^3/year by 2015. This development has been accompanied by major technology research. It allowed IDE Technologies to build the world's largest sea water reverse osmosis plant in Ashkelon and some 400 plants in 40 countries across the world. Considerable work has been carried out on cost and energy saving modular designs and lower outlays for equipment and maintenance.

In addition to these large plants, there are around 30 small mostly brackish water desalination plants that desalinate about 30 million m3/year. Most of these installations are in the Arava and the Negev. Some plants are intended to help rehabilitating the southern part of the coastal aquifer, which has been adversely affected by salinity due to over-extraction.

New infrastructure of dams for storm runoff and reclaimed waste water
To be able to utilize flood runoff and recycled water beneficially, requires local storage and distribution networks. Country-wide some 230 new reservoirs have been constructed to impound runoff, floodwaters and recycled water and provide the water largely to nearby agricultural developments. Over time, each dam will have its agricultural water users, including fish farming. Water not required by consumers is recharged into aquifers, where available, through spreading basins and dual-purpose wells.

A new research emphasis is the management of these storages to utilize the water beneficially and minimize evaporation. The largest roof-covered reservoir has recently been built. A patent has been taken out for novel two piece balls, which, when covering a surface, prevent evaporation, lower the water temperature and reduce algal growth. They have been used extensively by Mekorot since 2011. Smart solutions regarding covering of open surfaces won the Prime Ministers Award for Innovation.

Rainfall enhancement
Cloud seeding for rainfall enhancement, both experimental and operational, has been carried out in Israel since 1960. As part of holistic water management, Israel is continuing with operational programmes of weather modification for managing the local atmospheric level, in particular over open water surfaces. The technology has shifted from cloud seeding via aircraft or rocket to the Russian ionization technology (ion generation from antennas on the surface which attach to condensation nuclei in the clouds and enhance the rate of droplet coalescence).

International water
In the present state of hostilities, the Water Commission with Palestine is the only transboundary instrument still in place. Diversion of over 90% of the water of the Jordan River by Israel, Jordan and Syria has resulted in the water level in the Dead Sea shrinking at a rate of more than one meter per year and its surface area shrinking by about 30% in the last 20 years. This is creating major environmental problems.

A solution under consideration is the Red Sea–Dead Sea Canal, a proposed conduit (pipes and brine canal) which would run from the Red Sea to the Dead Sea. It will provide potable water to Jordan, Israel and the Palestinian territories, bring sea water to stabilize the Dead Sea water level and generate electricity to support the energy needs of the project (Wikipedia). However, lack of trans-boundary cooperation is still hampering any resolution of this major environmental issue (Saab, 2010).

Research
Israel is one of the top R&D spenders per capita internationally, with 4.2% of GDP, compared to the United States' 2.8% and Germany's 2.9% in 2013 (Siegel, 2015). A number of R&D platforms have been created in Israel to encourage and promote R&D leading to industrial application. The Office of the Chief Scientist (OCS) of the Ministry of Industry, Trade and Labor is responsible for implementing the government's policy of encouraging and supporting industrial research and development in Israel through the Law for the Encouragement of Industrial R&D.

Water is regularly receiving innovation funding. The priority for water R&D was recently captured in a government policy statement: The Israeli water system will be a global center for technologies and innovation in professional areas of the water industry, and a groundbreaking example of managing water resources under conditions of shortage.

The Zuckerberg Institute for Water Research, founded in 2002, as part of the Ben-Gurion University of the Negev, links to the founding mission to spearhead development of Israel's southern region while taking its place in the global scientific community. A unique Masters curriculum in "Hydrology and Water Quality" was developed to meet the increasing need for hydrologists, water engineers, and water planners in Israel, the Middle East, and other places around the world. The program is founded on an interdisciplinary approach through the integration of science with engineering.

Outlook
South Africa and Israel have similarities in their physical environment and, despite the very different political and socio-economic conditions, they face similar water resources challenges. Paying attention to issues, approaches, successes and failures in Israel's water and development history, can provide pointers for the challenging water transition in South Africa in coming years.

References available on request

Risk management

Managing water: Embracing the opportunity of risk

It remains a risky business to manage water and provide water and sanitation services. Luckily there is now a handy implementation guide available for local water utilities on how to better manage these risks and embrace the opportunities it presents.
Jorisna Bonthuys reports.

The complex set of risks and uncertainties associated with drinking and wastewater systems requires risk governance to be at the heart of water service providers.

It is required by South African law, yet many municipalities are still struggling to integrate risk governance into their business, including their water and sanitation operations.

And although risk management practices are undertaken in many municipal water departments, these are often just focused on operational activities related to water quality and quantity (such as the Blue Drop, Green Drop and No Drop programmes, water safety and wastewater risk abatement planning). Risk management has not necessarily translated into risk governance at a more strategic level.

These and other issues were tackled by Andrew McDonald and Jessica Fell in a recent study funded by the Water Research Commission. McDonald worked at the consultancy firm Arup and Fell was a Masters student at the University of Cape Town at the time of doing the research.

Their study entitled ***Risk governance in the South African water services sector: business value creation and best practices*** investigated the nature and maturity of risk governance practices in a selection of water service authorities and water service providers.

The researchers looked at best practices both in the international and South African water sectors and developed an implementation guide on risk governance for local

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municipalities. This guide is the first of its kind for local water utilities. It aims to support those organisations that are still struggling to integrate risk governance throughout their water operations.

Says McDonald, "Now, more than ever, water resource managers, planners, users, and anyone who in any way impacts on the quantity, quality, distribution and use of water, must fully consider uncertainty, risk and opportunity in their decision-making.

"It doesn't matter if you are a municipality serving a village of 100 people or Rand Water serving the whole of Gauteng... The concepts of risk governance are equally important to all water utilities."

Deteriorating water services and the outbreak of waterborne diseases has resulted in many local service delivery protests over the recent years, the report indicates.

Now more than ever it is necessary for all stakeholders in the water sector to start this journey to ensure risk management is integrated into wider business functions and in doing so contribute to better service delivery and water stewardship.

In 2014 water contamination in Bloemhof (in North West) for instance affected over 500 people with diarrhoea and resulted in the death of three babies. Currently, South Africa has a child mortality rate of over 70 per 1 000 births. A major cause of these deaths is diarrhoea, indicating the presence of high levels of pathogenic organisms such as bacteria and viruses in drinking water.

Another example of such a failure (of risk governance) happened in Majakaneng (near Brits in North West) when violent service delivery protests broke out in 2015 after years of an inconsistent water supply. Says McDonald, "In such a situation, if the risk of failing infrastructure had been effectively assessed and managed, the violent protests could potentially have been avoided."

McDonald adds to this, "These incidents are a clear indication of a lack of robust risk management and governance, and illustrate the urgent need for a step change improvement in risk governance at a municipal level."

The water sector requires risks to be effectively managed within a framework of good governance to secure the safe, reliable and cost-efficient delivery of water services. "If the wide-ranging risks associated with water management are not effectively understood and controlled, there will be a continuation in the erosion of social cohesion, deterioration of public health and the constraining of social and economic development," he says.

"One just has to look at international examples such as Walkerton in Canada. A lack of local risk management, coupled with poor wider governance in the local authority, resulted in an outbreak of disease affecting thousands of people. The long term consequences of this were felt for years, including the state governor losing the next election and the water utility manager going to jail. Canada learnt from this and has made significant improvements in the way they understand and govern water related risks. Now South Africa needs to learn and make similar changes".

Study sheds more light

Of the more than 177 entities including local municipalities approached to participate in this study, only 13 participated in the research.

Says McDonald. "Although we don't have data to support this, I have a strong sense that many of the municipalities that did not respond have not integrated risk governance across their organisations."

The study focused on the nature and maturity of risk governance practices, using a specifically developed benchmarking tool. It also explored the interaction between risk management and governance activities and other business functions to identify where risk-based approaches are used to inform decision making and are adding value.

Basically, the researchers wanted to know: How are the operational risks identified? How are decisions made based on this? And: How is this rolled out at a municipal level to allocate budget and resources?

Their findings have provided "interesting insights" into how these organisations understand and manage risk, McDonald indicates.

The overall average risk governance maturity of the 13 organisations ranged from 2.4 (initial) to 3.9 (managed) out of a possible score of five. A similar study was done on a selection of international water utilities identified maturity scores between 3.5 and 4.5. "So when benchmarked against some international organisations, the South African utilities we assessed are doing OK," he indicates "However, we know there are many municipalities who we did not assess, that are likely to be struggling with risk governance, or not doing it at all."

He continues, "The results suggest that the sample included organisations that are already practising reasonably good risk governance and are going above and beyond the requirements of the legislation and guidelines." This is supported by the fact that all the organisations had an enterprise-wide approach with a risk manager, risk policy and risk framework. Some also had detailed risk implementation plans that were being used to roll out risk governance practices in the organisation. Furthermore, the organisations studied all had effective corporate governance structures in place, such as a risk committee and audit committee.

What does legislation say?

The management of risk is a requirement of South African legislation.The national government has recognised the importance of risk management in public institutions and has published various legislation and guidelines and has various regulatory mechanisms in place.

In terms of legislation, both the Public Finance Management Act (No. 1 of 1999) and the Municipal Finance Management Act (No. 56 of 2003) state that the Accounting Officer is responsible for establishing and maintaining effective, efficient and transparent systems and internal controls for financial and risk management. These requirements are usually interpreted to relate to financial and fraud risks.

The Disaster Management Act (No. 57 of 2002) also stipulates that local authorities need to appropriately plan for disasters through developing and implementing disaster risk management plans.
The Occupational Health and Safety Act (No. 85 of 1993) is concerned with risk to employee health and safety and requires employers to implement systems to manage these risks.

The National Treasury has also published the Public Sector Risk Management Framework and the Local Government Capital Asset Management Guidelines. These documents provide a generic guide to a national, provincial and local government for the implementation of asset and risk management strategies to allow them to meet the requirements of the legislation.

In the water sector, the Blue Drop, Green Drop and No Drop programmes all advocate risk-based approaches.

Embracing future risks

Now more than ever it is necessary for all stakeholders in the water sector to start this journey to ensure risk management is integrated into wider business functions and in doing so contribute to better service delivery and water stewardship. This must occur within a framework of good governance and accountability, McDonald believes.

Says McDonald, "None of these organisations has the luxury of operating in a risk-free environment and the risk profile they have requires an extra duty of care on management to contain these risks to acceptable levels. This is especially important to maintain public health.

"We are not only talking about operational risks, but also other risks associated with long-term planning and strategy, people and change management, finances, stakeholder engagement, reputation and climate change. Many risks are systemic, with their root cause outside the control of the municipality. These require a broader governance approach to identify and manage. You can no longer rely on traditional engineering approaches to identify and manage these risks."

Risk must be a central part of all decision-making, at all levels in the organisation, from strategic through to tactical, with decision-making structures and processes defined, he states. "This is because public sector organisations, such as water service authorities and water boards, are bound by their mandates to provide services in the interest of the public. Resources are scarce, and therefore decision making that accounts for risk can help allocate these resources more efficiently, to get more value for money. That's a win for the municipality, for National Treasury and for the rate payer.

"When it comes to decision making, we say let's look at it strategically. It is about taking a step back to identify the root causes and contributing factors of an issue.

"Take for instance a blocked pipe. What are the consequences if the pipe is not unblocked? How significant are the impacts – do we flood one street or do we flood a hospital? What has caused the blockage? How often do blockages occur? What is the long-term approach to preventing blockages in the future? Should this pipe be proactively maintained at all? Or should resources be allocated to another issue elsewhere considered a bigger risk, possibly even in a different department? These are the kinds of trade-off decisions that water managers need to be making all the time, and can really only do it properly when considering risk and working collaboratively."

Having a structured risk management system supported by sound risk governance is therefore a valuable management tool that can increase the prospect of success through minimising negative outcomes. "Always remember that the flip side of risk is opportunity, it's not just about the possibility of something bad happening."

He believes organisations need to develop step-by-step improvement plans that recognise the local context and limitations and are pragmatic about resources, budgets and capability. Importantly, change management, particularly relating to people, is necessary to ensure the improvements are sustainable.

Water often creates shared risks within a municipality, he says. "A risk in a water department could, for instance, be the reliability of a disinfection plant. When the plant fails there could be a health risk if the water has not been sufficiently disinfected. A risk for the water department might then become a contributing factor for a risk to the health department if suddenly the water quality is poor and everybody is getting ill from exposure to it. Do the water department and the health department discuss their shared risks? Are there effective risk governance structures to allow this cross functional working? In some municipalities, I suspect not. To do this well you have to be breaking down the silos in an organisation. If the risk manager is doing their job correctly, they can help do that."

McDonald continues, "Shared risks are also common across

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organisations, especially when it comes to infrastructure interdependencies. The challenges we have had recently with electricity has highlighted the interconnectedness of our infrastructure systems. If an Eskom substation fails, how does this impact on regional water supply many kilometres away? Do Eskom and the water utility share their risk registers and work together to prevent shared risks from materialising? These are important issues we need to address if we are to become more resilient to the shocks and stresses we now face".

Setting up for success

From the research it is evident that the organisations doing it well have a couple of things in common. Says McDonald, "Firstly, their executive managers are on board. They have recognised that it is important to manage risk. If senior managers don't have systems in place to manage risks, they are in contravention of the law."

"Secondly, they appoint a person as a risk manager or chief risk officer. This person has the mandate to establish the risk governance framework in the organisation. Where it works well this person is also competent in their job and has other people to help him or her, even if it is just one or two people. If it is just one risk manager who has to do this for the whole organisation they typically struggle because of their work load."

Small organisations who don't necessarily have people to resource a whole risk team, can also task people in other departments with some risk responsibilities, he says. "Identify risk champions or risk coordinators in other departments and include some risk governance responsibilities as part of their job description."

This is how risk-based thinking gradually gets embedded across organisations, he says. "The better you integrate across the organisation, the better the organisation can respond to risks."

His advice to local municipalities? "Use the model to benchmark yourself, this will help you to identify where you sit on the maturity scale from one to five. You can then identify areas of strength, that you can continue, and areas of concern, where you might want to improve. Start small and build on where you are already doing something well. This may be in other parts of the municipality and not necessarily in the water department."

The challenges of implementing successful risk governance in the water sector are well documented. Says McDonald, "The journey is demanding and can take up to 15 years. It requires strong and clear leadership, a common vision, a policy, framework and implementation plan, commitment and resources to implement the plan, good governance structures, open and transparent reporting mechanisms and regular engagement with all stakeholders.

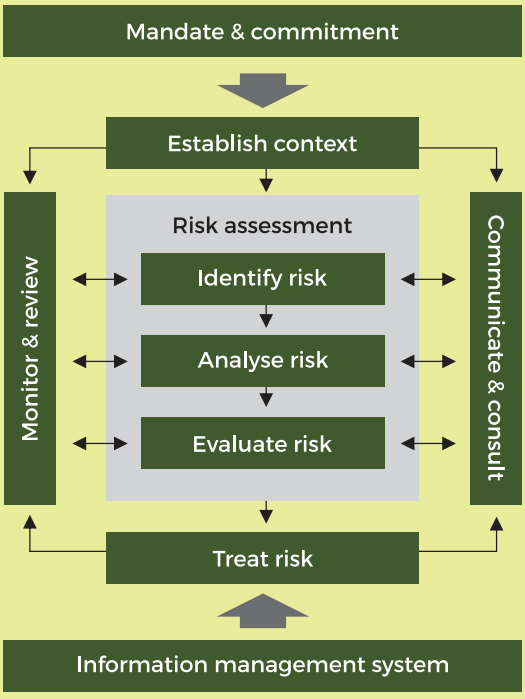
"Moreover, it requires a culture of risk awareness to be embedded in the organisation, which involves changing the mindsets of employees. The findings of the assessments have shown that some of these factors are in place or are being established. This is promising as it shows that these organisations have all started their journey to risk governance excellence."
The final report will be available later this year.

What is risk governance?

It is a complex term and has many definitions. The concept includes more than just operational risk management but extends to for instance organisational, environmental and financial aspects of a business and the way this is all integrated and coordinated.

Says researcher Andrew McDonald, "Risk governance includes a more strategic view of risk and the human and organisational factors. It includes accountability, collaboration, decision-making, sharing of risk and reward, communication, leadership and organisational culture."

Risk governance is different from risk management in that it is more inclusive of all stakeholders.
"The true value of risk governance comes when it is integrated into wider business functions. Many water sector organisations are successfully integrating risk into functions such as strategic planning, tactical planning, asset management, financial management, project delivery, climate change assessment and supply chain management," he says.



The risk assessment process.

Water resource management

Counting the drops – SA's water resource assessment project completed

South Africa's latest comprehensive national water resource assessment has been completed. Funded by the Water Research Commission (WRC), the Water Resources Study (WR2012) is the sixth national study to be undertaken since 1952, its main objective being to assist decision-makers at all levels of government to make informed choices about all policies concerning South Africa's water resources. Article by Allan Bailey, Bill Pitman and Wandile Nomquphu.

Each water resource assessment study builds on the technology and knowledge gained from the one that preceded it. The latest study, which covers South Africa, Lesotho and Swaziland, builds on the previous assessment (WR2005) by using updated and new data and information as well as new tools and technology.

A significant feature of WR2012 is the fact that, for the first time, a publicly-accessible water resources website was created (www.waterresourceswr2012.co.za) which allows for Web-based and interactive reporting on both surface and groundwater. The website contains all the GIS maps, WRSM/Pitman (previously known as WRSM2000 or the Pitman catchment model) and other hydrological models, time series data, spreadsheets and WRSM/Pitman associated networks containing all data. This is a big step forward for water resource practitioners.

GIS maps

Rainfall, runoff, water quality (in terms of total dissolved solids), WRSM/Pitman calibration parameters, land use and population maps have all been updated in the WR2012 study. GIS maps are available in hard copy and electronic format (from the website).

A statistical analysis was carried out on approximately 600 usable streamflow stations and the outcome was used to show six categories of streamflow gauging station on the map. This will help the user ascertain the quality of streamflow gauges and the reliability of data.

There is a totally new map based on the new present day analysis which analysed current levels of land use. Comparison were made against natural flow at 84 key locations throughout the country.

WRSM/Pitman model

The rainfall-runoff WRSM/Pitman model named after its innovator and developer, Dr Bill Pitman was a key part of this project and has underwent further enhancements during the

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study. Outputs from this model are used as the primary inputs to the Department of Water and Sanitation's water resources planning models.

The WRSM/Pitman monthly time-step model was used to analyse all catchments in South Africa, Lesotho and Swaziland with data up to September 2010. These networks and data sets are included on the website for users to develop their own analyses.

A number of additional user-friendly features were added:

- Enhanced graphical tools for zooming, panning, log scale and data inspection
- Addition of the latest irrigation methodology by Dr Chris Herold
- Ability to calibrate the storage at a dam with observed and simulated storage trajectories
- Additional graphs for massplot and cusum plots for rainfall and naturalised streamflow
- Calibration of numerous runoff models in one step

Present-day analysis

The study made comparisons of naturalised streamflow versus present day streamflow at 84 key locations throughout South Africa. This provides an indication of the human influence on our river flows. While there are many return flows in the system, the study indicates that there are many catchments in South Africa that have outflows that are, on average, considerably lower than they would have been under naturalised conditions.

The previous water resources appraisals have shown a decreasing trend of the estimate of average naturalised mean annual runoff, but the WR2012 study has come out virtually the same as the previous one (WR2005). Analysis shows the Vaal catchment to be the most heavily utilised, where the mean annual runoff (MAR) has been reduced by 66%, despite several transfers into the basin from the Lesotho Highlands, Thukela and Usuthu catchments. The least utilised catchment was found to be the Mzimvubu, where the MAR is reduced by only 8%.

Water quality analysis

During the WR2012 study, the simplified salt balance model SALMOD was analysed and calibrated for the entire Upper Vaal, Middle Vaal and Lower Vaal sub-water management areas (which have now been combined into the new Vaal WMA). This catchment is the most highly developed in South Africa with a great deal of land use/water use which impacts on water quality. Observed data was extended from 1974 to 2009. The final report provides data on flow, TDS concentration and TDS load at all the relevant water quality stations through the WMA.

Groundwater

Karim Sami compiled a comprehensive report on groundwater verification studies carried out in various parts of the country. Of particular interest was the updating of default groundwater parameters for every quaternary catchment (around 1 960) that are used in the Sami input screen of WRSM/Pitman.

Challenges and innovations

By far the biggest challenge of the study was the deterioration of data in the form of rainfall, observed streamflow, reservoir

The latest water resources assessment study shows that land use in the Vaal River has reduced the mean annual runoff by 66%.

records (dam balances), land use/water use and water quality. Rainfall is the most important and shows the biggest decline in terms of rainfall stations which have closed down.

This deterioration of data makes it harder for hydrologists and water resources practitioners to enter data of the necessary quality into water resource models. These models produce hydrological information on streamflow, yields of dams, water quality trends, future demand versus supply trends, ecological water requirements etc.

Obviously, the accuracy of the above information will become compromised should this very distressing situation continue. Although the number of streamflow stations that is used in the appraisals since 1969 has increased with every appraisal, already 200 of the 600 have closed down. Their historical records were used, but no new data are becoming available.

Rainfall data is the most important data source for all water resources models. Raw rainfall data is of little use as it normally has some missing and unreliable months. The website contains all usable rainfall station data which has been patched. Similarly, observed streamflow data has also been patched up to September 2010.

It is expected that the WR2012 website with all its available tools and datasets will greatly facilitate water resources studies in South Africa.

www.waterresourceswr2012.co.za

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Water KIDZ

Clean hands save lives

Your mom is telling you to wash your hands for the upteenth time and all you want to do after playing outside is eat your lunch.

Sound familiar? But what is so important about washing your hands anyway? While kids don't always listen when parents tell them to wash their hands before eating, after using the toilet, or when they come inside from playing it is actually a very important thing to do. Hand washing is by far the best way to prevent bacteria from spreading and to keep kids from getting sick.

Bacteria are microscopic organisms that live on, in and around people. They're extremely common naturally and you can find them in almost every environment on the planet, for instance in the sea, the air and even in our own bodies. Many bacteria are harmless and actually help us to stay healthy, for instance the good bacteria in our bodies that help us to digest food.

Some bacteria live on our hands without causing problems, but when you come into contact with large numbers of bad germs that can survive on your hands, (especially if your hands are warm, moist and unwashed) these can be transferred from your hands to your mouth and this can cause illness.

You can get germs on your hands when you touch objects and when you touch other people. Once germs are on your hands, they can get inside your body through a wound or when you touch your eyes, nose or mouth. You can also spread germs on your hands to objects or people that you touch. The most common infections are spread through touching.

Although we may think that hand-hygiene preventable infections are minor health issues, the reality is that they have serious consequences. Diarrhoea alone kills more than 2 000 children worldwide each day. In the time it takes you to read this, another parent will have lost their child to a diarrhoeal disease.

Research by the Global Hygiene Council found that last year over 80% of children visited a healthcare professional due to a common infection. This number can be reduced through effective handwashing, but we know that this isn't routine for everyone.

Global research into the handwashing behaviour of adults has found that, on average one in ten don't wash their hands every time they use a toilet, and around one in four don't wash their hands before eating. Another 43% don't wash their hands every time they sneeze or blow their nose.

This not only makes them more likely to suffer hand-hygiene preventable infections, such as diarrhoea, but also increases the risk of infection for their children who are likely to pick up habits from their parents. This is because children are even less likely to wash their hands than their parents.

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Because dirt (and germs) gets into every nook and cranny, it is important to wash your hands properly.

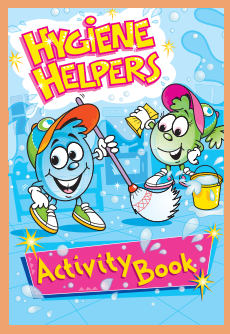
- First, wet your hands with warm water.
- Use a little soap and rub your hands together to make a lather.
- Next rub the palm of one hand over the back of the other (so it looks like you have ten fingers and one hand) and then swap hands.
- For your next move put your palms together again and interlace the fingers. Keep rubbing the soap in.
- Now rub the back of your fingers against the palms of the other hand.
- Wrap your right thumb with your left hand and wriggle it around until it feels clean. Swap hands.
- Squeeze your fingers together on your right hand and use them like a scrubbing brush on your left palm. Draw circles with your fingers, one way then the other. Swap hands.
- Rinse hands thoroughly with warm water.
- Dry hands with a clean, dry towel.
- Now your hands are clean it's time to get them messy again.

Regular handwashing is important, but especially before eating, after going to the bathroom, playing outside or with your pets, changing a baby's sibling's diapers and wiping or blowing your nose.

Handwashing is considered so important that it even has its own day! Every year, on 15 October, communities around the world highlight the importance of handwashing through Global Handwashing Day. The theme for this year's event is 'Make handwashing a habit!' The theme emphasises that handwashing must be practiced regularly to have an impact on health and wellbeing.

Five facts showing the importance of handwashing:

- It is estimated that washing hands with soap and water could reduce diarrhoeal disease-associated deaths by up to 50%.
- Researchers in London estimate that if everyone routinely washed their hands, a million deaths a year could be prevented.
- A large percentage of foodborne disease outbreaks are spread by contaminated hands. Handwashing can reduce the risk of foodborne illnesses and other infections
- Handwashing can reduce the risk of respiratory infections by 16%.
- In a study involving 16 primary schools and 6 000 students, the use of an alcohol hand sanitiser in the classroom provided an overall reduction in absenteeism due to infection by 20%.



Download the activity book

Teachers, you can download the Hygiene Helpers activity book on handwashing for free here, http://www.hygienecouncil.org/Portals/1/pdf/HH_activitybook_ARTWORK.pdf

You can watch a video on the importance of handwashing, here.

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Water Research Commission adopts Moreletaspruit

In celebration of Mandela Day on 18 July, the Water Research Commission (WRC) along with its partners, the Department of Water and Sanitation, Friends of Faerie Glen Nature Reserve, Adopt Moreleta Forum, Friends of Moreletaspruit, and the City of Tshwane launched a clean-up operation on the banks of the Moreletaspruit. The river transects the eastern suburbs of Pretoria. Basic water quality tests were also performed on the river using the miniSASS method, a citizen water health monitoring tool in which the health of a river is determined by the community of macroinvertebrates sampled. As a sign of its commitment to water resource protection, the WRC has adopted the Moreletaspruit catchment, in which it now resides given its new premises at Lynnwood Bridge.

WRC Research Manager, Bonani Madikizela, leads the miniSASS process to determine the health of the Moreletaspruit.

WRC CEO, Dhesigen Naidoo, sampling the Moreletaspruit for macro invertebrates.

Some of the WRC staff who joined the clean-up for the day were Silai Malisha, Keletsang Motsepe, Mapula Mabitsela and Ndileka Nkwenkwezi.

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MASTERS PROGRAMME IN ENVIRONMENTAL MANAGEMENT

MISSION STATEMENT

The Masters Programme aims to build environmental management capacity and skills required to manage human activities towards more sustainable outcomes, with specialization options in environmental, water and waste management. This is achieved through multi-disciplinary and international training collaboration. Particular emphasis is placed on the development of analytical skills and critical thinking through high quality research outputs. This will enable students to compete confidence as environmental practitioners in the national and international labour market.

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ENVIRONMENTAL MANAGEMENT

Main areas of research:

- Environmental Management
- Environmental Assessment

Course structure:

- The course consists of three modules:

  - Mini-dissertation (OMBO 873) - 100 credits
  - Environmental Management (OMBO878) - 40 credits
  - Environmental Assessment (OMBO879) - 40 credits

How it works

- Two year programme in a part-time format
- Three five day contact sessions per year in Potchefstroom
- Two research colloquia annually

OR

WITH SPECIALIZATION IN:
ENVIRONMENTAL WATER REQUIREMENTS (EWR)

Main areas of research:

- Water Management Policy implementation interface
- Ecological Drivers of Aquatic Systems
- Ecological Responders in Aquatic Systems

Course Structure:

- The course consists of three modules:

  - Mini-dissertation (OMBO 873) - 100 credits
  - Management of ecological drivers in aquatic systems (OMBO880) - 40 credits
  - Management of ecological responders in aquatic systems (OMBO881) - 40 credits

How it works

- Two year programme in a part-time format
- Three five day contact sessions per year in Potchefstroom

OR

WITH SPECIALIZATION IN:
WASTE MANAGEMENT

Main areas of research:

- Waste management policy implementation interface
- Waste governance and legislation
- Waste management innovation

Course Structure:

- The course consists of three modules:

  - Mini-dissertation (OMBO873) - 100 credits
  - Integrated Waste Management (OMBO882) - 40 credits
  - Waste Management Law and Governance - (OMBO883) - 40 credits

How it works

- Two year programme in a part-time format
- Three five day contact sessions per year in Potchefstroom

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

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

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

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THE POWER OF KNOWLEDGE TO THE PEOPLE