THE WATER WHEEL

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WATER SECTOR

Fourth Industrial Revolution - Moving South Africa towards 'Digital Water'

WATER IN CITIES

Changing behaviour, saving water – helping Capetonians to help themselves

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The Fourth Industrial Revolution is set to bring about a host of technological advances to the water sector. See the article on page 12.

FLUID THOUGHTS

WRC CEO, Dhesigen Naidoo

Empowering water and sanitation industrialisation as a route to economic recovery

South Africa's economy is being tossed like a cork in the stormy waters of an unprecedented and violent recalibration of the global economy. Some argue that this is a natural reaction to the adjustment from a unipolar single superpower world of twenty years ago to the one of multiple centres of power – economic, political and military – as we have today. This is especially severe as the old mitigation mechanisms of robust multilateral instruments, such as the United Nations and the World Trade Organisation are diluted as twenty-first century nationalism has become the overwhelmingly dominant paradigm.

But, South Africa, on most indices, appears to be wealthy. The rankings of the World Bank and the International Monetary Fund have South Africa as the 31st largest economy in the world based on the size of GDP. That puts South Africa in the top 15% globally in terms of the size of its economy. And yet, we will have a reasonable consensus that the average South African does not have the quality of life that corresponds with this wealth status. This was emphasised in August with the revelation that the National Credit Amendment Act is directed at providing relief to an astounding 10 million heavily indebted South Africans. This may be close to fifty percent of the economically active population.

This is backed up by a series of global indicators. Let us begin with the Global Competitiveness Index (GCI) 2018, which ranks South Africa at 67th out of 137 countries. The impressive 31st place when considering the country's market sophistication is balanced out by the dismal 114th place with respect to Human Capital in the GCI.

A key driver of a successful economy in the twenty-first century is innovation. This is the key competence to both navigate the risks of a highly competitive global economy while taking advantage of the all too few opportunities in a depressed international economic environment. The Global Innovation Index 2017 ranks South Africa at 58th out of 127 participating countries, again acknowledging a very high market sophistication, this time at 23rd in the world, and this is weighed down by an infrastructure ranking of 84th. This talks to the very difficult story of the 'Innovation Chasm' where the country continues to be a top twenty producer of knowledge globally through academic publications, but fails to derive the industrialisation dividend of that knowledge base because, as South African President, Cyril Ramaphosa, puts it in his address to the 25 Years of Democracy Conference on 23 July, " over the last 25 years, .., we have been less successful in addressing the structural faults in our economy."

One of those structural faults has to be the very weak industrialisation ecosystem that is punitive to potential Sunrise Industries. We continue to produce an impressive list of innovations and inventions produced by super-talented South Africans who have been forced to industrialise and produce elsewhere in the world. We then lose out on an opportunity to reverse the patterns on our technology balance of payments and, in turn, our export deficit. Why are we in this predicament more than ten years after the launch of the National Science and Innovation Decadal Plan 2008-2018, and the establishment of institutions to address the market failures of the Innovation Chasm, notably the Technology Innovation Agency?

The state of human capital is the primary concern, however. The WEF Global Human Capital Report (2017) puts the country at 87th in the world out of 130 participating counties where we are ranked 65th on capacity – read educational levels – and 90th on our track record in the development of the next generation. Given the high emphasis that the 4th Industrial Revolution is given, one would expect this to be higher. The most alarming component is that of deployment. This is the category that judges skills application in a system. The unemployment numbers, together with that special category of unemployed graduates and diplomates, contributes to our global ranking in this category of 109th in the world.

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How can it be that the 31st largest economy in the world, the country that has the 21st highest average salary in the world (between, Spain and Italy and higher than Korea and Portugal) on purchasing power parity (ppp) have such low performance indicators.? The reason why we sit at the event horizon of a black hole rather than riding the wave of global competitiveness is South Africa's gross inequality. This is substantiated by such parameters such as the Gini Co-efficient or Gini ratio that measures the differential share of wealth distribution. At present, South Africa has the worst wealth distribution of the countries measured in the world. The social and political cost of South Africa's inequality is well known, but the economic cost needs higher emphasis and deeper examination.

The solution tree is promising, but needs some catalytic actions. The water and sanitation research and innovation sector has developed a series of possibilities, both in the form of innovations and products as well as model strategies for industrialisation and business development that deserve a second look. South Africa as a top twenty producer of new knowledge in the water domain globally, unsurprisingly produces new solutions with a regularity that is almost clockwork. Many of these solutions, inventions and technologies have the potential not only to solve South African problems, but also have the potential to position South Africa as a major global manufacturing hub for these products.

Let me offer just three examples beginning with acid mine-water and its very close cousin, saline water (including seawater). Traditional desalination technology based on the gold standard reverse osmosis is highly effective, but with two fatal flaws. The first is that the processing has a very high energy budget, and, secondly, both the technology and the membranes are very expensive, both in terms of direct cost and maintenance.

The South African water research community, led by the Water Research Commission, is working on six lower energy, lower cost options that have been proven at laboratory scale and now need investment to complete the journey through pilots and demonstration before they can be used at scale as long-term solutions. These have the potential to deal with acid mine-water in the hotspots of Gauteng, Mpumalanga and KwaZulu-Natal as well as provide reasonable options for desalination in the coastal regions.

In addition to being a very effective means to deal with a very difficult pollution problem countrywide; it is also a very viable part of a diversified water supply strategy, and no-one needs reminding of the high scarcity risk in South Africa. Star among these is the homegrown technology of eutectic freeze developed by Allison Lewis and her team at the University of Cape Town.

Another suite is Fourth Industrial Revolution (4IR) water efficiency tools. These are a range of tools, devices and computer-based management tools to increase water and process optimisation to enable every drop to stretch further. There are tools available for most industry sectors and the research indicates no drop in productivity and even better, a potential increase in global market share as the world's markets become much more sensitive to water and other resource costs as part of their buying decisions. As an example, a computer-based intelligent irrigation scheduling system has been shown to save 80 million litres of water annually in just one irrigation scheme. These technologies, together with wastewater reuse on-farm, rolled out at scale, will have a huge impact on agricultural water use, and very importantly, make billions of litres of water available for new agricultural entrants and other users.

The third example is even more exciting. We have, like many places in the developing world, the crippling challenge of meeting the sanitation targets of the Sustainable Development Goals – the goal of universal access to improved – safe and dignified – sanitation in just over ten years. This is a daunting task in the current global economic climate as well as increasing water scarcity worldwide. We have as benefit South African ingenuity, as well as the partnership with the Bill and Melinda Gates Foundation Reinvent the Toilet programme, whic provides access to a range of revolutionary products under the banner of 'New Sanitation'.

New Sanitation products are sanitation solutions that share the following characteristics – they use either no or very little water on the one hand, which is already a very big plus. The top-end solutions are innovative in their engineering in that they operate without the costly sewerage infrastructure with waste treatment on site. This, in itself, addresses both issues of financial and water budgets. The genius does not stop there, however. South Africa is a key player in the global sanitation research and innovation network within which the exploration of beneficiated products from human waste treated locally is very advanced. The products include energy all the way from first stage processing as bio-char to bio-gas capture to liquid fuel and high calorie product extraction. This, combined with high-value lipids, proteins and specialist chemicals, will make us look at human waste is a completely different light in the near future.

These solutions will not only deal with the many service delivery backlogs and mitigating our pollution risks – if industrialised innovatively have the real possibility of turning South Africa's economic fortunes around swiftly and sustainably.

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NEWS

Multimillion Rand commitment towards safeguarding SA's water source areas

Nedbank has committed R25 million towards safeguarding critical water source areas, biodiversity hotspots and rural livelihoods, with a strong focus on the Eastern Cape. The money will be spent in partnership with WWF South Africa, which has a long working relationship with the bank.

For the past eight years, Nedbank and WWF have partnered to support sustainable farming across South Africa. The next five-year phase of this work will now be scaled up to secure water source areas, strengthen sustainable local economies and improve rural livelihoods to see people living in harmony with nature.

A recent study by WWF and CSIR revealed that 22 critical water source areas deliver most of South Africa's freshwater, with just 10% of the country's land area delivering 50% of its river flows. In order to protect South Africa's water security, WWF-SA has been working with key institutions to define, understand and improve the safeguarding and functioning of these areas.

The Eastern Cape is significant as South Africa's second-largest province, with an estimated population of 7 million people. It is also home to some of the country's most critical water source areas – delivering close to 20% of South Africa's water – and key biodiversity hotspots (including the Grasslands biome) and in urgent need of developing sustained rural livelihoods and employment for the youth.

Justin Smith, WWF-SA's Business Development Unit Head, said the organisation was focused on scaling-up numerous sector-specific interventions across multiple land use sectors. "We want to mobilise collaborative efforts through community-public-private-partnerships and coordinating the various components of our work within integrated landscape hubs, to work collectively at landscape level to balance competing demands and affect change.

"The landscape level is often the most appropriate level of action between national and local, allowing stakeholders to understand their own impacts and explore their shared risk and joint opportunities while being able to shape and influence the future they wish to see in the region."

SA, Japan collaborate to address pollution

Trade and Industry Deputy Minister, Nomalungelo Gina, has welcomed the R25 million Japan-South Africa collaboration project aimed at combating plastic pollution.

The three-year project, which was launched in Pretoria in July, is funded by the Japanese government and will be implemented by the United Nations Industrial Development Organisation (UNIDO) in partnership with the CSIR.

The project includes the assessment of new alternative materials, such as home-compostable bio-degradable plastic to substitute single-use plastic products, and the demonstration of the feasibility of such alternatives in collaboration with industry. It will also focus on opportunities for local manufacturing and economic development. UNIDO's international expertise in investment promotion in technology and innovation will be a catalytic element in the implementation, while the CSIR will bring to the project its extensive expertise in the assessment of possible new materials from a materials function and polymer science point of view. The CSIR will also ensure that applying new alternative materials to the South African context does not create new environmental challenges.

"I am delighted to take part in this groundbreaking ceremony between Japan and South Africa in an attempt to reduce marine plastics pollution through renewable means. The Department of Trade and Industry (dti) welcomes the support by the Japanese government and the partnership between UNIDO and CSIR, since biodegradable plastics locally are just being introduced," noted Gina.

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Environment department growing information on SA mangroves

The Department of Environment, Forestry and Fisheries (DEFF) has embarked on a process to improve knowledge and management of South Africa's mangrove systems.

In South Africa, mangroves' distribution range is limited to the eastern part of the country's 3 200 km coastline, from Kosi Bay estuary in KwaZulu-Natal and reach their Southern distributional limit at Tyolomnqa Estuary near East London, in the Eastern Cape. Generally, mangroves occur in sheltered estuaries that have a permanent connection to the sea; and occur in 31 estuaries along the East coast of the country.

There's a total of eight mangrove species occurring along the South African coastline. The three dominant species are the white mangrove (***Avicennia marina***), black mangrove (***Bruguiera gymnorhiza***) and the red mangrove (***Rhizophora mucronata***). With an additional three species (***Ceriops tagal, Lumnitzera racemosa*** and ***Xylocarpus granatum***) found in the Kosi Estuary that has recently been classified as occurring in the tropical biogeographic zone.

The area covered by mangroves in South Africa is small compared to other East African countries (total mangrove cover is currently estimated at 1 631 ha), and the largest mangrove forests are found in the subtropical areas (iSimangaliso Wetland Park and Richards Bay estuary).

Mangroves are incredibly important ecosystems. They serve as biodiversity hotspots, provide for livelihoods (e.g. fishing), serve as a buffer against storm surge, erosion and flooding, as well serving as carbon storage.

Mangroves are also one of the few forest types that have been listed as threatened ecosystems under the National Environment Management: Biodiversity Act, and are protected under the National Forests Act of 1998. Since mangroves form part of the estuary, they are managed through municipal Estuary Management Plans (EMPs), for example in the case of Durban Bay, uMnganzana, Ntafufu and Nahoon EMPs.

Source: DEFF

Millions earmarked to secure water resources in Mpumalanga

The Department of Water and Sanitation (DWS) has announced that it has set aside millions of Rands to mitigate water scarcity in regions in Mpumalanga that are experiencing dry conditions.

According to a statement, the department is planning to spend R28 million to revamp dwindling water resources in Bushbuckridge in this financial year. "The protest-plagued area relies almost exclusively on Inyaka Dam to serve about 20 villages with 90 000 people from Mariti up to Dwarsloop."

DWS also noted that due to drought conditions, the Mkhombo Dam level, which serves as the main source of raw water for the large semi-rural communities of Dr JS Moroka Local Municipality, Thembisile Hani Local Municipality and Sekhukhune Local Municipality, has dropped to an alarming 1.6%.

An amount of R18 million has been allocated to Dr JS Moroka Local Municipality to augment water supply through groundwater development. "Through the intervention, 11 boreholes are undergoing refurbishment, while 15 new boreholes have been drilled," the department said.

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GLOBAL

Green business gets a boost with new knowledge platforms

A global partnership of some of the world's largest organisations has seen the launch of two new knowledge platforms – the Green Industry Platform and the Green Finance Platform.

The launch took place at the High-level Political Forum for Sustainable Development in New York in July. These platforms provide the financial and private sectors with the latest research data, guidance and tools from leading experts and institutions to help green their operations.

The need for practical and targeted knowledge to support the transition to inclusive green economies is more urgent than ever, with recent reports showing the global decline of nature and calling for unprecedented action to reach climate targets as set out in the Paris agreement.

The Green Growth Knowledge Platform (GGKP) hosts a wealth of existing knowledge to support greener business, finance, and policy, from the return on investment on renewable energy investments to green bonds, sustainable infrastructure, green standards and regulations. The platforms offer everything from global-scale assessments on flows of sustainable finance to highly specialised guidance notes on 'turning waste into gold' in the bio-energy sector in Africa.

Ban Ki-moon, former Secretary-General of the United Nations and current President and Chair of the Global Green Growth Institute welcomed the launch of the two new platforms: "These are especially exciting times for the GGKP, already the world's largest dedicated repository of green growth resources, case studies, and national documents."

The Green Industry Platform and the Green Finance Platform will build on the existing Green Growth Knowledge Platform, which offers the latest know-how to support green policymaking at the national level. Users can browse by sector, country, region, or cross-cutting theme, including gender, jobs, climate change, circular economy and natural capital.

For more information,
Visit: https://www.greenindustryplatform.org/ or https://greenfinanceplatform.org/

One in four people live at high risk of running out of water

The world is facing a water scarcity crisis, with 17 countries, including India, Israel and Eritrea using more than 80% of their available water supplies each, a study has found.

Those countries are home to a quarter of the world's 7.7 billion people. Further population rise or dwindling water supplies could cause critical water shortages, the researchers warn.

"As soon as a drought hits or something unexpected happens, major cities can find themselves in very dire situations," says Rutger Hofste, a data scientist at the World Resources Institute (WRI), which released the data in August. "That's something that we expect to see more and more."

To gauge countries' risk – or 'water stress'- WRI updated its online calculator, called the Aqueduct Water Risk Atlas, with data from 1961 to 2014 on water use by households, industry and agriculture, as well as water-supply data from surface sources and aquifers.

"People immediately link [water woes] to climate change," notes Hofste, who is based in Amsterdam. "But economic and population growth are the biggest drivers." Water use has increased by 250%, from 1 888.7 km^3 in 1961 to 4 720.8 km^3 in 2014, the analysis found.

Population and economic growth is straining global water supplies. Data released by the World Resources Institute show that 17 countries — mostly in the Middle East, Northern Africa and South Asia — are under 'extremely high' water stress. That means they are using at least 80% of their yearly supplies. Another 27 countries in the 'high' stress category are using 40 – 80% of supplies. Less stressed countries, those using less than 40% of their water supplies, are ranked 'medium high' to 'low'.

Twelve of the 17 countries facing extremely high risk are in the Middle East and North Africa. Also in this category are Pakistan and India, where aquifer levels are among the fastest falling in the world.
Fore more information,
Visit: www.aqueduct/wri.org

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CLIMATE

Climate now biggest driver of migration – study

The effects of climate change, including floods and extreme temperatures have become more important push factors in migration than economic inequality or conflict, according to a global study. Article by Inga Vesper.

The study, undertaken by a team at the University of Otago, in New Zealand, looked at migration data from 198 countries of origin to 16 member states of the Organisation of Economic Cooperation and Development (OECD) between 1980 and 2015.

Researchers developed a model to understand the causes of migration, divided into effects of climate change, economic performance and political strife. The model showed that rising temperatures and a growing number of weather-related disasters now cause more migration than lack of income or political freedom.

Each 10% increase in temperature in an origin country caused an increase of 3% in migration from that country to the 16 destination countries, which included Australia, Italy, Spain and Germany. The study, published earlier this year in the journal, ***Global and Planetary Change***, also found that this migration happens in stages.

Dennis Wesselbaum, the lead researcher and an economist at the Otago Business School, explains that migration actually decreased for around five years after a temperature anomaly, before increasing for the next 20 years. "One explanation is that people move to places further away and have to save more money to finance migration cost, [or] that it takes time to identify the temperature shock," Wesselbaum said.

Raya Muttarak, senior lecturer of geography and international development at the UK's University of East Anglia, believes anther reason for the apparent delay is that people at first try "in-situ adaptation". "If you experience climatic shocks in the first year, you try different ways to cope, such as planting different crops, changing jobs, borrowing money. You're probably not trying to move straight away."

The researchers found that global temperatures increased by an average of 0.8 ^{O}C in the study period. They counted 100 weather-related disasters in 1980, but by 2015 this number had risen to 300 a year. Around 244 million people – 2.8% of the world's population – were classed as migrants in 2015 by the UN. However, the UN has said that it will not define climate migrants as refugees, a status that comes with more international support, citing concerns about watering down support programmes for those fleeing violent conflict.

A report by the UNFCC, the UN's climate change body, found last year that, globally, countries are failing to deal with climate migration adequately. "Recognising the causal factors behind this forced migration would require governments to apportion responsibility, both for the initial migration and for the solutions to it," said Steve Trent, Director of the Environmental Justice Foundation, which lobbies on environmental issues in the Global South. "In many countries this is politically toxic and, without international agreement on shared and coordinated action, proves politically very hard to deal with."

Wesselbaum is confident, however, that this problem will be recognised "sooner or later", adding that the results of his study offer a more nuanced understanding of how people respond to climate shocks. The climate migration model showed that migration remained stable after storms and drought, but increased significantly after floods and extreme temperature events. "Both developed and at-risk countries need more planning and policy to prepare for what is likely to be a growing trend of people wanting to move."

To view the journal article, Visit: https://doi.org/10.1016/j.gloplacha.2019.04.008

Source: SciDev.Net

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A USEFUL VIEW OF FINNISH WATER RESOURCES AND SERVICES IN A GLOBAL CONTEXT

Katko, T. ***Finnish water services: Experiences in global perspective*** (Mustasaari: Finnish Water Utilities Association, 2016)

Prof Tapio Katko, the UNESCO Chair in Sustainable Water Services at Tampere University of Technology in Finland, is an engineer and water historian who has been active in the international water research sector since the mid-1980s. For a significant part of his professional career he spent time overseas. Working in Africa and engaging with peers in Europe, especially after Finland in 1995 joined the European Union, Katko has built up a wealth of global insight into water resources and services. For almost four decades his acquired knowledge and insight has fed into Finland's water sector.

It is therefore of interest to take note of his latest publication, ***Finnish water services***. While his focus is on Finland's water sector history, there is evidence of a global water sector gaze and how Finland has managed to remain abreast of international developments.

Since gaining its independence from Russia in 1919, Finland, with a current population of about 5.2 million inhabitants, has excelled in a number of fields. The country's water sector is currently considered to be amongst the top 10 operations globally. ***The World guide to Corporate Sustainability and Responsibility*** (2017) singles Finland out as one of the world's top 'honest' countries. On Transparency International's 2018 global assessment list, Finland is the third least corrupt country (after Denmark and New Zealand) in the world.

The country's water sector is an outstanding example of a well-run state with a strong social democratic ethic, where a significant part of the population relies on state employment. Since the country's shift to a post-industrial society in the 1970s, Finland's economy has focused on developing a service society. The country's private sector has become an influential role player in generating wealth and development.

Apart from strong international ties, Katko remained a water-sector insider in Finland. He shares his comprehensive historical insight into the manner in which Finnish water sector services have evolved since the 19th century. The country and its people, more than often function in either the shadow of the neighbouring Scandinavian countries of Sweden, Norway and Denmark, as well as Russia in the east. Yet Finland has excelled in the fields of: ethical consumption; awareness of environment and climate change; its ability to embrace cultural adaptation; the country has maintained a good level of competitiveness; and its society nurtures sustainability. These environmentally-friendly traits feature prominently in Finlandfs water sector.

Of particular importance is Katko's exposition of the way in which Finnish water sector professionals and research community have maintained a strong engagement with developments in the water sectors of the most advanced, as well as developing countries of the world.

With more than 190 000 lakes with a diameter of more than 500 m^2, Finland's water 'problems' are primarily seated in dealing with wastewater and securing outstanding potable water for its users. Katko deals with both surface and groundwater resources and sheds light on progress in the field of water recharge systems – a field in which the country has made significant progress in recent times.

Of particular interest is the evolution of Finland's water sector and the manner in which education, research and development have played a pivotal role in the development of an outstanding water sector.

Part 4 of the study is a comparative survey of how Finland has managed to seamlessly adapt to global trends. In the field of services, the country is clearly at the cutting edge – thanks to the knowledge of its water sector being up to date with knowledge on exogenous trends. In planning for future water supplies, Finland is safely ensconced at the same level as Brazil, but potentially with the benefit of more insight on regional European trends and developments.

For the reader interested in gaining an insight into the development of water services in a modern European state there is a lot of food for thought. International partnerships, using international organisations to promote the interests of a national water sector, is a winning recipe. The proviso is a spirit of reciprocal engagement – a diplomatic skill that has been fine-tuned by Finnish water sector colleagues working in many parts of the world.

Katko, in the final chapter joins forces with Jorma Tainen to make a poetic statement on the importance of water services. Culturally it is a courageous statement, for the Finns who are traditionally known for their inwardly reserved characteristics. One verse provides a clue for the contemplative reader as a recipe for success in the contemporary social democratic state's water sector. It reads:
Keep services rolling!

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Access to water to guarantee supply
– not free, but at a fair fee;
the private sector is needed no doubt,
But public ownership gives customers clout.

Katko's work is of more than passing interest to South African water sector specialists interested in promoting a passion for promoting the task of our country's water resources and services.

Review by Johann Tempelhoff of the South African Water History Archival Repository (SAWHAR), North-West University.

Katko, T. ***Finnish water services: Experiences in global perspective*** (Mustasaari: Finnish Water Utilities Association, 2016) is available in printed and electronic form:

- **Printed copy**: Price 55.00 € plus postage
  Available at: https://vvy.etapahtuma.fi/J%C3%A4rjest%C3%B6rekisteri/Verkkokauppa2
- **E-Book**: IWA Publishing, Standard ePrice: £48.00 + VAT
  Available at: https://www.iwapublishing.com/books/finnish-water-services-experiences-global-perspective

WATER COMMUNITY MOURNS THE PASSING OF FEMALE ICON

The water community was shocked to hear of the untimely passing of Dr Thandi Ndlovu, founder and Chief Executive of Motheo Construction Group. Dr Ndlovu passed away in hospital in August following a car accident.

Born and educated in Soweto, Dr Ndlovu was heavily involved in politics, and at the height of the Soweto student uprising in 1976 she was serving as the Administrative Secretary of the Student Representative Council (SRC) at the University of Fore Hare. She was forced to abandon her Bachelor of Science Degree as a direct result of the oppression that followed.

Dr Ndlovu spent the next couple of years in training within the ranks of Umkhonto we Sizwe, the African National Congress Military Wing. In 1984, she resumed her studies at the University of Zambia, eventually completing a Bachelor of Medicine, Bachelor of Surgery (MBChB) degree.

Upon her return to South Africa following the unbanning of political parties, she opened a private medical practice in Orange Farm. After practicing for a few years, she decided to go into business, establishing Motheo Construction in 1997. During its 20-year history, the firm has developed into one of South Africa's leading, predominantly black female-owned construction companies, and a leading provider of social housing. Dr Ndlovu is also a former president of the Black Business Council for the Built Environment.

Dr Ndlovu believed in being a role model to others, especially young women. In a special publication to celebrate inspirational women, published by the Water Research Commission (WRC) in 2016, Dr Ndlovu said: "Appreciate the fact that for that little girl in your space to make it, you have to act as a role model. Whatever you do, develop that little girl in your space. When I look back, I realise that it was those role models I had around me who made me what I am."

She made a deliberate decision to employ women in her company. The name, Motheo, means ***Foundation*** in Sesotho. Among others, she developed young talent by partnering young, female engineers and quantity surveyors with older, more experienced mentors.

Dr Ndlovu's determination to succeed could be seen not only from the way she handled her business, but also in the way she handled her personal life. Being asthmatic did not prevent her from successfully summitting Mount Kilimanjaro.

Dr Ndlovu was a keen participant in the Department of Water and Sanitation's Women Empowerment Programme. She will be sorely missed.

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WATER SECTOR

Fourth Industrial Revolution - Moving South Africa towards 'Digital Water'

Just as messenger pigeons and horse-drawn carts faded into obscurity with the invention of the telegraph and motorised cars, the new age of digital "thinking machines" is set to revolutionise the management of one of the world's most critical resources. Article by Tony Carnie.

Umgeni Water

"Luddites of the Information Age face a losing battle. Technology, once introduced, can't be shoved back in the bottle – resistance to digital innovation is futile."

"Water professionals are often considered, rightly, to be conservative, cautious or late adopters. Yet several potent trends make digital water no longer optional, but rather inevitable."

These were some of the sobering challenges delivered to water industry leaders at the launch of the ***Digital Water*** programme at last year's World Water Congress in Tokyo. More recently, the International Water Association (IWA) published a new report to help water utilities track their progress while moving from manual and analogue into the digital era.

There is no simple definition of this broad term 'digital water', which encompasses a wide range of innovations and emerging process changes – anything from automated sensors and flow meters to robotics, artificial intelligence and machine learning. One example comes from Berlin, where technology boffins have deployed motorised robotic cameras to scour the German capital's 9 725 km-long sewerage network to detect tiny pipeline cracks and faults, before ageing underground sewers rupture and cause smelly and expensive spillages on the surface.

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Another example comes from KwaZulu-Natal, where hydrologists from Umgeni Water were able to gaze into a digital crystal ball of sorts – and then make some adjustments to dam levels to ward off a potential Day Zero crisis for Durban and Pietermaritzburg during the recent drought.

The new IWA report (***Digital Water: Industry leaders chart the transformation journey***) notes that growing cities of the future have some tough times ahead in managing scarcer and less reliable water resources. The report also provides a gateway for water utilities to access knowledge on research, technology and innovation in the digital water space.

IWA hopes to inspire the international water sector to adopt a 'smarter' approach to water management, including the development of new off-grid schemes; projects to reuse or make better use of wastewater, and the installation of data-driven systems that help to integrate and optimise smart pumps, valves, sensors and actuators. This includes the concept of getting devices to 'talk' to each other and making use of smartphones to send real-time information to customers and colleagues.

One of the first developments in this area was the introduction of the Supervisory Control and Data Acquisition (SCADA) system that combined computers, networked data communications and graphics for water treatment and distribution, as well as in other areas such as power generation and manufacturing.

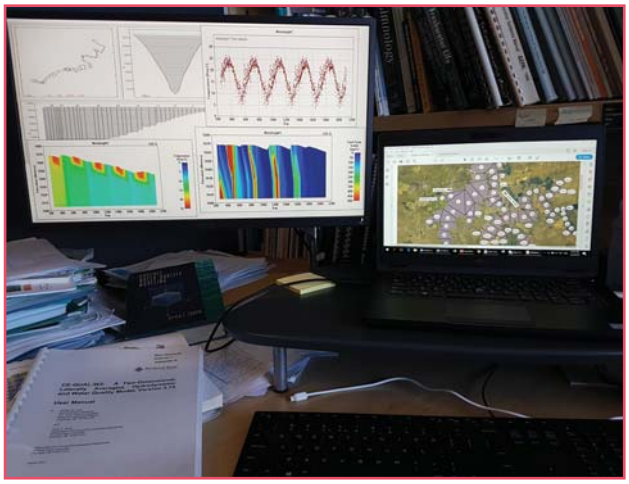
The authors of IWA's new report believe that emerging digital developments will allow water utility companies to implement "radically different system configurations" which can help to reduce sewer overflows, cut non-revenue water losses dramatically, and introduce cost efficiencies that were unimaginable a decade ago.

The report is largely based on interviews and inputs from nearly 50 utility executives, including case studies involving Umgeni Water and Rand Water in South Africa. Recalling the story of Cape Town's countdown to the 'Day Zero' crisis as one example of many other large modern cities struggling to address current and future water shortages, it states:

"Umgeni Water has used digital technology to better manage its water resources and protect its customers from the same fate as

Tony Carnie

Umgeni Water Senior Manager, Dan Naidoo, suggests that digital transformation cannot happen overnight, but believes new technology advances will assist homeowners to start measuring their water consumption in Rands on a daily basis.



Rand Water

The adoption of a range of digital technologies has enabled Rand Water to optimise the management of water resources in the Vaal River catchment.

Cape Town residents. Hydrologic models paired with monitoring devices have allowed (Umgeni) to optimise storage levels in dams and reservoirs."

In a separate interview with ***The Water Wheel***, Umgeni Water Senior Manager, Dan Naidoo, said the utility was still around the half-way mark in its digital transformation journey. "We started about 10- 15 years ago with more advanced computer systems and by starting to measure better," he said, recalling that during the early 1990s, several operations – from process control to data collection - were done manually by operators and recorded on paper.

The early adoption of hardwired meter counters to a central control room and the ability to remotely open and close valves were among some of the initial changes to enable remote operation via telemetry, electronics and computers.

"Over time, the biggest change was in the adoption of online instrumentation to measure water quality parameters in real time, thus reducing much manual lab testing and improving process control of the treatment process."

This eventually led to fully-automated processes for a number of operations such as filtration plants, backwashing cycles and chemical dosing. "We are moving towards more digital systems, but we favour an organic process rather than an overnight step change."

Naidoo believes the key is respond timeously, noting that costs for other advanced technologies, such as solar power, had dropped rapidly in recent years.

During the recent drought – when dam water levels receded after three successive years of below- average rainfall – Umgeni Water was able to use computerised hydrology models to balance water levels more effectively and to simulate drought scenarios as they developed.

To buffer water levels in the four critical Umgeni system dams (Midmar, Albert Falls, Nagle and Inanda) which supply Durban and Pietermaritzburg, water was pumped across from the

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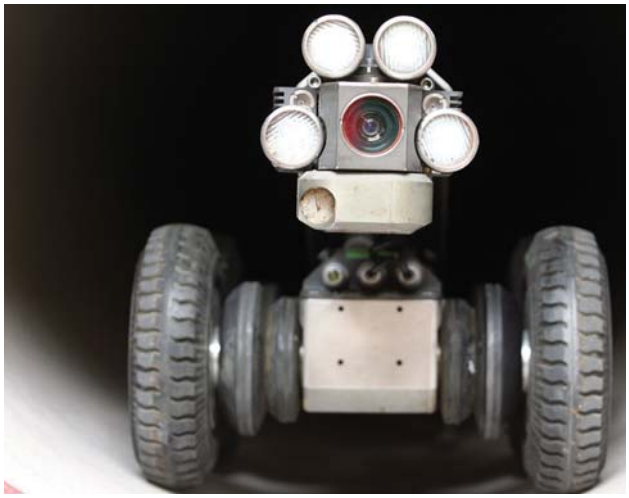
Berliner Wasserbetreibe



Berliner Wasserbetreibe

The German water utility, Berliner Wasserbetriebe, has developed robots equipped with fisheye camera lenses and other advanced technology to inspect Berlin's 9 725 km long sewer network for underground cracks and other faults.

comparatively wetter Mooi River system into the rapidly drying Umgeni catchment. As water was drawn down from the two lower dams (Nagle and Inanda) more water was pumped across via the Mooi River transfer scheme to replenish the upper dams (Midmar and Albert Falls)

Naidoo said Umgeni Water also acted swiftly to reduce water demand by calling for voluntary reductions by urban water users. However, when this call for voluntary curbs led to only negligible reductions, Umgeni Water and other water sector officials approached Cabinet to approve mandatory cuts before a crisis developed.

"Don't forget that we also lose revenue when there are water restrictions – so we don't take such decisions lightly," he noted.

Naidoo said the benefits of digital transformation cannot occur overnight. For example, large volumes of historic data will still have to be converted into digital format. Umgeni Water has also conducted audits to ascertain how staff may need to be reskilled as digitisation continues.

Naidoo believes that rapid advances in technology will reduce the time taken to complete microbiology tests, and also lead to new branches, such as nano-biology, to detect microplastics and a wider range of other contaminants.

Writing in the ***Journal of Clinical Microbiology***, researchers Paul Bourbeau and Nathan Ledeboer have suggested that the winds of change are moving quickly towards the automation of microbiology laboratories.

While there was a perception that humans could perform tasks faster than machines, and that machines did not have the critical decision-making skills to process microbiology specimens, they cautioned that microbiology laboratories had entered an age of "monumental change"

Changes are also underway in Gauteng, according to Prof Hamanth Kasan, General Manager of Rand Water's Scientific Services Division. Rand Water's application of digital technology now includes PLC/SCADA systems for water treatment operations and control, as well online water quality monitoring, catchment modelling, telemetry systems for management of reservoirs and automatic meter reading.

Prof Kasan said that "culture is important" and utilities had to "overcome fear of data and transparency". As younger engineers entered the workforce, the willingness to explore digital technologies was growing. According to Prof Kasan, the migration to digital technology in the water sector was not simply about saving money and was expected to result in several benefits, such as improved customer services, improved and consistent water quality, reductions in wastage and better public health and environmental protection.

Other benefits would include transparent monitoring and management for optimisation across the water value chain. "With application of technical change there are risks and benefits. Risks include cybersecurity and the need for enhanced skills, relevance and the sustainability of technologies."

It would also require an organisational culture change to embrace new ways of working, as well as measures to control vandalism to ensure the security of installations. "But, with proper planning, selection of appropriate technologies and thorough execution, these risks can be mitigated," he maintained.

Prof Kasan believes that, in the longer term, the digital revolution could lead to more widespread use of robotics and automation for conducting complex water analyses, as well as real-time monitoring of the condition of pipelines and the use of drones for sampling and to monitor catchments and pipelines. Other new innovations were expected to include new digital apps for customer management and optimisation of water consumption.

Elsewhere in the global water sector, the city of Taipei has also been moving towards digital solutions following a severe drought in 2002. The IWA report notes that partly by introducing new sensors, smart meters and pressure control systems the greater Taipei area had not experienced a water shortage in 17 years.

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"In the longer term, the digital revolution could lead to more widespread use of robotics and automation for conducting complex water analyses, as well as real-time monitoring of the condition of pipelines and the use of drones for sampling and to monitor catchments and pipelines."

Ghana Water's Chief Technology Officer, Richard Otoo, said the utility had experienced a 14% increase in revenue after digital technologies increased water bill collection efficiency and provided customers with a menu of payment options that included mobile money payments and direct debit through banks.

In India, digital technologies have modified the profile of the workforce at the water utility company VA Tech Wabag. Company Vice President, Gyanendra Saxena, said projects once needing 10-15 operators now require only 3-4 operators, "freeing up personnel for other, more demanding tasks (e.g., tasks requiring human interaction, emotion, decision making, and complex skill sets)."

Another example comes from Florida, where the local water utility installed sensors on several lakes that are prone to flooding during hurricanes. The new sensors and software help to detect downpours in advance, allowing the system to automatically drain down the storage volume ahead of a major storm.

In an era of climate change and declining water quality, the use of satellite remote sensing, GIS technologies and other visualisation tools can also help water managers to prepare for heavier stormwater flows during severe floods, to ration water ahead of droughts and to monitor algal blooms.

IWA says sensors can be dispersed to optimise resource use (e.g., chemical use for water treatment), and to detect, diagnose and proactively prevent pipe bursts, water discoloration events, or sewer failures.

Thinking machines and the power of data processing

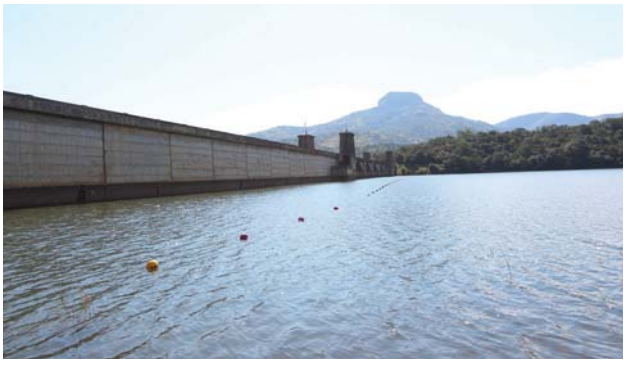
Dragan Savic, CE of the Netherlands-based KWR Water Cycle Research Institute, notes that there has been an **explosive growth of digital data technology over the past decade. This includes m**achine learning and artificial intelligence (AI) systems that can recognise patterns in data and "learn" over time, updating algorithms as new information is presented.

When paired with software sensors and communication networks, AI allows for the strategic and cost-effective operation of utilities, including better planning and execution of projects, better tracking and understanding of resource-loss in real time, more efficient collection and distribution networks, and maximum revenue capture and customer satisfaction.

Augmented and virtual reality (AR and VR) technologies had potential to support decision making in the field by providing holographic representation of pipes, cables and other assets.

IWA Executive Director, Kala Vairavamoorthy, cautions that global water utilities are next in line to experience the disruptive force of innovative technologies. "Ready or not, digital tools have quite literally shifted power to the people," he said, noting that disruptive ventures such as Uber and Airbnb had not requested permission from regulatory agencies, elected officials or trade associations.

"Unfortunately, all too often the large entrenched interests have tried not to adapt, but rather to restrain the tide of digital technology . . . The water sector must learn from other sectors to instead embrace the potential changes already underway."



Umgeni Water

During the recent drought - when dam water levels in KwaZulu-Natal receded after three successive years of below-average rainfall, Umgeni was able to use advanced hydrology models to balance water levels more effectively and to simulate drought scenarios as they developed.

The full IWA report is available at: https://iwa-network.org/publications/digital-water/

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DOMESTIC WATER USE

Changing behaviour, saving water – helping Capetonians to help themselves

Green 'nudging' tools can play a key role in ensuring city water security during periods of extreme drought. Jorisna Bonthuys reports on some of the research conducted by behavioural economists in Cape Town during the recent drought.

Cape Town survived a historic three-year drought that threatened to shut down the city's water supply at the height of the crisis in January 2018.

During the course of the drought, a team of behavioural economists from the University of Cape Town (UCT) worked with the City of Cape Town to test how green 'nudging' tools — interventions to encourage behavioural changes that could aid the meeting of environmental/conservation goals — could get Capetonians to adopt more water-wise behaviour.

Prof Martine Visser, lead researcher on this project and Director of UCT's Environmental Policy Research Unit (EPRU), was recently awarded a prestigious National Science and Technology Forum (NSTF) award for her research in this field. She is a professor of economics at UCT's School of Economics and the research chair of the African Climate Development Initiative (ACDI), an interdisciplinary research hub at UCT.

The NSTF-Water Research Commission (WRC) Award that Prof Visser received recognises research, conducted over the last five to 10 years, that was aimed at achieving sustainable water management and generating knowledge and solutions.

Prof Visser's research was supported by the EPRU's team of behavioural economists (including Kerri Brick, Johanna Brühl, Samantha De Martino, Megan McLaren and Kenneth Berger) as well as electrical engineer, Prof Thinus Booysen, from Stellenbosch University. The researchers explored how nudging tools and clear communication messages can influence society's water usage.

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Ashraf Hendricks/Groundup

A near-empty Theewaterskloof Dam during the height of the Cape Town drought.

In the summer of 2015, the team started an experiment to see if they could influence Capetonians to become more water-wise. Their work involved collaborating with officials and politicians at both city and provincial level to build capacity within government institutions. The research was funded by the WRC, with support from the City of Cape Town and the South Africa-Norway Research Co-operation on Climate Change, the Environment and Clean Energy.

"The lessons learned in Cape Town also apply to other municipalities facing the twin challenges of population growth and resource constraints."

The nudges took the form of a series of simple, positively worded messages that were communicated to households via their monthly utility bills, sent out by the city's municipal billing system. The wording in the messages were framed to improve people's understanding of the inclining block tariff system and the financial cost of water, whereas the other set of messages relied on more pro-social types of nudges. The expectation from the outset was that households from different income groups would respond to each of these messages, Prof Visser explains. "Random sampling and distribution of messages across different suburbs in the city meant that it was possible to compare households who had received messages and those who had not and to also determine which messages were more effective," she says.

Over a period of six months, Prof Visser and her team sent out nudges to approximately 360 000 households across different income brackets. The researchers tracked how households responded to individual messages. They also continued monitoring water usage in these households as the drought unfolded over the following couple of months.

Of the nine different green nudging messages sent out to the targeted households, the ones that elicited the most positive response from the biggest water users – the wealthier households – are the more socially-motivated ones. These messages promised to reward water-wise behaviour by publishing users' names on the City of Cape Town website, compared people to their neighbours or relied on people's intrinsic motivation to save water.

As part of their project, Prof Visser and her team helped the city design a 'water map'. This digital tool, rolled out in the summer of 2017/18, was designed to use social recognition as an incentive for Capetonians to voluntarily reduce their water usage. This online tool acknowledged households that were sticking to the city's recommended monthly water targets. It also allowed for a comparison of neighbouring households' water usage, and the overall water usage of entire suburbs.

The map designers chose to recognise pro-social behaviour rather than name and shame households that used too much water, Prof Visser points out in a press release. As such, the tool placed light green dots over free-standing homes that used 6 kilolitres (kl) of water or less per month. Households that used between 6 kl and 10.5 kl water per month were marked by a dark green dot on the map.

Prof Visser and her team, together with Prof Booysen, furthermore worked with the Western Cape Government and private donors to determine how the daily water use information supplied by smart water meters could help promote water conservation in schools. This initiative resulted in significant water savings and resultant reductions in 345 participating schools. While basic maintenance interventions resulted in upfront savings of 28% due to reduced leaks, behavioural interventions piloted in the study resulted in 15-26% savings. In terms of financial savings across the entire project for all the schools, the investment of R10,5 million resulted in an estimated saving of R39 million.

As the drought in Cape Town escalated, Prof Visser's team continued to work with the city's utility data, tracking how people responded to the different water-saving incentives (including price increases, water restrictions and related fines) that the municipality launched during the drought.

In addition to raising tariffs and increasing the stringency of water restrictions, the municipality adopted other demand-side measures during the drought, including the sometimes controversial "Day Zero" communication campaign aimed at promoting water-wise behaviour. This campaign utilised scare tactics to change consumer behaviour. Faced with the threat of Day Zero — the day when the city's taps were expected to run dry — consumers reduced their average household water usage from 540 to 280 ℓ per household per day between January 2015 and January 2018.

Across all suburbs, the fear of Day Zero actually occurring was an important factor in reducing water consumption. There were, however, distinct differences in motivation for engaging in water conservation. "Residents in the lower- and middle-income brackets considered tariffs and restrictions important motivating factors in driving water saving," Prof Visser points out. "In contrast, residents in higher income brackets were more strongly driven by social pressure."

Residents in the lower-income suburbs of Langa and Kensington, for instance, indicated that higher tariffs and water restrictions were their primary concerns, while Rondebosch respondents

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listed civil duty and social pressure as the key drivers behind their efforts to save water. The behaviour of middle- and higher-income households did not change much in response to water price increases or the behavioural nudges.

"Inequality remains a significant challenge within the city and its surrounds, and was identified as a critical factor to consider when planning responses to the recent water crisis," Prof Visser says.

Cape Town provides a prime example of how a municipality can use nudges to reinforce government policy, Prof Visser believes. "Green nudging can be utilised by both small and large municipalities to ease pressure on overstretched water supplies," she says. "This tactic may benefit the many other cities and towns impacted by water stress during extreme drought." In recent years, other metros such as Nelson Mandela Bay as well as smaller municipalities in the Western Cape have, for instance, been under significant stress with regards to their water resources. Of the eight metros in South Africa, seven implemented water restrictions in the summer of 2016/17 due to low dam levels.

Spotlight on the drought

The 2015—2017 drought in the Western Cape (the worst in a century) has served as the backdrop for innovative research performed at the ACDI. This research has already yielded valuable new insights about the drought and changing water risk in the region.

Evidence suggests that a significant part of the drought may be attributed to climate change and that more events of this nature can be expected. Events like the recent multi-year drought are becoming the "new normal" in southern Africa due to unfolding climate change. Not only the likelihood, but also the severity of extreme climate events are expected to increase in the near future.

Extreme weather is becoming more common in the region, ranging from heat waves and severe droughts in Cape Town and Gaborone to record floods in Johannesburg and Maputo.

What this translates to is a need to be better prepared for extremes and to continuously drive and plan for resource efficiency, Prof Mark New, director of the ACDI, indicated in a recent interview. "Climate change means that climate patterns, including rainfall amounts and timing, are shifting, thereby impacting on water resource planning," he points out. "Municipalities and water resource managers in southern Africa should brace themselves for impending extreme weather and its impact on humans, nature and infrastructure."

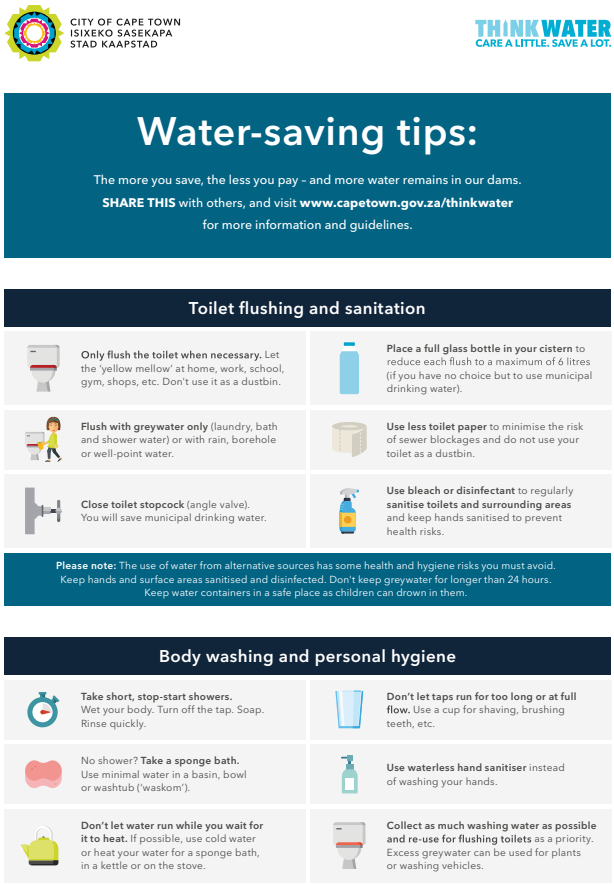
Prof New is driving efforts at UCT to understand changes in climate risk on the continent, and how humans are contributing to them. His particular area of expertise is termed 'climate attribution science'. This field of science involves attributing human-related causes to extreme weather events associated with climate change, as well as measuring the impact these events have on related loss and damage. This impact will be felt across society, especially in urban areas that are experiencing rapid growth largely through informal and poorly planned peri-urban expansion.

Until recently, most climate attribution studies were performed in the Global North. New, however, collaborated with leading experts to determine the anthropogenic influence on the drivers of the recent Western Cape drought. Their research, based on historical rainfall and dam inflow data, shows that human-induced climate change and its effect on rainfall patterns rendered the drought roughly three times more likely to occur than would have been the case in a world without human impact.

The research also highlights how the frequency of a drought of this degree has changed over time because of human influence in the province. Events like this one, which almost had Cape Town's taps running dry, are now no longer likely to happen every 50 years, but every 15. "Both the frequency and severity of climate-induced disasters are increasing. At the same time, the extent, duration and seasonal distribution of rainfall are changing. Along with higher temperature levels and increased evaporation, the implications of drought and climate change for run-off and long-term assurance of water supply are serious," New emphasises.

In theory, the Western Cape's water resource system should be reliable 49 out of every 50 years, but its designers did not consider changing climate risk profiles. The risk of water resource systems failing is increasing as the climate changes.

New believes climate attribution research is vital to inform the planning of water management systems within the context of drier and hotter regional conditions.



One of Cape Town's water-saving campaign posters.

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"Residents in the lower- and middle-income brackets considered tariffs and restrictions important motivating factors in driving water saving. In contrast, residents in higher income brackets were more strongly driven by social pressure."

Building adaptive capacity

Many lessons regarding the management of water risks and security issues during times of drought have been learned, Prof Visser points out. "The lessons learned in Cape Town also apply to other municipalities facing the twin challenges of population growth and resource constraints," she says.

One such lesson is that household-based tariff blocks place a disproportionate burden on poorer households where backyard dwellers are present. Sharing clear, relevant information with members of the public during times of crisis is also key to driving behavioural change, according to the research.

Although rapid-onset disasters often have devastating effects, slow-onset climate events such as drought can also detrimental. Cities must build their adaptive capacity to effectively respond to extreme events, Prof Gina Ziervogel states. Ziervogel, based in UCT's Department of Environmental and Geographical Science, is a research chair at the ACDI.

As climate variability increases and the impact of climate change becomes more acute, cities need to take a critical look at their preparedness, Ziervogel indicated in a recent report titled ***Unpacking the Cape Town Drought***. This report, compiled for the National Treasury's Cities Support Programme, aims to ensure that lessons learned from Cape Town will inform other municipalities when they adapt to drought and water insecurity.

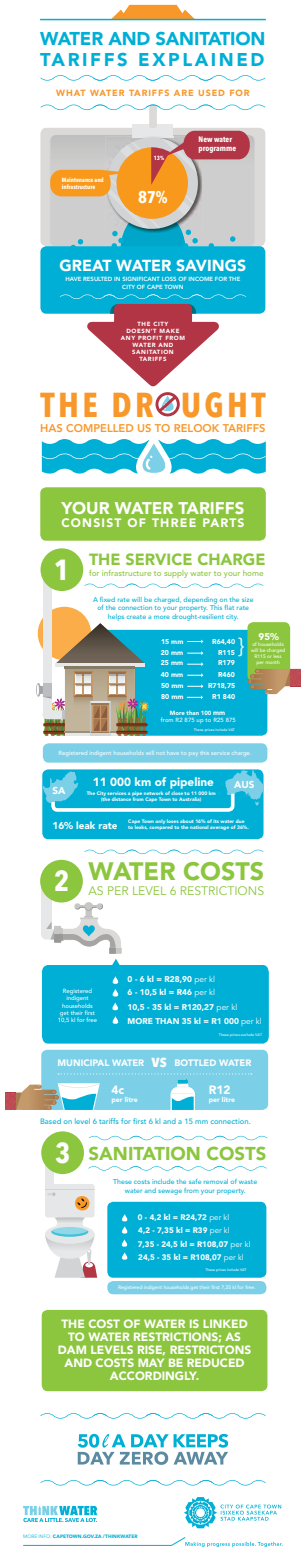
The drought illustrated how important it is to be prepared for extreme events, be they climate-related or other, as well as the need to build community resilience. Local governments, Prof Ziervogel's research indicates, must focus on several areas to successfully strengthen urban water resilience and better adapt to climate change. These areas include improving data collection and communication, strengthening governance, improving collaboration within municipal departments, engaging with experts, and enabling flexible and adaptive decision-making.

Climate change is a concern that should be better integrated into water planning, Prof Ziervogel points out. Many of the problems related to water quality and quantity and to extreme events like flooding in urban areas could be aggravated by the impacts of climate change.

To build adaptive, water-wise cities, municipalities need a vision and plan for implementation — a more nuanced and holistic response that recognises the role of people, partnerships, leadership and the overall water system.

Prof Ziervogel concludes that increased support across different spheres of government is needed to promote awareness of the importance of accounting for climate change in planning efforts and to ensure buy-in from municipalities in this regard.

For more information, visit www.acdi.uct.ac.za and https://efdinitiative.org.



An inforgraphic released by the City of Cape Town during the drought.

WATER AND HEALTH

Your daily dose – How SA is handling the threat of microbial resistance

Low levels of antibiotics in our drinking water may contribute to the growing threat of antimicrobial resistance. Article by Sue Matthews.

By now many of us have heard of somebody in our circles who has fallen victim to drug-resistant infection or disease. Antibiotic resistance is the most pressing problem, to the extent that hospitals are now widely feared as a place to 'pick up a superbug', such as methicillin-resistant ***Staphylococcus aureus*** (MRSE), rather than being viewed as a safe place to recuperate from operations and illness. But the problem extends to other antimicrobials, such as antivirals and antimalarials too, so the term 'antimicrobial resistance', or AMR, is more commonly used nowadays.

In April, the United Nations Ad hoc Interagency Coordinating Group on Antimicrobial Resistance released a report warning that drug-resistant diseases could cause 10 million deaths each year by 2050 – an alarming increase from the current estimate of at least 700 000 deaths annually, including 230 000 due to multidrug-resistant tuberculosis. The report, entitled ***No Time to Wait: Securing the future from drug-resistant infections***, noted that more and more common diseases such as respiratory tract infections, sexually transmitted infections and urinary tract infections are untreatable, that lifesaving medical procedures are becoming much riskier, and that our food systems are increasingly precarious.

About a month after that report was released, the topic was in the news again, with headlines like 'World's rivers awash with

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dangerous levels of antibiotics' (***The Guardian***) and 'Superbug threat grows as rivers contaminated with antibiotics' (Eyewitness News). This was a result of a press release issued by the University of York in the United Kingdom, reporting key findings of a global study that sampled rivers in 72 countries and found antibiotics at 65% of the sampling sites.

"The results are quite eye-opening and worrying, demonstrating the widespread contamination of river systems around the world with antibiotic compounds," one of the project leaders, Prof Alistair Boxall, was quoted as saying. "Many scientists and policymakers now recognise the role of the natural environment in the antimicrobial resistance problem. Our data show that antibiotic contamination of rivers could be an important contributor."

The most prevalent of the 14 commonly used antibiotics tested for was trimethoprim, detected at 307 of the 711 sites. Although mainly used to treat urinary tract infections, it is also used to treat Pneumocystis pneumonia in HIV-infected patients. The research team compared concentrations of all the antibiotics with 'safe' levels – the Predicted No Effect Concentration (PNEC) established by the AMR Industry Alliance – and found that these limits were most frequently exceeded in Asia and Africa. Likewise, sites where antibiotics exceeded the limits by the greatest degree were in Bangladesh, Kenya, Ghana, Pakistan and Nigeria.

South Africa was included in the study, but more detailed, country-specific results have not yet been released. The study involved sending sampling kits across the world to partners who were asked to take samples along their local river system, freeze them and courier them back to the University of York for analysis. In South Africa, the CSIR's research group leader for source-directed scientific measures, Dr Melusi Thwala, acted as the local partner. Pending publication of the report, he was at liberty to say only that the sampling was a once-off screening exercise along the Pienaars River to the east of Pretoria, with five sampling sites between Boschkop Road and the R513, just below the Baviaanspoort Wastewater Treatment Works to the north of Mamelodi.

We already know, however, that antibiotics are detectable not only in our rivers, but also in our drinking water, thanks to two Water Research Commission-funded projects led by Prof Carlos Bezuidenhout of North-West University. The first of these, completed in 2016, was entitled 'A scoping study on the levels of antimicrobials and presence of antibiotic resistant bacteria in drinking water' (**WRC Report No. KV 360/16**). Samples were collected from raw water and final treated water at three drinking water production facilities in Gauteng and the North West Province, and tested for a variety of antimicrobials. These included antibiotics (ampicillin; chloramphenicol; erythromycin; neomycin; oxytetracycline; streptomycin and trimethoprim), fungicides (amphotericin B and tolnaftate), pharmaceutical and personal care products (triclosan; 3,4-methylbenzylidene and DEET) and agrochemicals (BenfuraCarb; carbofuran; 2-chlorophenol; 2,4-dichlorophenol and chlorpyriphos). The results showed that a cocktail of these substances enter drinking water production facilities in the raw water, although the levels were very low. Generally, the levels were further reduced by the drinking water production processes, in some cases to below detection limits in the final treated water.

Antibiotic resistant bacteria (ARB) were also detected in raw water at all three facilities, and results indicated that these were not completely removed by the drinking water production processes. Based on these findings, the research team recommended that further research be conducted to investigate the relationship between antibiotics, ARB and physico-chemical parameters. Furthermore, they suggested that the presence of antibiotic resistance genes or other genetic materials in both ARB and in bulk water be investigated.

This follow-up work was done in the second research project entitled 'Antibiotic resistant bacteria and genes in drinking water: Implications for drinking water production and quality monitoring'. Sample collection was expanded to eight drinking water production facilities of various sizes (between 2.5 and 4 000 Ml/day), the largest of which supplies water to a population of 12 million people. All the facilities achieved high Blue Drop scores for microbiological and chemical quality in 2012, and have at least one filtration step before chlorination.

The results confirmed that the quality of drinking water was affected by upstream land-use and human activities, which are a source of antibiotics, ARB and associated genes that could be reduced but not completely removed by the current drinking water production systems. In addition, genes potentially

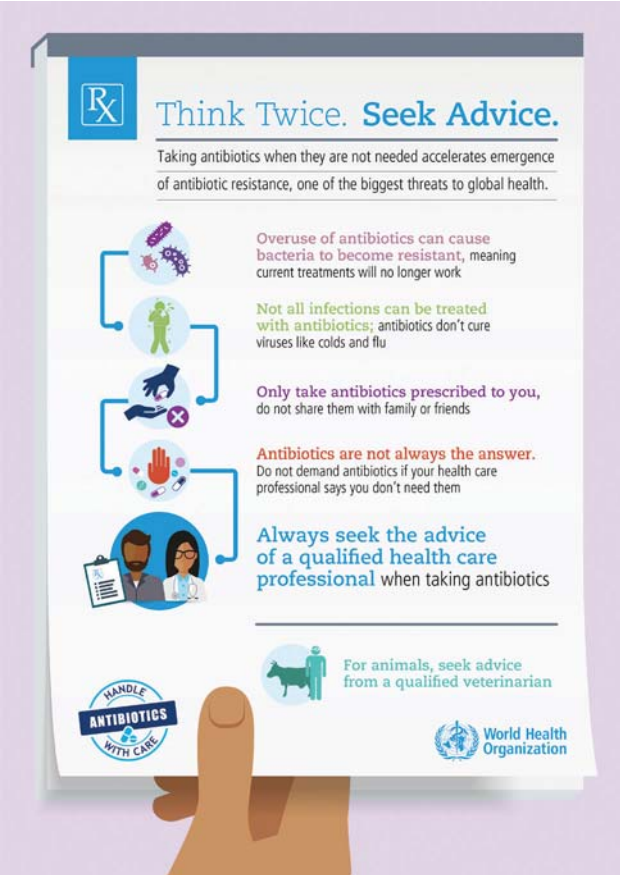
A poster from the World Health Organisation warning against the misuse of antibiotics.

responsible for antibiotic resistance phenotypes could be detected in isolated and purified bacteria that were resistant to multiple antibiotics. "This is an indication that the genes are functional and dissemination of such genes could potentially have detrimental consequences should they be transferred to infective pathogenic species," the research team note in the conclusions of the report. "Such multiple antibiotic resistant pathogens will be difficult and very costly to treat."

A large percentage of the bacteria isolated from both raw and drinking water had virulence features in the form of extracellular enzymes that could allow for the invasion of host tissue. The research team therefore suggested that a further investigative study be done on the health-related impacts of the identified bacterial species and their virulence. They also gave a number of other recommendations, including the use of rapid enzyme-linked immunosorbent assays (ELISAs) at drinking water production facilities as part of their water safety plans, which would allow antibiotic residues in water samples to be quantified and provide trends over time. "The cost for setting up the equipment and analysis is not prohibitively high," they note.

Importantly, though, the levels of antibiotics most frequently detected in the raw and drinking water –trimethoprim, colistin, beta-lactams and in some cases ciprofloxacin – were between 10 and 1 000 times below the PNEC. For example, the PNEC for trimethoprim is 500 ng/ℓ and this drug accounts for about a quarter of all antimicrobial use in South Africa, which has the world's largest anti-retroviral programme. Only five of the eight drinking water production facilities were screened for antibiotics, but in raw water trimethoprim was below the level of detection at one of these, between 0.4 and 1.1 ng/ℓ at three of the facilities and just under 39 ng/ℓ at the remaining one – yet even this fell to 0.5 ng/ℓ in the treated water and 0.2 ng/ℓ in the distribution network.

WHO



Taking antibiotics when they are not needed accelerates emergence of antibiotic resistance, one of the biggest threats to global health.

It would, therefore, not make economic sense at this stage to introduce advanced treatment processes, such as ozonation, distillation, reverse osmosis and advanced oxidation, at all drinking water production facilities. These methods, typically only used where the available source water is of low quality, or for water reclamation from industrial or domestic wastewater, and for seawater desalination, have very high initial setup and start-up costs. They also have high ongoing expenses in terms of energy consumption, replacement of filters and membranes, and employment of skilled staff to operate and maintain the systems. So what should be done?

"Addressing the antibiotic resistance crisis requires a collaborative, multisectoral, and transdisciplinary approach, taking into consideration the linkages between human health, animal health and the environment – the One Health approach – as well as the contributing bacterial interactions both in clinical and non-clinical settings," says WRC Research Manager for the project, Dr Nonhlanhla Kalebaila. "From a water quality management point of view, more effort needs to be dedicated towards environmental antibiotic resistance surveillance, as well as water safety planning and risk management."

Indeed, the One Health approach is what is advocated by the UN *No Time to Wait* report, which also recommends that countries:

- prioritise national action plans to scale-up financing and capacity-building efforts
- put in place stronger regulatory systems and support awareness programmes for responsible and prudent use of antimicrobials by professionals in human, animal and plant health
- invest in ambitious research and development for new technologies to combat antimicrobial resistance
- urgently phase out the use of critically important antimicrobials as growth promoters in agriculture.

South Africa's Department of Health originally launched its Antimicrobial Resistance National Strategy Framework 2014–2024 in October 2014 in response to the World Health Organisation (WHO) resolution on 'Combating antimicrobial resistance including antibiotic resistance', which was adopted by the World Health Assembly in May 2014, and was followed by the development of the WHO Global Action Plan for Antimicrobial Resistance in 2015.

More recently, the document has been revised in conjunction with the Department of Agriculture, Forestry and Fisheries (DAFF) now called the Department of Agriculture, Land Reform and Rural Development, and re-released as the South African Antimicrobial Resistance National Strategy Framework: A One Health Approach 2018–2024, although it is listed on the Department of Health's website as the AMR National Action Plan. It contains the following five strategic objectives:

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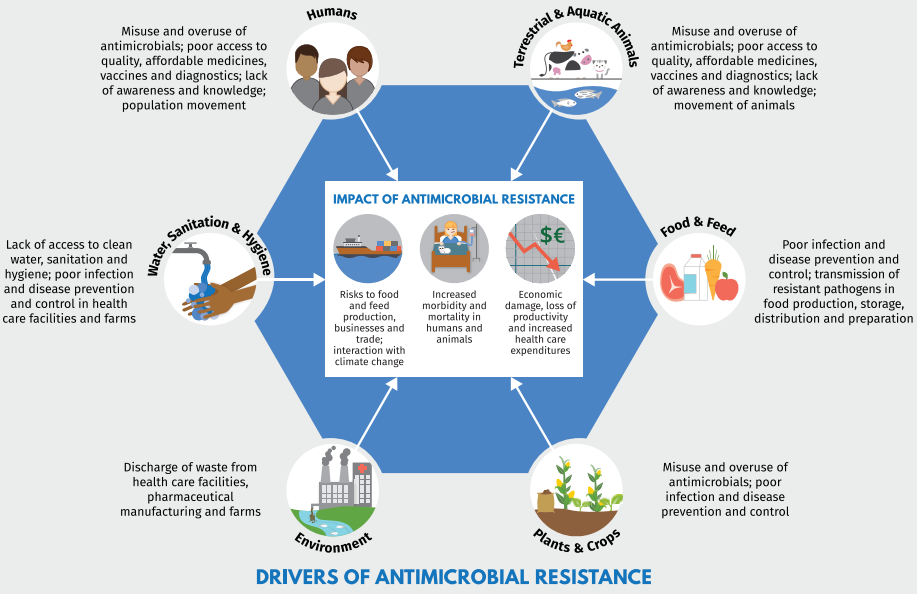
Fig 1. A One Health response to address the drivers and impact of antimicrobial resistance

"One Health" refers to designing and implementing programmes, policies, legislation and research in a way that enables multiple sectors and stakeholders engaged in human, terrestrial and aquatic animal and plant health, food and feed production and the environment to communicate and work together to achieve better public health outcomes.



The UN No Time to Wait report promotes the use of the 'One Health' response to antimicrobial resistance.

- Strengthen, coordinate and institutionalise interdisciplinary and intersectoral efforts
- Improve the appropriate use of diagnostic investigations to identify pathogens, guide patient and animal management and ensure good-quality laboratory systems
- Optimise surveillance and early detection of AMR
- Enhance infection prevention and control
- Promote appropriate use of antimicrobials in humans and animals.

Broad statements are made about the need for access to safe water and sanitation services to ensure good hygiene and reduce the spread of diseases, and for water quality monitoring to ensure fitness for human consumption, but this seems to relate to the standard microbiological and physico-chemical analyses that are currently required. Furthermore, the report, ***Surveillance for antimicrobial resistance and consumption of antibiotics in South Africa***, dated November 2018, makes no mention of water whatsoever. Compiled by the Surveillance Technical Working Group of the Ministerial Advisory Committee on AMR in collaboration with the National Institute for Communicable Diseases, private sector laboratories, DAFF, WHO, the South African Animal Health Association, and the World Organisation for Animal Health (OIE), the report presents information relating to AMR in humans and antimicrobial consumption in animals and humans in South Africa over the period 2012 to 2017. The only monitoring of antibiotic residues it addresses is that for meat products.

On the international front, however, the water-related aspects of the AMR problem are not being overlooked. The European Commission's science and knowledge service, the Joint Research Centre, published the technical report, ***State of the art on the contribution of water to antimicrobial resistance*** in 2018, while the journal ***Water*** (Vol. 11:1) published a special issue on 'Antimicrobial resistance in environmental waters' in early 2019, featuring 11 articles on monitoring and surveillance of AMR in natural aquatic systems and in effluent discharge from water treatment plants.

More to the point, however, is a March 2019 blog post written by Nicolai Schaaf, the Programme Manager for water and pharmaceuticals at the Stockholm International Water Institute (SIWI), titled 'Getting the priorities right in the fight against antimicrobial resistance'. In it, he outlines the steps he would like to see in terms of taking action against AMR:

- "***First: Tackle the empty development pipeline.***" Here he discusses the need to develop new antibiotics rather than focus on selling volumes, but suggests "lock away any new substance and only take it out when it is really needed".
- "***Second: Keep the antibiotics to when and where they are really needed***," in which he calls for the cessation of non-medical use of antibiotics, such as in the meat industry.
- "***Third: Reduce emissions from antibiotics production.***" In fact, he states, antibiotics should not leave the manufacturing site in any form other than as packed medicine.
- "***Fourth: reduce the dependency on antibiotics,***" in which he notes that we will not tackle AMR if we don't stop using antibiotics as a substitute for safe drinking water, sanitation and hygiene.

Clearly, solutions to the AMR problem focus on prevention, rather than cure. South Africa is on the right track with its latest Strategy Framework, but strategies are of course only as good as their successful implementation. We can all play a part in that, by ensuring we use antimicrobials responsibly.

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RESILIENT CITIES

Copenhagen – A city that banks on the blue gold below the surface

Petro Kotzé visited Copenhagen, in Denmark, to investigate what South Africa can learn from this world city that solely relies on groundwater.

South Africans are no strangers to the use of groundwater. Already essential to the water needs of towns such as Beaufort West and Musina, even large cities such as Pretoria and Johannesburg are partly dependent on this source. Cape Town is also banking on aquifers as part of the mix of diversified sources for a more water resilient future.

Still, the water below the ground remains an underutilised resource in South Africa. According to our most recent National Water Resources Strategy (second edition published in 2013) estimates of sustainable potential yield of groundwater resources at high assurance in the country is 7.5 km^3 per year. Current groundwater use is estimated at around 2 km^3 per year. Allowing for an underestimation on groundwater use, about 3.5 km^3 could be available annually for further development.

Regardless of the potential, many municipalities tend to turn to groundwater as a last resort during times of drought, though there are signs that the tide is turning. The City of Johannesburg, for one, recognises groundwater as a potential source to supplement potable water supply, and the city has embarked on a feasibility study to determine the areas with the biggest potential for groundwater use, and to identify what purposes it can be used for.

The appeal of using groundwater is large. Provided it is managed well, the environmental impact of harvesting groundwater is much lower than for sources such as large-scale desalination and

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even surface water systems, which requires large infrastructure for storage (dams and reservoirs). If water is stored underground, less is lost to evaporation. Also, tapping into groundwater is much faster to put into practice than constructing water transfer schemes or large desalination plants, and often cheaper. These reasons are part of the growing reputation of groundwater as a sustainable resource that can increase the resilience of a city and settlement.

Copenhagen, the capital of Denmark, knows this very well. The city is 100% reliant on groundwater for potable water supply, and enjoys water known as among the best and most environmentally friendly in the world. Furthermore, regardless of a fast growing urban population, ongoing concerns regarding groundwater quality, its location right next to Denmark's 8 700 km coastline and healthy government coffers, there are no plans to supplement future water supply with anything other than groundwater, including desalination.

Over the past decades, Copenhagen has set a globally recognised precedent for best practice groundwater use. This achievement takes ongoing effort and attempts to improve, says Trine Hybholt, project manager for HOFOR showroom, at Energy & Water – Greater Copenhagen Living Lab. Though the mix of factors influencing successful groundwater use differs significantly from one country to another, and even one city to the next, the key lessons for success from Copenhagen are surprisingly simple, and applicable to cities anywhere.

Water supply in Copenhagen

Copenhagen sits on the eastern coast of the island of Zealand. Until 2009, water supply included surface water treated with chlorine, explains Hybholt, but since then the city has been relying solely on groundwater abstracted from well-fields up to 55 km away from the city centre. Though aquifers also underlie the central part of the city, these are contaminated with the customary mix of urban pollutants. In comparison, water from the outlying aquifers are of excellent quality, is easy to access and requires minimal treatment.

The wellfields where the city draws its water from consist of quaternary deposits overlying tertiary layers such as sand, clay and lignite followed by the limestone from where most groundwater is extracted (in some cases groundwater is extracted from the mesozoic layers of limestone). The aquifers are rain-fed, and water takes more than 30 years to filter through the layers of topsoil, clay and sand towards the limestone aquifer lying on average 30 m below, being cleaned in the process.

The water requires little treatment. After extraction, the water is put through a process of oxidation (i.e. it's aerated) to remove gases and fed through a simple sand filtration system to remove minerals such as iron and manganese. No chlorine or other chemicals are added, says Hybholt. From the treatment plants the water is pumped to a central height tank for distribution to consumers via a gravity-fed system. Electricity is mainly used to power pumps for water supply to residencies over five storeys,

Copenhagen's famous lakes comprise three rectangular lakes curving around the western margin of the City Centre.

Trine Hybholt, project manager for HOFOR showroom at the Copenhagen Living Lab.

says Hybholt. Even then, all pumps are energy efficient and solar panels installed at the waterworks have lowered external power consumption by 25% on an annual basis.

In this way, HOFOR (the Greater Copenhagen Utility) extracts about 52 million m^3 (0.052 km^3) water annually for its 1.1 million customers in Copenhagen and the greater Copenhagen area. The utility is municipally owned, with ownership of the water and wastewater services shared between eight municipalities.

Still, like cities elsewhere, water supply in Copenhagen is not without challenges.

Challenges to water supply

For one, though relatively small, Copenhagen is growing fast; around 10 000 more people call it home each year. Hybholt says that for HOFOR, this implies that 365 000 m^3 more water needs to be supplied annually.

Second, water quality is an ongoing concern. Denmark has a rich agricultural history, with more than two thirds of the landscape altered for this purpose. The impact of intensive farming practices has filtered underground, and groundwater contamination by pesticides and fertilizers are not uncommon, says Hybholt. At the wellfields closer to the city centre, the mix of potential contaminants include pesticides and fertilizers used by private households, contamination from paints and oil, and industrial pollution. "Large-scale and long-term abstraction of groundwater also has an undeniable impact on the environment," explains Hybholt. "The truth is, what we did 50 and 100 years ago can still affect the water quality today and what we do today will affect the future."

To continue a guaranteed supply of safe and reliable water to residents well into the future, HOFOR applies a number of interventions to ensure the sustainability of their water supply – something that is at the top of their priorities, notes Hybholt. The utility is not going at it alone, and the success of its mission is built on support from national government, municipalities and the residents themselves.

Protecting the integrity of the resource

The protection of groundwater outside the city is regulated by the national Water and Nature Plans, implemented by the Danish Environmental Protection Agency (EPA). Permits for HOFOR to extract water from the outlying well-points are thus reviewed and awarded by the EPA.

Permission to abstract water is granted on conditions to compensate the environment for the resulting impact, and HOFOR consequently has to secure a minimum flow in the streams above the surface that are affected as a result of groundwater abstraction. This is done through admission of groundwater, surface water, wastewater or rainwater.

HOFOR also adheres to comprehensive groundwater protection plans that includes strict specifications of land use in the catchment areas, assessments of all known sources of pollution, identification of vulnerable areas and monitoring.

One example in application, says Hybholt, is that farmers are compensated to stop using pesticides and other potentially harmful substances close to drilling holes. In other instances, farmers are compensated to switch from agricultural crops to planting trees to reforest the catchment areas, for improved control of potential sources of contamination in areas deemed important to water supply. In other areas limits for the use of fertilizer and pesticides are set. In urban areas close to well points, HOFOR runs regular campaigns to warn residents about the impact of private use of herbicides on their drinking water.

Still, the utility is always on the lookout for new potential sources of water. "We are always investigating new drilling areas and the impact of pumping more from our current fields," says Hybholt. "We never know when there might be contamination found, and our water supply potentially compromised."

To ensure a continuous supply of safe water regardless of the circumstances, Copenhagen's tap water is among the most heavily controlled in Denmark, with the same safety regulations as those applied to food processing (the international ISO 22000 standards).

Maintaining the quality of drinking water

Hybholt explains that they do not have historic data on which pesticides and fertilizers were used where, but they investigate the historic land use of the areas earmarked for exploration as far as possible. She says they have drilled around 750 access

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The Copenhagen Living Lab includes an exhibition of the city's sewerage system.

points – some of which were shut down when the groundwater was found to be contaminated. Once part of the water supply system, HOFOR applies a comprehensive control programme, which entails testing for bacterial contamination daily at several points along the water-supply system, from the waterworks, along the pipe network and at the final distribution point. Should there be a case of contamination, a control system kicks in during which the affected residents are notified and water supplied by trucks in the interim period until the problem is fixed.

A large part of their work to keep the water resource safe, is also to use it as efficiently as possible.

Water consumption and loss

Reducing residential demand for water is key to relieve any pressure on the resource, as the domestic sector is by far the largest water consumer in Denmark. The average water consumption in households in Copenhagen peaked in the 1960s at approximately 235 ℓ per citizen per day, but the figure has been decreasing steadily since. Then HOFOR set the optimistic target of reaching 100 ℓ per person per day by 2020 – a target that was unexpectedly reached ahead of schedule in 2017.

Hybholt says these results were won through sustained efforts maintained at various levels. Households were motivated to switch to water efficient appliances such as toilets, washing machines and showers, and the utility runs ongoing campaigns and education programmes on various public platforms and at schools to motivate people to use less water.

Some of the largest cuts in water use were obtained by the installation of private water meters at households, usually resulting in a decrease of about 25% of household water use, she says. Now, under Danish legislation, all properties connected to common waterworks must have water meters installed, though old buildings with several flats are only required to install one water meter at property level new buildings must have one for each flat.

Hybholt notes that there are more factors at play. Though nothing in comparison to buying bottled water, water is perceived to be expensive by consumers in Copenhagen, so people are more inclined to use it sparingly. This is helped along by a growing awareness of the importance of sustainable living by the Danes, reinforced by constant education campaigns, and large-scale success stories such the rehabilitation of the Copenhagen harbor, to the extent that it is now a popular public swimming facility. "The clean harbour has created a lot of understanding of the concept of sustainable water use," says Hybholt.

Still, they are not done. "Now that we've reached our target of 100 ℓ per person, we've set ourselves a new one, and are aiming for 90 ℓ of water per person by 2025", she says.

The city is also setting the trend in curbing water loss in the distribution system. In comparison to a worldwide average of 36.2% (and an average of 36.8% in South Africa, according to research published by the Water Research Commission in 2013), water losses for HOFOR amounts to 7%. This is achieved by

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controlling the pressure in the supply system, replacing old pipes and running a systemised leakage detection programme.

"The process is an ongoing one, and we are constantly trying new approaches to sustainable water use, and reduce our water use," notes Hybholt. "For example, the water that the sand filters are flushed with used to go to waste, but they are now able to reuse up to 85% in the water works."

Though the city has won international recognition for its quality of water supply, the core lessons it can share with other urban areas that aim to supply residents with clean and safe groundwater are simple, explains Hybholt.

Lessons from Copenhagen

The key is to use the resource sustainably. For groundwater, this includes not over-extracting from the aquifer. Second, the utility must ensure that the water quality is not compromised. Then, the basin that the aquifer is located in must be kept healthy. "It is inevitable that you will have an impact on the environment, but your impact must be sustainable," explains Hybholt.

To achieve this, Hybholt says the water must be understood as part of the water circle – a limited resource that we have to reuse over and again in order to survive, and thrive.

"Copenhagen residents are immensely proud of the fact that we are a city that drinks such clean water from the tap." While groundwater is still being seen as a backup plan in some countries, the opposite is the norm in Copenhagen. "The concept of clean, available groundwater is ingrained in us so deeply, it's difficult to even imagine sourcing water from anywhere else."

Sources

Denmark in Figures 2019, published by Statistics Denmark

- *https://iwa-network.org*
- *www.hofor.dk*
- *www.wrc.org.za*

The Copenhagen harbour water front. Cleanup campaigns have resulted in the areas becoming popular for swimming and socialising.

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ECOLOGICAL INFRASTRUCTURE

Protecting our water-related ecological infrastructure by building an investment case

Is ecological infrastructure worth the investment? A current study is aiming to find out. Article by Alanna Rebelo and Nadine Methner.

Alanna Rebelo

Relatively pristine ecological infrastructure: the headwaters of the uMngeni catchment, the Mthinzima tributary near Mpopomeni.

Climate change projections for South Africa suggest more variable rainfall and more extreme rainfall events, with predictions of increased floods and droughts. With a mean annual rainfall of only 450 mm per year, and equivalent potential evaporation of about five times this, South Africa is a water scarce country. Simultaneously, demand for water is outstripping supply in most provinces due to population growth and economic development.

The saturation of possibilities for more dams, the cost to maintain our failing water-related built infrastructure, and the inability of water treatment works to treat increasingly polluted water, suggest that alternative solutions need to be investigated for enhancing South Africa's water security. One promising investment opportunity is the maintenance and restoration of our ecological infrastructure (EI), including wetlands, rivers, and strategic mountain catchments.

There are a significant number of studies in South Africa and globally demonstrating the clear water-related benefits of investing in this ecological infrastructure concomitant with rising recognition in policy at international and national levels. Despite this, there is limited uptake by private sector investors, and investments made by government remain at a relatively small scale in comparison to investments in hard infrastructure. One of the reasons is that most studies have failed to holistically assess the socio-economic effects of those investments.

How can investments in ecological infrastructure buffer society against hydroclimatic risks, including droughts, while providing socio-economic benefits? Does investment in ecological infrastructure provide opportunities for job creation, poverty alleviation and social upliftment? These are the kind of questions that a multi-disciplinary team of researchers from the universities of Cape Town, Stellenbosch, KwaZulu-Natal and Copenhagen are tackling through a transdisciplinary research project called "Socio-Economic Benefits of Investing in Ecological Infrastructure", or SEBEI. The two-year project, which started last year is funded by the Danish International Development Agency.

SEBEI aims to provide an evidence base of the socio-economic and hydrological benefits of these investments and to showcase them in a prototype investment case. There are six study sites being investigated in this study, three in the Berg-Breede catchments (Western Cape) and three in the uMngeni catchment (KwaZulu-Natal). The Berg-Breede is part of one of the most important strategic water source areas in the country, and the uMngeni catchment is of great economic significance as

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it contributes 11% towards South Africa's GDP.

In addition to quantifying hydrological, ecological and livelihoods impacts, the researchers are tackling these complex questions by engaging with key stakeholders from government, NGOs and the private sector who are involved with implementing or funding investments into ecological infrastructure. This transdisciplinary process includes four rounds of workshops in each region throughout the duration of the project.

These iterative stakeholder engagements are aimed at joint learning and sense making of the emerging understandings from project results and allows key stakeholders to codesign and be kept informed of the project methodology as well as to validate the outputs. Two rounds of workshops have taken place to date, in November 2018 and April 2019, and here we describe some of the key findings and outcomes of this process.

One of the main activities at the first workshop for the Berg-Breede catchments (Cape Town) and uMngeni catchment (Pietermaritzberg), was to get a better understanding of: (1) What motivates investments in ecological infrastructure? (2) What is needed to make a sound case for investment in EI at different scales? (3) What are the major barriers to investment? The participants were divided into groups of 'implementers' and 'investors' to discuss these questions (yielding a total of eleven groups, with five in the Berg Breede, and six in the uMngeni). The reason for distinguishing the two categories was the assumption that people investing in ecological infrastructure may have a different perspective from those implementing specific activities.

For this first workshop in the Berg-Breede catchment, stakeholders numbered 28, in addition to the SEBEI team, about half of whom were from national, provincial and local government, a quarter from NGOs such as conservation trusts, and a few from academia and the private sector (Figure 1). In the uMngeni catchment, stakeholders numbered 14, about half from academia, a quarter from local government, and a few from NGO's and the private sector.

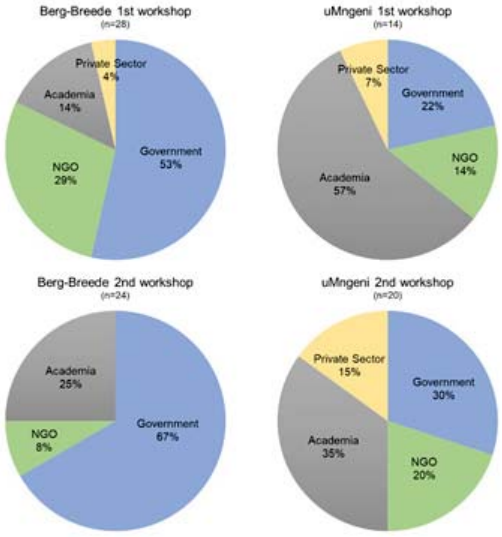

Figure 1. Sectoral diversity and numbers of stakeholders (excluding the SEBEI team) attending the transdisciplinary workshops in the Berg-Breede and uMngeni catchments, South Africa.

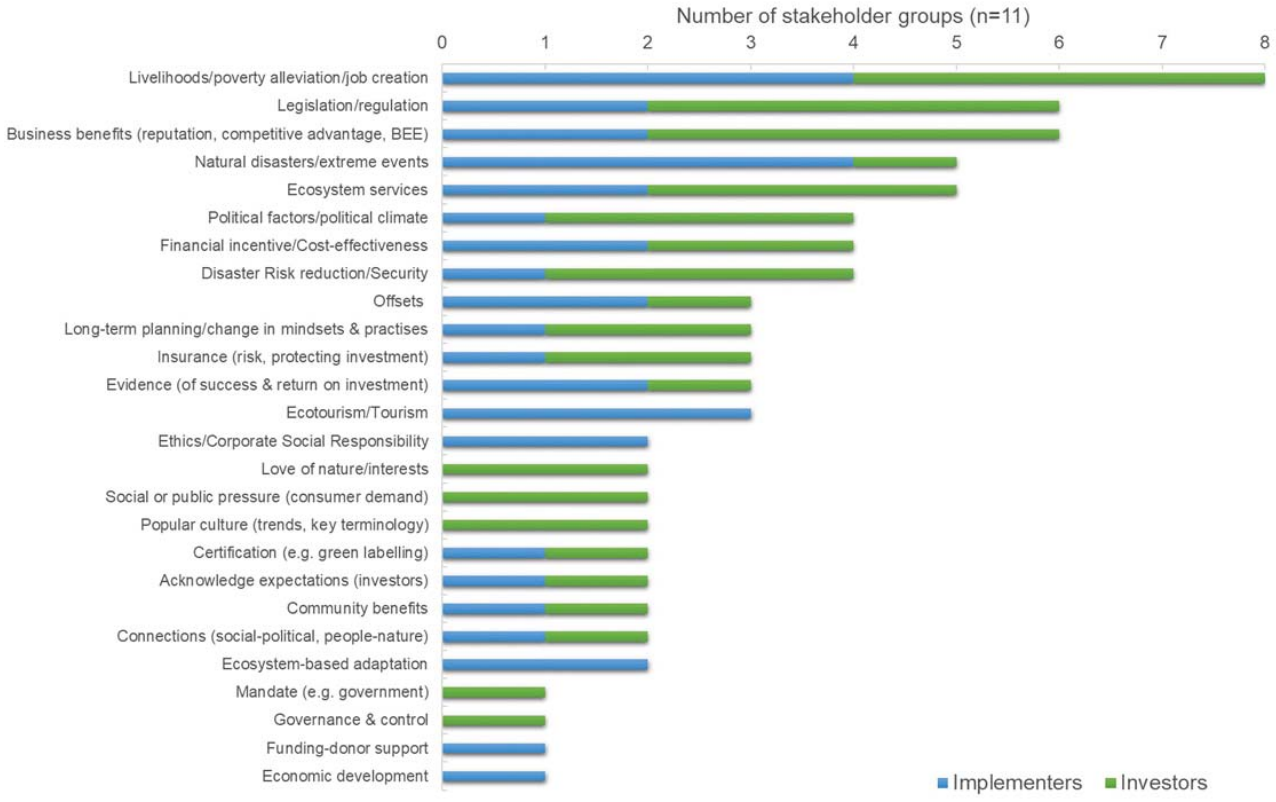

Figure 2. What motivates investments in ecological infrastructure?

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Several working groups pointed out that motivation to invest in ecological infrastructure depended on the type of investor (e.g. communities, municipalities, national government, private sector). Both implementers and investors felt that the most important motivation for investment into ecological infrastructure was improved livelihoods and poverty alleviation (Figure 2). This was closely followed by motivations such as legislation/regulation, business benefits, natural disasters and supply of ecosystem services. Factors such as mandate, certification, and social pressure received less attention as factors motivating investors.

Stakeholders made 39 suggestions on how to make a sound case for investment in EI at different scales (Figure 3). The most common suggestion was an evidence base, both in terms of the financial return on investment, but also in terms of the value of ecological infrastructure in mitigating disasters. Strategic, long-term planning, communication and trust, credibility, reliability and efficiency were also commonly identified by stakeholders. Collaboration, clear terminology and champions were also highlighted by some stakeholder groups to be important.

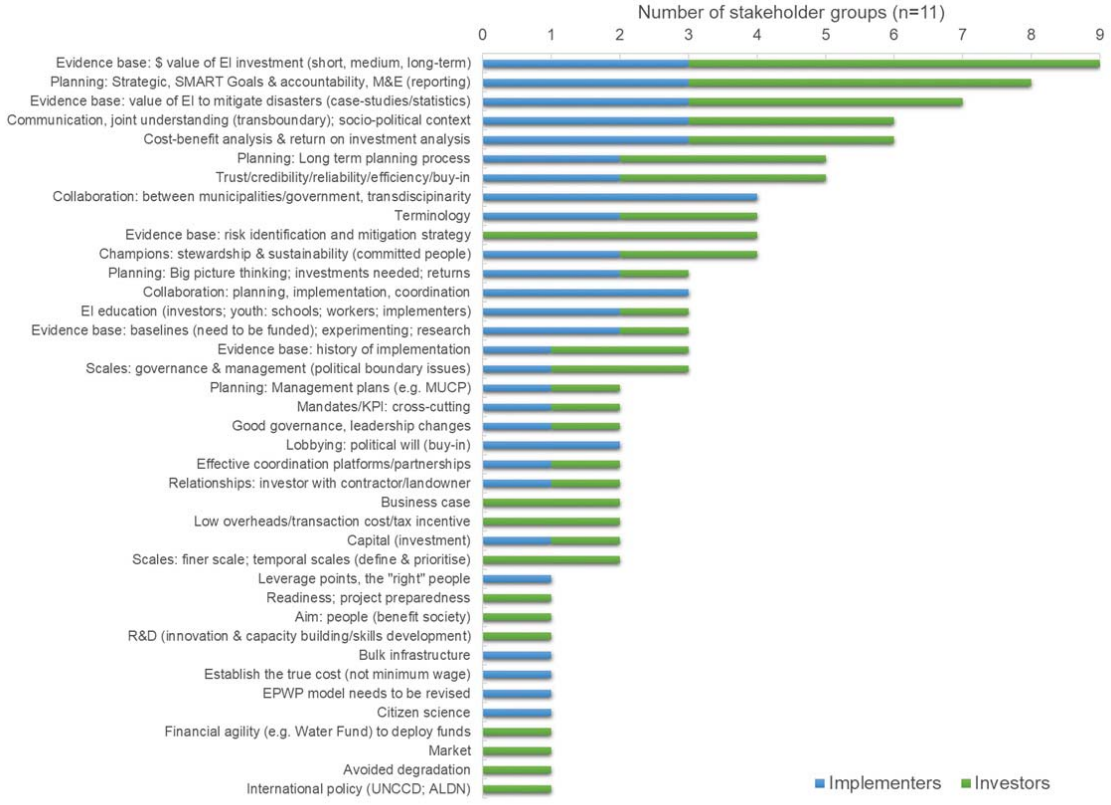

Figure 3. What is needed to make a sound case for investment in ecological infrastructure at different scales?

Stakeholders identified 55 distinct barriers to investment (Figure 4). The most critical barriers being lack of coordination/partnerships, timeframe incompatibilities (short-term needs vs long-term goals), lack of scientific evidence, and lack of effective leadership (governance). Bureaucracy, terminology, shortage of money, lack of trust and lack of capacity to build relationships were also highlighted as important barriers. Surprisingly, risk was identified by few stakeholder groups to be an important barrier.

Overall, a strong message emerging from this initial set of stakeholder workshops was the need for an evidence base for the benefits of ecological infrastructure, as well as the need for better coordination (partnerships), communication (also linking to terminology used), trust, credibility, and leadership. These findings demonstrate that SEBEI is well positioned as a research project in addressing the knowledge gap of an evidence base. Policy-oriented projects, such as the SANBI GEF6 EI for Water Security project will be able to address some of the other challenges and gaps.

At the second workshop in the Berg-Breede catchment, 24 stakeholders were present, two thirds from all three spheres of government, a quarter from academia and a small number from NGOs. In the uMngeni catchment, there was a greater sectoral diversity and attendance in the second compared to the first workshop, with 20 participants, about a third from academia, a third from national government, and the final third composed of NGOs and the private sector.

In order to create outputs both useful and relevant for ecological infrastructure investors and implementors, we invited participants at the second set of workshops to co-design specific aspects of the SEBEI project methodology in three working groups. Firstly, as part of the governance group, we validated several typologies of implementation models that resulted from the ecological infrastructure intervention

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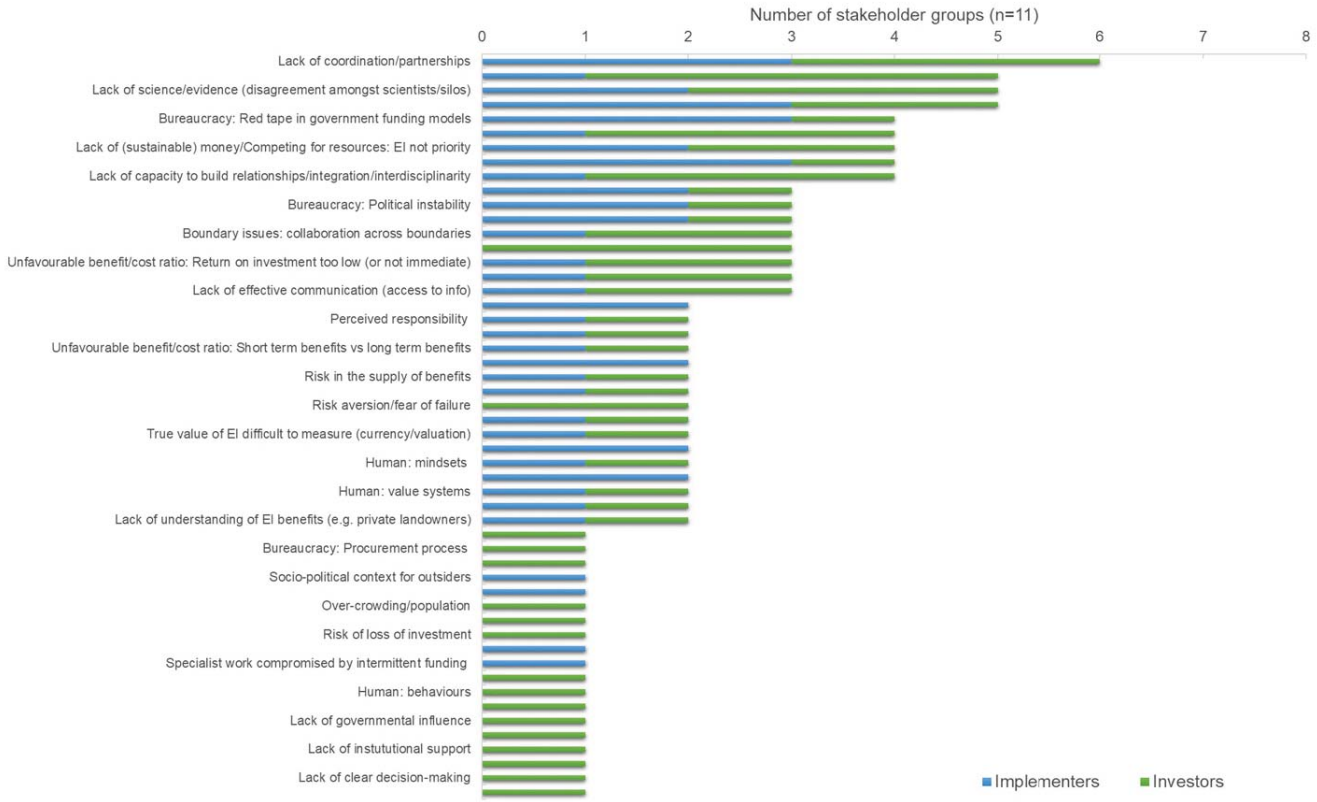

Figure 4. What are the major barriers for different types of investors?

What is Ecological infrastructure?

Ecological infrastructure can be defined as "the underlying framework of natural elements, ecosystems, and functions and processes that are spatially and temporally connected to supply ecosystem services; it is how natural capital stocks are organised to provide ecosystem goods and services " (Dominati et al. 2013). Examples are wetlands, rivers, strategic water source areas, mountain catchments etc.

An Ecological infrastructure intervention is an action* to enhance certain ecosystem services in a spectrum of landscapes (from natural to transformed), informed by an understanding of ecology. Examples include, inter alia, the actions of the Working for Water and Wetlands programmes (SEBEI 2019).

*Actions can be artificial or natural, including artificial wetlands, permeable pavements, alien clearing, wetland revegetation, and gabions and weirs to halt erosion.

inventory. Secondly, for the socio-economic benefits group, we asked stakeholders for input on which indirect benefits to people (employed, on-site and downstream) they thought would be important for the SEBEI project to attempt to measure.

Thirdly, for the mapping and modelling group, we critiqued investment scenarios, scales, and maps of invasive alien trees. Three scenarios are being modelled: the first the current state of ecological infrastructure, the second the 'best case' and the third, degradation of ecological infrastructure on a timeframe (e.g. 20 years) selected by stakeholders. One aspect of this state of ecological infrastructure included alien tree invasion, and others include wetland drainage and health and sustainable land management. The invasive alien tree maps that were validated were of the current state of invasion for both catchments, based on a classification of Sentinel2a imagery in Google Earth Engine.

The feedback received from stakeholders was extremely valuable, and important knowledge-sharing relationships were built at both workshops, and will guide our research going forward. In the Berg-Breede, slightly shorter timeframes for ecological infrastructure investment scenarios were deemed more relevant (5, 10, 20 years), whereas in the uMngeni stakeholders felt that 20-25 years would be more useful from a planning and policy perspective.

One of the main lessons learnt through this transdisciplinary workshop process is that it is not easy for researchers to get private sector investors into the same room as implementors and government investors. This is a critical recommendation for

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future projects. The SEBEI team has since adapted and initiated an additional parallel process of engaging with high-level private sector investors around similar questions. The third round of SEBEI workshops will be held on 20 November 2019 in the Berg-Breede catchment, and 22 November 2019 in the uMngeni catchment, and the SEBEI team encourages stakeholders to use this opportunity to participate in this interactive engagement with the project team to strengthen the case for investment into ecological infrastructure.

South Africa's strategic water source areas

South Africa's strategic water source areas are areas of the country that have recently been identified to be the most important in generating surface water and groundwater for the country's consumption. Collectively the strategic water source areas produce 50% of South Africa's mean annual runoff, but cover only 8% of the surface area of the country. It is recommended that the strategic water source areas of the country are protected and restored, as this is of direct benefit to all downstream users, who are dependent on the water resources provided by this critical ecological infrastructure.

Alanna Rebelo

Relatively pristine ecological infrastructure: Palmiet Wetlands in the Riviersonderend River of the Breede Catchment.

We are confident that the SEBEI project, with the help of both investors and implementors, will be able to produce a useful proto-type investment case that will assist in securing adequate investment into ecological infrastructure in South Africa in the future. This is one step in the right direction to becoming a more resilient society in the face of the risks and uncertainty associated with anthropogenic climate change and water security.

The SEBEI project in context

The SEBEI (Socio-Economic Benefits of Investing in Ecological Infrastructure) project links with several other important projects on a similar theme in both the Berg-Breede and the uMngeni catchments. Here we give a brief overview with a focus on policy-related projects, but do not include all the related research projects, of which there are many.

In ***both catchments***, SEBEI investigates similar questions to the SANBI GEF6 project entitled: "EI for Water Security". However, the GEF6 project dovetails well with SEBEI, as it undertakes no research, but focusses on policy and capacity development incentives for mainstreaming biodiversity and ecosystem values into national, regional and local development policy and finance in the water sector.

In the Berg-Breede, another important project is that developing an Ecological Infrastructure Investment Framework (EIIF) for the Western Cape by DEADP Western Cape Government and the CSIR. SEBEI is working closely with this project to share insights. Additionally, there is The Water Fund in the Western Cape (The Nature Conservancy), which SEBEI is attempting to engage with, which puts forward a Business Case for ecological infrastructure restoration as a critical component of efforts to enhance water security for all users of the Western Cape Water Supply System. SEBEI also attempts to attend and engage with the Freshwater Forum, which is a collaborative platform on ecological infrastructure related matters in the Western Cape.

In the uMngeni, the most notable project is the uMngeni Ecological Infrastructure Partnership (UEIP) led by SANBI. The UEIP coordinates ecological infrastructure projects and integrates ecological infrastructure solutions to support built infrastructure investments in addressing challenges of water security in the uMngeni catchment. An important research project in the uMngeni that SEBEI interfaces with, is the GEF5 project on Biodiversity & Land-use with the aim to ensure that biodiversity continues to provide essential ecosystem services to municipal residents.

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WATER AND SOCIETY

Exploring the socio-hydrological assessment of two small municipalities in the Western Cape

An interdisciplinary study is exploring how small municipalities are adapting to water scarcity, and what lessons can be applied to other settings facing similar water crises. Article by Germaine Owen, Amber Abrams, Kirsty Carden, Sue Harrison, Callies Selala & Bernelle Verster.

A roadsign warns of drought conditions in 2017 outside Malmesbury, one of the towns managed by the Swartland Municipality.

Water scarcity is widespread globally, and is increasingly a major concern in Southern Africa. The Western Cape is no exception; its recent multi-year drought has sparked considerable reaction and adaptation. The impact of water scarcity is influenced by location, including both region and nature of settlement.

To develop our understanding of this at the scale of small municipalities, and in collaboration with the South African Local Government Association (SALGA), we conducted a socio-hydrological assessment of water management in Prince Albert and Swartland municipalities over the winter (May to July) of 2018. In addition to understanding how municipalities have adapted to water crises, the study was also an exploration of interdisciplinary research processes and methodologies in order to understand different perspectives of a given context, and to identify lessons for other interdisciplinary studies.

Following desktop reviews, two-day visits to each municipality were carried out by a research team from the Future Water research institute at the University of Cape Town. These visits followed a mixed methods approach of focus group discussions, transect walks, semi-structured interviews, and observations, with target respondents from the municipality, nature conservation, community groups and farmers, as well as the education, media, tourism, and local business sectors.

Questions drew on different themes ranging from technical aspects, such as water supply, wastewater and solid waste infrastructure and management to the socio-relational aspects of water scarcity, including drought impacts and emerging

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responses, coping and adaptation mechanisms, tensions, health concerns, cooperation (social cohesion), equity and economic concerns, and reflections on the municipality's public engagement processes.

This article discusses some of the prominent themes that emerged in this study, with particular reference to the recent (2016 to 2018) drought. The discussions present context-specific scenarios on the water-supply situation and alternative measures in place or envisioned in these municipalities. Further, adaptation measures adopted, people's responses to these, and recommendations by the research team for building resilience in these towns are presented.

Water supply in the Prince Albert and Swartland municipalities

The Prince Albert Municipality is one of three municipalities in the Central Karoo District, with Prince Albert town, in particular, regularly experiencing issues of water scarcity. Some areas of the district, such as Klaarstroom, Leeu-Gamka, and Prince Albert Road are reliant on groundwater. While water availability is a concern for all, for Klaarstroom residents, in particular, the focus is more on water quality. Prince Albert town itself sources the bulk of its water from groundwater (nine boreholes), with surface water from the Dorps River supplementing supply.

Surface water is allocated such that the formal agricultural sector receives about 66.7%, via concreted furrows known as ***leiwater***, while the municipality is allocated 33.3% for residential purposes. The North-End community relies only on municipal water through in-house tap connections, with no ability to draw on the ***leiwater*** system. Surface water supply in Prince Albert town is managed by the Kweekvallei Irrigation Board, which operates as the water users association in the area.

An assessment of the available hydrological information suggested that infrastructural capacity within the town does not meet the demand for both water supply and wastewater treatment at present. There are difficulties with monitoring the flow of water into the town, resulting in uncertainty around supply volumes. The municipality has proposed the building of a dam well as the development of an artificial groundwater recharge system in Prince Albert town and Klaarstroom to boost water supply in the area. The need for more water storage capacity (i.e. reservoirs) was a widely discussed theme among most interview respondents.

The Swartland Municipality falls within the Berg-Olifants Water Management Area and receives the bulk of its potable water from the West Coast District Municipality (WCDM), served by the Berg River (as the main water supply), through the Swartland and Withoogte distribution systems. Both of these bulk distribution schemes are cross-border schemes that supply water to the Swartland Municipality and two other municipalities. There are eight distribution systems: six, including Malmesbury and environs, are fed through the Swartland system and two from the Withoogte system.
The main challenge for water supply is the augmentation of existing water sources from the WCDM. The immediate priority intervention is to implement a water demand and pressure management programme, including replacing old and damaged pipe networks to minimise water losses; this will also help to reduce high water bills amongst residents. Alternative water augmentation options, such as groundwater, rainwater harvesting, water reuse for potable and non-potable uses etc. are also being investigated for different areas in the Municipality.

Drought impacts

The impacts of the 2016-2018 drought in the Western Cape – reported as one of the worst on record – were widely experienced. Community members from the North-End of Prince Albert, for example, expressed that "there isn't enough water for everyone" and "it is difficult at home." One dairy farmer in the South-End of Prince Albert had to reduce the number of animals in her dairy herd from 50 to 25 to adapt to the crisis, with related financial losses.

The Zwartberg High School in Prince Albert reported poor hygiene conditions at its facilities, and learners were anecdotally reported to have "stomach bugs" as a result of water shortages. Financial losses were noted from poor harvest of lucerne. Existing long-lived shrubs at the Wolwekraal Nature Reserve succumbed to the shortage of water and the adjacent river dried up. The impacts of the drought also exacerbated social differences, highlighting the ways in which people in the North-End and South-End communities were affected by and adapted to the drought. The South-End community is perceived to have coped better than the North-End community because of their ***leiwater*** allocation which enabled upkeep of their pools and gardens.

This dichotomy raised the issue of water rights in the area which is embedded in the socio-politics of this region, as historically, properties in the South-End were allocated ***leiwater*** via their title deeds. Some of these residents suggested that their water rights were being violated because they have been asked to

Prince Albert town leiwater system passing in front of Zwartberg High School.

give a certain percentage of 'their' water to the municipality. The study highlights the need to urgently redress the issue of equity of water supply in the town, and recommends establishing dialogue through a task team of different stakeholders in order to discuss the redistribution of resources to mediate historic injustices.

Through using an interdisciplinary lens, the research team was also able to identify differentiated views linked to environmental risks with potential consequences for the environment and water availability in Prince Albert. There is a perception that the solid waste disposal site located near the nature reserve is negatively impacting the Dorps River, groundwater and the nature reserve through leaching of pollutants or through contaminated runoff.

The municipality, while confirming there are challenges at the landfill site, reported that there is no proof of pollution of the river and adjacent land. Dialogues between the municipality and interested persons would provide a constructive way forward around this. Safety concerns linked to the discharge of treated and untreated effluent from the wastewater treatment works into the nature reserve were also raised as a perceived threat, as well as potential negative impacts on the plant species that are endemic to the reserve. The municipality confirmed that treated effluent consistently meets irrigation standards as per the requirements of their discharge permit, but this study recommends further consultation between the municipality and concerned stakeholders to address these concerns.

The agricultural sector in Swartland was particularly affected by the drought, and the largest tourism event in the area – the Riebeek Valley Olive festival – was cancelled in 2018 because of very low olive production yields, with related financial losses. One of the farmers described the drought ***as*** "unheard of". One resident of Swartland municipality reported that "the whole process (drought) has actually been quite a shock." Small businesses, such as car washes, were also affected by the drought, and there were agricultural job losses, which heightened concerns about persistent droughts. A recurring theme among town dwellers and people living in farmlands was fervent praying for rain, not unlike that experienced in the Prince Albert Municipality. This could be viewed as social cohesion, empathy and understanding emerging from shared experiences and similar responses.

Methods of adaptation

During the drought, the two municipalities used different platforms to communicate the issue of water scarcity to their residents and the need for water conservation. In Prince Albert, the municipality set water restrictions of 90 ℓ per person/day, and information on the drought was circulated through social media, the local newspaper, the ***Prince Albert Friend,*** and radio, a dedicated SMS system, and ward committee meetings.

Further public engagement was made possible through the ***Drop the block*** campaign, which entailed encouraging residents to insert dense plastic blocks into toilet cisterns to reduce the amount of water flushed. For the most part, residents adhered to water restrictions and used alternative water sources (such as greywater) for flushing toilets and watering gardens. This indicated some level of cooperation at the interface between the municipality and its residents as a result of public engagement processes, and highlighted good practice for other municipalities to follow. However, it was also noted that some community members did not adhere to water restrictions and felt entitled to exceed their water allocation as rate payers. This reinforces the importance of communicating information on water scarcity and its impacts earlier to the public as well as providing reasons for water restrictions as remediation to the water crisis.

In the Swartland Municipality, the approach adopted to manage the crisis was three-pronged: technical (flow usage, pressure management etc.), financial (tariffs) and social (restrictions and awareness campaigns). The restriction of water usage to 50 ℓper person/day was successful in raising drought crisis awareness. Information campaigns on the drought were also run through public meetings and on social media with a dedicated Facebook page, as well as through the use of tools such as flyers, banners, notices, and bookmarks.

Cooperation in these campaigns was evident through people using greywater for gardens and flushing toilets instead of using freshwater, and in people switching from showering to using basins for bathing. In the township of Ilinge Lethu, car wash owners adapted, for example, by sourcing borehole water from the West Bank farmers and using rainwater collected in rainwater tanks.

Farmers adapted to the crisis by implementing zero till planting, which allows seeds to be planted regardless of how dry the soil is. Good adherence to water restrictions was confirmed through monitoring of water usage by the municipality, although there were some incidences of non-compliance (e.g. the prison facility). Whilst some Ilinge Lethu community members suggested that the municipality had not planned ahead properly, there was a general sense that the drought had raised awareness on the importance of conserving water, with some residents suggesting this as a positive outcome.

The tourism sector noted that visitors to the area had generally complied with the water restrictions although had found them a "hard pill to swallow" in the beginning. The drought encouraged people to be creative in finding additional water saving tips; the ways in which people shared these with others (e.g. through Facebook) was a positive outcome, indicating an emerging sense of social cohesion in the face of the crisis.

In conclusion, the interdisciplinary processes and methodologies have provided an opportunity to learn different aspects of a given context, as well as what aspects to build on in future studies of this nature. This study highlights opportunities both for the expansion of water supplies through alternative sources and for addressing efficiency of water use and water savings.

In both municipalities, local residents and communities found ways to cope with water scarcity, the majority of people adapted to water restrictions and engaged with communication and public awareness campaigns on the importance of saving water. However, ongoing education on issues of water scarcity and public responses is necessary. The study offers recommendations to encourage multi-faceted collaborative action around water scarcity, so that municipal officials, local professionals, and residents actively engage in addressing and finding solutions for managing all water related matters in their local area.

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THE WATER WHEEL

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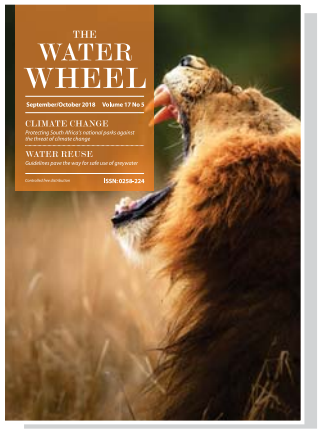

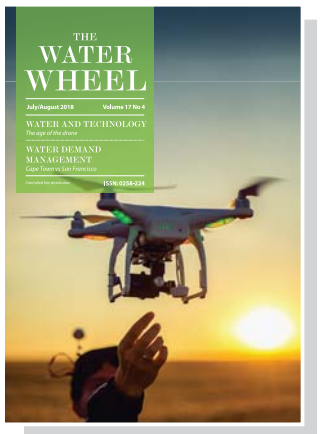

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WETLANDS

Extinguishing subsurface fires in peatlands with the sprouting water pressure method

A new methodology has successfully been applied to deal with peatland fires in the Western Cape. Article by Piet-Louis Grundling (Working for Wetlands), Althea Grundling (Agricultural Research Council – Soil, Climate and Water), Liezl De Villiers (Overstrand Municipality) and Heidi Van Deventer (CSIR).

Globally, peatlands (wetlands with high organic substrates or peat) are under pressure, with peat fires ranging from the tropics in Indonesia since the 1990s to the latest peat fires reported in the Arctic in *the Economist* of 3 August 2019. According to the publication, the peat fires are a manifestation of climate change, and therefore likely to increase in future.

The occurrence of several subsurface fires in peatlands across the country has been reported by conservation agencies and environmentalists during the recent regional drought. Excessive water abstractions, combined with droughts, have resulted in fires burning the substrate of the peatlands, and consequently reducing their functionality (ecoservices) such as a resource for grazing and cultivation, biodiversity as well as water storage, baseflow maintenance and carbon sequestration.

Peatlands are unique wetland systems that sequester large amounts of soil carbon. The global carbon stored in peat is estimated to be in the order of 500 billion tons, approximately 30% of the world's soil carbon (more than that of forests); as well as storing 10% of the world's freshwater.

Peat forms as substrate in wetlands under permanent saturated conditions, capturing and storing atmospheric carbon through wetland vegetation, resulting in a positive carbon balance. However, water abstraction, draining and erosion in peatlands result in unstable water levels, desiccation of peat and the inability to sequester or store carbon, resulting in degraded wetlands becoming nett releasers of carbon. In semi-arid regions such as southern Africa, peatland degradation is mostly caused by the interruption of groundwater and / or interflows from hill slopes, by water abstraction, forestry and invasion by alien plant species. Forestry in the catchments of peatlands in semi-arid landscapes is of special concern as it negatively affects peatland hydrology. Furthermore, erosion due to altered runoff often results in gully formation and draining of peatlands.

Photo supplied

An uncontrolled veld fire, combined with drought conditions, caused the burning of the Onrus peatland, in the Western Cape.

A combination of droughts and over-extraction of groundwater may also lead to the desiccation of peat. Desiccation cracks form when the peat dries out and, if the substrate is ignited either through lightning or planned surface burns, such surface fires will spread along these cracks into the peat subsurface. The heat generated by burning peat can be in excess of 400 °C, and can subsequently cause the subsurface moisture in deeper layers of the peat to rapidly evaporate.

Depending on the depth of the substrate of the peatland, such a fire can smoulder for months below the surface of the peatland. The intensification of drought conditions across South Africa and a continuous drop in groundwater levels resulting from water use and no recharge is likely to increase the prevalence of peat fires.

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It is critical that the incidences of peat fires are avoided completely through the proper management of water sources. Avoiding the severe drop of water levels in peatlands reduces the costs of intervention, damage to the surrounding landscape and loss of ecoservices.

Should a desiccated peatland be ignited, the most effective way of arresting the peat fires is to literally construct a dam wall downstream of the fire and then to flood the fire out. This is obviously not always feasible as a wall is expensive, and during a drought the volume of water required may not available. Previously the only other viable way to prevent a peat fire from spreading was to isolate the fire by trenching through the peat and allowing the affected peat to burn out. This is a destructive intervention that requires costly rehabilitation afterwards. However, recently a revolutionary effective, but simple, technique was applied by Working on Fire (WoF) to extinguish a peat fire in the Onrus wetland.

Onrus peatland fire

The Onrus wetland is located close to Hermanus, in the Western Cape. The wetland consists of an unchannelled valley-bottom wetland, with the vegetation cover comprising mostly endemic palmiet (***Prionium serratum***).

Palmiet wetlands are endemic to the coastal provinces of South Africa; are estimated to comprise less than 10% of South Africa's wetlands and are considered globally unique in their distribution. Palmiet peatlands are generally associated with valleys with a broad U-shaped floor in the Cape Fold Mountains with the peat, characterised by a high sand content, underlain by rocks. The Onrus peatland contains a peat layer of more than 7.25 m thick, dominated by a lower 4 m-thick sedge layer with a basal sand and not bedrock layer, which makes it unlike other palmiet systems elsewhere in South Africa.

This system is under severe threat of further degradation as it has been drained for agricultural purposes for the past 70 years and experienced sediment losses and geomorphological changes to its channel as a result of natural and accelerated erosion processes. Consequently, the peat has become desiccated, and alien invasive plant species have started to colonise degraded parts of the wetlands.

An uncontrolled veld fire ignited the desiccated peat on 11 January, resulting in sub-surface and occasional surface fires. Several attempts were made by the Overstrand Fire Service Department to extinguish the hot spots, with little or no success due to sub-surface burning.

On 1 May, a team of WoF was deployed on site to support the Overstrand Municipality in controlling and extinguishing the fire. The highly effective technique applied by WoF to extinguish this peat fire is a spike branch spray (sprout), which was developed in 2018 by Martin Bolton (a peat fire specialist) during his work in fighting peat fires in Indonesia. The spike branch is a pipe with holes (a sprout) that sprays water under pressure below the peat surface to rewet the peat in order to dose /suppress peat fires. Desiccated peat is hydrophobic and can therefore not be rewetted from the surface. Quite often water runs off along desiccation cracks into either adjacent drains/dongas/streams without rewetting the peat below the surface.

The spike branch spray approach is time-consuming, but effective in winning the fight against the subsurface fire, since it wets the peat below the surface, and allows it to cool down, effectively dosing the fire by drowning it. The treatment consists of two spikes and a nozzle spray working on a 10 x10 m grid, which treats (dosing/extinguishing) the subsurface fire for an extent of 1 m^2 at a time to a depth of 1.5 m.

Initially, progress is relatively fast, but it slows down at areas where the heat is intense. Spots of up to 400 °C have been measured just below the surface, therefore the heat can be four times higher with an increase in depth. Three intervention campaigns were implemented from the ignition of the substrate, until the fire was suppressed on 21 June.

To date, the WoF teams have not sustained any injuries, which could be attributed to excellent planning, proper training and the technique that wets the peat subsurface.

The primary objective of further intervention in the Onrus fire at this point in time is to curb the spread of the underground fire. However, the rehabilitation of the peatland will be part of a long-term, multiple departmental and integrated approach, which will require political will, funding and administrative support across a number of phases:

- Phase 1 was initiated to ensure that the fire is extinguished by means of the WoF techniques.
- Part 2 of the objective of Phase 1 would be to stabilise the head-cut erosion moving towards the pristine part of the wetland (Working for Wetlands is in the process of submitting an operational plan for this purpose). This phase needs to happen as a matter of urgency to ensure that the head-cut does not cause further damage to the system.
- Phase 3 is the rehabilitation plan, a planned catchment–to–coast project, which should include all the different aspects required for the restoration of the system. The rehabilitation Plan will require further investigation and specialist input for a long-term management plan of the Onrus River Peat Wetland System.

On 21 June, the WoF teams officially declared their work on the site as completed. The Overstrand Municipality's Environmental Section and Fire Department then monitored the wetland every morning until the end of July to ensure that any visual re-ignition of the fire was observed.

At the time of writing, Rob Erasmus from Enviro Wilfire was also monitoring the site through a drone, which is equipped with a heat sensor camera, or FLIR imagery, to locate any underground fires. He was taking imagery every two weeks of the site until it was considered stable and secure.

Protecting peatlands in South Africa

Peatlands are poorly protected in South Africa. It is estimated that between 30% and 50% of the extent of peatlands are located within the iSimangaliso Wetland Park on the east coast

C de Kella/Working for Fires

1. The spike branch spray approach involves a spike that sprays water along its length and can penetrate the hardened dedicated peat crust (top layer).

2. The spike rewets the dedicated peat along its length in a 360 spray as it penetrates the peat.

3. The method cools down the peat effectively by drowning it.

of the KwaZulu-Natal Province. This protected area includes three Ramsar sites, namely, Kosi (estuarine, lakes and swamp forests), Lake Sibaya (a freshwater lake or limnetic depression) and the Lake St Lucia System (lakes, estuary, wetlands, mires and swamp forests).

The Kruger National Park hosts the Mahlapanga and Mfayeni Hot Spring Mires, whereas the Marakele National Park (Limpopo Province) also includes peatlands. Some peatlands also fall in another four of South Africa's Ramsar sites, including Verlorenvlei, Drakensberg, Ntsikeni, and the Marion and Prince Edward islands). The efficacy of protection is, however, constrained by a lack of knowledge on several aspects of wetlands, such as the extent of wetlands in South Africa, which of these are peatlands, and the ecological status of all wetlands in order to determine their management and conservation requirements.

In addition to the uncertainty, poor enforcement of relevant environmental legislation and policies and a lack of quick and effective response to disaster events, is hampering the protection of wetlands, and peatlands, in particular. Furthermore, most of the peatlands in semi-arid regions are dependent on sustained groundwater and/or hillslope intermediate flows. Consequently, their management should consider both catchments and the associated landscapes as part of an integrated strategy to manage and conserve these peatlands.

Not only should land use practices within the peatland and adjacent to it be managed, but also in related catchments; and especially those that could impact on the water and sediment balance of a peatland. Lastly, since most peatlands occur in rural areas, a precautionary rule should be to limit any activities that could jeopardise the integrity of peatlands, while stipulations of authorisations, in terms of the relevant legislation, must be strictly adhered to, while monitoring and compliance enforcement by the relevant authorities should be executed continuously.

In the past three decades, the application of wetland management has been undertaken through several legislative mechanisms, including the Conservation of Agriculture Resources Act (CARA, Act 43 of 1983), the National Environmental Management Act (NEMA, Act 28 of 2008), the Environmental Impact Assessment (EIA) policy and Water Use Licence Authorisations (WULA) regulations 21c and 21i of the National Water Act (Act 36 of 1998).

These interventions have resulted in a number of positive outcomes, namely:

- Limited granting of commercial wetland cultivation authorisations, resulting in increased protection of the peatlands;
- EIAs and WULA regulations which had been enforced on any peatland-related impacts and consequently resulting in a decrease of development and dams being built within or upstream of peatlands;
- The prohibition of peat extraction authorisation for agricultural purposes; and
- A decrease in afforestation and mining authorisations within and upstream of peatland.

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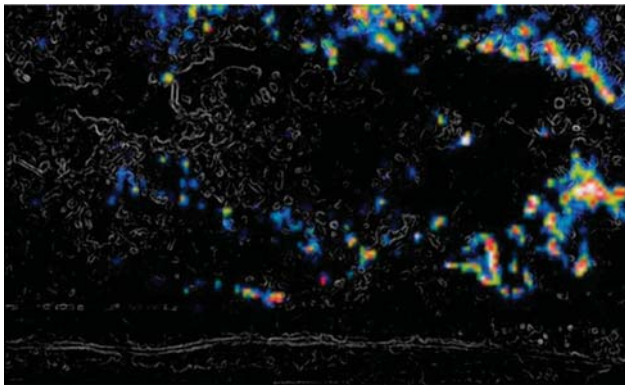
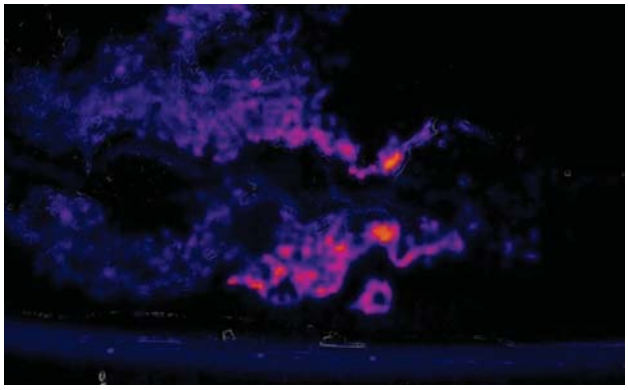
All images supplied

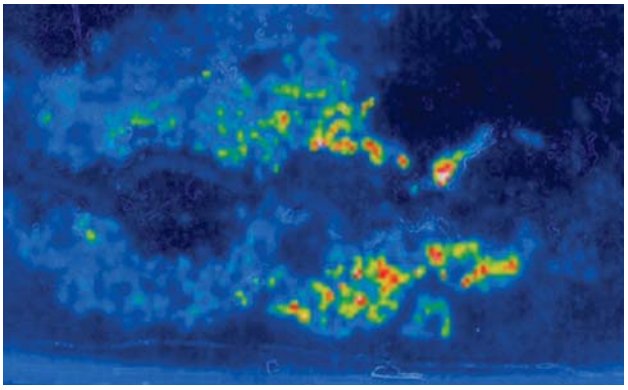
Aerial photograph for 8 February 2019 showing the burnt surface areas of the desiccated peatland areas.



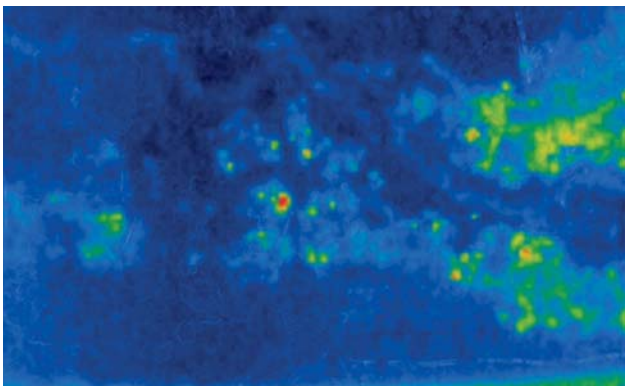
Thermal imagery for 8 February 2019 showing the sub-surface fire areas of the desiccated peatland areas.



Thermal imagery for 5 March 2019 showing the sub-surface fire areas of the desiccated peatland areas as the sub-surface fire intensifies.



Thermal imagery for 18 March 2019 showing the sub-surface fire areas of the desiccated peatland areas with 2 major intense fronts.



Thermal imagery for 18 March 2019 showing the sub-surface fire areas of the desiccated peatland areas with some intense hots spots.

These successes illustrate that the intervention effort through legislation, policy and enforcement is critical, and should be continued. Peatlands, as do all wetlands, do not occur in isolation, and are an integral part of and connected to terrestrial and wetlands components of broader landscapes. Changes in any part of a catchment will likely impact on wetlands within the catchment, but more so those that are downstream of the impact. The cumulative effect of poor protection and compliance, climate change and increasing demand for water (surface and ground) will ultimately determine the fate of our peatlands.

Conservation management should take note of modern advances in sustainable utilisation of carbon stores, including rewetting of peatlands, wise use practices, paludiculture (the practice of crop production on wet soils, predominantly occurring on peatlands), and carbon trading in order to secure the long-term storage capacity of wetlands. The dearth in knowledge on the distribution of peatlands in South Africa, their ecological and conservation status as well as their functioning generally result in poor management, a lack of a coherent national conservation strategy and response to pressures.

Consequently, peatland management actions in South Africa should focus on a number of priorities, including (but not limited to) location and mapping the country's peatlands; determining their ecological condition; taking proactive steps to conserve the most pristine peatlands; and controlling the use of these wetlands.

In conclusion, the authors recommend the following three top priorities for addressing the negative impacts on South African peatlands:

- A complete peatland inventory and status assessment (determining their present ecological state);
- Enforcement of legal compliance, extension and control in the use/exploitation, especially in the forest plantation industry, agriculture and water supply to municipalities; and
- A disaster response protocol for peatlands in peril: prevent and control peat fires as well as rewet degraded sites; arrest erosion.

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SMALLHOLDER FARMING

Creating climate change resilient communities Part 1: Community climate change adaptation process design

A current Water Research Commission (WRC) project is assisting smallholder farmers to better adapt to the challenges brought about by climate change. Article by Erna Kruger.

More extreme weather patterns with increased heat, decreased precipitation and more extreme rainfall events; increase of natural hazards such as floods, droughts, hailstorms and high winds that characterise climate change place additional pressure on smallholder farming systems. This has already led to severe losses in crop and vegetable production, and mortality in livestock. Smallholders are generally not well prepared for these more extreme weather conditions and experience high levels of increased vulnerability as a consequence. A significant proportion of smallholders have abandoned agricultural activities and this number is still on the increase.

It is becoming clear that climate change will have drastic consequences for low-income and otherwise disadvantaged communities. Despite their vulnerability, these communities will have to make the most climate adaptations. It is possible for individual smallholders to manage their agricultural and natural resources better and in a manner that could substantially reduce their risk and vulnerability generally and more specifically to climate change. Through a combination of best bet options in agro-ecology, water and soil conservation, water harvesting, conservation agriculture and rangeland management a measurable impact on livelihoods and increased productivity can be made.

Processes such as collaborative, participatory research that includes scientists and farmers, strengthening of communication systems for anticipating and responding to climate risks, and increased flexibility in livelihood options, which serve to strengthen coping strategies in agriculture for near-term risks from climate variability, provide potential pathways for strengthening adaptive capacities for climate change.

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Mahlathini Development Foundation, its partners and collaborators (including universities, non-government organisation, corporate social investment initiatives, district and local municipalities and government departments), have been working within the socio-ecological and social learning space to assist smallholder farmers in KwaZulu-Natal, Limpopo and the Eastern Cape to improve their resilience and adaptive capacity to climate change by designing and testing a participatory smallholder level decision support system for implementing climate resilient agricultural practices.

Within this process smallholder farmers explore and analyse their understanding of climate change and the impacts of these changes on their livelihoods and agricultural systems. They explore adaptive strategies and measures (local and external), prioritise appropriate practices for individual and group experimentation and implementation, assess the impact of these new practices and processes on their livelihoods and re-plan their actions and interventions on a cyclical basis.

This allows them to make incremental changes over time in soil and water management practices, cropping and livestock management and natural resources management, within the limits of their own resources, vision and motivation. This provides a viable model for CCA implementation and financing at smallholder level.

Recent participatory impact assessments have shown remarkable improvements in resilience in the space of just one to two years of focussed local action.

The WRC-funded adaptive research process entitled 'Collaborative knowledge creation and mediation strategies for the dissemination of water and soil conservation practices and climate smart agriculture in smallholder farming systems' is exploring best practice options for climate resilient agriculture for smallholders. The project is also evaluating the impact of implementation of a range of these practices on the resilience of agriculture-based livelihoods.

Alongside this, a decision support methodology and system has been designed to assist smallholders and the facilitators who support them to make informed and appropriate decisions about choices of a 'basket of options' for implementation at a local level.

The research process is broadly divided into three elements for purposes of clarity, although all three elements are tackled concurrently:

- Community climate change adaptation process design
- Climate resilient agricultural practices and
- A decision support system

This article focuses on the design of the community level process.

The community climate change adaptation process design broadly comprises:

- Situation and vulnerability assessments; baselines and farmer typologies
- Climate Change dialogues; Exploration of climate change impacts, adaptive strategies and prioritisation of adaptive measures and
- Participatory impact assessments: Resilience snapshots

(The vulnerability and participatory impact assessment methodologies will be discussed in two follow-up articles)

Climate change dialogues

A participatory methodology has been developed to allow groups of farmers to explore the impacts of climate change, potential adaptive strategies and to prioritise local adaptation measures. Seven community level workshops have been conducted across three provinces, involving around 250 participants. Table 1 provides a summary of this community level analysis.

Climate change impacts on livelihoods and farming			
	KwaZulu-Natal	Eastern Cape	Limpopo
Water	Less water in the landscape; streams and springs dry up, borehole run dry, soils dry out quickly after rain	Less water in the landscape; streams and springs dry up, borehole run dry, soils dry out quickly after rain	Less water in the landscape; streams and springs dry up, borehole run dry, soils dry out quickly after rain
	Dams dry up	Dams dry up	Dams dry up
	Municipal water supply becoming more unreliable	Municipal water supply becoming more unreliable	Municipal water supply becoming more unreliable
			Need to buy water for household use – now sometimes for more than 6 months of the year
			RWH storage only enough for household use.
Soil	More erosion	More erosion	More erosion
	Soils becoming more compacted and infertile	Soils becoming more compacted and infertile	Soils becoming more compacted and infertile
			Soils too hot to sustain plant growth
Cropping	Timing for planting has changed- later	Timing for planting has changed- later	Can no longer plant dryland maize
			All cropping now requires irrigation – even crops such as sweet potato

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Climate change impacts on livelihoods and farming			
	KwaZulu-Natal	Eastern Cape	Limpopo
Cropping			Drought tolerant crops, such as sorghum and millet grow, but severe bird damage
	Heat damage to crops	Heat damage to crops	Heat damage to crops
	Reduced germination and growth	Reduced germination and growth	Reduced germination and growth
	Seeding of legumes becoming unreliable	Seeding of legumes becoming unreliable	Seeding of legumes becoming unreliable
	Lower yields	Lower yields	Lower yields
			Winter vegetables don't do well – stress induced bolting and lack of growth
	More pests and diseases	More pests and diseases	More pests and diseases
	Loss of indigenous seed stocks		Loss of indigenous seed stocks
Livestock	Less grazing; not enough to see cattle through winter	Less grazing; not enough to see cattle through winter	Less grazing; not enough to see cattle through winter
	More disease in cattle and heat stress symptoms	More disease in cattle and heat stress symptoms	More disease in cattle and heat stress symptoms
	Fewer calves	Fewer calves	Fewer calves
	More deaths	More deaths	More deaths
Natural resources	Fewer trees; too much cutting for firewood	Fewer trees; too much cutting for firewood	Fewer trees; too much cutting for firewood
	Decrease in wild animals and indigenous plants	Decrease in wild animals and indigenous plants	Decrease in wild animals and indigenous plants
	Increased crop damage from wild animals such as birds and monkeys	Increased crop damage from wild animals such as birds and monkeys	Increased crop damage from wild animals such as birds and monkeys
	Availability of indigenous vegetables has decreased		No longer able to harvest any resources due to scarcity
			Increased population puts pressure on resources
Social	More diseases	More diseases	More diseases
	Increased poverty and hunger	Increased poverty and hunger	Increased poverty and hunger
	Increased crime and reduced job opportunities	Increased crime and reduced job opportunities	Increased crime and reduced job opportunities
			Increased food prices
			Increased conflict
			Inability to survive

Table 1: Summary of climate change impacts from community level workshops (2018)

Although the impacts discussed were similar across the three provinces, the severity of these changes are a lot more obvious in Limpopo.

From these impact diagrams community members discuss adaptive measures and strategies; what they have already tried and what they would like to try. Here the new ideas or innovations can then be introduced by facilitators, as they are requested by the community members. Table 2 is illustrative and includes the adaptive measures suggested by the participants in Turkey village (Lower Oliphant's' Basin – Limpopo).

Turkey CC workshop; December 2017			
Impacts	Description and linkages	Outcomes	Potential adaptive measure
Reduced water availability	Dams dry out, boreholes provide less water, rivers dry out, less rain	Reduced production, hunger, diseases, no jobs, poverty, crime, death	More boreholes, more dams, water management, irrigation in evenings and early morning, mulching, trench beds (keep moisture in and soil cool)
Drying of environment	Soils are hotter and drier, drought, plants wilt, increased pests		Save plant residues for animals, buy fodder, control pests on animals
Reduction of resources	Deforestation, Fruit trees die, livestock, wild animals die		Planting of trees after they have been cut down; make use of paraffin stoves and electricity, government involvement in solving the problem,
Extreme heat	Early fruiting, trees wilt	Poor crop health	Shade netting
Shortage of water	Rivers dry out, municipal supply only once per week. Boreholes dry out	Lack of education towards saving water	NGOs and government to assist Trench beds, mulching, save water in dams, drip irrigation, irrigate in evening, boreholes, greywater

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Turkey CC workshop; December 2017			
Impacts	Description and linkages	Outcomes	Potential adaptive measure
Reduction of resources	Less grazing, seed shortage, trees are removed, indigenous animals are no longer there	Increased vulnerability of the people, forced to move to urban areas	Donations for/of seed Rather use paraffin stoves than firewood. Only chop down mature trees to allow others to grow, planting trees, government intervention Taking care of indigenous plants Plant fodder for livestock
Soils	Poor cultivation practices, soil erosion, dry soils, sandy soils		Using crop residues and manure, conservation agriculture, mixed cropping
Social repercussions	Less or no food, health problems, no jobs	Burning of buses, divorce, separation of families, poverty, crime	Getting access to health care, parents must work
Shortage of implements			Setting up cooperatives for government support, use animal drawn traction- oxen and donkeys, improvise, make our own tools, make use of hand hoes

Table 2: An example of potential adaptive measures from the Turkey (Limpopo) climate change dialogue process

A list of specific practices is summarised from these discussions and categorised into the five climate resilient agriculture themes. An example is given below of this process conducted for a learning group from Ezibomvini Village in Bergville, KwaZulu-Natal.

Table 3 outlines the practices and their categories.

	Natural RM	Soil	Water	Crops	Livestock
Shade Cloth Tunnels			■	■	
Bed design		■		■	
Mulching		■	■		
Natural pest and diseases				■	
Rainwater harvesting			■		
Trench bed		■	■	■	
Composting		■		■	
Conservation Agriculture					
Fodder crops					■
Underground water tank			■		
Mixed cropping				■	
Conservation of wetlands and streams	■		■		
Burying of disposable pampers	■		■		
Reducing burning of grazing veld	■				■
Greywater use			■		

Table 3: Suggested practices for farmers, categorised into the 5 primary themes

Participants then prioritise these practices in order of importance for implementation and change as a group. This depends on local conditions such as drought, harsh weather conditions and the like.

The preference ranking for this group was as follows:

1. Underground rainwater harvesting tanks
2. Shade cloth tunnels
3. Trench beds
4. Mulching
5. Natural pest and disease control
6. Mixed cropping (fields and gardens)
7. Compost
8. Fodder crops
9. Conserving wetlands and streams

It is also possible here to do a matrix ranking exercise where you elucidate from the groups their criteria for prioritisation of practices, which is a very important step in the community-level decision making process.

This provides a broad action plan for implementation, which is developed further into an individual farmer level experimentation plan. Participants choose from these prioritised practices which ones they will try out in their own homesteads and devise a broad plan of how to intervene in the communal activities such as conservation of wetlands. This process provides a good agenda for securing external support from roleplayers in the development sector (government departments, municipalities, CSI- and NGO-funded projects).

In the next issue, we will explore all the CRA practices that have been implemented by the communities to date and the impact of these on their livelihoods.

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CAPACITY BUILDING

South Africa's journey to development via science, technology and innovation

Newly released report indicates progress and challenges to realise the potential of science, technology and innovation to meet South Africa's social and economic development goals. Article by Petro Kotzé.

Science, technology and innovation (STI) are seen as primary drivers of economic growth, job creation and social-economic reform in South Africa. In fact, the country's National Development Plan, a detailed blueprint for how South Africa can eliminate poverty and reduce inequality by the year 2030, places STI at the centre of its development agenda. STI is seen as a key enabler of the needed economic transformation, especially in light of the emerging Fourth Industrial Revolution (4IR), in which technologies and trends such as the Internet of Things (IoT), robotics, virtual reality and artificial intelligence (AI) are changing the way we live and work.

For more than two decades, the government's long-term approach for the STI sector was guided by the 1996 White Paper on Science and Technology. To keep pace with major shifts in global and local economies over the past 20 years the policy was recently updated, resulting in the release of the 2019 White Paper on Science, Technology and Innovation. This White Paper intends to increase the contribution of STI to address the socio-economic challenges faced by South Africa. New policy shifts relate to changes associated with the 4IR and enhancing the innovation culture in society and government, for example. It supports social and grassroots innovation, and increases the focus on inclusivity, transformation and linkages in the National System of Innovation (NSI).

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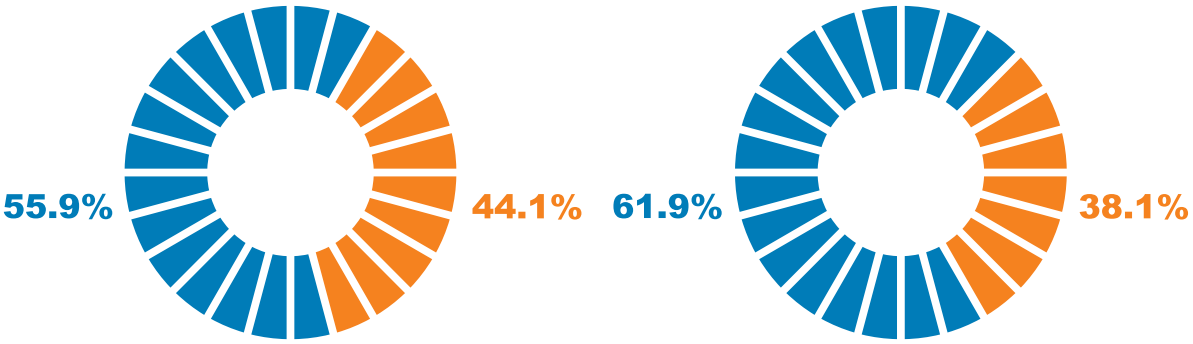
SOUTH AFRICAN FEMALE RESEARCHERS (2015/16)



RATIO OF MALE TO FEMALE RESEARCHERS
SOUTH AFRICA

RATIO OF MALE TO FEMALE RESEARCHERS
GLOBAL FIGURES

The NSI can loosely be described as a country's collective efforts to foster technological innovation, and includes the higher education system, private and public institutions. In his foreword to the 2019 White Paper, Dr Phil Mjwara, Director-General of the Department of Science and Innovation, remarks that though the NSI has shown good progress since the adoption of the 1996 White Paper, challenges remain. These include fragmented policies across government, and the need to expand partnerships with business, academia and civil society. Furthermore, the NSI is significantly underfunded, and the participation of black people and women at the highest levels (e.g. as professors) remains too low.

Progress towards meeting the goals of the White Paper is stipulated in indicator reports and, an updated analysis has just been released. The ***2019 South African Science, Technology and Innovation (STI) Indicators Report*** provides an overview of the performance of South Africa's NSI, and the state of science, technology and innovation in the country. Over and above, it evaluates the contribution of the NSI to achieving South Africa's development objectives.

A measure of STI progress

Dr Mjwara explains that the report is based on the South African Innovation Scorecard, a framework that consists of public sector activities (so called 'enablers'), firm activities in STI and outputs. "Most of the enablers that are monitored through the indicators report form part of the White Paper policy intents," he says. Dr Mjwara names examples of policy intents to include strengthening governance of public NSI institutions; expansion of the NSI; strengthening of government's role as enabler for innovation; upgrading and expansion of research infrastructure; and improvement of levels and efficiency of STI funding.

According to Dr Mjwara, the indicators report is also useful to monitoring policy intents related to the support for, and collaboration with, the business sector and the improvement of innovation to revitalize existing sectors (so-called firm-level STI activities).

Finally, says Dr Mjwara, the indicators report monitors the socioeconomic outputs related to the White Paper policy intents. These include the support of innovation for social and grassroots innovation and the adoption of a broader concept of innovation beyond research and development (R&D).

Key findings

The report findings are clustered into six broad categories. They are (1) research and development (R&D) expenditure; (2) STI human capital; (3) STI funding and support, scientific publications and patents, innovation and entrepreneurship, and (6) innovation for inclusiveness and social impact.

Key concerns raised by the report include that South Africa has lost its competitive advantage in terms of medium-technology exports when compared to the average of other upper middle-income countries. The country dropped from 44th to 67th position on the Global Competitiveness Index between 2007 and 2017, and from 38th to 58th position on the Global Innovation Index between 2007 and 2017.

The report notes that during the same period (2007 to 2017) Government significantly reduced the funding of business expenditure on research and development (BERD) from 21.67% to 3.07%. The report states that it is unclear if this reduction in funding is at the initiative of government or as a result of the slowing down of economic activity experienced by the business sector. "The latter might be the real situation as BERD, as a percentage of gross domestic product (GDP), decreased from 0.58% in 2007 to 0.39% in 2017. The deceleration of innovation at firm level resulted in a deterioration in the country's rankings in both the Global Competitiveness Index and the Global Innovation Index."

Another concern is the decline of private sector investment in R&D. As a result, South Africa did not reach its target of 1.5% of the country's gross domestic product (GDP) spent on research and development. Instead, spending reached only 0.82% (in 2016/17) regardless of government spending more on R&D than its allocated budget during the same period.

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Still, there were also plenty to feel positive about, as indicated in South Africa's performance in each of the specified categories:

Research and development expenditure

- South Africa's target of 1.5% gross expenditure on research and development (GERD) as a percentage of the country's gross domestic product (GDP) target is on par globally (though, as stated, it was not realized)
- Government funding of research and development (R&D) was more than its budget, but aggregate levels of gross private sector investment in R&D has declined in recent years

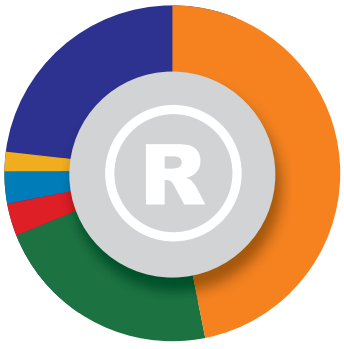
Science, technology and innovation human capital

- South Africa matches other upper middle-income countries in terms of the production of human capital capacity (formal qualifications), but lags behind in terms of the deployment, development and know-how of its human capital
- South Africa had a higher portion of female researchers than the global average. Locally, the ratio of male to female researchers is 55.9% (male) and 44.1% (female) in comparison to the global figures of 61.9% (male) and 38.1% (female)
- White researchers made up the largest portion at 50.5% with African researchers the second largest portion of 32.2%
- There has been a decline of South African researchers in the business sector, from 47.2% in 2008, to 36.1% in 2016. The projected figure for 2019 is even lower, at 29.3%
- Doctoral graduates have increased from 67.1% in 2008, to 54.7% in 2016 and then to 73.3% in 2017

Science, technology funding and support

- For the first time, government funding of R&D was more than its allocated budget. In the year 2016/17 government funding was R16 428 billion, in comparison to a budget of R14 851 billion.
- Government funding of R&D for the higher education sector is on the increase, rising from a share of 45% in 2010/11 to 56.1% in 2016/17
- Government funding for R&D for the business sector continued to decrease, dropping from a share of 9.6% in 2008/09 to 2.8% in 2016/17
- The total estimated number of business incubators in SA are 105, 57% of which are supported by the public sector

PROVINCIAL R&D EXPENDITURE 2016/17



Gauteng: **46.0%**
Western Cape: **23.3%**
Limpopo: **2.0%**
Mpumalanga: **2.0%**
Northen Cape: **1.5%**
Other provinces: **25.5%**

The NSI in practice

In his keynote address during the launch of the 2019 South African Science, Technology and Innovation (STI) Indicators Report, Mjwara highlighted some of the projects undertaken by the NSI that are contributing to the core long-term objectives of the new White Paper. Highlighted projects include:

- The Spatial Temporal Evidence for Planning in South Africa tool, or stepSA, developed by the CSIR. This decision-support tool provides an overview of regional scale settlement patterns, enabling the profiling of specific settlements and the analysis of demographic and economic trends of a set of settlements of a similar scale and type. The data supports planning for effective service delivery and the prioritisation of long-term, high-impact public investment in cities, towns and rural settlements.
- The Isidingo Drill Challenge is intended to encourage the design and prototyping of a new and innovative rock-drill concept to be used in deep-level mining. It is hoped that a substantially improved innovation will speed up the mining process, increase production, reduce energy waste and enhance worker safety.
- The development of lithium-ion battery packs for stationary and mobile energy storage applications with the company Maxwell and Spark. The batteries are cost effective, reduce carbon emissions and operate at lower noise levels than conventional energy systems.
- The possibility of battery technology to convert diesel-powered taxis to reduce the greenhouse gas emissions of the transport sector.

Scientific publications and patents

- South Africa experienced an increase in the number of scientific publications per million inhabitants during the identified period, from 192 in 2008 to 350 in 2017. This is more than the global average of 307
- South African scientific publications experienced an annual growth rate of 7% (between 2008 and 2017)
- For research areas related to the 4IR South Africa has the highest world share of scientific publications in AI and the IoT. We have a global share of 1.01% (AI) and 0.68% (IoT)
- South Africa is lagging behind the average patent applications per million inhabitants for upper middle-income countries. The global average is 592, but South Africa has seen a decline from 42 in 2008 to 38 in 2017. This has been highlighted as a concern, as forecasts would have the country remain at 37 patent applications per million inhabitants for a three year period, until 2020

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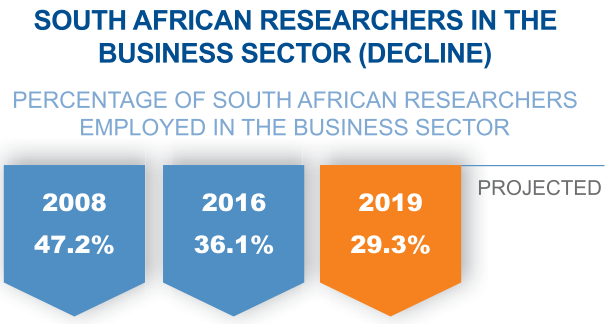
- The highest number of patents were granted to universities and science councils. In the past eight years was 38 was awarded to the CSIR and 31 to Wits

Innovation and entrepreneurship

- Several key institutions of the NSI are contributing significantly to the success of operation Phakisa (a government initiative to fast-track achievements related to the targets of the National Development Plan) across the areas of ocean economy, mining, chemical and waste and biodiversity economy
- South Africa has lost it competitive advantage in terms of medium-technology exports when compared to the average of other upper middle-income countries. The trend likely to continue beyond 2020, when South Africa is likely to rank below the lower middle-income countries in terms of the export of low-technology products

Innovation for inclusiveness and social impact

- South Africa is ranked 113th on the Human Development Index. This is relative to the average for upper middle-income countries (which is 90th). The cause is low ranking in life expectancy at birth component, where we are listed 161st out of 189 countries.
- Factors that prove challenging for South Africa's ranking on the Social Progress Index are personal safety (ranked 135th out of 146 countries), health and wellness (ranked 102nd) and nutrition and basic medical care (ranked 100th).
- The country also lags behind many world economies (including most low-income countries) in adopting renewable energy technologies for electricity production. This indicates the presence of carbon lock-in caused by abundance of relatively cheap coal deposits in the country.



STI for economic and social democracy

According to Dr Petrus Letaba, Senior Specialist STI Measurements and Evaluation for the National Advisory Council on Innovation (NACI), the results indicated by the reports can also be used as indicators of the success of South Africa's economic and social democracy.

"In terms of social democracy, the indicators report highlights key societal areas, derived mainly from the Social Progress Index and Human Development index," he says. Some of the social challenges highlighted by the report are our low ranking on the Human Development Index mainly as a result of our low ranking for short life expectancy at birth and, in terms of the Social Progress Index, our low rankings for personal safety, health and wellness and nutrition and basic medical care. Letaba says "the indicators report therefore highlight these societal challenges for potential solutions from the innovators, policymakers, entrepreneurs, inventors and scientists."

"On the economy, the indicators report recognises the role of small, medium and micro enterprises for upliftment of South African economy," explains Dr Letaba. "However, these companies often struggle to access the innovation value chain at the expense of large monopolies and oligopolies." According to Dr Letaba, these are covered in the report under issues such as technology-based incubators and entrepreneurial universities.

Dr Letaba says that as the indicators assess the performance of the South African NSI over time, they should be used as guidance for stakeholders in the public and private domains, and in other research institutions and the likes. The indicators highlight areas of progress that could be as a result of the success of current initiatives, policies and plans, he says. "The report also alerts to areas that warrant further intervention in order for the country to fully address the challenges facing society and economy," he says. "Some of these challenges may stem from a number of historic issues that need different transformative approaches in order to address them."

Sources:

- *2019 South African Science, Technology and Innovation Indicators Report, published by the National Advisory Council on Innovation*
- *2019 White Paper on Science, Technology and Innovation, published by the Department of Science and Technology*
- *The national system of innovation concept: an ontological review and critique, by Sibusiso T. Manzini for the CSIR*

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100-YEAR-OLD WASTEWATER TREATMENT PLANT STILL SERVING THE CAPITAL CITY

The oldest infrastructure at the Pretoria's Daspoort Wastewater Treatment Works might have been constructed more than a hundred years ago, but this has not prevented it from still providing an essential service to Pretoria.

South Africa's administrative capital was founded in 1855 and became the centre of government in 1910 during the founding of the Union of South Africa. By 1904, the population of Pretoria had reached nearly 40 000. At this time, the town engineer, HD Babcock, submitted the first plans for a sewerage system to the Town Council. Although his plans included a wastewater treatment plant, construction on the Daspoort Wastewater Treatment Plant did not start until 1913.

Completed in 1920 to the design of Town Engineer, F Walton Jameson, the plant is located on the banks of the Apies River, adjacent to the central business district, and today is one of ten sewage treatment plants serving the residents of Pretoria. The first works at Daspoort comprised screens, grit removal channels, primary sedimentation tanks (Dortmund tanks), 16 biological filtration units, and separate sludge digestion in rectangular tanks. The design capacity was about 9 Ml/day.

Although various improvements and extensions have since been made to the plant the original biological filters are still in use. The plant has a current capacity of 55 Ml/day.

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DEEPLY ROOTED IN SOUTH AFRICA WATER SOCIETY

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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