

THE WATER WHEEL

January/February 2019

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WATER HISTORY

In the footsteps of RJ Gordon

RESEARCH PARTNERSHIPS

*Flourishing research partnership pays off for
Western Cape tourist attraction*

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WATER
RESEARCH
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CONTENTS

- 04** **UPFRONT**
- 10** **WATER HISTORY**
Water history – In the footsteps of RJ Gordon Part 2
- 14** **RESEARCH PARTNERSHIPS**
Flourishing research partnership pays off for Western Cape tourist attraction
- 18** **DROUGHT MANAGEMENT**
Optimising risk-based drought restriction analysis
- 22** **ALIEN INVASIVE PLANTS**
Biological control agents help tackle water weeds in SA
- 27** **WETLANDS**
Pressures on the wetland hotspot regions of the Northern Cape
- 32** **GROUNDWATER**
Groundwater issues in digital news reports – A descriptive analysis
- 36** **WATER-ENERGY-FOOD**
Assessing the state of the water-energy-food nexus in South Africa
- 38** **LAST WORD**
Novel earth observation technology wins national prize

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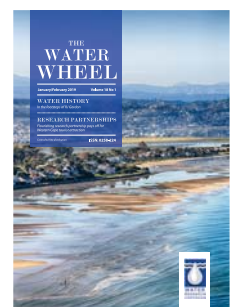
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*We follow the journey of
RJ Gordon and revisit the water
landmarks he came across.
Article on page 10.*



FLUID THOUGHTS

Water-energy futures



WRC CEO, Dhesigen Naidoo

South Africa is once again walking on the knife edge of an energy security crisis.

We, again, appear to be two steps short of continuous rolling blackouts in the most extreme scenarios of demand management. Diversification of the solution box is key to a more comfortable energy future. And in doing so thinking out of the transformer box is key.

One of the earlier energy enterprises in human history was of course water. Firstly, using the kinetic energy in running water to turn water wheels, then moving on to more sophisticated engineering in the form of traditional hydropower from large dams and reservoirs.

“Research and innovation have expanded the possibilities in the water-energy portfolio exponentially over time.”

Research and innovation have expanded the possibilities in the water-energy portfolio exponentially over time. Some of the possibilities are refining the older techniques for the modern age. This includes the upgrade of traditional hydropower with miniaturisation to develop a suite of appropriate energy solutions on or close to site. Better turbine technology and the increasing of our understanding of water flow dynamics now makes it possible to harvest vast amounts of energy from our existing water infrastructure. Installing laminar flow turbines to capture the energy in our large pipelines is the modern-day equivalent of the old water wheels.

The Water Research Commission and BloemWater have collaborated on this technology. The net result is an international award-winning solution run on conduit hydropower that now has the Bloemwater headquarters getting all of its electricity needs from the micro-hydro unit, making it the first off-grid water utility headquarters in the country and continent.

The second option is an extension of this concept to stored energy in the form of the vast amounts of potential energy that

‘sits’ in every water tower and reservoir in every city and town in the country. As has been demonstrated in WRC-University of Pretoria projects – the installation of a nano-hydropower unit to capture the energy from the water exiting the towers every day.

This gives us the possibility of new energy in the Gigawatt-hour range if we refit and exploit the many thousands of existing suitable reservoirs and water towers around the country. This combination could organise for not only the marked decrease of electricity demand from an already strained electricity grid. In addition, the water sector has the real possibility to become a significantly energy supplier to the system from these new non-traditional sources.

This is very promising, and this is only the tip of the iceberg. Even more revolutionary are the latest developments in wastewater treatment technologies. This comes in the form of optimising the generation and capture of biogas, primarily in the form of methane as a principal energy source. This channel is extending rapidly with increased innovation in the direction of hydrogen production and the optimisation of microbiological fuel cells or MFCs.

We are on a global trajectory that says that wastewater treatment plants of the future will be a significant part of the energy generation fleet. In a country where we clearly need a wastewater treatment plant renewal we would be amiss if we did not grasp the opportunity to retrofit our existing plants to optimise the energy generation potential while increasing their capacity to better manage the wastewater treatment load. This will be a significant win-win situation.

Combining our efforts in addressing the national challenges on water and energy in a joint strategy is key. The water energy nexus will determine our future national security, our ability to improve the quality of life of all our peoples, meet our sustainable development goals, as well as our international competitiveness.

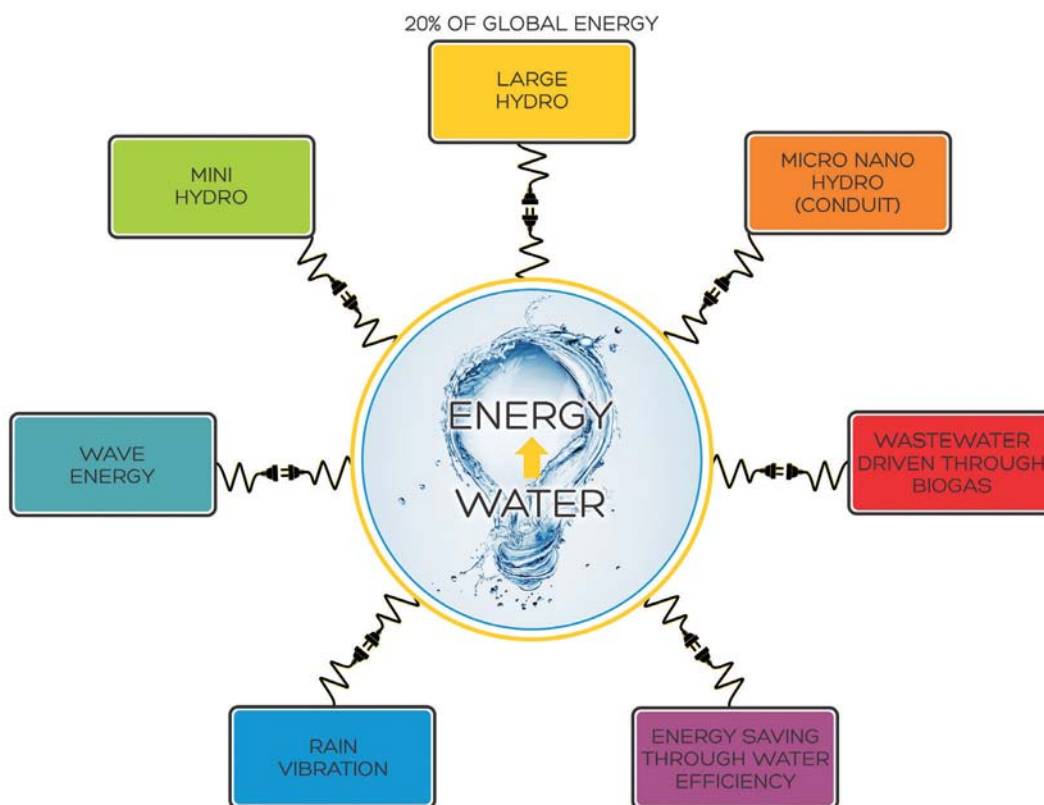


Figure 1. Water has always been a central pillar electricity production before being overtaken by the fossil fuel revolution. The aspiration toward a lower carbon future and the massive advances in science and engineering has made possible a new 'hydropower'. Water has several energy generating possibilities from traditional hydropower and wave power generation to the harvesting of 'raindrop energy' through capturing the energy generated by raindrop vibrations.

WATER DIARY

Faecal sludge management 17-22 February

The 5th International Faecal Sludge Management Conference (FSM5) will be held in Cape Town. The conference will advocate and share good practice and innovation to improve how faecal sludge is managed and contributes to meeting the sanitation needs of 4.5 billion people lacking access to sustainable sanitation services. The event will be co-hosted with AfricaSan.

For more information, visit: <https://fsm5.susana.org/en/>

Consulting engineering 6-7 March 2019

Consulting Engineers South Africa is hosting their annual Infrastructure Indaba at the Durban International Convention Centre. The theme for the event is 'Engineering the future now'.

For more information, visit: www.cesa.co.za.

Science education 6-12 March 2019

South Africa's National Science Festival, Scifest Africa, will be celebrating its 23rd anniversary event in Grahamstown, Eastern Cape.

For more information, visit: www.scifest.org.za

Intermittent water supply 7-9 April

The first IWA Intermittent Water Supply Conference will be held in Kampala, Uganda. The conference aims to advance the knowledge and share experiences on intermittent water supply (IWS) and to frame the problem of IWS within its technical, institutional, financial and social contexts.

For more information, visit: www.iws2019.org

Young Water Professionals 23-27 June

The International Young Water Professional (YWP) Conference will take place in Toronto, Canada. This conference is one of the vehicles in which the IWA supports YWPs to develop themselves to be at the forefront of decision-making.

For more information, visit: iwa-youngwaterprofessionals.org

World Water 25-30 August

Hosted by the Stockholm International Water Institute, World Water Week will be held in Stockholm, Sweden, with the theme 'Water for society – including all!'.

For more information, visit: www.worldwaterweek.org

NEWS

Water minister calls on SA innovators



Water and sanitation industry players have been urged to tap into new local technologies and solutions that will address the service delivery challenges that plague the sector.

Speaking at a ministerial event on 10 November last year, Minister of Water and

Sanitation, Gugile Nkwinti, lamented the fact that despite so many innovators in the sector, South Africa still faced myriad water challenges.

“We need to look at new ways of providing the services that we are responsible for, thus the need for this

interactive session with this group of innovators [so we can] be informed of and find out what new technologies and thinking are on the market to assist this beautiful country to resolve its delivery challenges.”

Nkwinti addressed some 450 delegates who had gathered during the Ministerial Interactive Session in Boksburg. The session was Nkwinti’s response to a number of sector stakeholders and innovators who have inundated his office with offers of solutions to challenges in the sector.

The event offered a platform for historically disadvantaged innovators to showcase their work.

Source: www.sanews.gov.za

New freshwater crab species discovered in Eastern Cape

A new ‘pearl white’ freshwater crab species has been discovered in the Eastern Cape forests.

Prof Savel Daniels, a molecular taxonomist at Stellenbosch University, says crabs are relatively well studied in South Africa, but for some reason forests have been neglected in sampling efforts.

“Nobody has ever intensively sampled the forests in the Eastern Cape where we (incidentally) found the species at Mbotyi.” The study formed part of the Eastern Cape Forestry project, one of the Large Integrated Projects funded by the

Foundational Biodiversity Information Programme. Mbotyi is a picturesque forested region northeast of Port St Johns and adjacent to the East Coast of South Africa.

The crab, which shimmers in the presence of light, was collected from under stones found in small streams which flow towards the coast. In a case of what phylogeographers call ‘sympatry’ the pearly white crab lives alongside a known rust brown species belonging to the African freshwater crab genus *Potamonantes*.

Like a divorced couple who still share the same house, the two related (but genetically distinct) populations are sympatric because they exist in the same geographic area and thus frequently encounter one another without breeding.

Daniels found no morphological characteristics with which to distinguish the *P. sidneyi* crabs from the new Mbotyi species except for the striking colour difference. The latter was inspiration for the naming of the new species, namely mhlophe meaning ‘white’ in isiXhosa.

Source: www.fbip.co.za

Civil society organisations celebrate court victory over Wakkerstroom mine decision

The North Gauteng High Court set aside the 2016 decisions of former Mineral Resources Minister, Mosebenzi Zwane, and the late Environmental Affairs minister, Edna Molewa, to permit a new coal mine to be developed in the Mabola Protected Environment near Wakkerstroom, Mpumalanga.

The case was brought by the coalition of eight civil society organisations challenging a range of authorisations that have permitted an underground coal mine in a strategic water source area and a protected area.

The Mabola Protected Environment was declared under the Protected Areas Act in 2014 by the Mpumalanga provincial

government as part of the declaration of more than 70 000 ha of protected area in the Mpumalanga grasslands. This followed years of extensive research and planning by a number of government agencies, including the Department of Environmental Affairs, the South Africa National Biodiversity Institute and the Mpumalanga Tourism and Parks Agency.

In 2016, without public consultation and without notice to the coalition, the two ministers gave their permission for a large, 15-year coal mine to be built inside the protected area. The court set aside the permission and referred the decision back to the two ministers for reconsideration on the basis that they did not take their decisions in the open and

transparent manner or in a manner that promoted public participation, and that the decisions were therefore procedurally unfair.

“South Africa has long recognised that the grasslands of Mpumalanga, KwaZulu-Natal and Free State are incredibly important to the country’s natural heritage. The grasslands are important water sources, and home to a range of production sectors that underpin economic development,” notes Yolana Friedmann, CEO of the Endangered Wildlife Trust. “In the case of Mabola, the protected environment falls inside a strategic water source area which feeds some of South Africa’s biggest rivers.”

Environmental practitioners go online



The launch of online registration for environmental assessment practitioners (EAPs) late last year was a historic moment that marked the formalisation of a vigorous and growing environmental profession.

This was according to the Chairperson of the Environmental Assessment Practitioners Association of South Africa (EAPASA), Snowy Makhudu.

The environmental impact assessment (EIA) process is a crucial mechanism used to regulate the impact of development activities. The Department of Environmental Affairs as well as provincial environmental departments are responsible for EIA processes and ensuring the timely and accurate execution of EIAs. Environmental impact assessment has been compulsory in South Africa since 1997.

“Since the emergence of environmental assessment as a distinct discipline in the 1970s, South Africans have earned praise internationally for making significant contributions to environmental assessment theory and practice,” noted Makhudu. “South Africa is about to embark on an initiative that is – on the available evidence – the first legally-based compulsory EAP register in the world.”

The new EIA regulations, in terms of the National Environmental Management Act came into effect in July 2006. The regulations sought to streamline the process while addressing concerns raised by stakeholders over timeframes, duplication and inter-governmental cooperation.

EAPs will have access to an online registration system (www.eapasa.org) for entering their qualifications and work experience to prove competence for registration.

Source: www.sanews.gov.za

GLOBAL

Massive urban expansion threatens natural habitats



City expansion has accelerated in recent decades, so much so that, by 2050, we could be creating a city the size of London every seven weeks if current trends continue, a new study warns.

Urban growth presents extreme challenges to biodiversity and ecosystem services due to the ongoing loss and fragmentation of habitats, says Burak Güneralp, assistant professor of geography at Texas A&M University.

"The message is clear: We have to take action and we must do it quickly. The challenges presented by urban expansion for conservation of biodiversity and ecosystem services we all depend on are only going to get more intense as the world continues to urbanise."

The findings, which appear in a Nature Conservancy report, show that by 2050, there will be 2.4 billion more people in cities. This means:

- Humanity will urbanise an area of more than 460 000 additional square

miles, larger than the entire country of Colombia.

- People could destroy more than 70 000 square miles of natural habitat by 2030.
- Natural habitats likely to be lost to urban growth store an estimated 4.3 billion tons of carbon dioxide. This would be the equivalent of the annual carbon dioxide emissions from 931 million cars on the road.
- Urban expansion could especially affect coastal areas and by 2030 researchers predict urban areas will more than double, increasing the number of those urban dwellers who depend on protection from natural ecosystems to more than 330 million people.
- Countries expected to lose the most natural habitat due to urban growth include the United States, Brazil, Nigeria and China.

Solutions to the problems could include more effective integration of local governments in national planning efforts; encouraging and empowering

cities to incorporate protection of biodiversity and ecosystem services in their planning efforts; leveraging the work of international institutions such as the Green Climate Fund and the Global Environmental Facility; and coordinating the work of the United Nations Convention of Biological Diversity to find ways to combat these future problems.

"Cities have been called one of mankind's greatest inventions," Güneralp says. "But we should not be blindsided by the potentially detrimental impacts of the ongoing rapid urban expansion, not even in the US or in Texas. In fact, this unprecedented urban growth presents us with a fleeting opportunity to act so that it takes place in a way that safeguards biodiversity and ecosystem services that are so critical for human wellbeing."

To view the original report, Visit: <https://bit.ly/2QPJqC9>

CO₂ emissions on the rise for first time in four years – UNEP warns



A report by the United Nations Environment Programme (UNEP) shows that global carbon dioxide (CO₂) emissions rose again during 2017 after a three-year hiatus, highlighting the imperative

for countries to deliver on the Paris Agreement to keep global warming to below 2°C above pre-industrial levels.

The report was released in November, just

days before the key UN climate change conference known as COP24, which took place in Katowice, Poland. The UNEP report follows the Intergovernmental Panel on Climate Change (IPCC) report on global warming, released last October, which cautioned that emissions had to stop rising now, in order to keep temperature increases below 1.5°C, and reduce the risks for the well-being of the planet and its people.

“If the IPCC report represented a global fire alarm, this report is the arson investigation,” said UNEP’s Deputy Executive Director, Joyce Msuya. “The science is clear, for all the ambitious climate action we’ve seen – governments need to move faster and with greater urgency. We’re feeding this fire while the means to extinguish it are within reach.”

To read the report,

Visit: <https://bit.ly/2KsiXrW>

Increased soil contamination puts food security at risk

Urgent action is needed to address soil pollution and contain the multiple threats it poses to global food safety and security.

This is according to the Food and Agriculture Organisation of the United Nations (FAO), who marked World Soil Day on 5 December.

Thousands of chemicals, which are commercially produced on a large scale, plastic and electronic waste, non-treated wastewater can all become a source of soil pollution, paving the way for pollutants to enter the food chain with serious consequences for the health and wellbeing of people and planet.

“About 33% of all soils are degraded – and soils continue to deteriorate at an alarming rate,” said Deputy DG Maria Helena Semedo at the World Soil Day Ceremony at FAO’s Rome headquarters.

“Soil acts as a filter for contaminants. But when its buffering capacity is exceeded, contaminants can enter the environment and the food chain. This undermines food security by making crops risky and unsafe for consumption.

“Human activities are the main source of soil pollution. It is in our hands to adopt sustainable soil management practices,” she added.

Semedo called for greater political support and significantly increased investment towards healthy soils. Maintaining healthy soils helps ensure safe and nutritious foods and is essential for achieving the Sustainable Development Goals and Zero Hunger.

The theme for this year’s World Soil Day was ‘Be the solution to soil pollution’.



WATER HISTORY

Water history – In the footsteps of RJ Gordon Part 2

In Part 1 of this article in the previous issue, we left Robert Jacob Gordon and his travelling companions in the area that was later to become Port Elizabeth. Here, we join them again as they make their way back to Cape Town. Article by Sue Matthews.

All historical images attributed to Robert Jacob Gordon, courtesy of the Rijksmuseum



The Keurbooms Estuary at Plettenberg Bay, February 1778.

Resuming their journey, the explorers arrived at the Gamtoos River on 24 January 1778, but could not cross it for two days because it was flowing fast and full. Having waited for the level to drop, they managed to pull the wagon's lead oxen across with a leather strap, but Gordon noted: "At times this river rises very high as one can see from what has been washed up, and sometimes remains impassable for a month."

By the mid-1800s, river-crossings were easier because a pontoon was operated at the site where the Ferry Hotel stands today, but high water levels continued to cause periodic travel delays of several days. The problem was only overcome when a bridge across the river was opened in December 1895. This single-lane structure is still in use today, but most traffic uses the newer bridge on the N2 national road, 1.5 km downstream.

A day after fording the Gamtoos River – having outspanned at a local stock-farm – Gordon rode out to inspect the mouth, which he recorded as running south-east into the sea, with heavy surf in the channel. The estuary is considered a permanently open one, but it has closed on a few occasions during drought conditions, most recently in early July 2018.

Such was the severity of the 2018 drought that by the end of August the level of the Kouga Dam – the largest of three dams in the Gamtoos catchment and an important water supply both for farmers downstream and for city-dwellers in Port Elizabeth

– stood at only 6.8%. Heavy rains in early September began filling the dam, but – due to the closed mouth – also caused back-flooding of a holiday resort on the banks of the lagoon and of agricultural fields on the floodplain. The local municipality therefore artificially breached the mouth on 11 September last year as an emergency measure, after obtaining permission from the environmental authorities.

Back in 1778, our intrepid travellers left their host's farm near the Gamtoos River and moved to another at the Seekoei River, which Gordon noted had flowed into the sea during the past rainy year, but was otherwise blocked up. The Seekoei estuary featured in national television news in spring 2017, after high seas had overtopped the beach berm and inundated the causeway joining the resort towns of Paradise Beach and Aston Bay, forcing residents to use a gravel road round the head of the estuary instead. The causeway, as well as other infrastructure built at the mouth and numerous farm dams and irrigation offtakes in the catchment, have all severely impacted estuarine functioning, and are believed to have caused an increase in flood risk and fish kills.

In the past, the mouth was frequently dug open by residents or municipal officials, but with the promulgation of the NEMA: EIA Regulations in 2010 such artificial breaching became illegal unless it is done in accordance with a management plan agreed to by the relevant environmental authority.

On 30 September 2017 the Kouga Municipality breached the estuary after environmental authorisation was obtained on the basis of it being an emergency, and a Mouth Management Plan has subsequently been developed by estuarine scientists at Nelson Mandela University.

Exploring the area, Gordon rode west along the beach for an hour-and-a-half to the Kromme River, which borders the current-day village of St Francis Bay. It was here that the country's first estuarine marina was later developed, starting in 1959. Today, sedimentation of the canal system – aggravated by reduced flushing by periodic floods due to two major dams upstream – severely limits boat navigation, particularly at low tide.

The following day, Gordon went fishing at the mouth of the Kabeljous River, where he "caught a good type of mullet and springer". Named after the abundant kabeljou, or kob, that were historically caught here, the river forms a shallow lagoon just to the east of Jeffreys Bay, and only opens to the sea during floods.

Departing the area on 4 February 1778, Gordon followed the coast and crossed the Tsitsikamma River, until he came to a river with steep cliffs that prevented him from going any further. He named this the Steile Krants River, but he was clearly referring to the Groot River, just beyond the present-day settlement of holiday homes known as Eersterivierstrand.

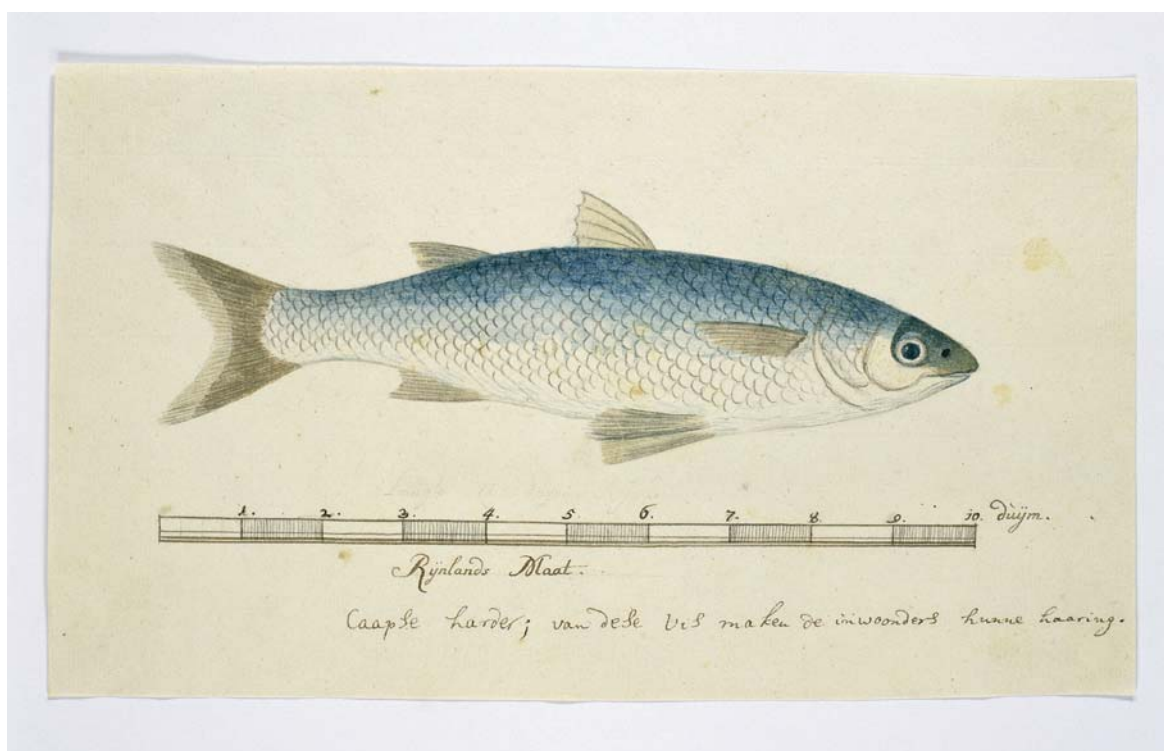
Turning inland, he bore north-east across the coastal plain and traversed the mountains via the Kareedouw pass into the Langkloof to meet up with the wagon, which he had sent on an inland route. After a few days travelling through and resting in the Langkloof, where he noted that the peaches were beginning

to ripen, he set out from Avontuur to cross back over the mountains to the coast.

"This was on a difficult road, and Mattys Sondag had given me wrong directions and I had got onto one of the stoniest and steepest of roads so that Schumacher, the artist, who was the only person with me, quite gave up and I was at a loss to know what to do with him. However at the top of the range I discovered a road with my spy-glass, and wandered around for a long time."

Fortunately, upon crossing the upper reaches of the Keurbooms River he encountered a herdsman, who guided him over the mountains. At 10 o'clock that evening they finally arrived at the farm Wittedrift on the Bitou River, several kilometres upstream of where it flows into the Keurbooms River estuary. It was towards the end of this year that the Governor of the Cape, Baron Joachim van Plettenberg, visited the area and erected a Dutch East India Company beacon on a hill overlooking the sea, giving rise to the name Plettenberg Bay.

The following morning, 14 February, Gordon rode down the Bietou Valley, which he noted "is bordered with forests, giving it a beautiful prospect. Going through along the beach, I found that the Keurbooms River had accumulated much quicksand so that I was unable to cross it." Instead he went westward across the Piesang River to beyond Robberg, before heading back to Wittedrift. The next day, he again tried but failed to cross the Keurbooms River mouth "on account of the quicksand", so he continued exploring the area, noting that he "saw two herds of buffalo grazing on a plain, each of two to three hundred head".

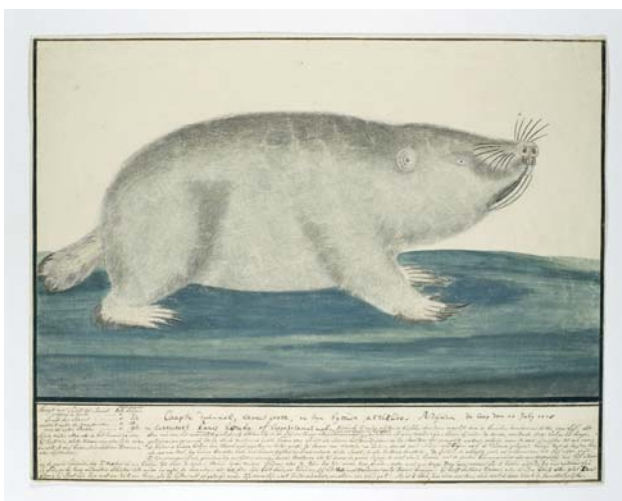


The harder or southern mullet (*Liza richardsonii*) is the most likely species of mullet that Gordon caught in the Kabeljous Estuary, although striped mullet (*Liza tricuspidens*) and flathead mullet (*Mugil cephalus*) also occur there.



Gordon's depiction of the Knysna Estuary in 1778 is a stark contrast to the picture today.

Gordon's depiction of the Keurbooms River estuary – a panorama almost two-and-a-half metres wide – shows the mouth in the middle of the low barrier dune separating the permanently open estuary from the sea. Its position is slightly south-west of this today, but it has shifted dramatically during the intervening 240 years, sometimes with catastrophic consequences. In the late 1800s the mouth was close to the south-western end of the barrier, where a rocky outcrop known as Lookout Rocks prevents its further advance, but in 1915 a flood broke open a new mouth at the north-eastern end, directly opposite the river inflow. Research conducted by the late Dr Koos Reddering revealed that the mouth had then migrated southward at a rate of about 30 m per year between 1915 and 1980, and would keep going until it again reached the south-western end, despite this side of the barrier – site of the popular Lookout Beach – having by then been stabilised with alien acacias.



Gordon's encounter with the Cape dune mole-rat while visiting Groenvlei could have had disastrous consequences. He wrote: "On the beach here I experienced once again the discomfort and danger caused by dune moles, for my horse crashed head over heels, falling on my leg, though only injuring it lightly."

The prediction came true rather sooner than expected, however, when four days of heavy rain and stormy seas broke open a second mouth at Lookout Rocks on 23 November 2007, taking with it the intervening barrier, the acacia forest, parts of a carpark and the swimming pool of a guesthouse. A sand-spit soon reformed where the original mouth and barrier had been, but the mouth at Lookout Rocks remained open.

Almost five years later, in July 2012, a smaller flood broke through the barrier just under a kilometre to the north-east, and within six months the Lookout Rocks mouth had closed in favour of this new mouth. Retired oceanographer Dr Eckart Schumann described and analysed the geomorphological changes that occurred during the 2006—2012 period in a paper published in the November/December 2015 issue of the *South African Journal of Science*. The mouth has subsequently moved a little to the north-east, but it changes constantly under the competing influences of river flow, tides and waves.

Gordon's small party continued their journey, and after riding for five-and-a-half hours reached the farm Melkhoutkraal, allocated to Stephanus Terblans at the Knysna River estuary. After visiting what is now known as The Heads and observing waves breaking in the mouth, despite the calm weather and only a light westerly wind, Gordon noted that "It would be impossible for even a hooker to enter here".

On this count he was proved wrong, because the estuary later became a busy shipping port. It was George Rex (the longstanding legend that he was the illegitimate son of King George III of England has been debunked) who lobbied for this after purchasing Melkhoutkraal in 1804. He recognised that the commercial potential of the surrounding forests could not be realised if the harvested timber had to be transported to Cape Town by ox-wagon. The Royal Navy transport brig Emu became the first ship to attempt entry on 11 February 1817, but she ran aground in the mouth.

Two months later, the Podargus succeeded where the Emu had failed, and the following year a harbour pilot was appointed

to guide ships through the Heads and deep-water channels. Nevertheless, numerous ships went to a watery grave before the harbour was eventually decommissioned by the Government in 1954, because road and rail transport options meant it was no longer cost-effective. Today the estuary is used only as a small boat harbour, although the South African Navy traditionally brings a ship through The Heads to berth at Thesens Jetty for the duration of the Knysna Oyster Festival each July.

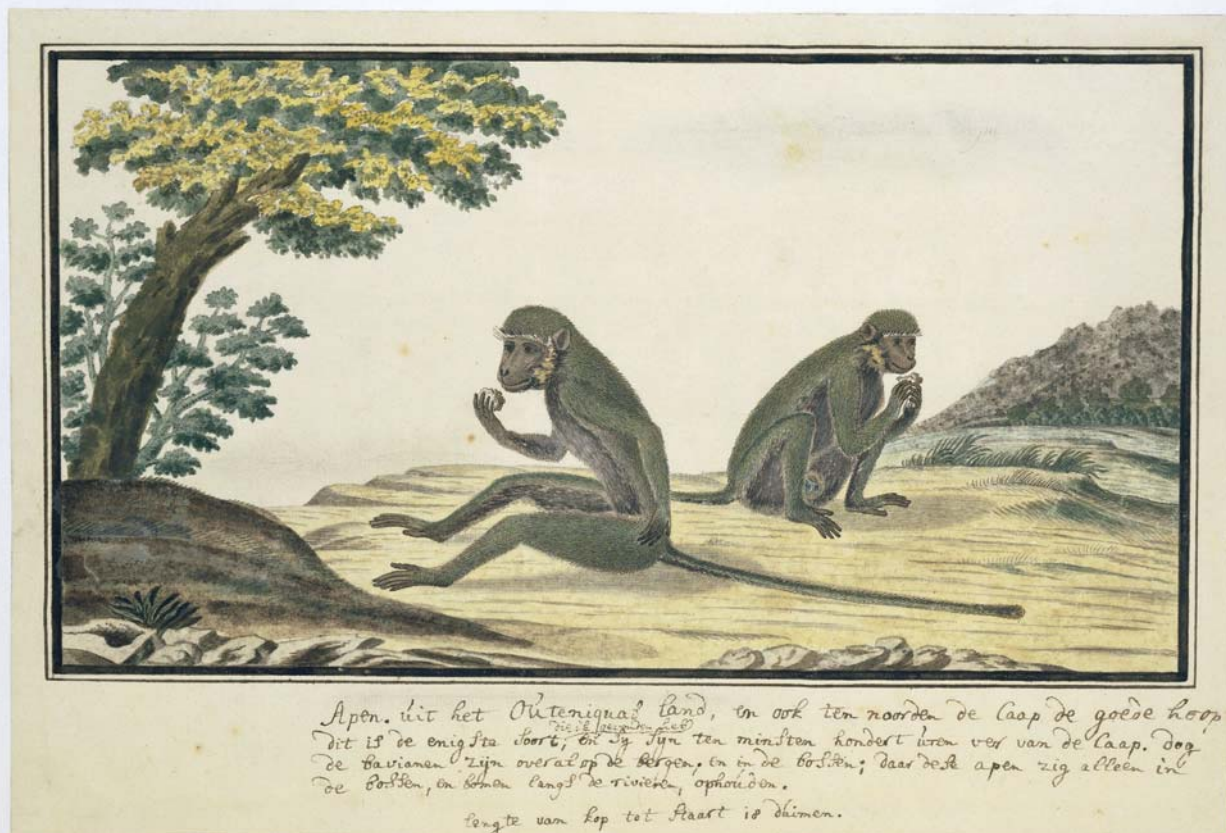
After spending a night at Melkhoutraal, Gordon crossed the Knysna estuary in its uppermost reaches, passed to the north of Ruigtevlei, and rode along the coastal plateau above Swartvlei, which he described as "a large lake that mostly flows out into the sea but is sometimes blocked by sand in June or July". After a wretched night under the leaking roof of the Kleinhoogkraal hut, he "rode south-east onward to the shore and after a distance of an hour reached Drievleien, the farm of a certain Seele a few musket shots distance from the shore. This is where the people from the Langkloof come fishing, using a dangerous wagonroad north of here which comes over the mountains called Duivelskop, or Nanni Douw, which means 'Finger Road'. It starts at a certain Widow Beulen's in the Langkloof. A high ridge of dunes separates these vleis from the beach. They are salty."

He is undoubtedly referring to the Wilderness National Park's Rondevlei, Langvlei and Eilandsvlei (or Island Lake), and the

Duivelskop track is now a popular 4x4 and mountain-bike route starting at the Louvain Guestfarm and descending into the Bergplaas forestry plantation. He continued eastward as far as "the long and deep Groenvlei... this spring has fresh water", where his horse fell head over heels – slightly injuring Gordon's leg – after stepping into a dune mole-rat burrow. Groenvlei today forms part of the Goukamma Nature Reserve, managed by the provincial conservation agency, Cape Nature.

Gordon's group left the area on 19 February, crossing the Kaaimans River drift that the N2 national road skirts today, and overnighting at farms at Great Brak, Mossel Bay and Gourits River, the mouth of which he observed as being "a long musket shot wide and full of breakers". They took a more inland route to cross the Duiwenhoks River near present-day Heidelberg, and from Swellendam veered behind the Riversonderend mountains to return to Cape Town via Franschhoek, arriving home on 8 March 1778.

Five months later, Gordon departed Cape Town for another five-month exploration. This and his other two journeys will be covered in future issues of *The Water Wheel*.



Gordon noted on his illustration of vervet monkeys in Outeniqualand that they occur only in the forests and in trees along rivers.

RESEARCH PARTNERSHIPS

Flourishing research partnership pays off for Western Cape tourist attraction

Vergelegen has not only helped protect water resources by clearing vast tracts of invasive alien vegetation, but also by hosting early research on pesticide pollution that has since been expanded upon in Water Research Commission funded projects. Article by Sue Matthews.



What is thought to be the largest private alien-clearing project in South Africa has – after 23 years – achieved its goal of removing 2 200 hectares of invasive vegetation from the slopes of the Hottentots Holland mountain range, which towers over Somerset West in the Cape. In the process, long-dormant streams have begun flowing again, verdant wetlands have re-established, and fynbos plants and animals have flourished – so much so that the land has been approved for declaration as a private nature reserve.

The site of this inspiring initiative is Vergelegen, the historic estate founded by Willem Adriaan van Der Stel in 1700, shortly after he had succeeded his father as Governor of the Cape Colony. Today the estate is owned by Anglo American and is a popular tourist attraction, offering top-notch restaurants, wine-

tasting, heritage exhibits and beautiful gardens.

Alien-clearing work began on a small scale in 1995, and was initially funded from the estate's trading profits, but in 2004 Anglo American decided to bankroll the project from Head Office so that progress could be accelerated. The 3 000 hectare estate was demarcated into 26 management units, each with different alien species, densities and challenges. While the steep slopes higher up were covered in pine trees, the lowland areas were infested with eucalypts and acacias, reaching densities as high as 10 000 stems per hectare in places.

Removing these invaders was a massive undertaking, at times requiring a workforce of up to 300 people. Now that the initial clearing has been completed and only follow-up work

is required to remove regrowth from the soil seedbank, there are just 75 contractors on site, but the project has provided an average of 137 employment opportunities per year over its 23 year lifespan. The on-the-job training provided to these contractors, including business skills such as budgeting and tax administration, has allowed them to find work elsewhere, and their rigorous operational and safety standards mean that they are held in high regard on other alien-clearing projects.

Insights from the Vergelegen experience have been documented for the benefit of others, because this was the subject of an MSc thesis by Jacques van Rensburg, who was also the environmental manager of the alien-clearing project for more than seven years. His thesis – submitted to the University of Stellenbosch in March 2017 – covers the period up to 2016, and two chapters from it have been published as papers with his supervisors, well-known invasive alien plant scientists Dr Brian van Wilgen and Dr David Richardson. Their paper in the *South African Geographical Journal* (Vol. 100, No. 2: 180-195) reconstructs the spread of invasive vegetation at Vergelegen and examines the factors contributing to the problem. The findings show a clear link between human activities, changes in land use – primarily due to agricultural development – and the spread and proliferation of invasive vegetation.

The second paper, published in the *Transactions of the Royal Society of South Africa* (Vol. 72, No. 3: 207-216) focuses on the challenges of managing the invasion. Most notably, the alien-clearing operations between 2004 and 2015 cost a staggering R43.6 million, which was 3.6 times more than originally estimated! The escalation was partly due to a wildfire that swept through Vergelegen in 2009, triggering a mass germination of soil-stored seeds in areas that had already been cleared. Undoubtedly, though, the vast majority of private landowners would not be able to afford the initial and follow-up work required to remove large stands of invasive alien plants.

This research was just a small component of the scientific effort at Vergelegen, because the estate has allowed students and staff from both local and foreign universities to conduct fieldwork on their land. An Environmental Trust established in 1995 to guide the first phase of the alien-clearing project promoted the concept of Vergelegen as a 'Centre of Learning Excellence', and more than 20 qualifications have so far been obtained on the basis of research performed there.

Interestingly, one of the first of these research projects gave rise to a suite of projects funded by the Water Research Commission (WRC). Dr James Dabrowski, currently leading a WRC-funded project (K5/2707) entitled 'An integrated approach to managing and mitigating the risk of agricultural non-point source pesticide pollution to the aquatic environment', began working in the Lourens River flowing through Vergelegen as a University of Stellenbosch honours student in 1999, and the following year continued with more in-depth research for his MSc degree. His co-supervisor for both projects was Dr Ralf Schulz, an aquatic ecotoxicologist who now heads the Institute of Environmental Science at the University of Koblenz-Landau in Germany, but was then visiting Stellenbosch regularly as a post-doctoral researcher.

"He was very keen to get a student involved, and since there wasn't much prior work of this nature that had been done in South Africa, it seemed like a new and interesting thing to do," says Dr Dabrowski. "Our idea at the beginning was to try and get a basic understanding of pesticide contamination in the Lourens River, so our initial work focussed on simple runoff monitoring, and also sampling when Vergelegen and its neighbour Lourensford were doing spray applications. Once we had established that pesticides do often occur in the river there, the next logical step was to move on to ways of mitigating and managing pesticide contamination."



Going, going gone! A Vergelegen alien-clearing contractor fells one of the last remaining eucalypts.



With the removal of water-guzzling alien plants, streams are flowing again and riparian vegetation is flourishing.

"We did some basic ecotoxicological studies, where we set up stream microcosms and exposed whole communities of macroinvertebrates to field-relevant concentrations of pesticides – quite low concentrations similar to what we found in the river – for a certain period of time. The concentrations we measured did seem to be having an effect at a community level, so we then used a GIS-based modelling approach to try and predict hotspot areas in the catchment, with the idea of implementing management initiatives to minimise pesticide transport into the river."

"That's how we got into our research on constructed wetlands, which was really very interesting," continues Dr Dabrowski. "We were able to show that those wetlands trap pesticides coming from the small tributaries flowing through the orchards – both water-dissolved and sediment-bound pesticides – and not only were the concentrations coming out of the wetlands significantly reduced, but so was the toxicity to aquatic invertebrates. Once the constructed wetland at Vergelegen was shown to be so effective, Lourensford built one in a tributary on their side of the river too."

Dr Dabrowski moved to the Freshwater Research Unit at the University of Cape Town for his PhD, but still used the Lourens River as his study site, and Dr Schulz again served as co-supervisor. His thesis, submitted in June 2004, was entitled 'A comparison of runoff- and spray-drift-related pesticide

contamination in agricultural surface waters: exposure, effects and mitigation'. For this research, GIS-based modelling, validated by field-based sampling, was used to predict loading of azinphos-methyl (AZP) – the most commonly applied insecticide in the catchment – in the river from runoff and spray-drift events.

Runoff was found to be the more important contributor to non-point source pesticide pollution in the catchment, but experiments with mayfly nymphs showed that these insects had a greater behavioural response to spray-drift exposure. This can be attributed to pesticide from spray-drift being directly dissolved in the water, rather than associated with suspended sediment in runoff events, when flow volume and velocity is also typically higher.

For the mitigation aspect of the research, Dr Dabrowski compared the effectiveness of aquatic macrophytes in reducing pesticide input from runoff- and spray-drift. The results showed that a vegetated stream is more effective than a non-vegetated one in reducing pesticide concentrations from both pathways, but those derived from spray-drift are better mitigated than those from runoff. This is because emergent aquatic macrophytes intercept spray-drift before it lands on the water surface, significantly reducing water-dissolved pesticide concentrations. Predictions showed that 50% macrophyte coverage in combination with a 5 m buffer strip resulted in as large a reduction in drift deposition as the combination of a 10 m buffer strip with 0% macrophyte coverage.

A few years later, while employed as a Principal Researcher at the CSIR, Dr Dabrowski successfully applied for WRC funding to develop a risk indicator methodology to estimate the relative exposure and risk of pesticides in surface waters (K5/1854). Essentially, the methodology was designed to predict the impacts of pesticides on water quality by integrating pesticide use, toxicity and physicochemical data of pesticides with site-specific geographic and climatic characteristics. The Lourens catchment was again used for the field study, which set out to validate the predictions of the risk indicator methodology through sampling of pesticide levels in water and sediment.

"We wanted to see if we could predict which of a variety of pesticides applied are most likely to enter water resources, and which of those are likely to have the highest risk to aquatic biota," explains Dr Dabrowski. "That was quite a successful project, because we were able to show a clear link between what we modelled and what we monitored. So the pesticide risk indicator was potentially very useful in terms of being able to identify the pesticides in a particular catchment requiring more careful management."

The next WRC project (K5/1956) – featured in the January/February 2016 issue of *The Water Wheel* – took a broader view, by investigating the risks posed by pesticides in water resources to environmental and human health at a national level.

"We did monitoring in three different catchments throughout the country to get more baseline information on pesticide contamination, created a series of pesticide use maps, and also developed a way of prioritising which pesticides to monitor, given that each crop has a variety of different pesticides – in

the form of herbicides, fungicides and insecticides – that could potentially be applied. Monitoring all them would be problematic, because the laboratory analyses is very expensive, so there was a need to identify which were most important.”

“The current project has built upon this work, and it’s more about developing tools to try and manage pesticide contamination. It aims to develop a framework allowing us to identify high-risk areas throughout the country. The pesticide use maps from the previous project just show where different pesticides are applied. However, risk implies not only use, but how toxic the pesticides used in an area are, what geographical conditions exist that might make pesticides more mobile – so it incorporates use, toxicology, environmental chemistry and geographical parameters all in one. We’ve actually developed three different maps that portray risk towards fish, aquatic invertebrates, and aquatic macrophytes and algae.”

The project has provided an average of 137 employment opportunities per year over its 23 year lifespan.

“There is also more focus on catchment-scale modelling approaches. Given the limitations associated with monitoring, modelling can be very useful in identifying areas at a much larger scale, and also in postulating certain management options and seeing what effect they are likely to have on pesticide concentrations in the river in the long term. We’re also developing a risk indicator tool that will be able to tell a farmer or catchment manager which are the highest, medium and lowest risk pesticides registered for use on a particular pest of a particular crop, since the active ingredients can be quite different in terms of their toxicity to aquatic biota and their mobility in the environment. It’s just a way of informing people of the most environmentally friendly choice of pesticide.”

The project is due to be completed in 2022, so progress and/or the final outcomes will be covered in a future issue of *The Water Wheel*. In the meantime, however, it is worth noting that Vergelegen management report that the alien-clearing project has resulted in such a proliferation of insect life that natural predators have allowed insecticide sprays on the estate to be reduced by 75%!



HelenOnline / Wikipedia

The Lourens River that flows through Vergelegen was used as a study site for initial research on pesticide pollution that has since spawned a number of WRC-funded projects.

DROUGHT MANAGEMENT

Optimising risk-based drought restriction analysis

How can quantitative economic analysis be applied to optimise risk-based drought restriction analysis in South Africa? A recent study examined. Article by Sarlet Barnard and Riekie Cloete.



South Africa's water-stress situation, especially in terms of agriculture, was, is and will always be a point of discussion and necessitate research. Since the early 1980s, drought restrictions were managed using risk-based multi-user priority rules and stochastic systems analysis for operational and development planning of the water resources in South Africa.

Recent droughts motivate the development of a quantitative decision-support tool to determine how water management can be optimised by implementing operation rules and express it in socio-economic indicators. The water resource planning and developing models and the water economic modelling system were 'married' for this purpose.

Hereby, the economically optimum restriction rule definitions for drought management as well as the scheduling of augmentation requirements can be derived.

A Water Resource Planning Model (WRPM) analysis is subject to reservoir standing storages, system operating rules, user allocation and assurance of supply requirements and curtailment criteria. The operating rules are defined by means of a penalty structure in the network solution. The solver analyses each time-step in the analysis and identifies the 'least-cost' solution to enable the model to follow the defined rule.

Guidelines were developed by the Department of Water and Sanitation (DWS) in 2006 for the management and operation of water-supply systems during normal and drought conditions.

These guidelines have assisted with the development of water-supply system specific operating rules to discern whether the water supply from the resource needs to be curtailed for a given year or not. The decision on curtailment is mainly influenced by the dam levels at the end of the rainy season, which is defined as

May in the summer rainfall regions and September in the winter rainfall regions. It is important to establish the severity of the level of curtailment, when it is needed, the timing thereof and possible relaxation after the drought subsides.

User Sectors	User priority classification (Criteria: risk of curtailments)		
	Low (5%)	Medium (1%)	High (5%)
	Proportion of water		
Domestic	30 <i>Gardening Water</i>	20 <i>Human Consumption Hygiene</i>	50
Industrial	10	60 <i>Power Generation Petro Chemical Industry</i>	30
Strategic industrie	0 <i>Annual Crops</i>	0	100 <i>Permanent Crops</i>
Irrigation	50	30	20
Restriction levels:	0 <i>All Low Priority Use Restricted</i>	1 <i>All Low & Medium Restricted</i>	2 <i>All Use Restricted</i>

The driver behind stochastic risk analysis is the priority classification of the different water user sectors as configured in the WRPM. The definition of the priority classification or criteria for risk of curtailments has largely been based on expert opinion and qualitative economic criteria.

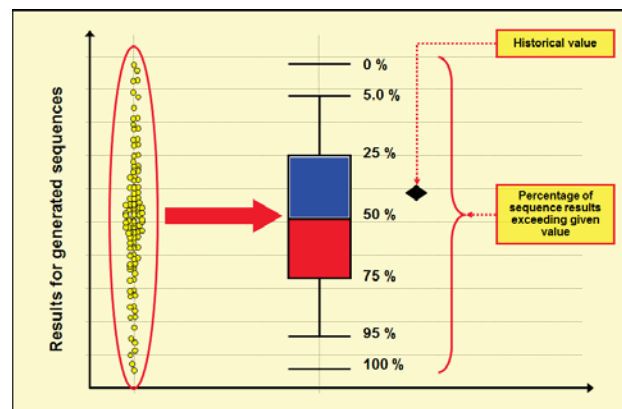
A proportion of the water demand of each user sector is classified at different priorities in terms of assurance of water supply.

A higher assurance of supply will mean a lower risk of curtailment. In the given table for example, 30% of the domestic use is regarded as gardening water and will be classified at the lowest assurance of supply which in this case has a 5% risk of being curtailed. Furthermore, 20% of the domestic user sector is classified at a medium assurance of supply and 50% at a high assurance of supply. For strategic industries the total demand is often classified at a high assurance of supply.

For the irrigation sector a measure of classification can be the type of crops produced within the water-supply system. These can either be annual crops such as cabbage, irrigated sugarcane and maize, which start production mostly in the first year, or permanent crops such as orange- and mango trees. Permanent crops are usually classified at a higher assurance of supply than the annual crops, as their production cycles take longer than a year and thus return on investment takes longer to realise.

Drought curtailments are simulated for water users with different assurance of supply requirements regarding their allocation from a specific water resource. Short-term operation analyses are carried out for a five- to ten-year operation period. Results in terms of system storage and curtailments are generally presented in a box-and-whisker format, illustrating the exceedance probability of a certain value over the analysis period.

Decisions concerning assurance of supply levels to the different water user sectors in water resource systems have not been scientifically established and don't always reflect the optimum outcome. This poses a problem, especially during times of drought.



The box-and-whisker plot.

The impact different water users have in a river catchment on the economic indicators such as gross domestic product (GDP), low household income and employment, can be established by undertaking a quantitative economic analysis.

The macro-economic indicators are calculated by making use of the Water Impact Model (WIM). The WIM model is water sector specific and has, until this study, been applied in various Department of Agriculture, Forestry and Fisheries (DAFF) and multinational studies. These include 'Determining the economic viability of different planning options and options for the joint Maputo River Basin Water Resources Study (2006-2007)'; 'Development of an ecological water requirement policy and water management plan to implement the ecological water requirement policy for the Komati River Basin (2008-2009)'; 'Vaalharts/Taung irrigation area (2011)' and 'Implementation of the water resources classification system and determination of the resource quality objectives for significant water resources in the Letaba (2012-2013)'.

The WIM model is a dynamic, computerised water entitlement model, customised for the irrigation sector, whereby economic benefits, possible water reduction and capitalised impact can be classified and computed. It provides a tool to create an appropriate economic baseline against which to measure the possible impact of changes in water availability by means of scenarios. The macro-economic impact of possible water reduction on the individual producers, the community and the economy in the selected catchments can then be determined.

The economic baseline is used to estimate the impacts of the water restrictions and is explained as follows: Current production, deducting curtailed production, estimates the loss in production due to water restrictions.

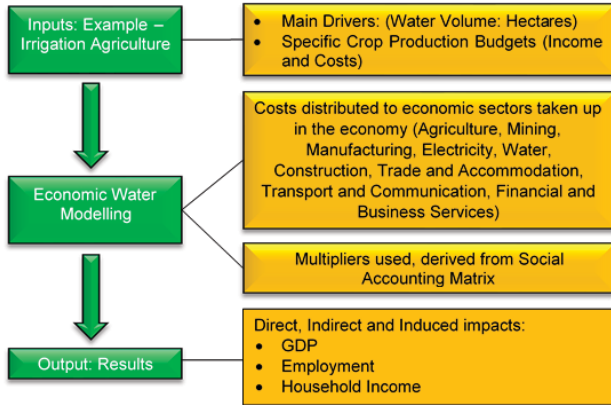
GDP and employment are presented in terms of direct, indirect and induced indicators or impacts:

- Direct impacts refer to impacts occurring directly in the irrigation or water dependent activity.
- Indirect impacts refer to those effects occurring in the different economic sectors that link backward to a specific sector due to the supply of intermediate inputs used in the production process.
- Induced impacts refer to the chain reaction triggered by the salaries and profits (less retained earnings) that are

Drought management

ploughed back into the economy in the form of private consumption expenditure.

The impact on household income, and especially low household income, is a good indicator of the impact on poverty levels in an area.

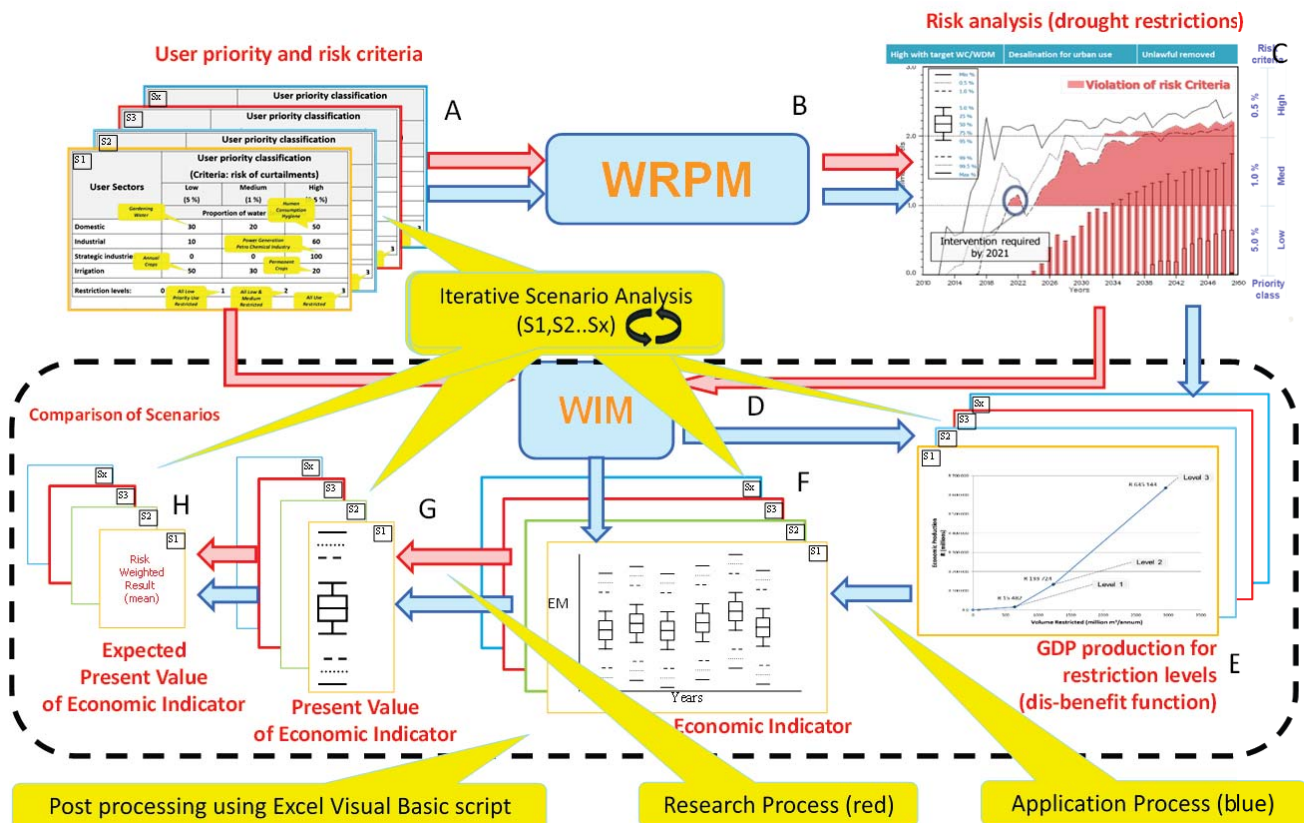


By cementing the WRPM and WIM as a unit, an economically optimum user priority classification can be derived to improve equitable water resource allocation and drought management. Such a linkage was tested by post-processing of the WRPM output using Excel Visual Basic open script.

The user priority and risk criteria definition or table is the primary input dataset to be varied in the scenario analyses. The objective is to evaluate the economic implications of alternative settings of the user priority table with the aim to find the optimum or most suitable set of parameters.

The Present Value (PV) of the economic indicators will be used to have one single comparable value for the economic output of the WIM, for all the simulated sequences, for each scenario per selected study area.

To account for the time value of a time series of monetary indicators, the Present Value of each of the 1 000 sequences have to be calculated to provide a probability distribution of the PV.



The procedure on which the Assurance of Supply Model (ASM) is based. The steps include: **A.** The user priority and risk criteria definition, **B.** Water Resource Planning Model (WRPM), **C.** Risk analysis (results from WRPM), **D.** Water Impact Model (WIM), **E.** Gross Domestic Product (GDP) vs. restriction relationship, **F.** Economic Indicators, **G.** Present Value of Economic Indicator and **H.** The Expected value (mean) of Economic Indicator.

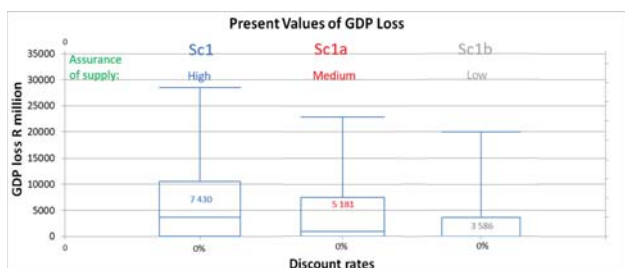
The economic indicators ensure the proposed method can be used to evaluate time dependent decisions such as, whether moderate drought restrictions should be implemented immediately, or can be delayed until later when more severe restrictions are implemented at a certain risk.

The three study areas that were selected to test the methodology include the Orange River Project, the Groot Letaba and the Mhlathuze Water Supply Systems (WSS's). The major water resources within these WSS's, from which the water supply is subjected to be restricted in times of drought, are: The Gariep and Vanderkloof dams, Tzaneen Dam and the Goedertrouw Dam respectively. The irrigation agriculture sector uses 63%, 69% and 36% correspondingly of the water supplied from these resources. Quite a diverse selection of crops is cultivated within these WSS's and it is important that the viability of farming and the direct and indirect impact of water restrictions on the regional economy are not jeopardised.

Furthermore, the total contribution of the irrigation agriculture sector to the GDP, household income and employment within these WSS's can be summarised as follows:

Water Supply System	GDP	Household Income	Employment
	(R million)		(Numbers)
Orange River	14 166	11 004	148 442
Groot Letaba	2 463	2 247	20 370
Mhlathuze	613	618	5 851

It was expected that with a reduction in water supply, the scenarios rendering the lowest present values of loss for the economic indicators, would be the more favourable. It is, however, important to determine if the farmer will be able to continue farming on a sustainable level despite the reduction in the water supply.

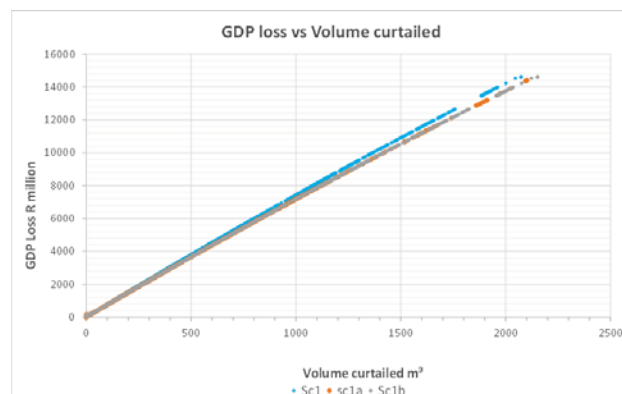


The expected risk weighted present value of loss in GDP as a result of reduction in water supply from the combined Gariep and Vanderkloof dams for three different scenarios.

Regional relationship curves were derived from the results showing the loss in the specific economic indicator resulting from a volumetric reduction in water supply. In the curve below, it can be seen that a reduction in water supply of 500 million m³ will result in a GDP loss in the order of R4 000 million.

The development of the new decision support tool and the link between the Water Resource Models and Water Impact Model, was successful. The current WIM's output indicates a linear relationship between volume curtailed and the economic

results. For general economic impact analysis, a weighted average enterprise budget per annum was sufficient. To indicate the feasible reduction in water supply per each crop production stage, a more detailed research and model developing is recommended to strengthen and extend the modelling system.



It was found that during the actual drought in 2016, restrictions might not have been required had alternative assurance of supply criteria been applied. Fortunately, during the 2018/2019 Annual Operating Analysis of the Orange River System, DWS considered alternative user priority definitions to be investigated and analysed as a scenario.

Decisions concerning assurance of supply levels to the different water user sectors in water resource systems have not been scientifically established

It is recommended that farmers diversify and incorporate mix-crop farming as much as possible for farming to remain economically viable when water use is restricted. The writers go so far to emphasise this as a pilot study of which only a sub-section of the primary economic sector – irrigation agriculture – was assessed. This creates the opportunity to expand the model to the other water-dependant users in the secondary and tertiary economic sectors.

It can be extended for the same study areas, or other study areas in need of re-evaluating operating rules. Such improvements have however commenced in other studies i.e. the Thukela-Vaal Transfer scenario analyses as part of the development of operating rules for the Integrated Vaal River System as well as the development of operating rules for the Lesotho Highlands Water Project Phase II.

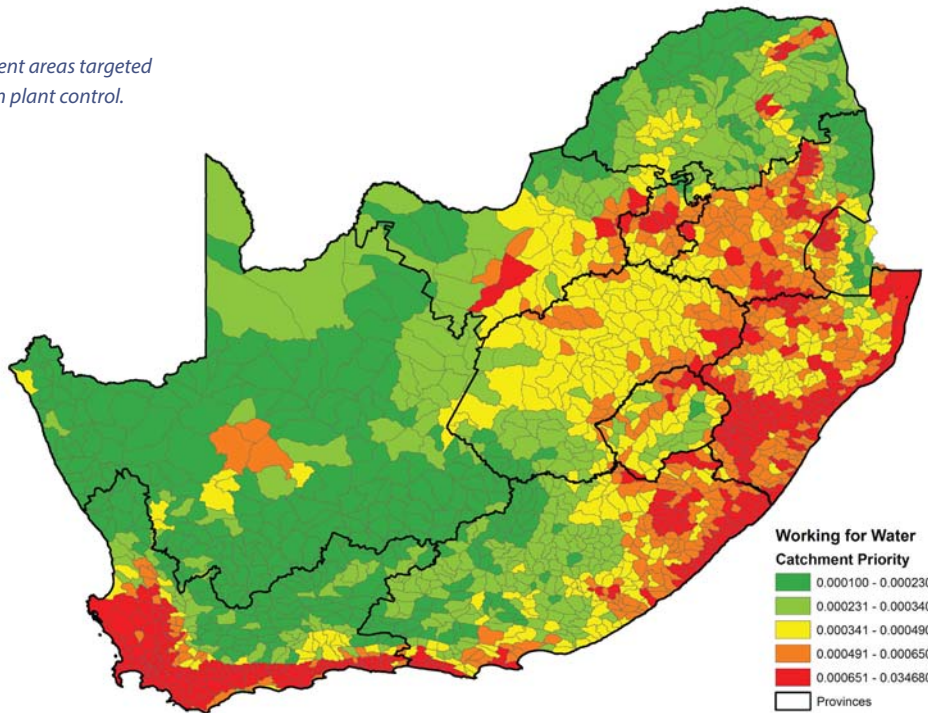
Similar studies and application of the ASM in another drought stricken WSS's, such as the Western Cape, are encouraged.

ALIEN INVASIVE PLANTS

Biological control agents help tackle water weeds in SA

They are tiny, reliable and their contribution to society often goes by mostly unnoticed. Yet many of the biological control agents being studied and mass-reared by scientists in the Eastern Cape are playing a huge role in the ongoing fight against alien invasive plant species. Article by Jorisna Bonthuys.

Priority catchment areas targeted for invasive alien plant control.



Scientists linked to Rhodes University's Centre for Biological Control (CBC) in Grahamstown are playing a pivotal role in efforts to halt the spread of alien invasive plants in South Africa by employing biological control agents.

The centre is involved in the research and 'deployment' of natural enemies of weeds in local conditions. Earlier this year the CBC received a three-year contract of R68-million from the Department of Environmental Affairs to focus on 54 weed species spreading across the country.

These biological agents are mass-reared under strict conditions, including in portable pools and plastic tunnels at CBC's approved insect rearing facilities.

The research is driven by a consortium of universities, and CBC's team works closely with the Agricultural Research Council on this. The consortium is led by Rhodes University and includes scientists from the University of Cape Town, the University of KwaZulu-Natal and Wits University.

Scientists working at the centre are focusing their efforts on the sustainable control of alien invasive plants using insects or pathogens. They are interested in understanding the ecological dynamics of invasive pests, as well as aquatic and terrestrial weeds, among others.

Weeds of concern

Alien invasive plants are of both global and local concern, according to Prof Martin Hill, CBC's Director and Head of the

Department of Entomology at Rhodes University. These plants, including water hyacinths and some Acacia species, have now spread over more than a tenth of South Africa's land area.

Prof Hill was recently appointed as a SARCHI research chair (in terms of the South African Research Chairs Initiative). His work includes finding sustainable ways of controlling invasive plant species – a challenge he considers of “national importance.” “The challenge to arrest or even reverse the trend of weed invasions remains huge. We are looking at ways to harness biological control measures for the future.”

The challenge remains huge. Of the 2 034 alien species known to have established populations outside of cultivation or captivity, 775 have become invasive. Of these, 107 have caused severe negative impacts on the environment, affecting 80 000 km² (1.4%) of the country's land area.

Current mechanical and chemical control measures reach less than 3-4% of this invaded area per year, according to research by Prof Brian van Wilgen and Prof John Wilson, both from the Department of Science and Technology-National Research Foundation Centre of Excellence for Invasion Biology at Stellenbosch University (SU). Given spread rates between 5 and 10% per year, current control measures are not enough to contain or reduce the problem, according to a recent SU press release.

Profs Van Wilgen and Wilson are the lead authors of South Africa's first national report on the status of invasive species published by the South African National Biodiversity Institute (SANBI) in November. The report, titled *The Status of Biological Invasions and their Management in South Africa 2017*, paints a worrying picture about the effects of weeds in the country. The most troubling indicator it highlights is the one measuring the level of success in managing invasions. It stands at only 5.5%. This is despite the fact that at least R12 billion has been spent over the past 20 years as the researchers point out.

Invasions by alien plants are rapidly extending across the globe, leading to large-scale ecosystem damage. This damage is aggravated by climate change, pollution, habitat loss and human-induced disturbance, according to the Convention on Biological Diversity. Invasive species spreading outside their natural habitats is now considered one of the greatest threats

to biodiversity worldwide. Since the seventeenth century, alien invasive species have contributed to nearly 40% of all animal extinctions for which the cause is known.

At least R6.5 billion worth of ecosystem services are lost every year as a result of alien invasive plants, according to published estimates.

In South Africa, the total area infested by alien invasive plants doubled from 10 million to 20 million hectares between the mid-1990s and 2007. Some alien species have a strong foothold in many important catchments and water source areas. “Most of the invader plant species spread exponentially when there are no biological control interventions in place,” Prof Hill explains.

These water-thirsty plants are literally sucking catchments dry at the expense of humans and nature. Weeds also affect water quality negatively, adding to South Africa's water woes. Given the country's water risks, stopping the spread of these plants in crucial catchment areas should be a priority, WWF-SA states in a recent fact sheet titled *Farming for a drier future*.

It is, for instance, estimated that these plants are reducing the water supply to the Theewaterskloof Dam in the Western Cape by 30 million m³ per annum. This dam is one of the six main dams providing water to the City of Cape Town's metropole area and many exporting agricultural producers. This volume of water lost to alien invasive plants is equivalent to the full capacity of the Upper Steenbras Dam.

Eco-friendly, cost-effective option

Despite the challenges posed by invasive plant species, there have been successes dealing with them on a local scale. One such example is the use of biological control methods: of the 60 invasive plant species targeted for biological control thus far in South Africa, 15 species are now under complete biological control and another 19 species under a substantial degree of biological control.

“Biological control measures, or the development of host-specific natural enemies, offer a cost-effective alternative and long-term solution for dealing with this problem,” says Hill. Scientists focus their efforts on priority catchments to optimise the resources available.



Courtesy of CBC

Example of a small reservoir at Rheenendal (in the Southern Cape), before and after a biological control agent was used to suppress weed density. The Rheenendal pool was covered by kariba weed before biological control methods were used.

In numbers

20 million	Number of hectares overgrown by alien plants in SA
379	Number of alien invasive plants listed in SA's national legislation
93	Number of biological control agents used in SA
90 litres	Amount of water used daily by one (alien invasive) pine tree
59	Number of weed species targeted using biocontrol agents
1913	Date first biocontrol agent was released in SA

The estimated cost-to-benefit ratios highlighted by the SANBI report indicate that, for every R1 invested into biological control measures, economic losses caused by alien invasive plant invasions of between R8 and over R3000 have been avoided.

In 1963, in her influential book *Silent Spring*, Rachel Carson warned the world of the environmental and human health dangers of pesticide use. Carson, a scientist and ecologist, promoted the use of biological control as an alternative method for suppressing insect outbreaks and weed infestations. Despite this warning, the global expenditure on pesticides has increased annually, reaching some \$65.3 billion for 2017. The use of

agrochemicals, especially certain pesticides, have many negative impacts on the environment.

Biological control is a particularly appealing solution because it is not: toxic, pathogenic or dangerous to humans. They are also particularly useful when employed alongside integrated pest management. "In some cases, mechanical and chemical methods still have to be used, given dense stands of these alien plants in certain areas," Hill explains.

These "weed-warrior" insects also have the advantage of being self-perpetuating once established and are specific to their host plants, adds Philip Ivey, a project manager at the CBC. "The adult mirids and planthoppers CBC uses as biological agents will, for instance, only feed, survive and reproduce on water hyacinths."

Strict quarantine measures and permit conditions are in place, and extensive research is done before biocontrol agents are released, Hill explains. "Biological control agents are only released when there is scientific proof that these agents can safely be released," he emphasises. This happens once they have been cleared for release by the regulatory bodies; the Department of Agriculture, Forestry and Fisheries and the Department of Environmental Affairs; and if they conform to current legislation.

So far, only 120 of the potential 270 biocontrol agents (species) identified for possible local use have been approved by South African authorities. This is according to Ivey indicative of just how strict and rigorous this process is.



Michael Pinyana

Rosali Smith, a PhD student at CBC, releasing the fly larvae targeting Brazilian water weed into the Nahoon River with the help of Ahmed Khan, Director of Operational Support and Planning in the Department of Environmental Affairs. This weed, native to South America, was first recorded in South Africa in 1963. It reproduces through vegetative means. Any plant fragment, even as small as 1 cm, can develop into a new plant.

What does the term 'biological control of alien invasive plants' mean?

This term refers to the use of highly host-specific natural enemies (usually plant-feeding insects and mites, and plant pathogens), known as 'biological control agents', that are introduced to control alien invasive plants which cause problems in a particular area.

This method has been used in 130 countries to control the spread of alien invasive plant species. Globally, approximately 550 biological control agents have been released to date.

In South Africa, many alien invasive plants, including floating invasive aquatic plants, cacti, shrubs and Australian Acacia species, have been targeted successfully over a century using this method.

Biocontrol agents for change

During the 1970s and 1980s, floating aquatic weed plants became the targets of biological control efforts in South Africa. It is also a crucial part of the strategy being employed by the government's Working for Water teams to tackle problems with alien invasive plants.

So far, five floating and one submerged aquatic species have had agents released against them locally. Four of these, namely the kariba weed, water lettuce, parrot's feather and the red water fern, have each had a single agent released. The scientist considers them to be under complete or substantial control. "This means that if the biological control agents are used correctly and water quality improves, these weeds should no longer pose a threat to aquatic ecosystems," Ivey explains.

Biological control measures also contribute substantially to the reduction in the invasiveness of water hyacinths. But there are some areas in the country where additional measures, mostly herbicide application, are still needed to bring these weeds under control. These are usually areas where the system is polluted with nitrates and phosphates.

The identification and control of invasive species is a continuous and ever-evolving problem. Every year, more species are identified as problematic and more effort is invested in finding new and effective biological control agents.

CBC, for instance, recently released a fly to halt the spread of Brazilian waterweed (*Egeria densa*) in local water bodies. This fly (*Hydrellia egeriae*) is the first released control agent developed by the CBC (which was established almost one year ago). It is also the first biological agent released to target this particular aquatic weed in the country. Brazilian waterweed is considered a significant weed elsewhere in the world and emerging as a problem weed in South Africa.

The effects of the biological control agents differ on their host plant. Some of them limit plant growth and may cause the weeds to die while others only target seed production and thus reduce the rate of population growth of a particular plant gradually rather than damaging adult plants. "CBC tests potential control agents in quarantine to make sure that they are host-specific, they only feed on the target weed, and they are sufficiently damaging to reduce the vigour of the plant or its seed production," Ivey says.

What is the difference between alien plant species and invasive species?

Not all invasive plants are considered weeds. Approximately 380 of the 9 000 plant species that have been introduced into South Africa are considered as such.

Alien invasive plant species (or weeds) are species whose introduction and spread outside their natural distribution threatens water sources, grazing resource, biological diversity, and affects human and animal health. These plants originally came from other countries or regions. In most cases, plants have been brought to South Africa for economic or ornamental reasons (including as garden plants or for forestry purposes).

A total of 773 plant species, including aquatic alien plants, are considered 'neutralised alien plants' in terms of the Southern African Invasive Plant Species Atlas (2016).

These plants do not have natural enemies or factors limiting their growth in South African. Water hyacinths are, for instance, a problem in many local water bodies.



Biological control agent, *Neohydronomus affinis*, on water lettuce.



Inside the Waainek facility.

Of the 2 034 alien species known to have established populations outside of cultivation or captivity, 775 have become invasive.

The larvae of the fly recently 'deployed' by CBC near Grahamstown to halt the spread of Brazilian waterweed feeds on the plant's leaves, which reduces its photosynthetic capacity and induces secondary infection. This damage reduces the plant's biomass and its invasive impact. About 10 000 fly larvae were released in October in the Nahoon River.

CBC's scientists cultivate alien invasive plants in controlled greenhouse environments at its Waainek and Uitenhage mass-rearing facilities. The bugs are then mass-reared on their host plants which are kept in portable pools in temperature-maintained plastic tunnels. "On average, three to four years are needed to do this testing," says Ivey. "If there are problems with maintaining the population in quarantine, this obviously takes longer."

Biological control measures have been used successfully for more than a century in South Africa. For several decades, South Africa has been recognised as one of the top countries globally

with regard to research on the biological control of weeds.

Hill says biocontrol methods have already enabled efforts to reduce the area infested with alien cactus plants from 900 000 hectares to less than 100 000 hectares in South Africa.

"Where conventional (chemical and mechanical) methods of getting rid of alien weeds prove ineffective to deal with the problem, biological control agents often provide the only sustainable solution," says Hill. "Investing in biological control offers huge long-term benefits and attractive returns of investment. These methods can arrest or even reverse the spread of invasive plants and the impact thereof when used as part of an integrated management strategy," he concludes."

For more information, visit www.ru.ac.za/centreforbiologicalcontrol

WETLANDS

Pressures on the wetland hotspot regions of the Northern Cape

Courtesy Heidi Nieuwoudt



Pressures on depressions in the arid Northern Cape Province are often poorly reflected in models used to determine the ecological condition of inland wetlands. Research currently being undertaken in the province has revealed a number of hotspot regions along with associated pressures. Article by Dr Donovan Kotze, Dr Betsie Milne, Heidi Nieuwoudt and Halcyone Muller.

Historically, pressures on arid depressions in the Northern Cape have been poorly reflected in national products which modelled the ecological condition of inland wetlands using land cover datasets. Researchers in the province sought to address these shortcomings by amalgamating their expertise into a preliminary synthesis which they presented during a Northern Cape Wetland Forum meeting on 14 November 2017. The forum was attended by 17 people, representing a variety of organisations ranging from six government departments to universities, municipalities, private consultants and South African National Parks.

The presentation centred mainly around two topics, namely:

- The identification of a number of key inland wetland hotspot regions in the Northern Cape. Hotspot regions were considered areas where a larger density of wetlands may be present compared to other areas in the Northern Cape. Hotspot regions were not related to bioclimatic

information but merely a visual demarcation of areas where the extent of wetlands appear more than other areas.

- Listing the state of key pressures found within each of the hotspot regions.

The intention was to inform conservation and rehabilitation planning.

Dr Betsie Milne and Heidi Nieuwoudt identified the extent of six hotspot regions in the Northern Cape Province where a higher density of depressions or 'pans' occur (Figure 1). Pressures on arid depressions in the Kalahari, Bushmanland, Ghaap Plateau and Upper Karoo hotspots (Figure 1, regions 3 – 6) were identified by Dr Milne following direct observations in combination with general assumptions towards impacts that might affect the functioning of these systems.

Unlike typical wetlands, the arid depressions in these four regions are characterised by the availability and successful development of a sustained crustacean egg bank. These crustaceans are tiny little invertebrates that specialise in temporary waters. They survive desiccation by producing millions of dormant eggs during inundation, which then get deposited in the sediment where it dries up to form an egg bank. Eggs can only be seen under a microscope at 50 times magnification (Figure 2). Any pressures potentially affecting the soil characteristics and hydrology were therefore considered.

In addition to these four regions, the Kamiesberg massif (Figure 1, region 1) has also been identified in the Working for Wetlands strategic plan for the Northern Cape (2013) as an important centre of endemism. It is a distinctive and unique bioregion that is located around the high lying region of the uplands – an area just north of the town Garies, and constituting a key priority for conservation by virtue of the remarkable biodiversity and high levels of endemism. Quaternary catchments F50E, F50A and F30A (inclusive of the Swartleentjies, Groen, Buffels and Spoeg systems) have been identified as supporting the priority wetlands of the region. These catchments are critical high water-yield areas and the wetlands fall within two important vegetation types, Kamiesberg Granite Fynbos and Namaqualand Granite Renosterveld.

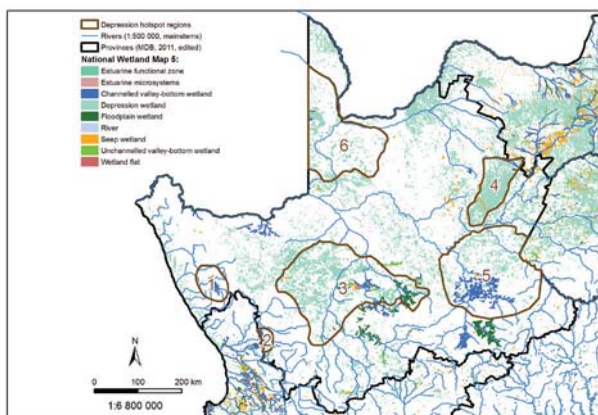


Figure 1. Depression hotspot regions of the Northern Cape, identified through the work of Betsie Milne (SAEON) and Heidi Nieuwoudt (DEA). Regions include: 1. Kamiesberg Uplands; 2. Nieuwoudtville; 3. Bushmanland; 4. Ghaap Plateau; 5. Upper Karoo; 6. Kalahari.

The Kamiesberg uplands dominate groundwater recharge in the catchments of the area, therefore playing an important role in sustaining groundwater as a resource (SRK, 2010). Kamiesberg Granite Fynbos is restricted to the Kamiesberg Uplands, a factor making it a key element of any conservation strategy for the area. This vegetation type supports a very high number of endemic plant species, with at least 29 endemics (or near endemics) wholly restricted to or found primarily in this vegetation type. Namaqualand Granite Renosterveld is almost entirely endemic to the Kamiesberg (all but 30 hectares of its global distribution is found here). The Renosterveld also supports a rich diversity of plant species, especially geophytes.

Wetlands within Namaqualand Granite Renosterveld have been identified as special habitats in need of particular conservation

attention in view of their high levels of transformation, importance in terms of biodiversity conservation, and as water sources.

The Nieuwoudtville Plateau (Figure 1, region 2) is a distinctive and unique bioregion and a key priority area for conservation by virtue of the remarkable biodiversity and high levels of endemism. The Namaqualand Biodiversity Sector Plan highlights the importance of this area in terms of biodiversity. The area is regarded as a centre of bulb endemism, and is home to a great diversity of plants and vegetation types. It is also a hotspot for invertebrates, and the area surrounding Nieuwoudtville is known to have a variety of insects – notably certain endemic monkey beetles that are key pollinators for many of the regions unique plant life.

The area surrounding the town of Nieuwoudtville is also a centre of endemism for bees, and the only place in the world where plant and bee endemism overlap. Quaternary catchments E32E, E40C and E24K have been identified as supporting the priority wetlands of the region. These catchments are critical high water-yield areas and also important support systems for rivers and aquatic species of the area.

Pressures

Subsequently, the type of pressures, their extent and intensity were presented by Dr Donovan Kotze. Table 1 summarises how the intensity and extent of impacts varies greatly across the different wetland hotspots of the Northern Cape.

In the Kamiesberg Uplands and Nieuwoudville, cultivation is having the greatest magnitude of impact owing to its relatively high intensity of impact and high extent. While livestock grazing also has a high extent of impact in these two hotspots, its intensity of impact is less than cultivation. Additional important impacts are from invasive alien plants and dams.

In Bushmanland, Upper Karoo and Ghaap Plateau hotspots, the extent of wetland cultivation is lower than in the wetlands of the Kamiesberg Uplands and Nieuwoudville hotspot regions, but livestock grazing greater. In addition, several depression wetlands are impacted by mining, especially by diamond and gypsum mining in the Upper Karoo and salt mining in the Kalahari and Bushmanland; albeit with a very limited extent.

In the Kalahari, cultivation of wetlands is absent and impacts from grazing more limited in extent than in the other hotspots. Cultivation pressures of wetlands in Bushmanland are mainly restricted to seasons of flooding, i.e. once every 13 – 16 years and only for a period during which the wetland is inundated or saturated. This presents a possible severe and direct pressure on the crustaceans, coinciding with their time of reproduction.

Betsie Milne



Salsola sp. established in old plough lines on a pan near Brandvlei.

do show groundwater interaction, especially at hypersaline pans with permanently saturated soils. These areas are also generally associated with salt-mining activities. The Dwyka geology of this region produces high-quality underground brine that is exploited for salt mining. Apart from the physical disturbances that salt mining operations cause to the wetland surface, further modifications occur when large volumes of groundwater is extracted and pumped onto the surface to allow crystallisation of salt through evaporation.

Groundwater in the Kamiesberg region is greatly affected by boreholes. Local towns are directly dependant on the aquifers for water provision. In the communal and farming areas fountains are utilised for basic needs. Abstraction for irrigation is not very common.

Dams/diversions

Dams and diversions are most profound in the Bushmanland region, where drainage areas have been cut off. The Sakrivier floodplain and its main tributaries, for example, have been cut off by numerous dam walls to retain water for longer, eventually limiting hydrological connectivity. Additionally, many depressions in the Upper Karoo, Kalahari and Bushmanland have been excavated to create a damming effect within the depression and ensure prolonged water availability to livestock, as well as to create evaporation ponds for salt mining.

These geomorphic changes to the inland wetlands alter microhabitat conditions. This said, it has recently been proven

that freshwater dams built by farmers also provide additional habitat types to increase aquatic biodiversity in the region. Damming within depressions also allowed for research in 'live pools' and in such a way distribution of unknown species could be discovered. These added advantages are complimentary to the agriculture-biodiversity relationship. A paper, which elaborates more on this topic, is being drafted by Dr Betsie Milne.

No major dams for water provision to towns exist in the Kamiesberg. Farm dams have been constructed on commercial farms for irrigation of grazing fields for cattle – mostly occurring in degraded valley bottom wetlands.

The extent of water diversions and artificial drainage channels associated with cultivation has not been quantified and remains uncertain. However, interpretation of satellite imagery provides some indication of the extent of these impacts.

Invasive plant species

Prosopis spp., including both *Prosopis glandulosa* (Honey mesquite) and *Prosopis velutina* (Velvet mesquite), are prolific woody invasive plant species from arid regions of America. The pods produced by the trees are highly palatable. The seeds are, however, indigestible and livestock, especially cattle, spread them in rangelands. The result: multiple trees growing and replacing natural species in the landscape. *Prosopis* spp. has a low sensitivity to water quality and has a very deep root system that easily taps into groundwater. As a result, it poses a significant threat to biodiversity and ecosystem services where it outcompetes with indigenous plant species, particularly in the riparian zones.

According to the National Environmental Management: Biodiversity Act (NEM:BA), *Prosopis* spp. are listed as category 3 invasive plant species in the Northern Cape Province. However, should it occur on river banks; it should be regarded as category 1b invasive plant species which allows for no exemptions in having the species present. Dr Elna van den Berg of the Agricultural Research Council (ARC) has modelled the extent of *Prosopis* spp. in the Northern Cape Province (Van den Berg, 2010) using remote sensing and Geographical Information System (GIS) methods. The results showed a high density of the invader primarily around river courses as well as other inland wetlands. The overall accuracy of the prediction was 72% and therefore allows targeted intervention in these areas.



Salt crusts (left) and permanently saturated soil (right) of the Loch Maree salt pan.



Betsie Milne

Climate change

In 2012, Conservation South Africa (CSA) generated a comprehensive Climate Change Vulnerability Assessment for the Namakwa District Municipality (NDM). The key wetland hotspots identified in the workshop, Kamiesberg Uplands, Nieuwoudtville and Bushmanland, are all located within the NDM. The report summarises the likely impacts for the District as a result of expected climate change. It highlighted the more sensitive and more resilient areas ecologically, and identified those areas that contain the most vulnerable populations and/or the most important natural resources for ecosystem-based adaptation.

Dr Holness and Prof Midgley (Bourne et al, 2012) developed three climate scenarios for the Namakwa District. Under all scenarios the greatest warming is projected for the south-central interior (Bushmanland wetland hotspot area) and along the Orange River in the north, and the coastline particularly to the south. The most stable areas in terms of projected temperature change are around Sutherland in the south east and in the Kamiesberg uplands and Nieuwoudtville, where higher altitudes limit temperature increases. Rainfall maps demonstrate greater uncertainty where best case scenario predicts an increase in rainfall around the Kamiesberg and into south central and south east NDM, but the intermediate and worst case scenarios predict a reduction in the rainfall across NDM.

Another process mapped the areas important for supporting climate change resilient ecosystems and the socio-economic vulnerability of the NDM and ultimately the priority areas for Ecosystem-based Adaptation (EbA) was developed. EbA is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. Strategies within EbA need to consider ways to manage ecosystems so that they can provide the services that reduce vulnerability and increase resilience of socioecological systems to both climatic and non-climatic risks, while at the same time providing multiple benefits to the society.

EbA is well suited to rural landscapes, and implementation efforts can be easily aligned with job creation and other projects with significant social benefits. The Kamiesberg and Nieuwoudtville wetland hotspot areas had a high value for EbA to climate change impacts while a medium value was calculated for the Bushmanland wetland hotspot area based on values for ecological infrastructure, biodiversity priorities, climate resilience and social priorities.

In light of climate change as a threat to these areas, or rather the resilience offered by these priority areas, especially that of the Kamiesberg Upland system and Nieuwoudtville, maintenance, conservation and restoration of these systems are crucial to continue to provide socioecological resilience and absorb impacts of climate change related disasters.

Conclusion

In conclusion, across the hotspots generally, it appears that wetlands with open drainage (typically in valley bottoms) are subject to greater pressure from direct cultivation and alien plant invasion than wetlands with closed drainage (typically in depressions/flats). Wetlands with closed drainage tend to

accumulate salts to a greater extent than those with open drainage, and under the low rainfall conditions of the Northern Cape this accumulation is a major constraint in terms of cultivation and invasive alien plant infestation.

Highly saline wetlands and those with an impenetrable clay surface lacking any vegetation are also not subject to grazing pressure. Wetlands with open drainage have much greater potential for the flushing of salts potentially accumulating in the soil. These wetlands also generally have larger catchments, leading to a greater supply of water, which may potentially be impacted by upstream dams, diversions and abstractions. Impacts from groundwater abstraction are probably confined to some wetlands in the Kalahari and Bushmanland regions, which appear to have aquifer connections, while the majority of the remaining wetlands are likely to be perched well above the regional aquifer.

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Brian Culver (pictured) is a citizen scientist, incredible and passionate photographer, avid birder and local wetland activist! He is retired and has volunteered his time on many occasions to help out with SAEON activities, including accompanying Betsie on field trips. Being in work mode in the mud all the time it is difficult to take good photos, so it is always a great pleasure to have someone like Brian along.

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GROUNDWATER

Groundwater issues in digital news reports – A descriptive analysis

How often is groundwater mentioned in the digital press? Handré Brand did a quick study to find out.



Groundwater is a valuable, highly respected and complex commodity worldwide. Thousands of peer-reviewed research articles on groundwater are published in academic journals annually. *The Journal of Hydrology* serves as a good example. Valuable information is also available in other types of publications, e.g. textbooks, these, magazines and media articles. Journalists also report on groundwater issues in digital media.

Groundwater can be defined as subsurface water that moves due to the effects of gravitation, or as water that has not yet come into contact with surface water (Schmidt and Hahn, 2012). Groundwater can also be described as water that fills the pores, cracks, fractures and other cavities in geological structures under the earth's surface (Bradbury, 2018).

Ascot (undated) pointed out that groundwater has been used for millennia during the existence of the human species. Only the ways in which the source was used and managed changed over time, including the degree of exploitation, attitude towards and the utilisation of groundwater.

The strategic importance of groundwater is highlighted in arid areas where groundwater extracted from aquifers is used as an additional water source during periods of intense drought and water stress. Should groundwater abstraction surpass the natural groundwater recharge, overexploitation or groundwater depletion occurs (Wada et al, 2010).

Aims of this study

Water is a liquid of the water molecule H₂O, consisting of two hydrogen atoms and one oxygen atom (Helmenstine, 2017). It should then be expected that the major worldwide research interest in groundwater and the water cycle would come from the basic natural sciences. But the humanitarian-oriented information, research findings, and publications should also play an important commentary role within this knowledge area of the contemporary groundwater research domain.

From this premise, the primary research question of this study follows: What is the incidence and core focus on humanitarian-oriented reports on groundwater published by international online digital news media?

Method

In this study, a cross-sectional analysis was made of international digital news items published on groundwater during a specific and relatively short time period. Cross-sectional analysis is a quick method (Bhat, 2018) which is suitable for descriptive analysis. This study can accordingly be viewed as a selective summary of digital reports on groundwater obtained at a given point in time.

The online function *Google Alerts Daily Updates* was used as an instrument to capture all information that was published on Google under the keyword 'groundwater' for the period 18 August to 18 September 2018.

Specific selection criteria were applicable when a decision was made to include or not to include the detail of a specific digital report for the purposes of this study:

- Whether an article was immediately accessible or not
- Whether the content was applicable to the research question (letters to editors and notices of meetings or conferences were excluded)
- General knowledge and incomplete contributions were not included
- Information about extraction of groundwater by hotels and buildings as well as information on pipelines did not meet the criteria for inclusion
- The marketing process of companies, services or organisations were also excluded

The obtained content which met the selection criteria was summarised by a table under the following criteria:

Reference	Date published on Google Alerts	Author(s)/Nature of the study	Area/country	Core focus of the article/Keywords	Direct quotations from the text ¹
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1. Information in this column was utilised primarily as a tool to identify the core focuses (in column 5) of the individual publications and was later excluded in the final version of the table.

Table 1 - Viewpoints on groundwater (an example of the articles found)

Reference	Date published on Google Alerts	Author(s)/Type of study	Area/ Country	Core focus of article/Key words
1. https://academic.oup.com/femsec/advance-article-abstract/doi/10.1093/femsec/fiy164/5076029?redirectedFrom=fulltext	Aug 18, 2018	Geesink, P (et.al.) Friedrich Schiller University, Jena, Germany. Research study	Germany	Microbiology, Ecology , Microbes Growth promotion of groundwater bacteria.
2. https://onlinelibrary.wiley.com/doi/abs/10.1002/jctb.5801?af=R&	Aug 18, 2018	Perez-Mora, B.E. Journal of Chemical Technology and Biotechnology. Research article	Argentina	Toxication Arsenic absorption in contaminated groundwater.
3. https://www.ajol.info/index.php/ijbcs/article/view/176290	Aug 18, 2018	Djaouda, M (et.al.) International Journal of Biological and Chemical Sciences. Research article	Maroua (Far North Cameroon)	Quality assessment of groundwater. Assessment of bacteriological quality of groundwater from boreholes
4. http://www.thehansindia.com/posts/index/Andhra-Pradesh/2018-08-19/Groundwater-levels-seen-rising-in-State/406459	Aug 19, 2018	Pradesh, A. News report on The Hans India Website	State of Vijayawada, India	Groundwater Management and conservation

Reference	Date published on Google Alerts	Author(s)/Type of study	Area/ Country	Core focus of article/Key words
5. http://www.hastingstribune.com/news/lbnrd-board-signs-off-on-revised-rules/article_5f969704-a21e-11e8-b948-4b9172d0e12e.html	Aug 19, 2018	Raun, A. Journalist Report on The Hastings Tribune Website	Davenport, Nebraska, USA	Groundwater management.
6. https://www.hindustantimes.com/delhi-news/following-ngt-order-22-units-shut-in-ghaziabad-for-polluting-hindon-river/story-svWzCvhhvrKqL0YGBKrSVL.html	Aug 19, 2018	Correspondent Hindustan Times, Ghaziabad News Report	Ghaziabad, India	Pollution
7. http://www.foxla.com/news/local-news/simi-valley-residents-protest-city-proposal-to-use-groundwater-over-contamination-concerns	Aug 20, 2018	Melugin, B. Journalist News report on Fox11 News Website	Simi Valley, Los Angeles, California, USA	Contamination
8. https://www.stuff.co.nz/science/106280426/what-lives-beneath-microbes-in-nz-groundwater-have-vital-role-in-processing-contaminants	Aug 20, 2018	Cvitanovic, H. Science news report on Stuff Website	Golden Bay, New Zealand	Contamination
9. https://www.thehindubusinessline.com/news/science/ganga-drying-up-in-summers-due-to-groundwater-depletion-study/article24736218.ece	Aug 20, 2018	Mukherjee, A. News report on The Hindu Business Line	India	Decreasing flow and levels. Satellite images. Decline of Ganga groundwater inflow impacts on health of river.
10. https://qz.com/1353839/theres-a-time-bomb-for-us-mexico-relations-ticking-underground/	Aug 20, 2018	Schlanger, Z. Journalist Quartz (Online Magazine) Report	Mexico	Bilateral agreements and borders. USA, Mexico relations and cross border aquifers.

- To access the full table, contact the author at Email: HJB@sun.ac.za

Findings

In total, 29 Daily Updates were received during the period of 30 days showing 314 entries under 'groundwater' as the keyword. From the total number of entries, the content of 78 articles (24.8%) was in line with the selection criteria, and was included in the table. The number of publications which appeared in the popular digital press before selection over a period of 29 days, was on average more than 10 reports per day. This emphasises that the digital media (as expected) had a definite impact on the promotion of awareness, as well as the relevance and nature of groundwater, including the hydrological cycle.

The 78 selected publications could be classified into four main areas in terms of the type of publication. The areas were: news reports, research articles, seminars (including lectures and workshops) and professional opinions.

The number of countries to which the selected publications related was rather limited (19). The list included only two countries from Africa (Cameroon and Egypt) and two from South

America (Argentina and Colombia). The USA (50%) and India (24%) had the most references.

The core themes of the selected publications can broadly be classified as natural sciences (59% of entries) and humanities (41% of entries).

The reports listed in the natural sciences category mainly focused on the following core scientific issues: growth of groundwater bacteria, contamination and pollution, aquifer inflow decline, application of isotope techniques, recharge, radioactivity removal, groundwater flow origins and subsidence. Several academic disciplines, including geology, hydrology, chemistry, physics, microbiology and space science and engineering were represented in this sample of digital media reports.

Humanitarian issues related to groundwater were the primary focus of 32 entries. Most of these entries originated in the USA (16) and India (10) while the rest were published in Mexico,

Iran, Israel, Pakistan, Australia and France. The focus of these reports was mainly around groundwater management and conservation, bilateral agreements, and cross-border aquifers, groundwater permits, levies and taxes, over-concretisation in cities, groundwater acts, allocation of groundwater, preventative steps, sustainable groundwater plans, illegal boreholes, awareness lectures, monitoring, costing, biodiversity management and guidance programmes. The following academic disciplines, namely law, management, ecology, conservation, education, and accountancy were prominent in their association with the humanitarian and social science domain.

Conclusions

Based on the cross-sectional approach in this study, it appears that a wide range of reports containing humanitarian and social scientific content is being published on digital media. The incidence of the publications is satisfactory, and the core issues in these articles refer to management, policy formulation, legislation, and awareness promotion of the complexity of groundwater. This finding answers the basic research question of the study.

Concepts such as 'bringing humanity back' and 're-humanisation' are becoming increasingly popular across a wide range of contemporary society. Interest groups and activists could gradually exert greater pressure on groundwater management, legislation and policies in the light of human rights. An important point of departure could be to approach groundwater as a cutting-edge brand in order to "connect emotionally with people to build and maintain a community of loyal customers." (Heinemann, 2018).

Water is an indispensable nutrient. Developing, researching and publishing innovative, valid, reliable and well-founded groundwater management programmes, targeting adults as well as schools seem to be a key future priority. In agreement with this viewpoint, White (2018) stated: "We must ensure that our groundwater management is effective and robust."

No studies on the attitude towards groundwater by the public, property owners or land owners were identified in this study, which may be a basic shortcoming in the literature reviewed. Brand (2018) in his study on the attitudes of property owners towards groundwater concepts and the extraction of groundwater by means of boreholes, found no consensus between the respondents a) whether groundwater abstraction by boreholes has an influence on the water table, b) whether they supported the common good principle, and c) whether they will share borehole water between neighbours even if an official regulation prohibits the sharing of groundwater. This is a finding which be explored in more detail by duplicating the study of Brand and using larger and stratified sampling methods.

Critical evaluation of the study

The basic shortcomings of this study are the following:

- It is a survey of a specific type of literature (digital press reports), published over a relatively short period (30 days).
- From an academic perspective this analysis focused primarily on secondary reports, which were not peer-

reviewed, and were mostly popular literature written by journalists.

- The study could be duplicated using scientific literature published on Google Scholar, Ebsco Host or other academic databases.

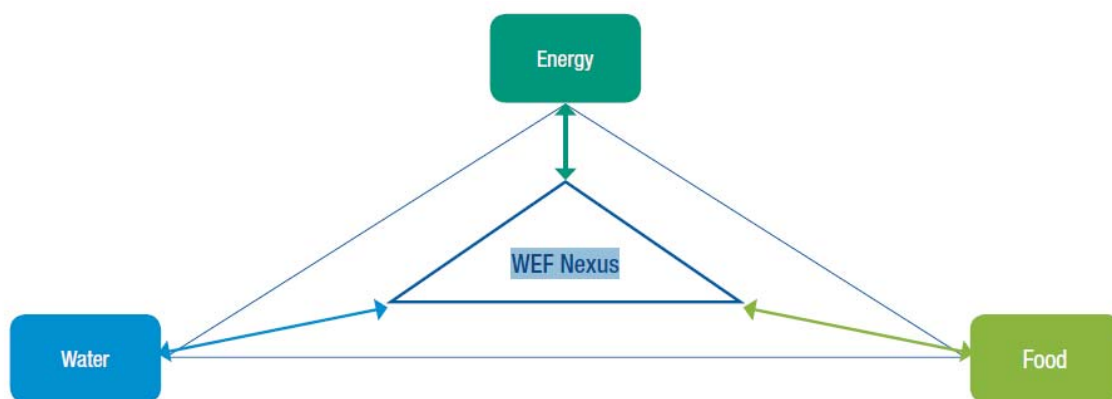
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WATER-ENERGY-FOOD

Assessing the state of the water-energy-food nexus in South Africa

The Water Research Commission (WRC) has identified the water-energy-food (WEF) nexus as one of its focus 'lighthouse' areas of research. Unlike integrated water resource management, which is water-centric in nature, the goal of the WEF nexus is to approach resource management more holistically by utilising a multi-centric philosophy. Each resource sector within this sector has an equal weighting. In its latest study on the subject, the available information and knowledge about the WEF nexus in South Africa was reviewed through a WRC project.



The water-energy-food nexus.

The water-energy-food (WEF) nexus is broadly defined as an approach that considers the interactions, synergies and trade-offs of water, energy and food when undertaking the management of these resources. Water, energy and food securities are inextricably linked, with usage within one sector influencing the use and availability in the adjacent sectors.

The WEF nexus is gaining recognition internationally as an intersectoral approach to resource management and sustainable development. The WEF nexus is a focus research area for the WRC. The WEF nexus presents an opportunity for policymakers, researchers and development agencies to integrate the sectors to optimise the use of the resource base, maximise synergies and minimise trade-offs and conflicts.

In this latest project, the WRC led a review of available information and knowledge about the WEF nexus in South Africa. More specifically, the study reviewed past, present and

ongoing work on the WEF nexus, focusing on the current status, potential, challenges and opportunities for intersectoral WEF nexus planning.

Main results of the study

Much of the WEF nexus information that has been produced has a regional SADC focus. South Africa, however, has significant opportunities to implement WEF nexus-thinking in resource management.

Solar power generation, water reuse and recycling, and precision agriculture are examples of opportunities that could contribute to intersectoral optimisation. For South Africa and the region, it is imperative that the WEF nexus approach be closely aligned with the United Nations Sustainable Development Goals (SDGs), particularly to SDG 2 (zero hunger), SDG 6 (clean water and sanitation) and SDG 7 (affordable and clean energy).

A diverse set of challenges hinder the effective implementation of the WEF nexus in South Africa. As a developing country, South Africa's primary focus is on alleviating poverty, inequality and corruption while attempting to increase economic growth.

Secondly, resource management and policy development are generally sector-specific, with little acknowledgement of adjacent sectors. Thirdly, data related to the three sectors, and especially their interactions, are frequently unavailable, inaccessible or unusable due to scale, unit or temporal differences. Furthermore, WEF nexus implementation will be subject to its inclusion in national policies and standards, implying the integration of the water, energy and agricultural departments at planning level.

Recommendations from the study

A systematic analysis of existing WEF nexus framework in academic and grey literature resulted in the development of a South African framework that considers the three sectors as well as technological innovations, human-wellbeing, SDGs and different drivers of the WEF nexus.

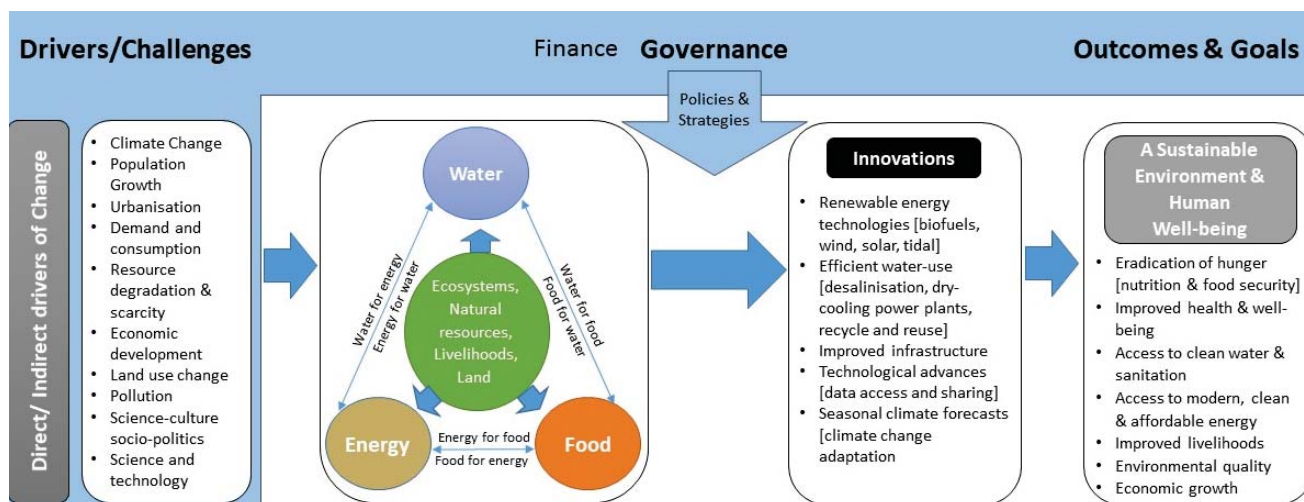
It is proposed that this framework be utilised as a point of departure for future research related to the WEF nexus in South Africa. To this end a research agenda for the WEF nexus in South Africa is proposed in the final report of the study.

It is recommended that future research on the WEF nexus focus on the following:

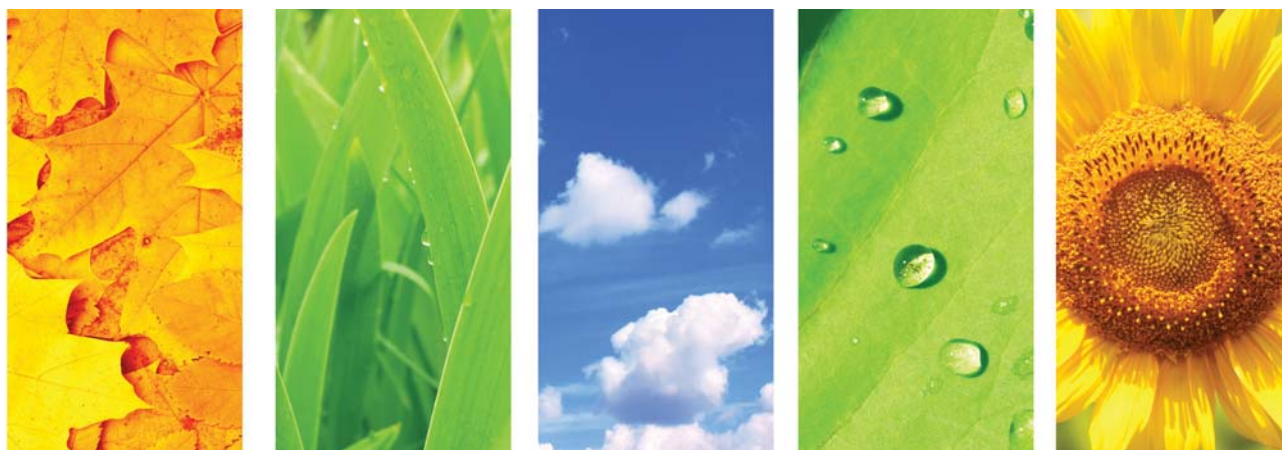
- Developing an integrated model, indicators, metrics and indices to monitor and evaluate the WEF nexus in South Africa and creating a WEF nexus database.
- Translation of existing knowledge to inform policies for integrated sustainable resource management among the WEF sectors
- Participatory research aimed at demonstrating the applicability of the WEF nexus at the local level, especially among the poor, and generating cases that demonstrate how the WEF nexus could assist in achieving the SDGs.

South Africa is well positioned to achieve these goals as there are large datasets already in existence. The development of a WEF nexus model, indicators, metrics and indices would help to unlock the value of such existing data and also guide the generation of new datasets.

To order the report, *Assessing the state of the water-energy-food nexus in South Africa (WRC Report No. KV 365/18)* contact Publications at Tel: (012) 761-9300, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.



The proposed water-energy-food nexus framework for South Africa.



NOVEL EARTH OBSERVATION TECHNOLOGY WINS NATIONAL PRIZE



Judging Criteria for Proposals



The prize judging criteria.

The South African developed earth observation technology to map and monitor water use of irrigated agriculture has won a significant prize. The prize, led by international firm DigitalGlobe, followed the 2018 Open Innovation Challenge for Novel Applications of Earth Observations. The competition was co-sponsored by various organisations, including the South African National Space Agency (SANSA) and the Technology Innovation

Agency. The winners were to receive access to the DigitalGlobe's GBSX Platform and the Licensed content. This includes DigitalGlobe's 18-year, 1 000 Petabyte library of high-resolution, multispectral imagery, as well as pre-built machine learning and remote sensing algorithms. In addition, the winners can access the latest imagery from NASA's Landsat and ESA's Sentinel data.

Led by the Centre for Geographical Analysis at the University of Stellenbosch, and co-funded by the Water Research Commission and the Department of Agriculture, Forestry and Fisheries, the winning technology makes use of machine learning and freely available satellite imagery (Sentinel-2 and MODIS) to identify actively growing crops, determine whether the crops are being irrigated (or not) and to quantify the water used by the crops. The technology was used to map all irrigated crops in South Africa and to quantify the water used by such crops in 2014/15. Near real-time monitoring of water use was combined with earth observation and machine learning to drive economic growth.

The developers expressed the hope that the exposure following the award would lead to the operationalisation of the technology.

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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