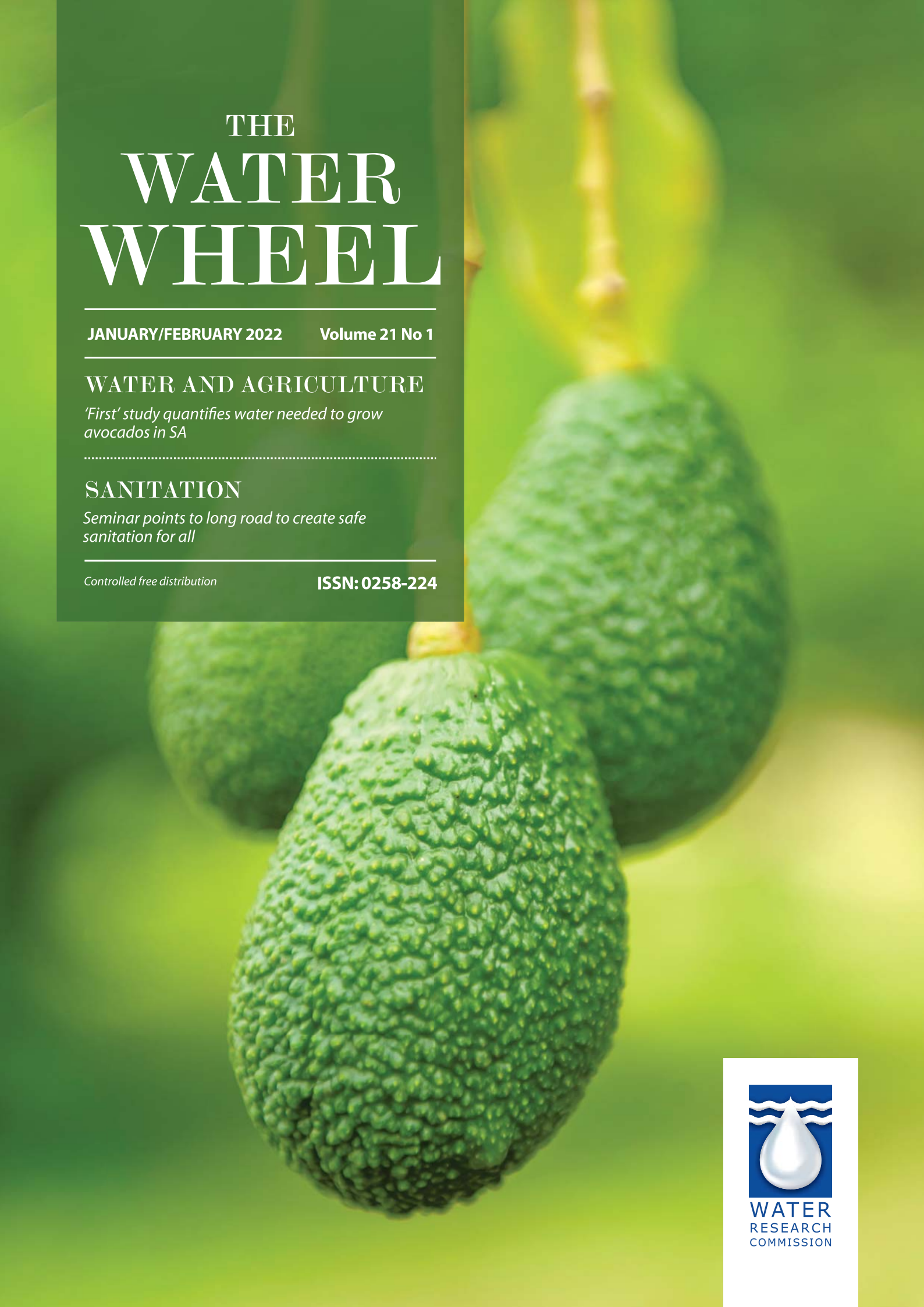

THE WATER WHEEL

JANUARY/FEBRUARY 2022 Volume 21 No 1

WATER AND AGRICULTURE

'First' study quantifies water needed to grow avocados in SA

SANITATION

Seminar points to long road to create safe sanitation for all

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WATER RESEARCH COMMISSION

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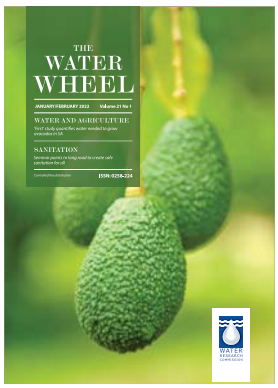
Contents



In one of the first studies of its kind in South Africa, researchers have quantified the water need of growing avocados in the country. *See page 10.*

NEWS

Global recognition for UFS professor

Prof Abdon Atangana, Professor of Applied Mathematics in the Institute for Groundwater Studies at the University of the Free State (UFS), has been elected a fellow of The World Academy of Sciences (TWAS).

He also received the World Academy of Sciences Award for Mathematics.

TWAS, described as the voice for science in the South, is working towards the advancement of science in developing countries and supports sustainable prosperity through research, education, policy and diplomacy. TWAS President, Prof Mohamed HA Hassan, congratulated Prof Atangana on this prestigious achievement: "Your election as fellow is a clear recognition of your outstanding contribution to science and its promotion in the developing world. We will be honoured to have you among our members."

Candidates elected as TWAS Fellows are scientists whose contributions to their respective fields of science meet internationally accepted standards of excellence, and they must have distinguished themselves in an effort to promote science in developing countries. Prof Atangana is known for his research to develop a new fractional operator, the Atangana-Baleanu operator, which models real-world problems. With this operator, he not only describes the rate at which something will change, but also account for disrupting factors that will help to produce better projections.

Among others, his models can advise people drilling for water by predicting how groundwater is flowing in a complex geological formation. Furthermore, his work can also be applied to predict the spread of infectious diseases among people in a settlement, forecasting the number of people who will be infected each day, the number of people who will recover, and the number of people who will die.

Prof Atangana says the election as fellow is a clear recognition of his outstanding contribution to science and its promotion in the developing world. "My work over the past five years has made a great impact in all fields of science, technology, and engineering."

Constitutional Court ruling against coal mining in water source area welcomed

The Constitutional Court's decision leaves intact a Pretoria High Court interdict granted in 2021, which prevents Uthaka (formerly called Atha Africa Ventures) from conducting any mining activities for the proposed Yzermyn coal mine near Wakkerstroom in Mmpumalanga, South Africa.

The decision is the latest milestone in a long-running legal battle by a coalition of eight civil society organisations, represented by the Centre for Environmental Rights (CER), to overturn the approvals given for the mine. At the time of writing, there were six court challenges pending before the High Court.

"Over the last six years we have done everything within our power to overturn the approvals given for this mine in order to prevent the long-term threat to water security in South Africa that would arise from coal mining – a highly water intensive and water contaminating form of mining – in this ecologically sensitive area," says Mariette Liefferink, CEO of the Federation for a Sustainable Environment.

"We welcome the Constitutional Court decision as an important local acknowledgement of the need to pause development of new coal mining, particularly in our strategic water source areas, when the impact of coal mining and burning of global warming is irrefutable. Our focus, particularly here in Africa, needs to be on building our resilience to climate change, not making it worse," says groundwork director, Bobby Peek.

The proposed coal mine would fall within a Strategic Water Source Area – one of only 22 areas where more than 50% of South Africa's freshwater originates.

BACK TO TOP

SA, Denmark renew water pact for five years

South Africa and Denmark have extended their working agreement to strengthen cooperation in the water sector for a further five years.

The Department of Water and Sanitation and Danish Environmental Protection Agency (DEPA), under the Ministry of Environment and Food, officially extended and entered into Phase 3 of their strategic collaboration and cooperation in the field of water sector, water use, and water resources.

The treaty was formally ratified by Water and Sanitation Minister, Senzo Mchunu, and Danish Ambassador, Tobias Elling Rehfeld. The two leaders exchanged signed letters of extension; discussed the Memorandum of Understanding (MoU), water sector challenges and current trends; and brainstormed a way forward.

The agreement will focus mainly on activities, including technology transfer, research and innovation with the purpose of supporting entities such as the Water Research Commission, and training and capacity building with an intention of exploring opportunities to strengthen capacity development through training and student support. The agreement will also focus on industrial water efficiency, with a view of gaining practical experience with water efficiency measures at industry level.

The Minister expressed his gratitude to the Danish Government for their assistance to ensure water security in South Africa. "Thank you for extending this agreement [and] we are genuinely excited about this partnership. This comes at a time when we are faced with a number of challenges in the water sector which we are confident that we will overcome, and this comes in handy [because] water is such an important resource, as you know that it has no substitute," Mchunu said.

Rehfeld indicated that through this partnership, issues including water saving, recycling processes, metering and monitoring technology will also be looked at. "This is a continuation of the existing partnership [and] we are looking forward to continuing with this partnership which has been in existence for a number of years now. We hope that we are making a positive contribution," Rehfeld said.

Source: SAnews.gov.za

Government committed to get dam augmentation project back on track – Minister

Minister of Water and Sanitation, Senzo Mchunu, has assured stakeholders of government's commitment to resolve challenges related to the Clanwilliam Dam project.

During a stakeholders' engagement late last year with local business leaders, Water and Sanitation Forums as well as the farmers of West Coast, an impassioned plea to the Minister to unblock challenges relating to the raising of the dam wall was raised.

The raising of the Clanwilliam Dam wall is the second-biggest infrastructure project being undertaken in the Western Cape and is part of the Olifants River Water Resources Project, valued at about R4-billion, according to the Department of Water and Sanitation said. The project entails raising the dam wall by 13 metres.

The Minister said the project team will also look for ways to reduce project time without compromising project integrity. "The department is acutely aware of the inconvenience caused by delays in this project and will work hard to speed up construction."

Meanwhile, Deputy Minister of Water and Sanitation, Dikeledi Magadzi, engaged the traditional chiefs and the communities at the two villages of Maswanganyi and Homu, in Giyani Limpopo. She led a series of community engagements as part of government's continued effort in mobilising community involvement and support in the implementation of the Giyani Bulk Water Supply Project.

The water pipe projects will bring bulk water to the Mopani District Municipality and Greater Giyani Local Municipality. Water will be sourced from Nandoni Water Treatment Works to Nsami. The R971 million project is expected to be finished by end of June 2022.

Source: SAnews.gov.za

BACK TO TOP

GLOBAL

La Niña impacts temperatures and precipitation – but not climate change

La Niña has developed for the second consecutive year and is expected to last into early 2022, influencing temperatures and precipitation.

Despite the cooling influence of this naturally occurring climate phenomenon, temperatures in many parts of the world are expected to be above average because of the accumulated heat trapped in the atmosphere as a result of record high levels of greenhouse gases, according to the World Meteorological Organisation (WMO).

Most models indicate that the 2021/22 La Niña is likely to be weak to moderate – slightly weaker than the 2020/21 event. Even so, climate-sensitive sectors like agriculture, health, water resources and disaster management will be affected.

La Niña refers to the large-scale cooling of the ocean surface temperatures in the central and eastern equatorial Pacific Ocean, coupled with changes in the tropical atmospheric circulation, namely winds, pressure and rainfall. It usually has the opposite effects on weather and climate as El Niño, which is the warm phase of the so-called El Niño Southern Oscillation (ENSO).

"The cooling impact of the 2020/21 La Niña – which is typically felt in the second half of the event – means that 2021 will be one of the ten warmest years on record, rather than THE warmest year. This is a short-lived respite and does not reverse the long-term warming trend or reduce the urgency of climate action," said WMO Secretary-General Prof Petteri Taalas.

According to the WMO Update, there was a moderate chance (70-80%) for tropical Pacific sea surface temperatures to persist at La Niña levels through the first quarter of 2022. This is based on forecasts from WMO Global Producing Centres of Long-Range Forecasts and expert interpretation.

Study investigates impact of human wastewater on world's coastal ecosystems

A study published last year has taken a granular look at global inputs and the effects of human wastewater on the world's coastal ecosystems.

"The motivation behind this research was a desire to have a fine-grain understanding of how wastewater is impacting coastal waters worldwide," says Cascade Tuholske, a postdoctoral researcher at Columbia University who conducted this study as a graduate student at the University of California, Santa Barbara. Tuholske is lead author of the paper, which has been published in the journal, ***PLOS ONE***.

While research on terrestrial threats to coastal marine ecosystems often focuses on agricultural runoff and what happens when fertilizer and livestock waste winds up in the ocean, Tuholske says, few studies investigate what happens when human sewage does the same.

"This isn't the first study to produce a global wastewater model, but it is the first study to map the inputs of nitrogen and pathogens from wastewater across 130 000 watersheds across the planet," Tuholske notes. "And this is important because there are trade-offs in the intervention space."

Information from this model, he says, could make those trade-offs clearer and management decisions easier to make.

The majority of human wastewater is discharged into the ocean around the world in a variety of treated and untreated states from sewage, septic, and direct input sources. Not surprisingly, major human wastewater sources are also places with dense human populations, which tend to aggregate around major watersheds.

"We estimate that 25 watersheds contribute approximately 46% of global nitrogen inputs from wastewater into the ocean," says Tuholske. "Nearly half as much nitrogen comes from wastewater as agricultural runoff globally, which is a huge fraction." Coastlines all around the world are affected by increased nitrogen, according to the paper.

Tuholske and colleagues created a data visualisation that maps globally the sources and destinations of nitrogen, a common element in both agricultural and human wastewater that causes eutrophication.

For Tuholske, whose research focuses on food systems, the model puts into stark relief the impact of modern diets on coastal ecosystems.

"What was really surprising through this research is how diets shifting to animal-based proteins are impacting marine ecology," he says. As countries get wealthier and incorporate more meat into their food systems, he explains, the more nitrogen shows up in the wastewater, in addition to the already high levels generated by agriculture. "The more burgers people are eating, the more nitrogen is getting into the ocean," he says.

- To view the original article, Visit: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0258898

BACK TO TOP

Sanitation workers the forgotten frontline workers says study

WaterAid/ Nelson Owoicho

New studies published by WaterAid have revealed that COVID-19 has exacerbated already horrendous conditions for sanitation workers around the world.

During the pandemic sanitation workers have been praised as 'COVID warriors' in some nations, but the non-governmental organisation has found many of these workers in developing countries have been forgotten, underpaid, unprotected and left to fend for themselves. Research carried out by WaterAid at the start of the COVID-19 pandemic on the safety and wellbeing of those who clear and dispose of faecal waste, reveals hazardous working conditions, a dangerous lack of personal protective equipment (PPE), poor training and legal protection, as well as loss of income for millions.

Findings from South Asia, Burkina Faso and Nigeria show that:

- 40% of sanitation workers interviewed in India and 39% interviewed in Bangladesh lacked any handwashing facilities at work
- A third of sanitation workers interviewed in Nepal did not receive any PPE from their employers
- 80% of interviewed sanitation workers in Burkina Faso thought the PPE they were given was unsuitable and even made accidents more likely
- 48% of sanitation workers interviewed in Bangladesh saw their incomes reduced during the pandemic

Sanitation workers include people who clean toilets and sewers, empty latrine pits and septic tanks and operate pumping stations and treatment plants as well as those who clear faecal waste manually, sweep garbage and transport faecal sludge. WaterAid's findings also include solid waste workers and cleaners.

Despite providing a vital service ensuring human waste is cleared, stored and disposed of safely, WaterAid found sanitation workers are often marginalised, stigmatised, and shunned as a result of their job. Many have worked on the frontline of the pandemic, throughout national lockdowns, in hospitals and quarantine centres and in the heart of communities with poor access to safe water, decent sanitation and good hygiene facilities.

Even without the threat of the virus, sanitation work is hazardous. The workforce risk being exposed to a wide variety of health hazards and disease and can often come into direct contact with human waste. Sharp objects in pit latrines and poor construction can cause injury and infection while toxic gases can make workers lose consciousness or even kill them.

- To access the report, visit https://www.wateraid.org/us/sites/g/files/jkxoof291/files/2021-11/sanitation-workers-the-forgotten-frontline-workers-during-the-covid-19-pandemic_0_0.pdf

New water strategy for African Development Bank

The Board of Directors of the African Development Bank has approved a new water strategy for 2021-2025 titled 'Towards a water-secure Africa'.

The five-year strategy, approved in November last year, aims to increase water security in Africa, and to foster its sustainable, green and inclusive socio-economic growth and development.

"This is a significant milestone for the bank in terms of seeing water development and sanitation as key components toward improving the quality of life for the people of Africa," said Dr Beth Dunford, the bank's Vice President for Agriculture, Human and Social Development. She said the strategy would help the African Development Bank Group expand its role as the continent's partner, while promoting integrated development and management of Africa's water sector.

The strategy will guide the bank's implementation of its policy on water, which it approved in 2021.

The water strategy's four pillars underscore the importance of water and sanitation for socio-economic development; sustainability, resilience, and inclusivity; food production and nutrition; and hydropower.

"Water is a key enabler for many of the United Nations Sustainable Development Goals, and the Bank considers water to be essential for life, health, dignity, empowerment, environmental sustainability, peace and prosperity," said Osward Chanda, the Bank's Director for Water Development and Sanitation.

BACK TO TOP

THE WATER WHEEL

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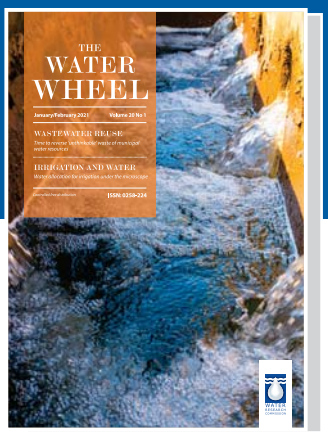

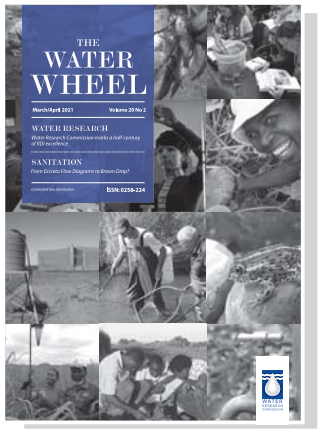

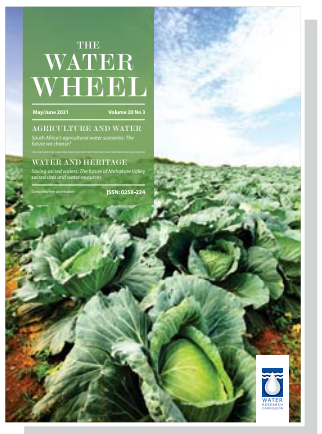

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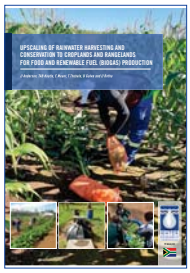
BACK TO TOP

NEW WRC REPORTS



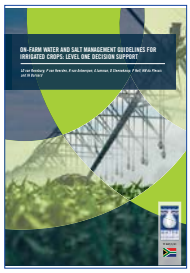
Upscaling of rainwater harvesting and conservation to croplands and rangelands for food and renewable fuel (biogas) production

Poverty and food insecurity are generic to many rural villages where villagers depend on rainfed agriculture and the exploitation of natural resources for household consumption and income generation. Subsistence agriculture in rural areas assists in relieving poverty and food insecurity and is an important sector for promoting economic development. Frequent droughts have highlighted the risks to human beings and livestock. While irrigation may be the most obvious response to drought, it has proved costly and can only benefit a fortunate few. Rainwater harvesting (RWH) is a low-cost alternative, where runoff water is harvested and utilised for productive purposes. Since livestock production is already an important component of many smallholder farming systems, manure can be used to produce biogas, which is a simple, cost-effective, environmentally friendly renewable energy source. Additionally, the by-products of biogas production provide organic waste of superior quality that can be used as a fertilizer.

Various RWH and biogas technologies are used at sites scattered around the country. However, there is no single rural village where an integrated approach to economic development based on food, energy and water security is used. The WRC funded a six-year project to assess the upscaling of RWH practices on croplands and rangelands for food and renewable fuel (biogas) production that will improve rural livelihoods without impacting negatively on the environment.

WRC Report No. TT 850/21

Link: https://bit.ly/3dpF0yX



On-farm water and salt management guidelines for irrigated crops

Irrespective of the location in the world, the opening of a tap to irrigate a crop field opens opportunities for increasing crop yields and land productivity. Intensification of agriculture, however, poses risks to crops and soils that demand management. One of the major risks of irrigation is accumulation of salts in the soil. Soil salts originate mainly from dissolved salts in irrigation water, fertiliser application, as well as mobilisation of salts in soils and parent material. Uncontrolled build-up of salts carries two threats to farmers, i.e. salinity and sodicity. Excess soil salt is a huge problem worldwide. Estimations show that approximately six percent of the world's total land surface is salt-affected. The latest predictions indicate that at least 90 000 ha of South Africa's irrigation soils are salt affected, and this impacts negatively on the livelihoods of farmers across all scales, i.e. subsistence farmers, smallholders, commercial- and mega-farmers. Hence, there is a need for guidelines to protect our soils and to improve crop yields for a broad spectrum of farmers with varying resources.

This project resulted in the development of three reports. The goal of **Volume One** was to develop a water and salt management guideline that can serve as a level one Decision Support System (DSS). Information in a level one DSS is in the domain of the public, therefore accessible to all types of farmers, irrespective of socio-economic environment.

Volume 2 was aimed at encouraging and supporting those farmers who want to change towards site-specific management, i.e. precision management of water and salts. The latest technology in site-specific management involves electromagnetic induction (EMI) surveys and ground-truthing of soil properties related to soil salts.

Volume 3 reflects on EMI research (upscaling) conducted on selected irrigation farms in the Northern Cape, Free State, Eastern Cape and KwaZulu-Natal. This is to achieve a deeper understanding of salt-related problems and their medium to long-term management. This type of decision support is on a research level and is aimed at serving the science community, although mega-farmers, corporations, and companies can also benefit from it in the medium to long-term. In this case, salinity models like SWAMP (Soil Water Management Program) were used to make medium to long-term estimates of salts on land productivity.

WRC Report No. TT 847/1/21 (Volume 1), TT 847/2/21 (Volume 2) and TT 847/3/21 (Volume 3)

Link volume 1: https://bit.ly/3GfGKXM
Link volume 2: https://bit.ly/3osuwoO
Link volume 3: https://bit.ly/3drh2n2

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BACK TO TOP

WATER AND AGRICULTURE

‘First’ study quantifies water needed to grow avocados in SA

In one of the first studies of its kind in South Africa, researchers, with funding from the Water Research Commission (WRC) and the South African Avocado Growers’ Association have succeeded in quantifying water use of avocado orchards growing in the country. The knowledge generated by the study paves the way for this profitable crop to be grown more water efficiently. Matthew Hattingh reports.

Nicky Taylor

Consider that incomparable fruit, the avocado. Botanically it’s a berry with a single, large seed. Slice its bumpy, purple-black skin. Split it asunder and behold a thing of beauty, if not a joy forever, to borrow from the poet.

High in fat, and with a subtle, buttery flavour that leans to the savoury, the avo is the key ingredient in dozens of dishes. Avocado ritz would be ***niks***, without it. And, holy moly, don’t forget guacamole!

Little wonder more people are eating them. South Africa, as of 2020, has 14 700 ha under avocado orchards, with about 800 ha added each year.

Trouble is, it takes a lot of water to grow one. Some 150-200 litres are needed to produce a single avocado of perhaps 250 g. The counter-argument is that avos are a high-value, high oil-content crop so comparing it with, say apples or oranges, is like comparing, well, apples and pears. Nonetheless, water is scarce in this country, with less to spare for more agriculture in the future.

Avocado trees are evergreen so need water year-round. Most of South Africa’s avos are cultivated in the east of the country, particularly in Limpopo and Mpumalanga, but increasingly in cooler sub-tropical regions, including KwaZulu-Natal and further west. So, while summer rainfall provides a big chunk of the tree’s needs, in dry spells and drought, irrigation is essential. But it must be done right.

Too little water and fruit will fail to set (transform from flower to fruit) or will drop off the tree and the harvest may be smaller

BACK TO TOP

or ripen unevenly. Individual avocados may also be smaller. They may be more likely to suffer from something called diffuse mesocarp discolouration (think brown or grey areas in the yellow part of the avo, especially towards the pointy end), or vascular browning (think stringy, brown bits).

Too much water and the tree's shallow roots rot and death beckons. It's enough to wind up avo lovers across the land, more so given the dearth of research on local avocado irrigation.

The good news is that the South African Avocado Growers' Association and the WRC have published a report examining water use in avocado orchards relative to yield.

The report, titled ***Water Use of Avocado Orchards – Volume 1*** (**WRC Report No. 2552/1/21**) is said to be one of "very few attempts to quantify water use of avocado orchards" under different conditions, including climatic regions, seasons and stages in the growth cycle.

"This study represents a significant contribution to our understanding of avocado orchard water use," according to its authors, Nicolette Taylor, Evidence Mazhawu, Alistair Clulow, Nico Roets, Stephanie Midgley, Theunis Smit and John Annandale. The team said they had succeeded in partitioning orchard water use into its two components: transpiration and evaporation, a rare achievement. Evaporation is when water changes to vapour on soil or plant surfaces. Transpiration refers to the water lost through the leaves of plants.

The distinction is important because, as the report explains, "transpiration should ideally be maximised in orchards, whilst evaporation should be minimised". It comes down to photosynthesis, the process plants use to turn energy from the sun into chemical energy, stored as sugars and starches. Without transpiration there can be no photosynthesis.

The report was the "first to provide reliable figures for water use efficiency and water use productivity". And its authors hoped it would help growers better design and schedule irrigation, taking into account weather predictions for the week ahead. This would allow optimal irrigation, limiting harvest losses and squeezing out water savings – particularly important during drought when growers must find ways to do more with less.

The findings were also expected to assist with planning and site selection for new orchards and in the issuing of water licences, making the process fairer.

The researchers began their work with a review of local and international journals and growers' association yearbooks and weighed up a number of different models for estimating water use. It was likely, they noted, that less than half of the country's growers schedule irrigation, this despite its well-documented value. But change may be afoot with the "increased focus on sustainable production and water restrictions".

Having identified gaps in the avo-watering body of knowledge, the team selected a number of well-managed orchards where they could do experiments and gather data.

At Everdon Estate near Howick, in KwaZulu-Natal from April 2017 to October 2020, the researchers studied a mature and intermediate orchard, as well one that had yet to bear a commercial crop. They sought to learn how the orchards responded to environmental conditions and gathered plant data, including the extent of the trees' canopies, which have a direct bearing on evapotranspiration. Water-use data was compared with yield and fruit price data in an effort to gauge the efficiency and productivity of water use for the two fruit-bearing orchards.

But KwaZulu-Natal is not a major avocado producing region, so measuring equipment was also set up at a fourth orchard, in Tzaneen, Limpopo. During the research, the team noted:

- The locations and size of the different orchards;
- Soil types;
- Spacing and density of trees and orientation of rows;
- Ages of the trees;
- Type of irrigation and quantities of water delivered;
- Canopy dimensions and cover; and
- The size, quality and quantity of fruit yielded at the different orchards.

To get a better handle on transpiration, the team measured the flow of sap in the stems of trees in the orchards in Howick and in Tzaneen. Total evapotranspiration was established at the three Howick orchards using eddy covariance systems above the tree canopies. Equipment atop masts logged details about the air swirling above the treetops, radiation, the passage of heat and other meteorological data. Canopy and soil temperatures were monitored too. The data gathered was analysed statistically to determine orchard evapotranspiration.

Alistair Clulow

PhD student Evidence Mazhawu digs a hole to insert soil water probes beneath the roots of an avocado tree at the mature orchard in Howick.

Alistair Clulow

Researchers from the University of KwaZulu-Natal prepare probes and logging equipment for the eddy covariance system in the mature orchard in Howick.

Meters linked to data loggers tracked how much water was used for irrigation, when and for how long. To better understand what happens to avocado trees and their fruit when they are deprived of water, a fifth orchard was selected for monitoring at the Agriculture Research Council Tropical and Subtropical Crops experimental farm in Nelspruit.

Over two seasons, trees were water stressed at different fruit development stages. Irrigation through a micro-sprinkler system was withdrawn during four growth stages: flowering; fruit set; fruit growth; and fruit maturation. To exclude rainfall from the experiment, the researchers put plastic sheets beneath the trees.

They stuck moisture probes into the ground at different depths near the roots. These measured soil matric potential. This is the relative availability of water held in the soil that the tree can suck up and use. The team restricted irrigation, drying the soil to a specific, carefully determined pressure level.
They marked flower clusters on the experimental tree and recorded the number of fruit each produced. New shoots were measured, leaf sizes recorded and the number of fruit that fell were counted daily. Fruitlets were examined in the lab to learn why they dropped.

Mature fruit were harvested and samples drawn and weighed. However, complications arose at this stage. "Unfortunately, a large number of fruit were stolen during the Covid-19 lockdown during 2020 and yield data for the 2019/20 season had to be estimated," the report noted.

During cold storage, fruit were weighed regularly and the moisture loss noted. After ripening, the fruit were examined for fungal decay and other disorders, including those kill-joys we encountered earlier, vascular browning and diffuse mesocarp discoloration. "Even though these postharvest physiological disorders develop during cold storage, pre-harvest stress conditions are strongly linked to their occurrence," said the authors.

Then it was time to crunch the numbers and compare the various experimental treatments.

So what were the results and the conclusions? Orchard transpiration was found to be largely dependent on canopy size. In young orchards with little shade it mostly consisted of evaporation from soil and transpiration from grass between tree rows. Mulches and reducing the area of surfaces wet by irrigation were recommended to save water.

How hot and dry it got made all the difference and changing weather caused transpiration and evapotranspiration to vary greatly from day to day. "Understanding the water balance in these orchards could go a long way to making water savings, especially during very dry years when water quotas are reduced," noted the authors.

Transpiration was found to be driven largely by solar radiation and vapour pressure deficit (a measure of humidity related to air pressure). However, transpiration did not always increase in step with vapour pressure deficit. It might track changes in humidity closely when vapour pressure deficit is quite low, but transpiration reaches a plateau passed a certain threshold and won't increase further, even if the vapour pressure deficit continues to rise. This suggested transpiration was at times limited by supply – the "rate at which the tree is able to transport water from the roots to the leaves". The authors advised this be taken into account when estimating water use with the crop coefficient approach, a demand-limited model.

The report evaluated three models. First, a crop coefficient

BACK TO TOP

approach. Here, a reference evapotranspiration value (estimated from weather station data and representing water use of a hypothetical, well-watered short grass surface) is multiplied by a coefficient calculated for the crop being studied (avocados) to calculate the crop's expected water use. But not so fast, put away the champers. Arriving at a coefficient can be a painstaking, experimental business.

To be widely reliable across many orchards and different climatic regions, a coefficient may need to take into account a host of parameters – seasons, growing stages, temperature, vapour pressure deficit and canopy density, for example. The researchers looked at some of these, noting the extent to which transpiration was over- or underestimated as parameters were tweaked.

They concluded the coefficient approach, while "still not sufficiently accurate to provide accurate estimates across all avocado orchards… represents a significant improvement on previously suggested crop coefficients". The model could be used with reasonable confidence for estimating transpiration for planning purposes, said the report.

The second model required reliable estimates of canopy conductance (vapour transfer from tree to atmosphere), as well as weather data. Its use as a predictor proved problematic, particularly when applied across a wide range of orchards.

The third model also sought to predict transpiration directly by using a mathematical approach to assess how transpiration varied with weather data. Transpiration was modelled daily

Vivek Naiken

Researchers (left to right) Ruvekh Singh and Alistair Clulow rig up an eddy covariance systems at the intermediate orchard in Howick.

Alistair Clulow

An eddy covariance system in a new avocado orchard in Howick, that has yet to bear fruit. Orchard transpiration was found to be largely dependent on canopy size. In young orchards with little shade it mostly consisted of evaporation from soil and transpiration from grass between tree rows.

and parameters set in the intermediate orchard in Howick. But, this empirical approach proved a poor traveller. "When these parameters were applied to the other two orchards, transpiration was poorly estimated," said the team. They questioned whether the model could be used for irrigation scheduling, but felt it marked a good start.

All in all, the models were found to be unpromising for day-to-day planning but of value for strategic planning. "This study represents a significant step in the right direction, as there have been no previous reports on modelling of transpiration of avocado orchards. Future modelling exercises should also focus on modelling of soil evaporation."

Orchard-specific information needed to be translated into water use models that could be applied more widely by growers, consultants and the government, said the authors. "Models that are easier to use and provide information for strategic decisions need to be considered, together with those models that provide accurate estimates on shorter time scales for tactical decision making," they said.

What of the water stress experiments? The study confirmed that avocado trees and yields were sensitive to even moderate spells of water deprivation. Growers should be vigilant in monitoring soil water conditions and scheduling irrigation, especially during the fruit set period when rainfall is usually quite low in many summer rainfall regions. Significant fruit drop can occur if trees are stressed at the time, the report said. As rains begin water stress is less likely to occur in orchards, but growers should still carefully monitor soil water and schedule irrigation to prevent the soil from drying out too much.

To download the report, ***Water Use of Avocado Orchards – Volume 1*** (**WRC Report No. 2552/1/21**), Visit: http://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/2552%20Vol%2012.pdf

BACK TO TOP

WEF NEXUS

Experts explore links between planning for water, food and energy and decision-making

The water-energy-food (WEF) nexus strategy is gaining recognition globally as an intersectoral approach to resource management and sustainable development. During a recent event, local experts explored how this approach helps keep natural resources in circulation for longer. Article by Jorisna Bonthuys.

South Africa needs to ensure that its natural resources remain in circulation for longer to alleviate food insecurity and deal with its challenges concerning water and energy. This was highlighted by Dr Luxon Nhamo, a Research Manager with the Water Research Commission (WRC), during a recent webinar focused on the WEF nexus. The event, held on 1 October, was hosted by AgriSA and ***Farmers' Weekly***.

The WEF nexus is an approach that considers the interactions, synergies and trade-offs of water, energy and food when managing these resources.

In their presentations, the panellists provided perspectives on how this approach helps address some of the country's most pressing issues.

Water, energy, and food securities are inextricably linked, with the usage of resources within one sector influencing the use and availability in the adjacent sectors. "Currently, more than half of South Africa's households are food-insecure," Nhamo said. Furthermore, 98% of the country's available water resources had already been allocated, while 86% of its energy is generated by coal.

BACK TO TOP

"We know that South Africa is the thirtieth driest country in the world and has serious water scarcity challenges," Nhamo added. "There is little room to manoeuvre." There is also a threat of novel infections and diseases spreading. The COVID-19 pandemic provides a recent example of this, he said.

These and other challenges are being compounded by climate change. Some of the strongest drying projected globally in terms of climate change is found in southern Africa. This is a region that is projected to become drastically warmer and, at the same time, generally dryer. As a result, the country is particularly vulnerable to the impacts of climate change on water, food security, health, human settlements, infrastructure and ecosystem services.

These challenges and their impact on livelihoods and wellbeing require transformative and integrated solutions to achieve sustainability. Nhamo said: "We need to understand the drivers of change, the risk and exposure level, nexus planning and sustainable food systems.

"We have socioeconomic changes that are taking place and also environmental changes. There are also external drivers within these drivers that are causing exposure and sensitivity."

Since 2012, the WRC and several universities have conducted studies focusing on this nexus. This includes work in the Umgeni River catchment in KwaZulu-Natal and the Berg River catchment in the Western Cape. Studies are underway to explore the potential, challenges, and opportunities for nexus planning, including the municipal level. Researchers are now focusing on technical and policy issues related to this approach.

A useful approach to strengthen livelihoods and wellbeing

Dealing with the challenges related to food, water and energy, and its interlinkages, trade-offs and effects also directly impact the household and farm level, Prof Stephanie Midgley highlighted. Midgley is an extraordinary associate at Stellenbosch University's Department of Horticultural Science and scientist for climate change and risk assessment in the Western Cape Department of Agriculture.

She pointed out that water, energy, and food cannot be considered in isolation as water is crucial for energy generation and food production. Notably, crop production is the largest regional consumer of freshwater resources and currently consumes a lot of energy. Water, in turn, is required to generate energy. Land can also not be optimally developed to help drive local economic and social development without access to water.

According to Midgley, the nexus approach offers a useful approach to strengthening local livelihoods and wellbeing. "These three resources are inextricably interlinked and interdependent — changes in the availability, usage and affordability of each component can either help or harm the other two components," she said.

"If we cannot find a balance between the challenges related to water, food and energy soon, this (water crisis) will become a reality."

Several studies on the water-energy-food nexys have been conducted in catchments such as the Umgeni River.

BACK TO TOP

Achieving household food security is an important goal of water-energy-food nexus activities.

While national policies increasingly address the nexus, many farmers and communities on the ground are not yet experiencing the intended benefits. "By far, the most important determinant of livelihood-WEF security is the affordability of water, energy and food in relation to total household income and other expenses," she said.

Decision-makers need a framework to understand the interdependencies, the trade-offs and the synergies between water, food and energy. From an agricultural and rural development perspective, the WEF nexus approach can help ensure more coordinated management and efficient use of natural resources across sectors and scales. This can enhance the integration of policy, planning, financing and governance, she said.

Adopting a WEF nexus approach will allow for balanced and sustainable increases in agricultural productivity, Nhamo added.

WEF nexus approach supports sustainable development

Prof Tafadzwa Mabhaudhi, the Co-Director of the Centre for Transformative Agricultural and Food Systems at the University of KwaZulu-Natal, provided an overview of progress towards achieving sustainable development goals through nexus planning.

The nexus approach is defined as an approach that integrates management and governance across sectors and scales. Mabhaudi said that some of the United Nation's Sustainable Development Goals (including those related to zero hunger, clean water, and sanitation and no poverty) are directly linked to the WEF nexus.

Mabhaudi has been developing a framework for linking the WEF nexus to the Sustainable Development Goals (SDGs), emphasising SDG 2, 6 and 7. In his presentation titled 'Assessing Progress towards Sustainable Development Goals through Nexus Planning', he explored how the WEF nexus approach can help to improve food and nutrition security.

Activities in one sector may influence or even constrain economic growth in the others. South Africa is, for instance, still highly dependent on coal for energy generation. The majority of coal is mined in Mpumalanga, which has some of the most arable land in the country. Therefore, energy-related decisions that do not consider the trade-offs these decisions might have on food and water resources could have adverse effects.

Mabhaudi said the nexus approach provides a valuable transformative adaptation decision support tool for integrated resources management. Nexus planning also offers the potential to monitor progress towards achieving SDG targets. "It is all about resource security for sustainable development," he said.

He indicated that data scarcity at different spatial scales is the major limitation to the success of nexus planning. There is also a need to upscale the use of nexus planning as a decision-making tool. This can help to leverage the implementation process and progress towards SDGs and subsequent monitoring and evaluation at the same time.

"The nexus approach essentially allows for you to have that sort of integration during the planning stage, which means you can mitigate some of those trade-offs," he said. "You can identify potential synergies that you can then leverage and maximise. So, it is very useful in terms of investment planning. It talks a lot about wanting to use that infrastructure as a catalyst for economic development and job creation."

"The scale of the challenges South Africa faces require innovative solutions to build resilience and attain development goals," Mabhaudi said.

Moving towards policy convergence

The presenters indicated that the COVID-19 pandemic had revealed the deep fragility of many aspects of South Africa's food, water and energy systems.

There is a need to move towards policy convergence instead of the current 'silo' approach, which requires the strategic engagement of the relevant departments at the decision-making level. "The pandemic has ushered us into the Fourth Industrial Revolution," Nhamo said. "We need to act now, and we need to act fast."

Agri SA's head of natural resources, Janse Rabie, agreed, referring to projections showing that South Africa would be unable to provide water to 17% of its population by 2030. "If we cannot find a balance between the challenges related to water, food and energy soon, this (water crisis) will become a reality. It will also lead to further unemployment and inequality," he warned.

Mabhaudhi said it was crucial to now move from "nexus thinking" to "nexus doing". "Better planning in terms of the nexus approach can help us mitigate the trade-offs (between water, food and energy)," he said. "It can also be a catalyst to drive infrastructure development and job creation."

BACK TO TOP

There is a need for investment in integrated innovation, Mabhaudhi said. Moreover, following a circular economy approach would be helpful, addressing water and sanitation issues simultaneously. "Also, you could turn waste(water) into a useful resource in agriculture and address the issues of food security within those areas. So you can implement the nexus thinking at the village level to address some of the constraints of informal peri-urban settlements."

Mabhaudhi considers the nexus approach useful in dealing with some of South Africa's spatial planning issues. In addition, this approach can inform decisions about design and help create more sustainable and resilient cities.

Tackling resource planning holistically

Engaging with the WEF nexus approach requires holistic and integrated thinking about how natural resource planning is done.

In this regard, Rabe said South Africa could not afford shale gas exploration in the Karoo or hydraulic fracturing ('fracking') from a nexus perspective. This region is already known for its resource scarcity, particularly water resources, he pointed out. He also expressed concerns about the impact of such plans on the country's already high per capita carbon footprint in the context of the climate crisis and South Africa's international obligations to reduce its fossil fuel dependency.

Given global trends and the region's severe water constraints, efforts to extract shale gas (and exploration for it) are not viable at this stage, he argued. Instead, South Africa should rather be exploring its renewable energy potential and investing in it.

Midgley said South Africa is under huge pressure globally to downscale its coal dependence and use and completely phase out coal. "The science is telling us that we have very little (fossil fuel) space left that we can exploit if we want to keep global warming to an acceptable, manageable level," she said.

Midgley said she believes South Africa needs to be ambitious in reducing its carbon emissions. Momentum is building globally to a much more rapid transition from fossil fuels to renewable energy sources. The technologies are available to roll this out, and renewable energy offers significant opportunities, including at the farm level.

Nhamo said it is also time to rethink the value of wastewater. Dealing with water pollution related to energy production is necessary, he said. The WRC is currently funding several projects to determine how to turn polluted water into water that can be used for irrigation purposes.

Midgley said the pandemic illustrated how important it is to plan in a connected way.

"The pandemic has underlined the vulnerability in our system," Rabe added. "Unemployment is increasing. Our ability to pay and afford basic services and commodities are becoming more and more inaccessible to people. I think that's the biggest thing that we've learned — the system is under stress.

"It is not just a planning issue. I think it's the way we are thinking or the way we interact with one another. And I think that's probably the most valuable contribution that nexus thinking can bring to addressing these issues. A host of issues in South Africa requires this kind of integrated thinking."

Midgley said that many of the solutions and the technologies to deliver integrated solutions are already available. "Energy is a potentially unlimited resource. The sun is an unlimited resource. After many years, we started to see that the massive rollout of renewable energy technologies is feasible. So I think there is a great reason for hope."

Many of South Africa's water, food, and energy problems cannot be solved using traditional sector-based approaches. "What we need is more coordination, better coordination and collaboration," Mabhaudhi said.

Service delivery must be improved across the country, the panellists emphasised. "Water and food cannot be made cheaper - the opportunity lies in energy," Midgley said. "We need to look at affordable resources, but this is something that politicians must do. Service delivery, specifically infrastructure, is key to this."

The need to upskill municipal officials to help strengthen service delivery will help to ensure uptake of this nexus approach.

Options to enhance resource use efficiency include increasing the land under irrigation, improving agronomic practices and exploring alternative water resources. "But is it feasible to increase the area under irrigation in South Africa to enhance food, water and energy security under the prevailing challenges?" he asked. "Do we have the land, energy and water resources?

"The National Development Plan says plans are intended to increase the land under irrigation by about 40 000 ha by 2030. Do we have the resources to do that? Where is the water? We are saying 98% of the water resources are already allocated. There is little room for development."

Midgley indicated some of the low-hanging fruit that decision-makers can address to improve resource use include reducing wastage, including water leakages and food wastage.

Improving water, energy and food security

Mabhaudhi believes the nexus approach helps to improve South Africa's water, food and energy security. This approach helps decision-makers understand resource complexities, synergies and trade-offs. "The lack of balance exists because of planning that was unaware of what the trade-offs were and decisions that were taken without considering the trade-offs — only the benefits.

"The nexus approach allows for that sort of thinking during the planning stage to mitigate some of the trade-offs. It is very useful in terms of guiding our investment planning."

"Adopting a WEF nexus approach will allow for balanced and sustainable increases in agricultural productivity," he concluded.

SANITATION

Seminar points to long road to create safe sanitation for all

Matthew Hattingh reports on the latest sanitation-related research as presented at a seminar hosted by the Water Research Commission in celebration of World Toilet Day on 19 November last year.

You're done with the paperwork, zipped up and are good to go. But before you quit the cubicle, you might be alarmed to learn of research by a Durban sanitation fundi that identifies toilet door internal pull latches as the surface in a public bog most likely to bear nasty bugs.

And it's not only latches. Toilet seats, external door handles and wash hand basin tap handles, were also found to be "highly contaminated" with ***E. coli*** bacteria according to the research, presented at a World Toilet Day webinar hosted by the Water Research Commission (WRC). ***E. coli*** are commonly found in faecal matter and can cause diarrhoea and other illnesses.

But before you swear off public toilets for good, a little context and a few caveats...

Preshod Ramlal was sharing findings of his study of 23 community ablution blocks serving residents in two crowded Durban informal settlements – Kennedy Road (population 11 000) and Foreman Road (7 148). And he stressed that far from being "health hazards", as one Sunday newspaper put it, these ablution blocks mark a positive step on a long road to improving sanitation for the city's poor.

"There seems to be a misconception that water-flushing, shiny-white toilets protect all users," said Ramlal, noting that those seemingly pristine porcelain thrones weren't without their faults. When flushed, they launched pathogens (disease-causing organisms) into the air and from there onto bathroom surfaces. Or conversely, when contaminated hands touch these surfaces. Nevertheless, his research made it plain that key contact surfaces in community ablution blocks were frequently contaminated

BACK TO TOP

and he warned that "almost everyone using these" risked infection over the course of a year.

Much needed to be done to improve matters. But indeed, the same held true across South Africa – a point other webinar speakers stressed, as they touched on related topics, including toilet troubles at cash-strapped state schools; the need for better sanitation management and maintenance; and the importance of securing the safety of the people who work with human waste.

The state of toilets at workplaces also got a look-in, with Nicky Naidoo, of Nemai Consulting, briefing delegates on a recent survey. It found facilities to be largely clean and well maintained, but that most were culturally insensitive and failed to cater for the disabled. Women were underserved too.

But let's return to Ramlal's research and dip a little deeper into community ablutions blocks or CABs, to use the acronym adopted by the eThekwini municipality.

A senior environmental health practitioner with the municipality's health department, Ramlal recalled how the city developed CABs in response to a continuing "mushrooming of informal settlements". Back in 2003, when he joined the department, shackland residents enjoyed no formal access to water and sanitation. Most relied on homemade pit latrines, risking disease, while open defecation led to "excessive environmental pollution levels".

CABs came on the scene after 2004, first as brick structures. But these took too long to build and suffered vandalism. The municipality later switched to using converted shipping containers and then modular or prefabricated designs. This cut installation and maintenance costs and, as a plus, meant CABs could be relocated. Today, 1.2-million people live in eThekwini's informal settlements, in 314 000 households, with 1 600 CABs serving the "vast majority".

CABs provide toilets, urinals, wash hand basins, showers and sinks for laundry. Caretakers clean them up to four times a day.

Ramlal, who is busy completing a PhD and has published, or is awaiting publication, of a number of scholarly papers dealing with CABs and some of the nasties lurking in them, set out to:

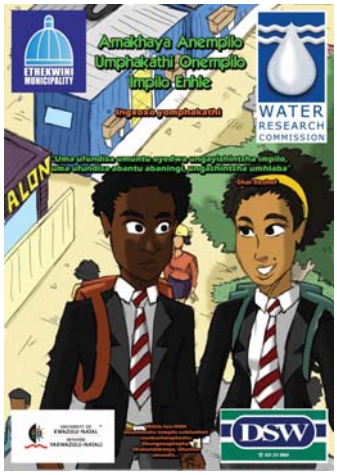
- Determine what contaminants could be found on selected contacts surfaces in eThekwini CABs;
- Establish whether contact with contaminated surfaces might cause users and their communities to develop diarrhoeal infections; and
- Identify difficulties facing caretakers.

He used swab sampling, behavioural studies and surveys to gather data. Gene sampling, sequencing and cloning helped establish which kinds of disease-causing microorganisms were to be found, and in what quantities on four contact surfaces – toilet cubicle door internal pull latches; cistern handles; toilet seats; and wash hand basin taps. With baseline pathogen levels established, further investigations followed.

To explore potential exposure points where users risked picking up diarrhoeal infections, eight different surfaces were swabbed for bacteria and ***E. coli*** concentration gauged. Samples were taken from toilet cistern handles and seats; internal and external toilet door pulls and latches; wash hand basin tap handles; shower tap handles; floor surfaces of toilet cubicles; and common floor-areas. To assess the probability of users falling ill, Ramlal measured ***E. coli*** concentrations on contact surfaces, the efficiency of it transferring to hands and from there to lips and mouths in sufficient doses.

SUSANA

Community ablution blocks, created inside shipping containers, are one of the sanitation solutions that the eThekwini Municipality has implemented.



The isiZulu version of a digital dialogue produced by the eThekwini municipality to share health and sanitation know-how and community ablution block dos and don'ts with residents of the city's informal settlements.

What did he find? ***E. coli*** concentrations on cistern handles ranged from about 3.5 to 7.5 log 10 CFU/cm^2, with a median value of about 5.5 and an upper quartile a little higher and a lower quartile a little lower.

Or, in layman's terms, when all the cistern handle samples were ranked from highest to lowest, the midpoint was about 10 to the power of 5.5 colony-forming units of bacteria for every square-centimetre of contract surface. And half of the cistern sample values fell within a narrow range – only a little more or a little less than 5.5 log 10 CFU/cm^2. The lowest concentration recorded among all the cistern handle samples was about 3.5 and the highest, about 7.5 log 10 CFU/cm^2. The median figure was a little lower for toilet seats than cistern handles, and for internal latches, slightly higher.

Based on these values, Ramlal calculated the risk of infection from the different surfaces based on how often they were touched. Taking the internal pull latch as an example, he calculated that almost three in every 100 people exposed may be infected if they touched it. Over the course of a year, with users touching the latch on average nearly twice a day, the probability was that everyone exposed would be infected.

And these being plague times, the study frequently found traces of SARS-CoV-2 on contact surfaces – most often on tap handles and cistern handles. "This goes to support the recommendation that washing of hands regularly could reduce risks of COVID-19 transmission," said Ramlal.

He calculated the risk of being infected with COVID-19 from the different surfaces, taking into account how often CAB users were exposed and whether the surface had been cleaned – which he found significantly reduced concentrations of infectious material.

In the case of toilet seats, Ramlal arrived at the following figures:
One-time risk: About 2 out of a 10 000 people infected (uncleaned): 2 out of 1 million people (cleaned);

- Daily risks (2-3 uses): About 4 out of a 10 000 people (uncleaned): 6 out of 1 million people (cleaned); and
- Annual risks: About 6 out of a 100 people (uncleaned): 8 out of 10 000 people (cleaned).

He detected a host of other microorganisms in the samples, including rare potentially pathogenic bacterial species such as ***Klebsiella michiganensis***; ***Pluralibacter gergoviae***; ***Kosakonia cowanii***; and ***Raoultella ornithinolytica***. The presence of pathogens on contact surfaces "signifies infection within the populations that use the toilets", he noted. Turning to difficulties faced by caretakers, Ramlal highlighted blocked toilets; faeces on toilet surfaces and floors; and stagnant greywater outside CABs.

What should be done to reduce risk? Public education and awareness were needed, but COVID-19 had prevented face-to-face campaigning. So the municipality and the WRC launched a lively digital dialogue with informal settlement residents, which can easily be shared on smartphones. The dialogue, written by Ramlal, blends poster art and the spoken and written word (with English and isiZulu versions) to drive home messages about home hygiene, sanitation, waste disposal and CAB dos and don'ts.

In addition, he suggested direct interventions to reduce risks of infections at CABs. These included:

- Providing soap for handwashing;
- Supplying rubbish bins;
- Improving monitoring and rapid response to complaints; and
- Caretaker training.

Training was a theme picked up by a number of the speakers at the webinar. Jeanette Neethling, of consultants Partners in Development (PID), listed training, tools, protocols and enforcement as key ingredients in better sanitation worker safety. Neethling spoke about PID's work to improve health and safety around pit latrine emptying and touched on sanitation management at rural schools.

Photo supplied

Partners in Development's work with the Sani Squad, a sanitation business in Snathing, near Pietermaritzburg, provides a useful example of how simple, but effective equipment combined with training and good management can help make pit latrine emptying safer.

BACK TO TOP

She agreed with Jay Bhagwan, the WRC's executive manager for water use and waste management, who in his welcoming remarks to delegates said: "Technology is not automatic and eternal, it needs operation and maintenance and it needs servicing." Neethling stressed that any toilet waste technology would only succeed if applied in concert with improved management and user behaviour. Operations and maintenance were "often the forgotten aspect of sanitation".

"Very few South African municipalities are actively planning for pit emptying, but many VIP toilets constructed across the country since 2001 have reached their capacity," she said. Users of pit and ventilated improved pit (VIP) latrines, the workers who emptied and maintained these, and the wider environment were increasingly exposed to pathogen-carrying faecal sludge.

Too often sanitation systems failed to separate people from their excrement, she said, citing a 2016 WRC project (**No. K5/2134**). The project, led by Bobbie Louton of Partners in Development, found that, "In many cases workers did not take the measures available to them to reduce exposure, indicating that either their knowledge of disease transmission or their attitude towards their own health or that of householders did not support safe work practice."

Louton's team visited 10 Durban homes to study how pit latrines were emptied and to collect sludge and stool samples. They found helminth eggs in nine of 10 pits and at 10 of 10 homes, concluding that all pits should be assumed to contain helminth eggs or similar pathogens. The eggs are laid by parasitic worms that can infest the human gut, absorbing nutrients and causing disease. Louton found that pit emptying introduced pathogenic faecal matter into homes, putting householders, sludge handlers and the public at risk.

Neethling touched on some of the reasons for this, sharing photographs of workers handling sludge and then touching household surfaces with dirty gloves; spilling sludge; climbing into pits for want of proper tools; and using household taps to clean up.

Photo supplied

Long-handled spades help Sani Squad workers keep sludge at more than arm's length.

Photo supplied

Sani Squad workers use a Pitvaq mobile pit emptying machine to avoid contact with faecal sludge. Groundsheets catch spills, protecting householders and the environment.

How might matters be remedied? She recommended:

- Training so workers better understand disease transmission and how to reduce risk;
- Better safety equipment, tools and facilities;
- Protocols, for example, to deal with inevitable spills; and
- Enforcing protocols and good practice.

How did this play out in the field? Neethling shared lessons from Partners in Development's work with the Sani Squad, a sanitation business that operates in Snathing, near Pietermaritzburg, emptying pits and septic tanks.

They used a Pitvaq pit emptying machine (developed by PID thanks to WRC research) and other tools, including long-handled spades, groundsheets and sludge drums with lids, to limit worker contact with sludge and to minimise spills. Training, multiple uniforms and personal protective equipment helped further.

Back at their depot after work, dedicated clean and dirty change rooms and cheap-and-cheerful shower facilities help staff clean up properly.

Drawing on her work with schools, Neethling told delegates that, as with pit emptying, protocols and detailed guidebooks had been produced (including by Partners in Development and available from the WRC). These helped schools and cleaners with the why's, what's, who's and how's of sanitation.

But she noted schools often lacked capacity and funds. Training of staff was vital, but the reality was many schools simply did not have cleaners. They needed materials and equipment and must be monitored and supported in their work as part of a team effort. She stressed that unless new infrastructure was accompanied by effective management programmes it was likely to fail.

Third-party monitoring and accountability were of great value when it comes to maintenance, particularly for those who aren't "purely motivated by the goodness of keeping toilets clean". "We believe the Department of Education has that role to fill."

YOUTH AND AGRICULTURE

Understanding the challenges first: the rural youth and rainfed smallholder farming

The youth have a crucial role to play in South African agriculture and ensuring that the nation has enough food. But while the country needs more food producers, its farmers are ageing. The average age of South African farmers is 62, despite the fact that young people (those between the ages of 18 and 34) make up a third of the population. Prof Edilegnaw Wale Zegeye of the University of the Free State's Agricultural Economics Department reflects on a current Water Research Commission (WRC)-funded project aimed at attracting more young people to specifically rainfed smallholder farming in South Africa.

Recent statistics from Statistics South Africa (2020) show that youth constitute over one third of the South African population. Unemployment among youth (15-34 years) is as high as 40 – 50%. Among the sampled rural households, 51.5% are not employed but actively seeking employment. Only about 10% are self-employed.

Experience requirement excludes most of the youth who have never been employed. Poverty levels are also higher for the rural youth. They are still the biggest beneficiaries (directly or indirectly) of social grants and remittances.

Agriculture is better placed to create job opportunities, especially in rural areas, for various reasons:

- Much of sub-Saharan Africa (SSA) farming systems are rain-fed and form an important part of the agriculture in the region;
- When both the direct and indirect effects of agricultural growth are taken into account, such growth is more poverty reducing than growth in other sectors; and
- With rising incomes and growing population, food demand is expected to increase in townships and semi-urban areas, which, in turn increases the incentive for rural youth to farm.

BACK TO TOP

To achieve national youth objectives on food security, employment creation and poverty reduction, it has become critically important to examine and understand the challenges and opportunities of linking the youth to profitable rain-fed farming and identifying appropriate entrepreneurial development paths. To this end, the Water Research Commission (WRC), through the former Department of Agriculture, Forestry and Fisheries is funding a five-year research and development project entitled 'Entrepreneurial development for establishing small farming businesses and employment by youth in rain-fed crop farming'.

In the absence of such a study in the past, the project recognises the need for more research in South Africa on the challenges and opportunities for pursuing entrepreneurial development pathways in rain-fed farming, linking the youth to profitable value chains, exploring avenues for establishing small farming business while empowering rural youth, and enhancing youth employment creation in rural areas. The project has been underway since 2018 under the leadership of Prof EW Zegeye. It is expected to contribute to food security, small-scale farm profitability, and rural youth employment.

The first step to achieve these rural development objectives is to examine the prevailing challenges. Drawing from the empirical findings thus far, this article summarises these challenges.

The study confirms that youth participation in agriculture is limited. The data gathered suggests that only 24% of the youth are engaged in rain-fed farming. Only 23% and 21% have farm income and own business as a livelihood strategy, respectively. Married youth and those with more dependents in their households have a higher propensity of participating in rain-fed smallholder farming, owing to their relative immobility and family responsibility. This suggests that some of the rural youths are farming not out of interest, but because circumstances have forced them to do so.

Many of the youth who participated in the WRC-funded study had a negative perception about agriculture as "laborious, old fashioned and non-profitable".

The project has identified several constraints, one of the main ones being the youth's general mindset and perception about smallholder agriculture, which is generally negative. Many young people see agriculture as laborious, old fashioned and non-profitable, and there is a tendency to associate smallholder agriculture with poverty.

These perceptions under young people are often created by the poor performance of their fathers and mothers in smallholder farming, which negatively influence their perceptions towards farming. The focus group discussions with agricultural extension officers also confirm that youth attitude is negative.

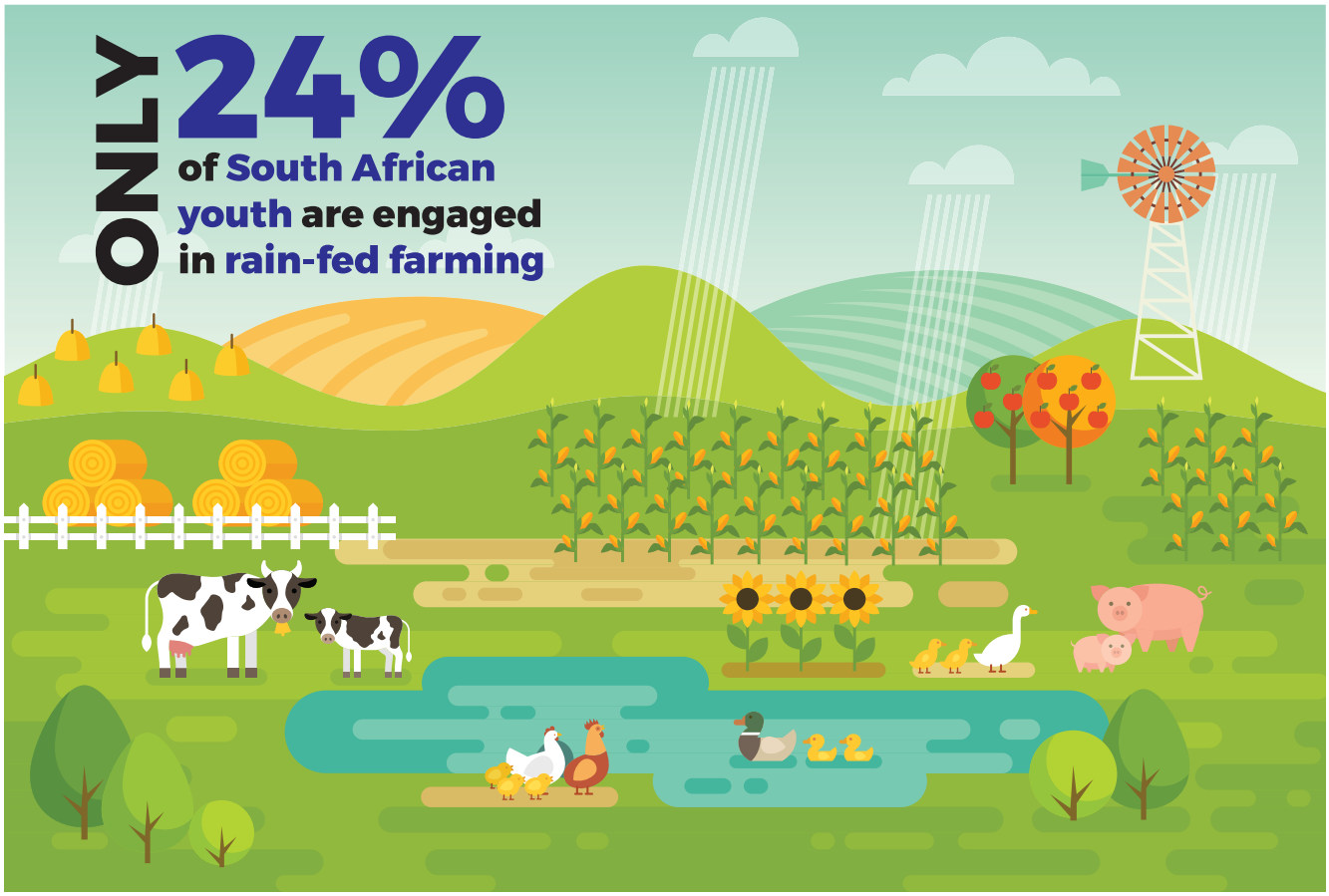
Agricultural value chain activities that entail vertical and horizontal coordination seem to be more attractive to the rural youth, because they are relatively not deemed 'dirty work'. However, the rural youth endowed with better entrepreneurial capacity have a lower propensity to participate in agricultural value-adding economic activities; they perceive other business opportunities in other sectors as more profitable.

The negative perception of the rural youth about farming must change. A mind-set shift – viewing agriculture as a source of livelihood is needed from the youth themselves. This mindset shift will not only attract youth to agriculture, but also reduce rural-urban migration and ensure a succession plan within the sector. Tailor-made training (on livestock production, rain-fed farming, managerial and entrepreneurial skills, and agricultural value-adding economic activities) must be provided to emerging smallholder young farmers to raise interest, change their mindset, and increase knowledge and skills in farming.

In addition, it is critically important to publicise success stories in agriculture – even though these stories are currently hard to find. Sharing farmers' success stories through platforms such as social media (WhatsApp, Facebook, Twitter, and Instagram), mainstream media and policy briefs, making the way it is packaged appealing to the youth.

Furthermore, there is a need to develop programmes meant to support a few model smallholder farmers in rural communities so that the success of these model farmers will make young people see the potential in farming. Mentorship programmes targeting the rural youth must link them with successful and experienced farmers and mentors. Agriculture should be marketed and promoted the same way other sectors market and promote their businesses, including the creation of more television and radio programmes. Moreover, workshops and seminars that allow the interaction of rural youth with successful farmers will convince the youth to change their perceptions and take up primary agriculture and agricultural value-adding economic activities.

Another challenge identified by the project team is the general poor understanding of what smallholder farming entails; only 21% of youth who participated in the study had received



agriculture skills training – mostly skewed towards those already in farming and most training on crop production. Only 20% of the participants are part of a learnership programme. No training was provided on livestock, water management, agricultural value chains and financial management, all issues identified by the participants. The basic education system has limited entrepreneurial content which, among other factors, has resulted in low entrepreneurial culture. This will require revisiting the curriculum.

Young people in rural areas lack access to land, financial capital, information and markets. Even though 64.2% of the participants have access to land, they do not own land. Access to agricultural land (the lack of land tenure security) affects the interest of the rural youth to participate in agricultural activities, particularly primary agriculture.

Most rural youth access land through inheritance from their parents and traditional leaders. They cannot invest in the land without permission from the owner. There is a need to improve land access for rural youth regardless of their age, gender, and marital status. Land markets will enable them to borrow, lease, and where possible, purchase agricultural land. Rural youth access to land and its security should be integrated to the land reform programme.

Participants confirmed that they did not have access to formal credit sources. Informal credit sources (e.g., stokvels) in rural areas of South Africa are not in line with entrepreneurial behaviour in that they are mostly consumptive and expensive. Production credit tailored for the rural youth is almost non-existent. It is critical to address this to engage them in both primary agriculture and agricultural value-adding economic activities. However, the youth should be mentored to ensure that the funds are used for the purposes stipulated or the credit service must be linked to services and resources such as agricultural input and output markets.

Access to relevant, tailor-made and adequate information is the key to unlocking rural youth entrepreneurship in farming. For most of the participants (78%), access to relevant and adequate information (crop varieties, inputs, new technologies, markets, prices, climate and so on) is a key constraint. Lack of information further limits youth participation; restricts performance of their enterprises; and reduces their incentive to engage in farming. There is a need to stimulate demand for agricultural information among rural youth through awareness creation and training. Owing to their unique features, there is a need to design specific information packages that can be used by the youth with interest in farming and value-adding economic activities. To this end, it will be imperative to reduce the cost of locating and accessing information.

For the youth who are currently engaged in smallholder farming, lack of access to markets affects the profitability of their farming, which, in turn influences the perception of the non-farming youth about agriculture.

Poor infrastructure in remote areas and high cost of data result in poor connectivity and limit the youth from fully utilising

BACK TO TOP

information computer technology (ICT), negatively impacting learning and skills development. Despite the prevailing constraints, their engagement with social media platforms is very high. The youth, as a techno-savvy generation, spend most of their time on their phones and social media platforms.

In terms of content, information is available on agriculture, however, the youth access content associated with luxurious lifestyles of famous/rich people, politicians, musicians, artists, models and sport personalities. This does not stimulate them to be interested in agriculture, but drives them away from agriculture and rural areas. Social media platforms and blogs must be tailor-made to cater to information needs of the South Africa rural youth where they can discuss and share information (on agricultural input and output markets, government programmes, and agricultural job and business opportunities). There is a need to invest in ICTs infrastructure to improve connectivity in rural areas so that these technologies can be accessible and affordable to the rural youth.

About 62% of the participants have never had contact with agricultural extension agents. Traditionally, agricultural extension services are designed for adults; the youth are a unique group of people that respond, react and think differently. There is a need to train agricultural extension agents so that they understand their information and services need to be tailor-made for the rural youth.

Regarding youth access and participation in agricultural and rural development initiatives targeting youth is poor and mostly not tailor-made. Most programmes are not evaluated in terms of impact; monitoring and evaluation is done with a focus only on the number of beneficiaries. There is mandate overlap and lack of coordination. Only about 14% of the participants were beneficiaries of the Department of Agriculture and Rural Development and rural agricultural programmes of non-governmental organisations on livestock, conservation agriculture, and home gardening. Most of the participants reported that the support had only short-term impacts on their lives.

Any project, programme or policy for the rural youth must start with a full understanding of their circumstances, challenges, endowments and mindsets. Strategies and policies that seek to attract youth to engage in agriculture must consider these important factors. South Africa urgently needs a national youth agricultural engagement policy to implement tailor-made strategies for the rural youth. Such strategies can lay the foundation for entrepreneurial development pathways in rain-fed smallholder agriculture.

Farm service agency, transportation, retailing, facilitation of training on farm business management, and agro-processing (virtually non-existent) are the most important rain-fed farming opportunities along the agricultural value chain that the participants mentioned. Less-complicated activities that can serve as a steppingstone for rural youth to engage in agriculture include retailing of farm inputs and outputs; serving as a farm agent; buying and reselling livestock and other agricultural products; buying and reselling of farm inputs; transportation of both inputs and outputs to different locations; and small scale agro-processing.

It is hoped that the results and recommendations of the project will lead to more active participation of youth in South Africa's agricultural sector.

Access to relevant, tailor-made and adequate information is the key to unlocking rural youth entrepreneurship in farming.

BACK TO TOP

OPINION

Prospects and limitations for a hydrogen economy in South Africa

Many countries around the world, including South Africa, are weighing up the prospects and limitations of the production and distribution of "green hydrogen" as part of a greener energy economy. So writes Bo Barta.

In South Africa, the process of building up a hydrogen economy is closely associated with the decarbonisation of energy generation, which is based primarily on the coal-fired power station. This process is being focused in South Africa on extensive development of renewable energy, mainly by the on-shore wind and solar radiation by means of solar photovoltaic (PV) and concentrated solar power (CSP) technologies.

The other technologies and resources available and suitable in South Africa are hydropower, biomass, tidal and wave energy generation, which seem rather unattended and omitted from the future production and export of green hydrogen.

BACK TO TOP

Table 1: Essential background about green hydrogen production by electrolysis in South Africa

By definition: **1 kg of hydrogen requires allocation of 8,94 kg (or 9 litres) freshwater** and overall reverse osmosis (RO) of sea or brackish water requires between 5 and 3,5 kWh of energy. NB: The **energy needed for splitting of water into hydrogen and oxygen** can be determined by following equation: **$\Delta G = n*F*E_{rev}$**; where: n = no. of electrons involved; F = 96 500 (Faraday's constant); E_{rev} = reversible voltage = $\Delta G/nF$ = 1,23 V.
Notes: (i) The water electrolysis powered by renewable energy sources (e.g., sun, wind, hydropower, tide/wave or even by biomass) can be integrated into a distributed energy system to produce green hydrogen for end use or as an energy storage medium. Alkaline water electrolysis is the most common technology used, but the production equipment is relatively complicated, including electrolyser, pressure regulating valve, lye filter and circulation pump, storage device, hydrogen purification and gas detection device and other modules. The density of hydrogen is 1/14 of air. (ii) The hydrogen production by electrolysis of freshwater, besides needing electricity, will utilise water in the consumptive manner, therefore subjected to all legislative requirements of the National Water Act (Act 36 of 1998). If the green hydrogen is exported, the production is classified as "virtual water" (e.g., export of citrus, vine, beer, etc.)

The hydrogen gas can be extracted from water by the process in electrolysing preferably of the freshwater or generated by steam reformation of the hydrocarbons (e.g. coal, oil, etc.). The product, so-called "grey hydrogen", which if combined with the carbon monoxide, can produce a synthetic gas (or syngas by Fischer-Tropsch technology) has been produced in South Africa for decades by the coal-to-gas giant, Sasol.

By international standards, the grey hydrogen can be labelled as "blue hydrogen" which is methane or coal derived, but the production process is accompanied with the carbon capture (e.g., in the defunct sealed mines, etc.). Any hydrogen generation processes described will need a reliable supply of electricity, which is rather inadequate and unreliable in South Africa at present. Unless both the reliability and stability improve the production of green hydrogen will be not guaranteed. The supplies from the RE sources are subject of intermittency without storage.

The entire South African economy is dependent on one only electricity generator and distributor represented by Eskom Holdings (Pty) Ltd. This entity generates and provides electricity supplies from the national electricity grid which is labelled internationally as the largest greenhouse gases (GHG) emitter on the African continent, due primarily to coal-fired generation. To rectify this situation and if South Africa would like to become a significant producer of green hydrogen as well as carbon-neutral fuels and other chemicals, it needs to synchronise the development of all types of renewable energy resources with the development and beneficiation of its platinum group metal reserves and appropriate conversion of the industrial synthetic-fuels production. However, the serious limitations to such development and conversion of the South Africa's economy are manifesting from where come from the large quantities of water of relevant quality as well as the renewable energy supplies to reduce dependency on the coal-fired generation.

South Africa is recognised as a water stressed country, and it has not much freshwater to spare for electrolysis, however, the country does have access to an abundance of seawater. This seawater has to be desalinated prior to entering the electrolyser, which becomes an expensive extra step with regard to primarily the electricity requirements. To date, research in this sphere suggests that a thin semi permeable membrane replacing the reverse osmosis (RO) membrane is placed in the electrolyser, this means by a principle that the seawater pushed through electrolyser does not require the RO membrane, but an electrolyser provides the RO function itself. Nevertheless, the price of such process is at present exorbitant in South Africa and the research is not fully concluded. Presently, a well-established electrolysis process is based on the Proton Exchange Membrane (PEM), which is making use of platinum iridium and hydrogen fuel cells (platinum is a catalysator) in water electrolysis which is depending on the cooling efficiency of adopted system. The PEM water electrolysis hydrogen technology can be connected to hydropower, wind, solar and other renewable/alternative (e.g., nuclear) sources of energy for the required energy inputs. Internationally, the green hydrogen technology (i.e., PEM electrolysis) supplier is Nel Hydrogen in Norway (info@nelhydrogen.com).

For the obvious reasons outlined above, the South African near-future options in producing green hydrogen are limited to primarily splitting good quality freshwater, which is mainly stored in existing medium and large dam impoundments. Several of those are underutilised as the allocations to the mining, urban/industrial and agricultural users are gradually reducing on account of the technological and social-economic changes within such sectors. It is estimated that about 30 dams (i.e., from a total of 5 100 man-made impoundments) can be equipped by a small to large electrolysis plants to produce the green hydrogen in a hybrid configuration of hydropower and floating solar PV rafts to reduce extensive evaporation as a positive trade-off. There are a few potential locations to focus on, mainly on existing dam storages close to and supplying presently the coastal metropolitan municipalities, which in the near to medium future will have to invest into a significant desalination processes to cover increasing demand for potable water and to cope with the consequences of the climate change increasingly manifesting in the Southern Africa sub region.

According to the ***Hydrogen Strategy and Investor Roadmap*** (HS&IR) introduced in South Africa in 2021, the country's yearly production of green hydrogen for local and import uses is envisaged in order of 3,8-million tonnes by 2050 (1 tonne = 1000 kg) – this appears to be a very low estimate and it is questioned. Thus, the freshwater requirements will be in order of some 34 million m^3 per annum. Such use of freshwater will be highly

consumptive subjected to South Africa's legislative requirements in allocation of relevant permits and if the green hydrogen will be exported, such water to be classified as the virtual water as is for instance water used and exported of the agricultural products. In South Africa, the water required for the generation of the green hydrogen by electrolysis could be available from gradually discontinued Eskom dry-cooling coal-fired power stations. The availability of freshwater for the generation of green hydrogen to be exported is a subject of more detailed investigation, particularly at the likely locations of large electrolyser installations. From the survey of public domain information sources on the implementation and development of green hydrogen infrastructure the following might be of interest and is presented in Table 2.

Table 2: **Known development of green hydrogen installations in selected countries as in 2020**

Project location	Description	Remark
Australia (Victoria)	10 MW electrolysis facility to produce green hydrogen at the wastewater treatment plant by 2023	Hydropower generation of electricity
Australia (Queensland)	3 000 MW green hydrogen electrolysis facility project is being designed for the export of green hydrogen	RE technology in generation of electricity
Australia (Tasmania)	A hydropower powered 250 MW ammonia plant installation producing ultimately some 250 000 tonnes/year for the domestic and international export	Hydropower generation of electricity
Canada (Quebec)	An electrolysis installation of 88 MW in capacity to produce green hydrogen of some 11 100 tonnes/year and some 88 000 tonnes/year of oxygen	RE technology in generation of electricity
DRC (Africa)	Kamoa Copper Mine is hydroelectricity powered from of hydropower installations of combined capacity of 240 MW to be producing the green copper output of some 600 000 t/year	Hydropower generation of electricity
Germany	A green hydrogen hybrid configuration project including installation of electrolysis plant of 100 MW in capacity planned for commission in 2025	RE technology in generation of electricity (wind and solar)
North Wales (UK)	a hydrogen modular reactor (HMR) of 3 000 MW using wind energy generation designed to produce some 3-million kg of green hydrogen by 2027	RE technology in generation of electricity (wind)
South Africa (Limpopo)	Anglo American Platinum developing a pilot plant of initial solar PV capacity of 3,5 MW to produce 1 ton/day of green hydrogen to power the fuel cells for running large haul trucks	RE technology in generation of electricity (solar PV)
South Africa (Limpopo)	10 MW solar power plant at the Zonderreinde PGMs mine intended to produce green metals; another 100 MW solar PV installation is planned at Mogalakwena mine in the Limpopo Province to be operational by the end of 2023	Both planned installations will be using RE solar PV sources in generation of electricity
South Korea	A liquefied hydrogen facility is being constructed for urban/ domestic supply of some 30 000 tones/year	Renewable energy source of electricity
Sweden	A hydrogen storage facility of some 100 m3 is being installed at the rock cavern some 30 m below the ground to be commission by 2024	Renewable energy source of electricity
Switzerland	A hydropower plant on the Rhine River of 2,5 MW in capacity is being installed for the production of some 350 tonNes/ year of green hydrogen.	Hydropower generationof electricity
Note: The financial outlay is very seldom given for the consideration of the public domain on the project development, but from limited information available it may be established that one MW of electrolyser capacity in South Africa might be in order of Rand 35 to 40 million (2020 basis). The production of green hydrogen on the background of international market prices amounts to Rand 70 per one kg at present.		

BACK TO TOP

EMERGING AGRICULTURE

South African Agri-parks: past, present and future

The South African Agri-parks is a Government initiative, aimed at revitalising agriculture, catalysing rural industrialisation and supporting emerging farmers. Betsie le Roux and Attie van Niekerk report on the latest research around this development initiative.

The Water Research Commission (WRC) funded the project titled 'Evaluation of the management and impact of water quantity and quality for Agri-parks in Gauteng Province, South Africa (**WRC Project No. K5/2823//4**).

An Agri-park is defined as 'a networked innovation system of agro-production, processing, logistics, marketing, training and extension services, located in a District Municipality. As a network it enables a market-driven combination and integration of various agricultural activities and rural transformation services'. The Agri-park model includes the following three units:

- The Agri-hub (AH) that would essentially provide financial and technical support to all farmers within a 20 km radius;
- Each Agri-hub would encompass several Farmer Production Support Units (FPSU) that will provide support on a local level; and The Rural Urban Marketing Centre (RUMC) will assist farmers with marketing of produce and the relevant administration. (Department of Rural Development and Land Reform, 2016).

By managing several small-scale farms as a single large entity, Agri-parks have the potential to provide capital, technical support and knowledge, which are critical services that are often not available to small-scale farmers. Through the Agri-parks

BACK TO TOP

initiative, it could also be possible to uplift emerging farmers, which is an important goal towards achieving food security and land reform, and limiting the rural-urban migration in South Africa. The way in which the Agri-park model integrates catchment- and local-scale management could enable more sustainable practices in agriculture and water management.

Problems experienced by and potential within Agri-parks

However, existing Gauteng Agri-parks are, in reality, old production units that were initiated by the Gauteng Department of Agriculture and Rural Development (GDARD). The main Agri-parks in Pretoria are Rooiwal, Soshanguve, Mamelodi and the Innovation hub. Agri-parks in Johannesburg include Westonaria, Eikenhof, Tarlton, and Merafong. None of these Agri-parks operate according to the Agri-parks model, for example, they are only a few hectares in size, as opposed to covering an area of 20 km radius around an Agri-hub, and therefore represents only one FPSU of an Agri-park.

In Pretoria, the Agri-park farmers are managed and supported by the City of Tshwane, which may represent some of the functions of the Agri-hub. However, this management does not provide some important services, such as laboratories, finance and marketing. The farmers are provided with the land and some infrastructure such as irrigation systems, but maintenance is not always done efficiently and important resources such as water are not developed and provided.

Chameleon sensor at Rooiwal, abandoned and disconnected.

During a survey of Agri-parks in Johannesburg (le Roux et al., 2019), it was found that 40% of farmers complained of water-related problems (including water quality, quantity and irrigation infrastructure problems). Water-related problems and access to markets the major concerns expressed by the farmers. In Pretoria, farmers' main complaint was a lack of water.

If the relationship between the farmers is cooperative in nature, as opposed to the current competitiveness, they may all feel that they could benefit from increasing water use efficiency.

How to understand the problems

The managers of the Agri-parks are often frustrated by the farmers' poor adoption of technologies that could improve their resource use efficiency and production outcomes. During the previous WRC project on Agri-parks (le Roux et al., 2021), several of these tools were introduced, but in general they are not used or maintained.

In Soshanguve a number of soil water sensors were wrecked through a misunderstanding with a contractor, in Rooiwal the chameleon sensor that was installed by the team was left disconnected in an old field. Mulching was promoted as a cost-effective way to save water and reduce weeds, both of which were extremely big problems at Rooiwal, but farmers were unable to use it when their fields reached a certain size. All farmers were positive about using sewage effluent for irrigation, and at Rooiwal, this is a potential source.

The question is; 'why are the tools and techniques not working?' The problem can be with the:

- Resources and tools available
- Labour and skill required to use available tools and to farm successfully
- Demand / lack of demand for the products

All of the above are influenced by the social context, culture and the things that motivate the farmer. Motivation can vary from passion for farming, survival, making money etc.

We agree with van Rooyen et al. (2017), the problems that are faced in the small-scale farming context are not only technological in nature, but also socio-economic. For example, we are of the opinion that water use efficiency will not be practiced by the farmers, unless the conflict due to competition for water is resolved. Currently at Rooiwal, the farmers share one groundwater pump. They are pumping in turn according to a schedule, and all the farmers feel that they are mistreated.

For that reason, they will pump water during the entire time that

BACK TO TOP

Farmers at Rooiwal Agri-park showing their harvested Swiss chard.

is allocated to them even if they could use less water, without considering the sustainability of what they do or whether there is enough water left for the next day. If the relationship between the farmers is cooperative in nature, as opposed to the current competitiveness, they may all feel that they could benefit from increasing water use efficiency.

Another fundamental issue that was identified in previous research is the role of the Agri-park managers. In the Pretoria Agri-parks, the current management role of the City of Tshwane is at times more restrictive than supportive. For example, the Rooiwal Agri-park is next to a wastewater treatment works (WWTW). Farmers around the Agri-park use the effluent for irrigation, and benefit from this resource.

However, due to the potential risks, the City does not allow the Agri-park farmers to irrigate with this water, putting them at a competitive disadvantage. If Tshwane officials had a direct business incentive to develop the Agri-park and achieve the goals of the model, they could have had the pressure and drive to develop the effluent into a safe resource. As it stands, paid officials are unlikely to push the boundaries of these Agri-parks, as they have no personal gain in doing so and often lack the necessary capacity. This is a problem that must be solved.

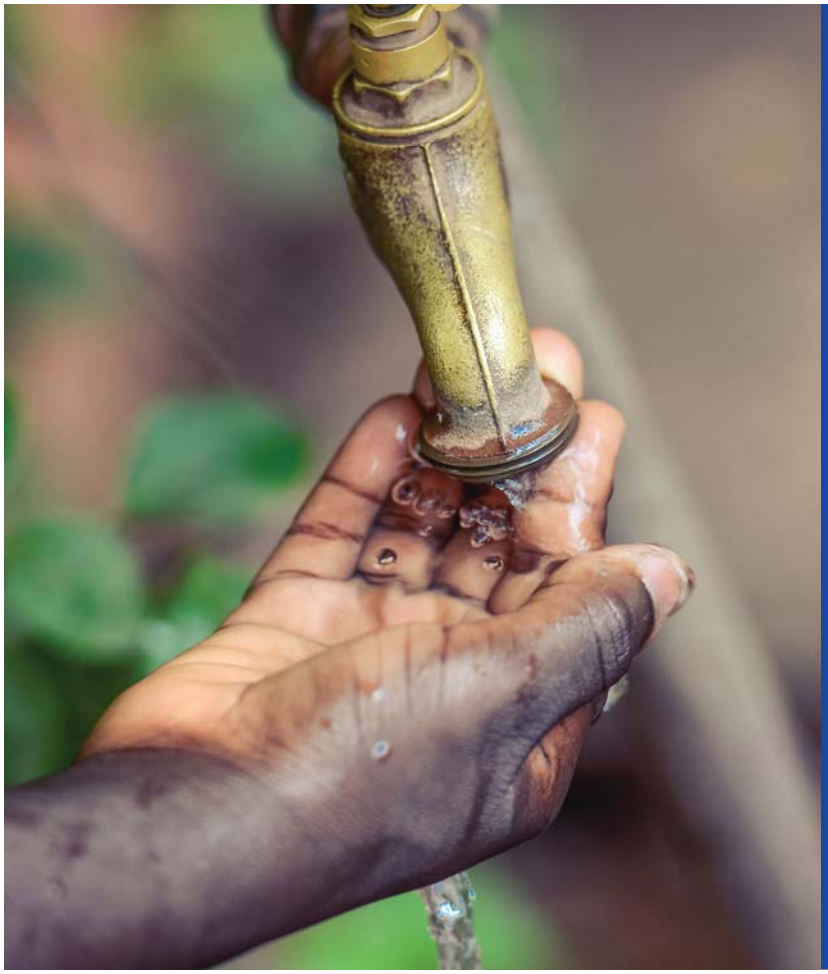
However, during the WRC project, the team has also found some strong points in the system, including highly educated individual farmers that are successfully producing and marketing their crops, farmers who take responsibility of their farms and exercise agency e.g., purchase equipment in cases where it is not provided. The team also found that alternative resources can still be developed, such as effluent water, chicken manure, organic waste etc.

Going forward, the way in which Agri-parks function must be reconsidered, to unlock existing potential within them. Processes and practices must be co-developed, with Agri-park farmers and managers, that would remove stumbling blocks such as competition, conflict and poor motivation.

A meeting with the Rooiwal farmers (February 2020) to discuss their problems and possible solutions.

GROUNDWATER AND SOCIETY

South African groundwater project shows the power of citizen science



About 30% of the water on the planet is under the ground, out of sight and not easily accessed. Little is known about this "invisible" groundwater. This is especially so in remote areas, such as the part of South Africa's Limpopo province where a research project called Diamonds on the Soles of their Feet is taking place. Article by Jacqueline Goldin.

Academics and residents are working together in two Limpopo villages, Ga-Komape and Ga-Manamela, to find out more about the areas' groundwater resources. This is important data: 74% of people in rural areas like these depend on groundwater for their crops and domestic water supply. People use this water but there's very little knowledge about how much there is, how it recharges, whether it is clean and so forth.

Over the past three years, residents from the villages have been trained to capture groundwater data. They use a simple dip meter, record rainfall levels from rain gauges and take images of water flows in rivers. This data is captured on smart phones and relayed to a website where it is available for government, researchers and planners who can use this to better understand what is going on under the ground –- after all, you can't manage what you can't measure.

This is what's known as citizen science. "Ordinary" citizens are no longer passive and disengaged but are actively engaged with scientists. The project is transforming volunteers in these remote rural areas from being passive and not engaging with science to becoming scientists themselves. The data being collected is verified, validated and made visible. It is taking science out of the laboratory and into the field, making science accessible to society so that they are part of the solution and not part of the problem.

BACK TO TOP

The tendency in citizen science projects is to focus only on the value of hard data. Our project is different: we are of course interested in the data, but are also concerned with transformation and empowering people. The aim of this work is to achieve a more just society through the democratisation of knowledge and improved water literacy. The project's name, "Diamonds on the soles of their feet" stems from the fact that farmers have a real treasure that they share with us as researchers – and that is of real value.

The residents are now curious about water. They have a sense of belonging to a geographical area beyond their homes, being part now of a wider project that extends from one side of the Hout River Catchment to the other. Their work has garnered international recognition, too. At the Falling Walls Summit, part of Berlin Science Week 2021 in early November [2021], Diamonds on the Soles of their Feet was selected as one of 20 winners from 189 projects in 80 countries across the globe.

Obstacles

The Falling Walls Summit asks scientists to show what walls have been broken down between science and society. In our project's case, there were several walls. The project started with funds from the Danish International Development Agency (DANIDA) through the University of Copenhagen three years ago. We chose Limpopo because it is a typical rural area where people are extremely dependent on ground water and also because it is one of South Africa's poorest provinces. When we started, there simply wasn't very much data about water in remote rural wells because it is very difficult to access these remote rural wells. Limpopo is a sprawling province; there are huge distances between villages and the roads are generally poor.

There was also an insidious historical divide between commercial farmers and small-scale farmers. Commercial farmers know a lot about water in their boreholes but the data they have gathered over the past decades has not been shared. Now, farmers see that there is a project caring about water for the future and they have shown their interest and willingness to be part of this, and to share their data.

Transcending disciplines

Then there was the wall that scientists often put up: between the humanities and sciences such as hydrology, engineering, geology and so forth. Some of the work needed to collect data is purely scientific, of course – but some of it is about empowering communities. As an anthropologist, working with water and society, I am clear that the protection and care of natural resources can't happen unless communities who are closest to that resource are involved. This means applying deeply participatory, ethnographic methods to solicit the views and knowledge of people living close to the wells.

There is a wealth of information that is not being tapped into. When looking for data on groundwater, the voice of hydrologists, geologists and other experts resonates, rather than the voice of community members who are often marginalised because they don't have the right jargon, or scientific terms to talk about water.

My doctoral thesis and related research was on shame and trust: shame is prevalent when people feel they are ignored and made to feel "stupid" just because they don't have the degrees or badges that give them recognition. The approach for this project is an "ethics of care". It really means acknowledging people who have rich indigenous knowledge and experience and are themselves often experts when it comes to water. Anthropologists have worked closely with communities and have tools and techniques which are part of the science kit. With this combination of approaches and science, our multi-disciplinary team has been able to break down some walls.

The aim of this work is to achieve a more just society through the democratisation of knowledge and improved water literacy.

Future work

As a result of collecting data, people in the villages are now curious about water. They want to know more and they are really proud of being able to read the data – in other words, to be water literate. The project has also resonated with tribal authorities, which effectively govern these rural areas.

This bodes well, as with authorities' buy-in, the project will more likely be sustainable. This interest and involvement could also be transferable to other domains, such as health, youth development and measuring water quality. Overall, it's about developing a community of practice: people who can work alongside scientists, taking science out of the laboratory and into the field.

This article was first published by The Conversation (www.theconversation.com)

CLANWILLIAM DAM – AGRICULTURAL WORKHORSE IN THE LOWER OLIFANTS

Clanwilliam Dam has a current capacity of close to 122 million m³.

Clanwilliam Dam, located in the lower Olifants River in the Western Cape, was one of the first large dams to be constructed in South Africa. Work on the dam started in 1932, and at the height of its construction, around 800 workers toiled away on site – employed as part of the government's employment programme during the Great Depression. The original dam, completed in 1935, was a mass concrete gravity structure with a centrally situated overspill section, 117 m long.

The ever-increasing need for water resulted in the dam being raised between 1962 and 1964. The overspill crest was increased in length, remodelled and raised by the addition of 3,05 m of mass concrete on top of the crest, and the installation of 13 crest gates, each 7,77 m wide and 3,05 m high. In addition, the non-overspill flanks were raised by 4,88 m by means of mass concrete.

A bridge superstructure was constructed across the dam to provide access for the operation of the gates. For stability, the dam is tied to its foundations by means of post-tensioned cables positioned along the centre line of the dam.

Clanwilliam Dam has a present height of 43 m, and a capacity of around 122 million m³. For the last decade or so, plans have been afoot to raise the dam by another 13 m. The raising of the dam will increase the yield of water supplied from the dam by 70 million m³/year. Clanwilliam Dam is one of the dams in South Africa featuring Roberts' splitters – an interesting energy dissipation feature designed by engineer, DF Roberts, and originally used on Loskop Dam. The feature comprises a series of projecting 'teeth' or splitters located on the downstream face of the dam.

BACK TO TOP

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.

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