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TECHNOLOGY FOR AFRICA | WITHIN PLANETARY BOUNDARIES







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TECHNOLOGY FROM AFRICA TO REACH GLOBAL SUSTAINABILITY GOALS

South Africa's international commitment to sustainable development needs to be aligned closely with local priorities, specifically the country's National Development Plan 2030. With 2030 now looming large, at the same time, the global community is acknowledging the significant work that remains to achieve the United Nations' Sustainable Development Goals (SDGs). South Africa reaffirmed its commitment to the SDGs during the SDG Summit in September 2023, pledging transformation in several critical areas.

At the CSIR, our researchers are working on technologies and innovations that help meet the needs of the continent while answering critical questions about how it can contribute to global sustainability goals.

From new options to generate clean energy, to designing net-zero, sustainable buildings in rural areas; from advancing circular construction, packaging and energy storage materials to developing digital tools for food value chains and precision agriculture; from creating African cell lines, personalised chemotherapies and affordable ultrasound devices, to plant-based antibodies for rapid viral screening tests — our capabilities are at the cutting-edge of technologies and innovations and help meet the needs of the present without compromising the ability of future generations to meet their own needs.

The CSIR is demonstrating its commitment to sustainability by dedicating its ninth biennial conference to this topic. In October 2025, as the CSIR officially celebrates 80 years of touching lives through innovation, we will join forces with the Global Sustainable Technology and Innovation Community (G-STIC) to host a joint event, the CSIR@80 | G-STIC conference in Pretoria, South Africa. The theme for the conference is *Science, technology and innovation for a sustainable future*.

This issue of *ScienceScope* showcases the work we are doing to support the 17 United Nations' SDGs. While it is not possible to cover all this work in a single publication, you are invited to register for the CSIR@80 | G-STIC conference — where you will not only be able to engage with our researchers and their work in this field, but also gain an international perspective from speakers from across the globe.

Be part of the conversation that will shape tomorrow - join us as we explore how African-led innovation is contributing to global sustainability.

Dr Thulani Dlamini
CSIR Chief Executive Officer

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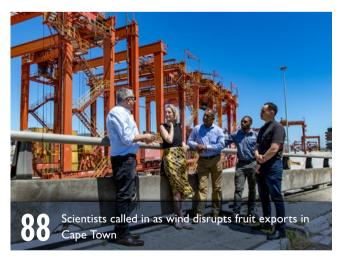
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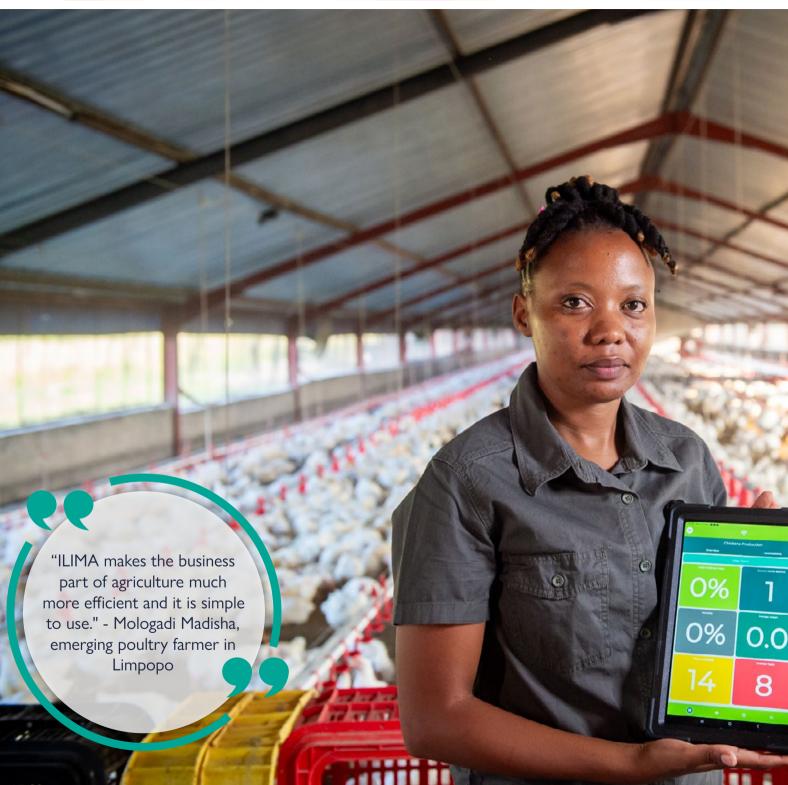
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The ILIMA platform is co-funded by the CSIR, with support from the DSTI South African National Blockchain Alliance programme and the DSTI Foundational Digital Capabilities Research funding programme. It addresses SDG 1, SDG 2, SDG 9, SDG 10 and SDG 11.



A FARM-TO-FORK APP FOR EMERGING POULTRY FARMERS

n the heart of Limpopo, where economic challenges often overshadow opportunities,
poultry farmer Mologadi Madisha uses a CSIR-developed application (app) to monitor her birds' feeding habits, vaccinations, thermal comfort, mortalities and sales. The ILIMA app was piloted in collaboration with Madisha and other small-scale farmers to ensure it has all the features they need to digitise farm management and connect them securely to their suppliers and markets.

"You know, farming itself is very stressful," says Madisha. "So, you'll want to have something convenient on your cell phone, monitoring even when you're not around the farm."

CSIR senior engineer Dr Richmore Dondofema says his team decided to pilot the ILIMA platform on Madisha's farm so they could identify the precise day-to-day activities that could be enhanced using the technology.

"The ILIMA app is part of our end-to-end logistics offering, in which we are connecting small-scale farmers with other actors along their value chains. This will include raw material suppliers, feed suppliers, chick providers and those who provide animal veterinary medicine," he explains. The platform will also connect farmers with abattoirs and clients, such as live markets or household buyers.

He says there are two stand-out features of the app.

First, it allows farmers to monitor activities remotely using their mobile phones. "Farmers are not always on the farm. They have to go out to look for feed or funding or they might attend training workshops. While they are away, the app allows them

(continued overleaf)

to assign tasks to whoever is at the farm and they can monitor whether those tasks have been completed," says Dondofema.

Second, blockchain technology embedded within the app ensures that every logged task is securely recorded and cannot be tampered with, allowing potential customers to trace the history of the product they are buying or consuming.

"That's where the principle of farm to fork comes into play," he says. He explains that today's market demands transparency around things like the use of growth hormones, medicines, feeding practices, farm conditions, storage and refrigerated transport to markets.

CSIR principal researcher Dr Isabel Meyer says the iteration of the app that has been specifically customised for poultry smallholders is just one digital solution within the broader ILIMA platform.

"In future, it will help emerging farmers in several sectors to join the value chain, including providing advice on modern farming practices, sharing data with decision-makers overseeing different agricultural sectors and providing access to critical suppliers and logistics providers," she says.

Dondofema says they are also expanding the app to assist dairy farmers, pig farmers and even cannabis growers. "This aligns very well with the UN Sustainable Development Goals – we are using innovation to target hunger, to reduce poverty and to make sure that we have inclusive growth," he says.

The word "ilima" has meanings like "interconnectedness", "communal action" and "ploughing" in several African languages, so Dondofema says the platform was aptly named.

"We feel like it's one of the greatest innovations," says Madisha, explaining that it was incredibly difficult to keep farming records like stock numbers and care schedules manually prior to using ILIMA. "It makes the business part of agriculture much more efficient and it is simple to use. I am glad the CSIR took this opportunity to dive into young farmers in the industry, especially in the hottest region in the country."

"For emerging farmers in Limpopo, ILIMA is more than an app," says Meyer. "It is a lifeline transforming livelihoods and fostering resilience."

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A FARM-TO-FORK APP FOR EMERGING POULTRY FARMERS

Limpopo poultry farmers are using the ILIMA app to monitor their chickens' feeding habits, vaccinations, thermal comfort, mortalities and sales. The app was developed by CSIR researchers alongside small-scale farmers to ensure that it has all the features they need to digitise farm management and to connect them securely to their suppliers and markets. The broader ILIMA platform will also be rolled out to support emerging dairy farmers, pig farmers and cannabis growers, with capabilities to provide advice on modern farming practices and access to suppliers and logistics, as well as share agricultural data with decision-makers.



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This work is undertaken at the CSIR Biomanufacturing Industry Development Centre and funded by the Department of Science, Technology and Innovation and the Technology Innovation Agency to boost local biomanufacturing businesses. It addresses SDG 2, SDG 3 and SDG 12.



SUSTAINABLE PROTEIN FROM AFRICA

he CSIR has developed a sustainable bioprocess to manufacture a fungal-based protein product for a South African business called MycoSure.

Dr Ghaneshree Moonsamy, a fungal expert at the CSIR's Biomanufacturing Industry Development Centre (BIDC), says protein production in a bioreactor offers many sustainability and cost advantages over livestock and crop protein production.

She says MycoSure will be leveraging this technology using fungal protein, for the first time in Africa, to help address global food security.

"The starting material for the protein product is *Fusarium* venenatum, a fungus known to have a high-protein content," says Moonsamy.

This organism's fruiting body is similar to other fungal fruiting bodies, including the common mushroom. A fruiting body usually sprouts from a mycelium, which is a network of fungal threads in soil or on a substrate. But when *F. venenaturm* is grown in a liquid culture, only mycelium threads grow.

The mycelium is the protein biomass, also known as mycoprotein, which can be dehydrated and packaged as a powdered food supplement. The CSIR recently completed this technology development for MycoSure and has licensed it to them.

Charles Reed, Mycosure's CEO, says current global predictions put protein shortages at 250 million tonnes per year by 2025. For him, the question prior to partnering with the CSIR was how they could help solve that shortage "within planetary constraints".

"When you look at the more conventional plant-based proteins like soy and maize, you need large areas of land and these plants have specific growth cycles that rely on consistent seasonal

(continued overleaf)

patterns and irrigation," says Moonsamy. "There are so many other factors that could influence your yield in the field, whereas in a bioreactor where you're growing the fungi, you have a lot more control over your production process."

The same goes for cultivated animal protein, with beef farming in particular contributing to excessive methane emissions that exacerbate climate change.

Moonsamy says the technology for fungal protein production addresses many of these environmental concerns and is already at a cost-competitive stage.

This is because scientists can reduce the cost of manufacturing by using raw materials that are locally available or that can be valorised from other industries, and because the process can be optimised to reduce water and energy consumption.

"The water used to clean the bioreactor, for example, can be recycled and reused up to three times, prior to discharge," says Moonsamy.

Bioprocessing also relies on microorganisms to facilitate the production rather than on harsh chemicals that could harm the environment.

Reed says that MycoSure will be the first company in Africa to use this technology to produce and export mycoprotein products for a variety of applications.

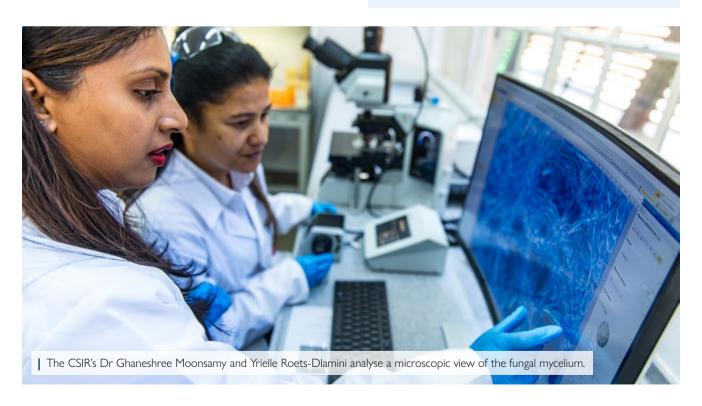
"Mycelium-based protein is a highly versatile ingredient and has a high-quality profile," he says, adding that it can be used in analogue meats, analogue dairy, baked goods, health bars, protein shakes and high-end pet foods.

"It's very suitable for the vegan and vegetarian market because the protein itself is coming from the organism, and it's not derived from animal sources," says Reed.

Moonsamy says the "art of bioprocess development" for the sustainable production of mycoprotein can, therefore, address global sustainability challenges around animal health, human health and food security.

She says the application of bioreactors in general also extends much further. Just at the CSIR, for instance, researchers have already produced biological cleaning agents, probiotics, bio-based fertilisers and enzyme-based diagnostics for a variety of other local businesses.

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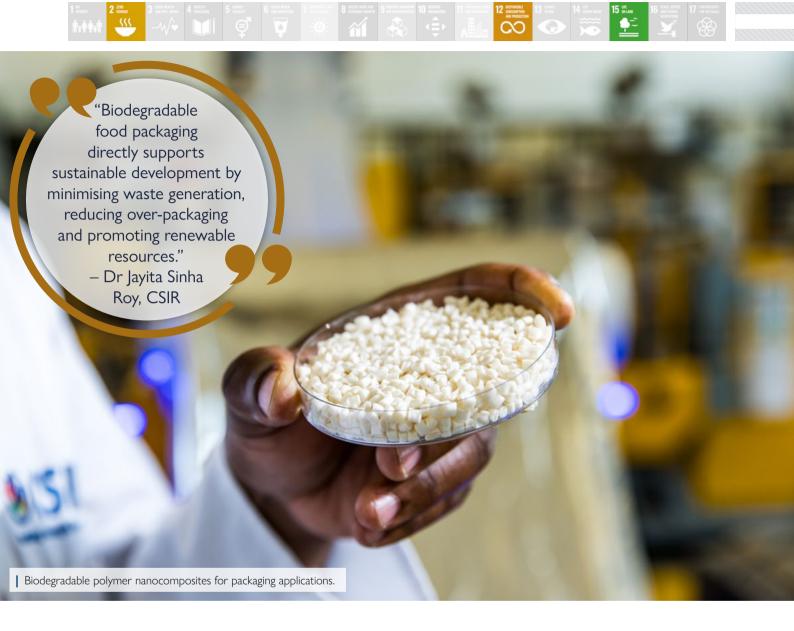
SUSTAINABLE PROTEIN FROM AFRICA

The CSIR has developed a mycoprotein product for local SMME MycoSure that can be added to soups, shakes and other foods. The starting material for MycoSure's mycoprotein is Fusarium venenatum, a fungus known to have a high-protein content. The CSIR creates biotechnology, bioprocessing and biomanufacturing-based technologies for novel food, cosmetic, cleaning and healthcare products that can be produced more sustainably by reducing land use, emissions and water use.





The plant-based mycoprotein powder as a final product after drying and milling. The powder will be marketed to food manufacturers as a local, sustainably produced and nutritious food supplement.



COMPOSTABLE FOOD PACKAGING READY FOR INDUSTRY TRIALS

esearchers at the CSIR have developed biodegradable food packaging that blocks oxygen, thereby preventing spoilage and extending shelf-life.

New CSIR-developed packaging presents a sustainable alternative to conventional plastics that pollute the environment. Dr Jayita

Sinha Roy, a polymer nanocomposites researcher at the CSIR, says the improved oxygen gas barrier of the packaging slows down oxidation, the process by which food spoils.

"The packaging can retain its shape and integrity even at high temperatures, making it suitable for ready-to-eat products that are often not recycled due to contamination issues," she says.

The development of this technology was co-funded by the CSIR and the Department of Science, Technology and Innovation. It addresses SDG 2, SDG 12 and SDG 15.







The biodegradable food packaging film produced at the CSIR pilot facility in Pretoria. The packaging blocks oxygen, thereby preventing spoilage and extending shelf-life. The polymers are also stable at high temperatures and have improved composting properties.

Unlike conventional plastic packaging, she explains, the polymer developed at the CSIR is more biodegradable and thus easier to compost.

"We were able to improve the mechanical property of the film to make it a bit stiffer," she says. "This CSIR technology ensures biodegradation of a packaging film of about 120 µm thickness, without any further interventions like shredding or powdering before composting."

She says that the technology has already been validated in pilot-scale production and the next step will be to collaborate with industry partners to integrate it into existing packaging processes and conduct market trials. "It can be easily adopted at an existing facility without any capital expenditure," she says.

The project has garnered interest from local and international entities, she says.

"Locally, South African companies are now exploring the development of sustainable packaging materials using biodegradable polymers, in alignment with the country's environmental sustainability goals," she adds.

She says that while conventional polymers are still less expensive than biodegradable polymers, conventional ultimately bear a larger environmental and economic cost. "Conventional packaging plastics end up in landfills if they are not recycled, while biodegradable polymers compost and return to nature."

Roy explains that biodegradation of packaging with a thickness as high as $120~\mu m$ is unique and does not generate ecotoxicity. "The soil used for composting packaging material remains fertile," she says.



However, she cautions that composting of biodegradable materials must be done in accordance with strict international standards. "In reality, these materials require specific conditions, such as industrial composting facilities, to break down effectively. Misunderstandings can lead to improper disposal, undermining environmental benefits. Therefore, clear communication about the end-of-life conditions for these materials is essential," she adds.









CSIR senior researcher Dr Maabo Moralo performs agroinfiltration of *Nicotiana benthamiana* (tobacco) leaves. The tobacco plant has the molecular machinery to produce complex proteins like antibodies. Researchers inject the antibody sequence into the plant using an *Agrobacterium* vector and are then able to purify the antibodies within seven days.

RAPID TESTS TO SCREEN FOOD CROPS FOR DESTRUCTIVE VIRAL INFECTIONS

ew point-of-care virus diagnostic kits, which will work similarly to a home pregnancy test or a Covid-19 rapid test, could soon help tomato, potato and banana farmers in South Africa detect outbreaks before they cause major losses.

CSIR researchers are developing the antibody-based biotechnology behind the rapid tests in partnership with the Agricultural Research Council (ARC), starting with tomato spotted wilt virus, pepper ringspot virus and banana bunchy top virus, respectively.

"We want the technologies and the products we are working on to add value in a laboratory setting, as well as in the field in southern Africa," says biotechnologist Dr Priyen Pillay, a lead CSIR researcher working on the project. He explains that while similar test kits can be imported from international suppliers, some do not detect local or indigenous viral strains.

"I have had a look at the genetic sequences of the proteins that these international antibody kits bind to and they are often significantly different from those that are devastating our local crops," he says. "So, it makes sense that those kits are not working for our farmers and we realised that we would need to find our own solution."

Pillay says the CSIR is using bacteria and plants to amplify target proteins unique to these local strains, which will then be used to create matching antibodies for use in diagnostics.

"We have managed to express the viral proteins in *E. coli* bacteria and the data is looking very good," he says. "We are (continued overleaf)

now upscaling for mass spectrometry analysis to confirm the identity of each protein and will then try to express the same viral proteins in tobacco plants."

Fellow CSIR biotechnologist Dr Lusisizwe Kwezi says the novelty of this approach compared to conventional methods, is that it is completely animal free and less costly, in line with international trends.

"Using *E. coli* bacteria and tobacco plants to express viral proteins has been proven to be much cheaper than conventional bioprocesses or production systems that involve animals, mammalian cells, insect cells and other eukaryotic-based technologies," he says.

Pillay and Kwezi explain that the ARC currently relies on lengthy and expensive laboratory testing using finite stocks of antibody serums that were generated in goats.

"Our collaboration thus arose from the need for a sustainable, more environmentally friendly antibody production platform," says Pillay.

He explains that the viral proteins they have expressed in bacteria and tobacco will now go to the CSIR's proteomics team to find matching antibodies. "They will look for antibodies that bind most strongly to the viral proteins within the anti-serum provided by the ARC and then they will determine the genetic sequence of the antibodies."

With the antibody sequence precisely matched to local strains, Pillay and Kwezi can again use tobacco plants to generate large amounts of pure, high-quality antibody.

"The tobacco plant has the molecular machinery to produce complex proteins like antibodies," says Pillay. "We inject the antibody sequence into the plant using an agrobacterium vector and within seven days we can purify the antibodies."

He says they plan to hand over pure, highly specific antibodies to the CSIR's diagnostics team, led by Dr Amanda Skepu. These antibodies will be immobilised onto special paper strips, which will then be assembled and packaged into lateral flow test devices using advanced instrumentation. The resulting devices will be provided to the ARC for testing before the end of 2026.

As the entire protein discovery process, antibody production and immobilisation and lateral flow device assembly can be done inhouse at the CSIR, the project will serve as a proof-of-concept that plant-based antibody production can be used for any











medical or agricultural application, including rapid tests. Plans are also in place for the successful crop virus rapid test kits to be commercialised and manufactured at scale locally.

"This project therefore speaks to security of supply and selfsustainability for South Africa's agricultural sector, but also to cost-effective manufacturing," says Kwezi.

He says both skilled and unskilled farm workers, at large agribusinesses or on smallholdings, as well as agricultural extension officers and port officials, will be able to use the simple test-strip device in the field to diagnose or survey viral infections in crops and produce. Lateral flow devices yield results in as little as 10 minutes, thereby addressing long delays and transport costs associated with laboratory testing.

"When I look at the expertise of the ARC and the CSIR, and how they complement each other to solve a problem of national importance within the agricultural sector; for me, that's phenomenal," says Dr Duduetsang Saku, a business development manager at the CSIR. "A project like this reflects our competencies as a nation and a capable state and it shows that collaboration is important."

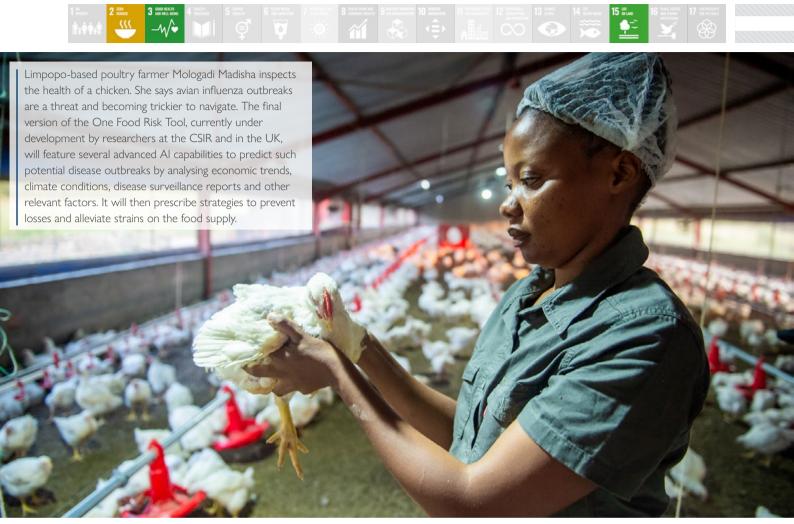
She says these first three antibody-based rapid tests will help safeguard tomato, potato and banana crop yields. They will also help ensure that the produce meets export standards and fetches fair prices in global markets.

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WE MAKE ENOUGH FOOD, SO WHY ARE SOUTH AFRICANS GOING HUNGRY?

rtificial intelligence (AI) researchers in South Africa and the United Kingdom (UK) have developed a prototype tool that will help government and farmers solve one of South Africa's biggest conundrums: we produce enough food, yet many of us go hungry every day.

"Official reports show that as a country we are food secure at the national level, but at the household level we are food insecure – this is a major challenge," says Dr Essa Suleman, a food system and animal health expert at the CSIR.

He is part of a team of researchers from the CSIR who, together with the Centre for Environment, Fisheries and Aquaculture Science (Cefas) in the UK, are working on the One Food Risk Tool.

The tool can sift through and analyse masses of public data around threats to food supply chains. Once the data is parsed, the tool can guide policymakers and decision-makers

in government, as well as farmers and producers, to solve problems.

"In poultry, for example, a big question for farmers is how to deal with pests and infectious diseases," says Suleman.

"We have regular outbreaks of avian influenza and other diseases, which means tens of thousands of chickens are culled. That's a massive socioeconomic loss and can drive prices up for consumers."

Limpopo-based poultry farmer Mologadi Madisha agrees that avian influenza outbreaks are becoming trickier to navigate and says it can be described as "a likely collapse of operations for most small-scale farmers".

"Usually, small-scale farmers do not have access to early warnings," she says, adding that she is hopeful that new technologies could alert her to outbreak risks, where to get help and generally how to control and mitigate disease outbreaks on her farm.

Suleman says that the final version of the One Food Risk Tool will indeed have several advanced Al capabilities to predict potential disease outbreaks by analysing economic trends, climate conditions, disease surveillance reports and other relevant factors. Then, it will prescribe strategies to prevent losses and constraints on the food supply.

But, he says, the tool will go even further up and down the value chain because food systems are incredibly complex.

To illustrate part of this complexity, we can look at poultry again, says Suleman: chickens feed on maize, so maize farming is another critical link in that value chain. "We need to know if there is going to be another drought in Gauteng and how will it affect maize production in the country five years down the line," says Suleman.

"If we are going to have a crisis, can we stockpile maize in advance? Are there other countries we can import from? Can we get farmers elsewhere to produce more?"

Suleman says the risk tool will help answer some of these questions. The tool forms part of the broader international One Food programme, which approaches the three interrelated pillars

of health – human health, environmental health and animal health – from a food perspective.

"The One Food programme puts food at the centre of those three pillars because, in essence, every organism requires food to survive," he says.

The CSIR is one of the lead institutions driving the programme in South Africa alongside Cefas, with Suleman as the technical colead for the broader One Food programme.

"As an organisation, the CSIR has a diverse set of expertise – in climate, nutrition, food production, animal health and AI - so we are in a prime position to lead some of this work," says Suleman. "We also have partnerships across the science, technology, and innovation and academic ecosystems in South Africa, and strong international networks."

He says the team developed the prototype in a year and they expect to hone its predictive capabilities within the next four years.

The team presented the prototype at the Food and Agriculture Organization (FAO) of the United Nations in Rome, Italy, in February 2025, and is testing it in specific scenarios. It can currently assess risks using information provided by expert scientists, public databases and research reports.

"We have a list of over 70 hazards, and if you try and score for each hazard, you have to generate nine individual scores for each health pillar," he says.

"The amount of computation is massive, especially when we start finding patterns in historical data to make predictions and prescribe solutions. Eventually it's going to be beyond the realm of human capability, and that's where Al comes in."

Suleman says that in his view, the risk tool will be one of very few AI products being developed globally that will make a significant, tangible impact on people's lives.

"The ultimate vision is that this tool will be accessible to other countries to plug in their own data and produce localised suggestions for interventions," he says. "Over time, one can then continuously monitor whether these interventions are working and that will be the real benefit in the long-term."

(continued overleaf)

He says they expect government representatives, policymakers and scientists to use the tool to address the imbalance between sufficient food production and food insecurity.

"The tool will help all of us bring to light things we may not have thought of using, including traditional approaches, but which may actually have significant impact on the food system," he says.

"As a country, for instance, we have several diseases affecting livestock production, but we do not know the impacts of those animal diseases on things like biodiversity; or how climate change in turn affects animal diseases; or even how all of these factors together affect people's access to enough nutritious food."

Even wildlife tourism can be negatively impacted by risks to the food system, he says.

For example, an outbreak of foot-and-mouth disease on a cattle farm next to the Kruger National Park can spread to the wild buffalo roaming there. Conversely, buffalo are reservoirs of pathogens like the foot-and-mouth-disease virus.

"So, One Food is not just about food production and food sustainability, but also about how it impacts other life on land and human social interactions."

While the CSIR has had significant support from the Department of Science, Innovation and Technology for the broader One Food programme and to develop the risk tool prototype, Suleman says more buy-in is needed from the international community and other national departments overseeing agriculture and the environment.

"We have a five-year road map for the development of the tool but that is dependent on the funding we can secure."

Besides becoming a vital decision-support tool and scientific research instrument, Suleman says plans are in place for it to one day be in the pockets of farmers themselves, as a mobile application providing alerts and suggesting actions to mitigate climate, disease and other risks to their day-to-day operations.

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SWITCH UNHEALTHY SCHOOL SNACKS FOR CSIR VEGGIE DRINK

ood scientists at the CSIR are calling on the government to provide South African learners with healthier food options, especially following recent reports of malnourishment among learners and snack poisonings near schools.

Dr Nomusa Dlamini, a food scientist and CSIR principal researcher, says school children are buying unhealthy and potentially contaminated snacks from vendors because there are often no healthy alternatives available.

The CSIR has worked with various government entities, researchers and communities to formulate and test a healthy alternative that could help address this problem – a nutritional drink made from indigenous vegetables, which are pre-cooked and dried into a ready-to-mix powder. The work was funded by the Department of Science, Technology and Innovation.

The drink could be supplied to schools directly through the Department of Basic Education and offers several nutritional benefits for learners, she says.

"The nutritional drink uses indigenous leafy green vegetables such as amaranthus and cowpea, as well as locally available grains such as soya and sorghum," says Dlamini.

"When we analysed these vegetables and the formulated drink, they were found to be nutritious, providing optimum nutrient content in terms of pro-vitamin A, zinc and iron. These vegetables and the nutritional drink can help alleviate malnutrition associated with vitamin A, zinc and iron nutrient deficiencies."

During trials conducted in schools and communities in Cofimvaba in the Eastern Cape, one school principal reported that her learners' grades improved after the drink was introduced as part of the school's feeding scheme, says Dlamini.

"We worked closely with the National Department of Health as part of the ethical considerations for this project," she says.

This product development was funded by the Department of Science Technology and Innovation. The CSIR collaborated with the Agricultural Research Council, Vaal University of Technology, University of Fort Hare, as well as communities in Alice and Cofimvaba in the Eastern Cape. It addresses SDG 2.



"We analysed the health indicators of learners who consumed the nutritional drink versus those who opted not to, focusing on growth, iron status and weight gain, especially in young children. We found that they grew taller, gained weight and their iron levels and overall health improved."

While the scientific results on the drink's nutritional impact are still being finalised for peer-reviewed publication, the drink was developed to address nutritional gaps identified in an initial study around learners' food intake in Cofimvaba, published in 2014.

Dlamini says the drink prototype is now ready for commercialisation. "The CSIR's primary target market for this innovation is the Department of Basic Education because of its mandate for South Africa's school nutrition programmes." However, other organisations that aim to improve school children's nutrient intake, including early childhood development centres, could also potentially take up the drink prototype.

She explains that while the product formulation was done at the CSIR's agroprocessing facilities, the CSIR collaborated with other research and technology organisations, such as the Agricultural Research Council, on the cultivation of amaranthus, the Vaal University of Technology for nutritional impact assessments, and the University of Fort Hare's accredited Agripark facility for product upscaling.

"Learners are important because they are our future. They are still growing, and we need to nurture them before they suffer from malnutrition, harmful snacks or poisonings," she says.



Pumeza Melane, a food researcher at the CSIR, demonstrates how precooked and dried indigenous leafy green vegetables and grains are turned into a nutritional powdered drink.

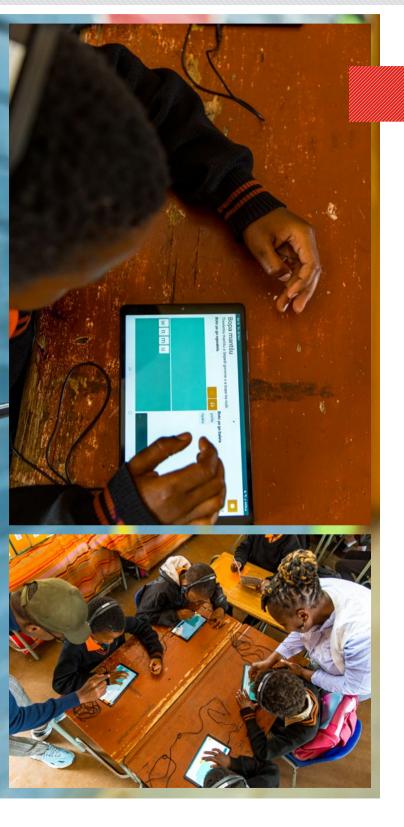






A grade three learner at Pheladi Nakene Primary School in Mamelodi, Pretoria, uses earphones and a microphone to practice Sepedi and English reading on the Ngiyaqonda! literacy app, developed by the CSIR. The app's language models generate text that is grammatically correct and suited to the reading level of the learner, and its voice technology generates true-sounding speech in South African languages. It also features speech recognition technology that provides the child with feedback on fluency and pronunciation.

This research was funded by the Department of Sport, Arts and Culture, using technologies developed in previous research projects funded by the South African Centre for Digital Language Resources. It addresses SDG 4.



AI HELPS SOUTH AFRICAN CHILDREN READ IN SEPEDI, ISIZULU, ENGLISH AND AFRIKAANS

he CSIR is piloting the Ngiyaqonda! literacy app at South African primary schools to help children read for meaning in their home language. The app draws on curriculum-approved content and the CSIR's local language text and speech technologies to create thousands of sentences for foundation phase learners to play through.

In March 2025, the CSIR team celebrated the successful completion of phase one of the Ngiyaqonda! pilot project with a handover of mobile devices to their first isiZulu-speaking pilot school in Soweto, Ebuhleni Primary School.

The application was also piloted with Sepedi-speaking grade three learners at Pheladi Nakene Primary School in Mamelodi and Afrikaans-speaking learners at Laerskool Die Krans throughout 2023 and 2024.

In recognition of the pilots' success and the positive social impact of Ngiyaqonda!, the CSIR donated the devices used at Ebuhleni Primary School during a project close-out event on Thursday, 13 March 2025.

"Piloting in schools is a vital component of projects like Ngiyaqonda! as it enables the project team to assess their efforts in real-world settings," says project lead Laurette Marais, who specialises in developing computational language resources for under-resourced languages at the CSIR.

She says that South Africa's infrastructure challenges, such as connectivity and electricity issues, make it essential to cultivate

(continued overleaf)



strong relationships with pilot schools and address potential challenges in using the app.

"By donating these devices to our pilot schools, we hope to strengthen our relationships with them and demonstrate our commitment to tackling this critical issue," she says. "Without their willingness to invest time and energy, as well as share essential practical insights with us, no amount of technological development would move the needle on South Africa's literacy challenges."

The most recent 2030 Reading Panel report revealed that approximately 80% of grade three learners in South Africa cannot read for meaning in any language.

"This means that every year, hundreds of thousands of learners leave the foundation phase unable to use their own language to write down their thoughts or read the stories of their own people," says Marais.

She says Ngiyaqonda! (isiZulu for "I understand") is a great example of how AI and digital solutions can enhance quality education through home language literacy. "An app like this can be deployed to millions of mobile devices at a speed and affordability that far surpass those of traditional learning materials."

Marais says her team integrated speech and text technologies into a gamified Android app that guides learners to compose sentences in their home language, as well as in English.

"Learners listen to sentences spoken by a computer-generated voice and then compose sentences using guidance from a grammatically reliable text-generation engine," she says. "The app

also allows learners to read sentences aloud and receive feedback on their fluency and pronunciation through an automatic speechscoring system developed specifically for children's voices."

Agnes Dhlamini , a grade three teacher at Pheladi Nakene Primary School, says that because the Ngiyaqonda! app presents her learners with text and sounds in a gamified format, it makes it much easier for them to learn how to build words and sentences in Sepedi and English.

"A learner understands when they must select the "A" sound and respond by pressing it. This allows them to recognise that the word they have selected is in the correct position," she explains.

"We are grateful to the CSIR for demonstrating that it is not only through books but also through technology that we are able to teach the learners to read, write and comprehend."

Marais says the team's research with Dhlamini and other teachers shows that Al solutions and other localised language technologies empower teachers, parents and, most importantly, learners to overcome barriers to education. "Our studies have convinced us that these technologies must be developed with urgency but also with great care."

She says that responsible AI for South African languages requires scientists to develop technologies suited to the real-world contexts in which they will be used. "This means they should align well with learning outcomes, be safe for children and integrate seamlessly into real teachers' classroom rhythms."

She adds that language models should generate text that is grammatically correct and appropriate for the learner's reading



AI HELPS SOUTH AFRICAN CHILDREN READ IN SEPEDI, ISIZULU, ENGLISH AND AFRIKAANS

The CSIR is piloting the Ngiyaqonda! literacy app at South African primary schools to help children read for meaning in their home language. The app draws on curriculum-approved content and the CSIR's local language text and speech technologies to create thousands of sentences for foundation phase learners to play through. Results show that Al solutions and other localised language technologies empower teachers, parents and, most importantly, learners to overcome barriers to education. The first phase of the study was funded by the Department of Sport, Arts and Culture, using technologies developed in previous research projects funded by the South African Centre for Digital Language Resources.

level, while voice technology should generate natural-sounding speech. Speech recognition technology must also accurately process children's speech to provide feedback on fluency and pronunciation.

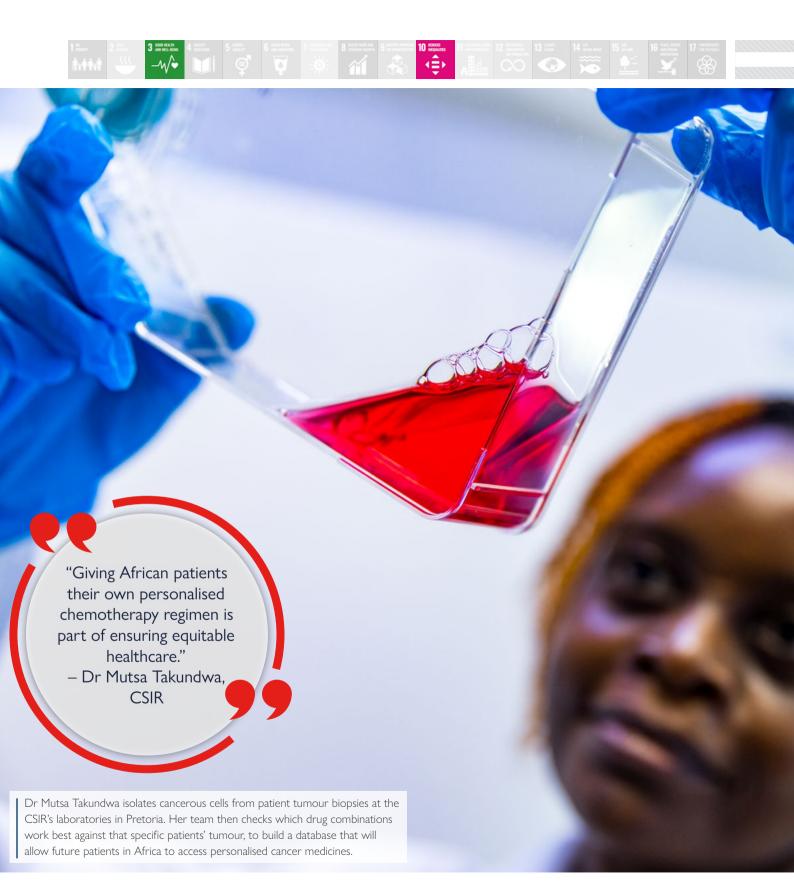
"In all of this, the linguistic features that make our languages unique must be centred," says Marais.

The Ngiyaqonda! project is one of a range of innovative speech, text and generative AI solutions developed by the CSIR to tackle educational challenges in South Africa. The first phase of the project was funded by the Department of Sport, Arts and Culture, using technologies developed in previous research projects funded by the South African Centre for Digital Language Resources.

Marais says the CSIR has applied for additional funding to advance to phase two and is actively seeking private sector partnerships to expand the initiative's reach and impact.

"The success of this project underscores the crucial role of collaboration between government, research institutions and end-users in maximising the social impact of technology," says Marais.







PERSONALISED CHEMO FOR AFRICAN PATIENTS

n a first for Africa, researchers are screening cancer tissue samples to find existing drugs that could be repurposed as effective chemotherapies for people of African descent. The CSIR and the University of Pretoria are building a database using tumour samples donated by consenting patients at Steve Biko Academic Hospital, so that future patients in Africa can access personalised cancer medicines.

Many of Prof. Greta Dreyer's patients already have late-stage pelvic cancer when they arrive in Pretoria, having travelled from neighbouring provinces where oncology specialists are rarer.

"Most of our cancer patients come from the outer provinces of Limpopo and the northern part of the Free State. Usually, they are already quite sick and visibly ill, having lost a lot of weight, and then we suspect cancer," she says.

The problem is that chemotherapy for uterine and ovarian cancers is extremely standardised, and tumours often stop responding after the first line of treatment, she says.

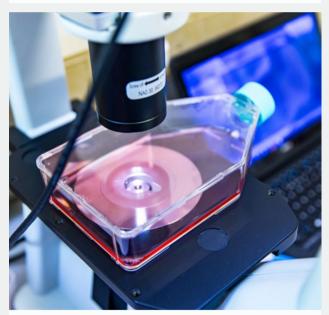
In addition, says the CSIR's Dr Mutsa Takundwa, there is very little data on how well African populations respond to cancer therapies and there are virtually zero clinical cancer trials on the continent.

"We are often at a loss to offer them something that will work," says Dreyer.

To give these patients better treatment options, Dreyer, who is the head of the oncological gynaecology unit at Steve Biko Academic Hospital and a professor at the University of Pretoria, has partnered with Takundwa's molecular biology team at the CSIR.



A patient undergoes chemotherapy at Steve Biko Academic Hospital. Chemotherapy for uterine and ovarian cancers is extremely standardised and tumours often stop responding after the first line of treatment. In addition, there is very little data on how well African populations respond to cancer therapies and there are virtually zero clinical cancer trials on the continent. CSIR researchers are screening existing drugs to find chemotherapy combinations that could work better for people of African descent.



For each cancer patient, the CSIR can screen 88 drugs and identify, through a viability assay, which drug is more effective. The idea is to screen drugs that are already approved and available on the market (including antibiotics and other therapies not necessarily intended for cancer treatments) to find combinations that could be more effective for African populations. This high-throughput drug sensitivity testing is possible thanks to the CSIR's JANUS G3 automated workstation, which robotically pipettes large numbers of individual samples at the same time.

"Almost all patients with uterine and ovarian cancer will first have surgery - they'll have an operation, which is either diagnostic, and we take biopsies or, if possible, we will remove the tumour," says Dreyer.

"If a patient consents to participate, they undergo the surgery and their biopsy is donated to the study," says Takundwa.

She personally collects the tumour samples from the hospital before isolating the cancerous cells at the CSIR's laboratories in Pretoria. Her team then checks which drug combinations work best against that specific patients' tumour.

"For each patient, we are able to screen 88 drugs and identify, through a viability assay, which drug is more effective," she says. The idea is to screen drugs that are already approved and available on the market (including antibiotics and other therapies not necessarily intended for cancer treatments) to find combinations that could be more effective for African populations.

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"When I first heard about drug repurposing and setting up a tumour growth facility (at the CSIR), where one can personalise chemotherapeutic drug choices, I was really excited," says Dreyer. "Drug repurposing is a fantastic way of relooking existing drugs — and affordable drugs — to make them work for us in a new way."



Prof. Greta Dreyer (left) is the head of the oncological gynaecology unit at Steve Biko Academic Hospital and a professor at the University of Pretoria. She has partnered with Dr Mutsa Takundwa's molecular biology team at the CSIR to develop personal chemotherapy options for pelvic cancer patients of African descent.



In a first for Africa, researchers are screening cancer tissue samples to find existing drugs that could be repurposed as effective chemotherapies for people of African descent. The CSIR and the University of Pretoria are building a database using tumour samples donated by consenting patients at Steve Biko Academic Hospital so that future patients in Africa can access personalised cancer medicines.

Takundwa explains that this approach cuts down the drug discovery process from about seven years to just three or four years, because the screened drugs have already gone through official efficacy and toxicity studies.

"They are approved drugs, but they are not used in cancer," she says.

While the current screenings are intended to build a database of tumour characteristics and drug responses associated with African genetics, the goal is to use the database to give African patients their own personalised chemotherapy regimen within the recovery period following their biopsy surgery.

Dreyer explains that doctors usually wait four to six weeks after surgery to begin pelvic cancer chemotherapy, during which time histology reports and counselling are completed. She says the ideal outcome of this study would be for Takundwa's team to determine the correct combination of chemotherapeutic or non-chemotherapeutic drugs for an individual within that waiting period.

"The burden of this disease is rising," says Takundwa. "But there are so few clinicians and the number of patients that these clinicians have to see is just astronomical." She says her role as a scientist is to bridge that gap by performing the research clinicians need to make better decisions for their patients.

In addition, she says, by focusing on gynaecological cancers, this research could help reduce inequalities, as women's health has historically lagged behind.









MOBILE ULTRASOUND DEVICE REDUCES RURAL STILLBIRTHS

mbiflow, a point-of-care medical ultrasound system for pregnancy care, is currently undergoing final clinical trials and certification, with key components manufactured at the CSIR's own pilot-scale laboratory.

Mobile, affordable and easy to operate, the Umbiflow ultrasound system for pregnancy care was designed by the CSIR and the South African Medical Research Council (SAMRC). The University of Pretoria (UP) has conducted extensive clinical trials involving nurses and midwives at primary healthcare facilities and antenatal clinics in remote and low-resource settings.

Jeremy Wallis, manager for industrial sensors at the CSIR, says that while Doppler ultrasound and sonar are not new technologies, their integration into a low-cost, easy-to-use device is innovative. The design has enabled a reduction in stillbirths in urban and rural environments in South Africa that lack sophisticated facilities and equipment.

"With thousands of stillbirths recorded every year, a simpler, lower-cost tool is needed to test for any possible fetal growth restriction early on, allowing the mother to be referred to a higher level of care," he says. "The Umbiflow ultrasound will indicate if the placenta is adequately supplying oxygen and nutrition to the fetus, determining whether referral to a hospital is needed."

Wallis explains that the handheld device plugs into any computer or tablet's USB port for power and uses its own software to display blood flow in the umbilical cord as waveform graphs on the screen. Audible pulses of the blood flow can also be heard, similar to traditional sonar screenings.

The device can also connect via mobile networks to medical experts and obstetricians elsewhere, providing real-time guidance and advice to the clinic staff conducting the tests.

Umbiflow has been extensively tested in multiple clinical trials with nearly 20 000 patients by a team from UP.

"Clinics using Umbiflow have seen up to a 43% reduction in stillbirths," says Wallis, adding that it has been clinically tested in Rwanda, Ghana, Kenya and India with support from the World Health Organization.

Wallis says that the CSIR is currently pursuing Conformité Européene (CE) Marking for Umbiflow as a prerequisite for market entry. CE is a mandatory conformity mark for regulating products sold within the European Economic Area and a range of low-to-middle-income countries, signifying that products meet high safety, health and environmental protection requirements.

The Umbiflow manufacturing team already holds ISO 9001 and ISO 13485 certifications, along with a manufacturing licence

from the South African Health Products Authority. This permits the CSIR to manufacture Umbiflow probes for clinical trial use.

Wallis says the team has recently worked on delivering 27 Umbiflow systems for UP's latest clinical tests, funded through philanthropy.

The devices will be used in the UmbiTshwane study at 22 primary healthcare clinics in Tshwane, as well as in the Siyakubona Study at 24 clinics in Gauteng, Mpumalanga and the Western Cape.

Lessons learned in developing and commercialising a medical device - through the Umbiflow development and trials - are currently being shared with small businesses through the Medical Device and Diagnostic Innovation Cluster (MeDDIC) Programme. MeDDIC is an initiative hosted by the SAMRC and supported by the Technology Innovation Agency and the Department of Science, Technology and Innovation.

MeDDIC was established to help SMMEs in the medical technology sector attain certification and promote the localisation of medical device development and manufacturing.

The CSIR operates as a technical partner for MeDDIC, which typically entails product development and testing, technical documentation, market access and compliance with the complex standards and regulations applicable to medical products.

"South Africa has a significant dependency on importation and the sector has complex regulatory requirements," says Wallis.

"At the same time, there is significant scope for innovation in the medical sector and, in particular, for solving our unique healthcare challenges."

"Innovation drives local manufacturing, which creates jobs, spurs exports and foreign investment and helps the economy," he adds.

Wallis says Umbiflow is just one example of a diagnostic tool that is technically sophisticated, yet mobile, simple to power and easy to use by clinic staff.

"The CSIR is also working on means of screening for illnesses such as TB, malaria or HIV/Aids, e.g., using a smartphone application. These epidemics are recognised under the UN Sustainability Goals (SDGs) with a deadline of arresting their spread by 2030."

A similar blood flow measurement ultrasound system is also under development for the early detection of conditions that lead to heart attacks and strokes.

"We continue to work with the SAMRC and other agencies who mirror our mandate and commitment to provide product solutions that meet real healthcare needs in this country," Wallis says.

ENQUIRIES: >> Jeremy Wallis

jwallis@csir.co.za



Mobile, affordable and easy to operate, Umbiflow is ideal for primary healthcare facilities and antenatal clinics in remote and low-resource settings. Audible pulses of the blood flow can also be heard, just like during traditional sonar screenings.







HERBAL REMEDIES TO SUPPLEMENT HIV CARE

partnership between CSIR researchers, traditional healers, regulators and the private sector has brought three HIV herbal remedies from Zimbabwe and Eswatini to market in the Southern African Development Community (SADC) region. The project was coordinated by the Southern Africa Network for Biosciences (SANBio), which is hosted at the CSIR.

"These medicines are a success story that demonstrates how Africa can develop and modernise its own medicines and healthcare solutions," says Prof. Ereck Chakauya, the CSIR-based manager of SANBio.

The three medicines – branded Mutombo, Menivir and Veravita – are based on the traditional knowledge of herbalists from Zimbabwe and Eswatini. They have been using plant-based remedies for over 10 years to assist with HIV and Aids management alongside antiretroviral therapies.

"While most herbal medicines may not treat the disease itself, they help manage the symptoms and opportunistic infections," says Chakauya.

"The reality on the ground is that communities often choose herbal products because they have minimum side effects, and research supports reduced resistance by the virus compared to single-molecule medicines. This is especially important in the era of antimicrobial resistance."

This project was coordinated by the SANBio, which is hosted at the CSIR. SANBio is an AUDA health and nutrition research platform that falls under the NEPAD programme of the African Union. It addresses SDG 3 and SDG 17.

He explains that every medicine developed by the CSIR and its partners undergoes rigorous testing for safety, efficacy and quality, and must be approved by the relevant regulatory authorities in each country where it will be used.

For these HIV/Aids remedies, the teams ensured that the medicinal plants would be harvested sustainably, with the prospect for further propagation, and that communities complied with the Nagoya Protocol on Access and Benefit-sharing.

"We signed agreements with communities to ensure the ethical use of their knowledge and that they are fairly compensated," says Chakauya.

The production process was established according to commercial good manufacturing practice and transferred to a private drug manufacturing company capable of generating all the necessary regulatory data.

"In essence, we developed a viable business model for community-based herbal products and these medicines are now in the process of regulatory approval by the competent authorities," he says.

SANBio is a health and nutrition research platform of the African Union Development Agency (AUDA), under the AUDA-New Partnership for Africa's Development (AUDA-NEPAD). The programme aims to eradicate poverty, promote sustainable growth and development, integrate Africa into the global economy and accelerate the empowerment of women.

"Our approach relies on science diplomacy through cross-disciplinary collaboration, mutual benefit and academic exchanges to leverage Africa's wealth of indigenous medical knowledge and rich biodiversity," says Chakauya.

He explains that the network's experience with the HIV herbal remedies project – funded by the SADC Secretariat – has led it to advocate for an African health research agenda. This agenda should include a fit-for-purpose intellectual property regime to protect local medicines, as well as country-specific and comprehensive pharmacopeia with inventories and guidelines on the medicinal properties of Africa's rich flora and fauna.

"What this project also demonstrates is that there *are* adequate research and development institutions in Africa, there *are* private companies that we can partner with to manufacture quality

products and there *are* mature regulatory institutions – such as the African Medicines Agency – to ensure that medicines are accessible and safe," he says.



CSIR researchers involved in developing complementary medicines for HIV and Aids management. From left: Dr Lindiwe Thete (senior researcher), Tina Chunga (senior process engineer), Makera Maloba (analytical chemist intern) and Dr Zandile Nxumalo (senior researcher).



Mutombo Immune Booster and Mhenivir are based on traditional herbal knowledge from Zimbabwe and Eswatini, where plant-based remedies have been used for over 10 years to support HIV and Aids management alongside antiretroviral therapies. These remedies were developed as part of a project coordinated by SANBio, hosted at the CSIR.

>> Ereck Chakauya echakauya@csir.co.za



This research forms part of the Department of Science, Technology and Innovation science awareness campaign in partnership with the South African Agency for Science and Technology Advancement, and it is funded by the Department of Science, Technology and Innovation. It addresses SDG 4, SDG 7, SDG 9, SDG 11 and SDG13.



COFIMVABA LEARNERS LOG GREEN SCORES FOR CSIR-DESIGNED SCIENCE CENTRE

outh Africa's first net-zero science centre, designed by the CSIR, is now an ongoing citizen science experiment in green building practices and a model for future buildings. Learners from two nearby high schools in Cofimvaba, Eastern Cape, use tablets to score the building's thermal performance, while its water and energy efficiencies are monitored in a digital twin building.

CSIR research architect Tinashe Dube says that the existence of this technology in a rural village proves it can be implemented anywhere.

Dube is based at the CSIR's Pretoria campus but regularly visits the Cofimvaba Science Centre to engage with and teach learners about the building's innovative construction materials, ventilation systems, solar energy, wind energy and water management systems.

The CSIR, in partnership with the Department of Science, Technology and Innovation (DSTI) and Eastern Cape authorities, designed and oversaw the construction of the science centre to demonstrate the feasibility of sustainable buildings. The centre serves 26 schools in the area and features additional exhibits designed by DSTI entities that encourage learning and careers in science and technology.

"This is the first science centre in the country that is built from scratch as a science centre," says Koki Selepe, DSTI Deputy Director: Science Promotion.

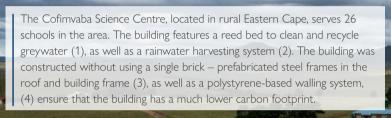
She says the building and its exhibits were developed to meet the needs of rural Eastern Cape communities and their environment.

(continued overleaf)

























With the province being so windy and sunny, for example, the centre shows that wind and solar energy are viable even in rural areas where municipal service delivery is challenging.

"We have another exhibit that focuses on agriculture – this region is rich in agriculture and these exhibits show the community how they can produce their crops using today's new technologies," she says.

The facility also features classrooms, laboratories for chemistry, physics and computing, and a multi-purpose lecture theatre that doubles as a planetarium. This supports the global Square Kilometre Array radio telescope project underway in the Northern Cape, involving institutions from over 20 countries.

Dube says the building also features a reed bed to clean and recycle greywater, as well as a rainwater harvesting system. "The building is self-sustaining, providing water to the taps."

She explains that the building was constructed for maximum thermal comfort using vents and a solar chimney, eliminating the need for additional energy for heating and cooling. "We used the principle of science that hot air rises and cold air sinks. When it's hot, the whirlybirds or the solar tower, will heat up. It will draw up all the hot air and pull cold air through the ducts. And, when it is cooler, it works in the inverse to force hot air down through the tower."

The building was also constructed without a single brick, she adds. "We used light steel frames for speed of construction and for insulation."

Prefabricated light steel frames in the roof and building frame, as well as a polystyrene-based walling system, ensure that the building has a much lower carbon footprint.

"These lightweight materials reduce transportation load and associated emissions," says Coralie van Reenen, lead CSIR architect on the project. "They also minimise the need for water and the use of cement in construction, and less construction waste is generated."

Van Reenen says the project has been an opportunity to turn research theory into practice, showcasing innovation and building science to support sustainability. She adds that the doors opened to the public in October 2020.

"The building has been completed and has become a research project in itself," says Dube. "It is now an experiment in which we monitor and evaluate whether the principles used in its design and construction, are working or not, and we've involved citizens."

She explains that grade 11 and 12 learners from Saint James High School and Cofimvaba Secondary School, both within walking distance of the centre, monitor the building's performance using tablets loaded with the CSIR's BROAD Facility Assessment Tool. 'BROAD' is short for 'Building Risk Operation And Design'.

"They come and check the data points, especially around temperature control and comfort within the building," says Dube.

"There's also a concept we use, called a digital twin, which is where you use data to monitor real-time occurrences," she says. "In this case, we use the data to monitor the real-time performance of the building from Pretoria while they're giving us the readings."

Dube says it is important to expose learners to green building practices and technologies like digital twinning early on so they will be equipped for technologically advanced careers in the future. This, in turn, will help bridge the gap between the more and less developed regions of South Africa.

She adds that the community and learners are also teaching scientists along the way.

"This being a rural area, there's a different sort of knowledge that the inhabitants of the area have just from living here. So, they'll be able to bring new learnings, new understandings and new applications of what we can do with digital twins and building monitoring when it's their time, which is very soon."

The CSIR and the DSTI plan to share and replicate the methods used in the planning, design, procurement, construction, commissioning and operation of the Cofimvaba Science Centre across South Africa.

"We are looking forward to enhancing the relationship and the work collaboration that we have with the CSIR in terms of linking the science with the everyday life of the people," says Selepe. "After having learnt enough here together with them, we will go and explore and expand the lessons learned here into the rest of the country."



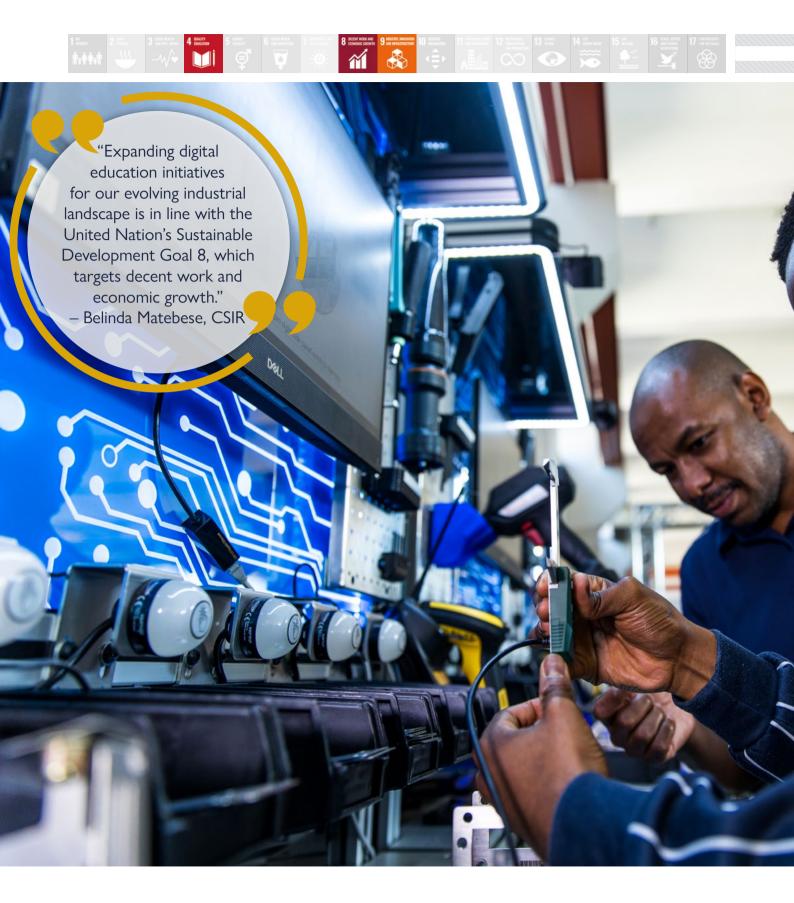


COFIMVABA LEARNERS LOG GREEN SCORES FOR CSIR-DESIGNED SCIENCE CENTRE

South Africa's first net-zero science centre, designed by CSIR research architects, is now an ongoing citizen science experiment in green building practices and a model for future buildings. Learners from two nearby high schools in Cofimvaba, Eastern Cape, use tablets to score the building's thermal performance, while its water and energy efficiency are monitored in a digital twin building. The CSIR, in partnership with the Department of Science, Technology and Innovation and Eastern Cape authorities, designed and oversaw the construction of the science centre to demonstrate the feasibility of sustainable buildings in all parts of South Africa.



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EXPLORE THE FUTURE OF INDUSTRIAL WORK AT THE CSIR LEARNING FACTORY

ore than 1 000 people have explored augmented reality, robotics, additive manufacturing, digital twinning and artificial intelligence (AI) through the CSIR's pilot Learning Factory courses over the past two years, and industry and technical colleges are now adopting the concept.

A learning factory is a space where South Africa's current and future workforce can explore technologies of the fourth industrial revolution (4IR) by interacting with hands-on practice stations and through online courses.

"For example, we have an area dedicated to three-dimensional (3D) printing, where people can learn the basics of 3D printing and learn to operate 3D printers," says Dr Belinda Matebese, who leads the CSIR Learning Factory team.

A special production line, made in collaboration with a local industry partner Jendamark Automation, also demonstrates how technology for industrial automation can work with humans using Al and machine learning.

Matebese says the CSIR's Learning Factory was set up in 2021, in partnership with the Engineering and Related Services SETA (MerSETA), to support skills development and innovation so that South Africa can leverage the opportunities brought by 4IR.

"This Master Learning Factory at our Pretoria campus was established as a pilot to demonstrate how South Africa can equip citizens for decent work in the future, in line with global sustainability goals," she says.



Matebese says free 4IR courses are also on offer. "We have beginner courses to show how these technologies fit into the South African context," she says, adding that enrolment has steadily increased. More than 600 enrolled in the first year and over 1 000 since courses began.

"This trend underscores the importance of expanding digital education initiatives to support South Africa's evolving industrial landscape," says Matebese, in reference to the United Nations' Sustainable Development Goal (SDG) 8, which targets decent work and economic growth.

Dr Sunveer Matadin , who manages the CSIR Centre for Robotics and Future Productions , says the CSIR's Master Learning Factory can be customised or replicated for industries, academic settings or community spaces to boost 4IR skills for better job opportunities, entrepreneurship and innovation.

"The Learning Factory has shown itself to be a model that is customisable and can work across industries and the country. It can bridge the gap between academia and industry."

Plans are in place to set up similar spaces at Technical and Vocational Education and Training (TVET) colleges and industries,

says Matebese, and the team wants to expand learning stations to include technologies around renewable energy and agriculture.

Such expansion relies on research from the CSIR team to align with the country's economic needs, and to lead in modern education and innovation. "We have, for instance, conducted a study to see what is required to set up a similar factory specifically for the mining industry in Limpopo," says Matebese.

The CSIR and MerSETA team are also setting up a pilot learning factory at the East Cape Midlands Technical TVET College. "This builds on previous work with the TVET to identify and address gaps in their curriculum, determine the scope and technology to be included in the Learning Factory and align it with industry needs to support the development of a skills pipeline in 4IR technologies," she says.

"We are creating solutions that focus on people, using technology to help them learn new skills," she adds. "This way, even people who don't have extensive formal education can learn to work with new technologies."

Matebese says the Learning Factory piloted a training programme for Master of Business Administration students from the



EXPLORE THE FUTURE OF INDUSTRIAL WORK AT THE CSIR LEARNING

The CSIR's Learning Factory is a space where South Africa's current and future workforce can explore technologies of the fourth industrial revolution (4IR) hands-on. It offers experiences in augmented reality, robotics, additive manufacturing, digital twinning, the Internet of Things (IoT), AI and more. The Learning Factory at the CSIR Pretoria campus is an adaptable model space that can be customised or replicated within industries, academic settings or community spaces to boost 4IR skills for better job opportunities, entrepreneurship and innovation.

Independent Institute of Education (IIE) MSA, where they interacted with some of the application stations (AR/VR), were introduced to blockchain and finished off with an innovation workshop.

"Students highlighted improvements in creative thinking, problem-solving and awareness of 4IR's potential for business opportunities and efficiency," she says.

One student remarked, "This is something that I can immediately implement into my work environment," which Matebese says reflects the programme's direct relevance to their professional lives.

"The collaboration holds great promise as we harness the best of both worlds: the CSIR's technical excellence and the IIE MSA

educational prowess. Together, we are dedicated to pushing the boundaries of skills development and innovation," says Marlene Bogaards, who heads the Research and Postgraduate Studies Unit at IIE MSA.

Matebese invites other members of the public, education institutions and industry to visit the facility by booking online and to enrol for free courses.



































ew research by the CSIR and its partners reveals that climate change denialism looms large in South Africa, with nearly half of the population believing coal to be a renewable energy source. These findings, among many others, were shared in the inaugural Citizens' Environmental Awareness, Beliefs and Behavioural Preferences In South Africa 2022 report, published in 2024.

"An environmentally savvy and informed society can be advanced with the Citizen Environmental Awareness Index, which will ultimately help South Africa achieve many of the United Nation's Sustainable Development Goals."

— Dr Lorren Haywood, CSIR



This research was funded by the Department of Science, Technology and Innovation through the National Research Foundation. It addresses SDG 4, SDG 12, SDG 13, SDG 14, SDG 15 and SDG 17.









School learners on a field trip to aid environmental awareness in Jonkershoek, Western Cape. New research by the CSIR and partners suggests that South Africa needs better educational interventions to increase environmental awareness, so that citizens are more likely to protect and conserve the country's natural resources.

A report on environmental awareness in South Africa, compiled by the Human Sciences Research Council, the CSIR and the Department of Forestry, Fisheries and the Environment, can now be used by policymakers and organisations to develop effective strategies for conservation and sustainability.

"This collaboration established the Citizen Environmental Awareness Index (CEAI) as a reliable framework for assessing and monitoring environmental awareness in South Africa and for enabling an understanding of the public's knowledge, attitudes and behaviours regarding key environmental issues," says CSIR senior researcher Dr Lorren Haywood.

She explains that the CSIR contributed towards developing the CEAI methodology behind the report, informing and shaping the national environmental awareness survey and analysing the survey data.

The index paints a picture of environmental literacy among the South African population to help identify gaps in environmental literacy programmes and other environmental awareness-raising initiatives in South Africa.

Haywood says the CEAI will be used by policymakers and organisations to develop effective strategies for conservation, sustainable growth and development. In this way, interventions

can be tailored to encourage environmentally conscious actions like recycling, reducing waste and conserving energy.

The survey reached approximately 3 500 respondents across the country's nine provinces, all of whom could choose in which of the country's official 11 languages they wanted to participate.

"In adopting this approach, we found it extremely difficult to explain certain environmental terms, such as 'biodiversity', because it is not easily translatable into different languages," says Haywood. "We had to ensure the questions were simple enough for respondents to understand, and in this case, decided to use the word 'nature' instead to make the survey more relatable."

The survey undertook to gain insight into the knowledge, attitudes and behaviours of South Africans around environmental themes such as climate change, air pollution, litter and waste, oceans and beaches, energy, water and biodiversity. "A special focus was placed on biodiversity because no previous survey had been conducted to find out how aware people are of the country's plants, animals and natural spaces," she adds.

When asked about the environmental problems they worry about the most, the top three concerns for survey respondents were water pollution, air pollution and drought or water shortages. Climate change, litter and waste and flooding were

also major concerns. The issue that worried people the least was the use of fossil fuels for energy.

Haywood says the index revealed that the majority of South Africans perceive the environment as referring only to the natural environment, rather than including the built environment and others.

Close to three-quarters of adults see 'animals and plants' (74%), as well as 'water, air and soil' (72%) as part of the environment, while a smaller share tended to include people as part of their definition (55%), and even fewer included the man-made environment (29%).

Of those who know a lot about environmental problems, 77% were 'very' or 'extremely' worried about these problems. This level of concern progressively declines as knowledge levels decrease, with only 24% of those who know nothing about environmental problems expressing concern.

When questioned about primary sources of information on environmental issues, conventional media sources predominated. Three-quarters of the public indicated that television remained their primary source of environmental information. Radio was the second most frequently mentioned information source, followed by social media and the internet.

Climate scepticism and denialism loomed large among respondents, who held conflicting views and interpretations about renewable energy and fossil fuel sources. A worrying finding from the survey was that 43% of South Africans mistakenly believed that coal is a renewable energy source. This is concerning, especially since these topics are covered in schools and have been for years.

The deep dive into biodiversity revealed that many South Africans have low awareness of its importance. This shows a need for education that connects biodiversity to ecosystem health and human wellbeing in a way people can relate to. By increasing awareness, South Africans will be more likely to take action to protect and conserve the country's natural resources.

"We have a long way to go in promoting understanding of these issues," says Haywood. "The use of infographics can assist in increasing understanding of environmental matters. Awareness raising through national campaigns can also be done to promote the actions based on the survey results."

Equipping the youth to be custodians of the environment is important, says Haywood. She would like to see school curricula

consider sustainable development as a subject for learners to promote improved understanding of the climate change issue, the value of recycling, the relationships between the self and nature, the value of healthy, functioning ecosystems and emerging issues such as the circular economy.

Haywood cautions that the survey does not explain why people lack awareness, concern or engagement in pro-environmental actions.

She says it is also important to remember that knowledge about the environment is interpreted differently between rural and urban population groups.

"For example, rural inhabitants have a better connection with the environment due to their dependence on natural resources compared to their urban counterparts," she says. "Between the two groups, they use different languages and words to describe elements they observe and enjoy from the natural environment, especially when it comes to terms like 'species'."

The survey does not measure the effectiveness of specific interventions or policies over time, meaning further studies are needed to assess the impact of awareness campaigns and education initiatives, she says.

Lastly, while the index is unique in its approach, comparisons with similar international indices are limited, making it challenging to benchmark South Africa's environmental literacy globally.

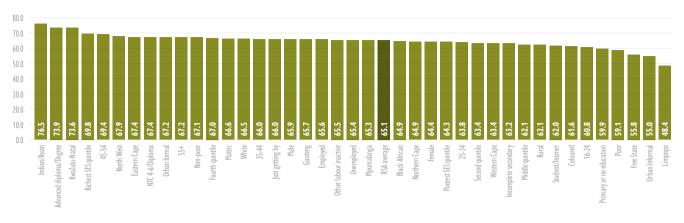
However, Haywood is confident that an environmentally savvy and informed society can be advanced with the CEAI, which will ultimately help South Africa achieve many of the United Nation's Sustainable Development Goals (SDGs).

"We are now in the process of analysing the results from the second national environmental awareness survey and plan to do so every second year," she says.

For this second survey, the CEAI project partners have teamed up with the Medical Research Council, as this year the intention is to conduct an in-depth evaluation of the awareness, concerns and actions of South African citizens regarding air quality. It will be ready by the end of this year.

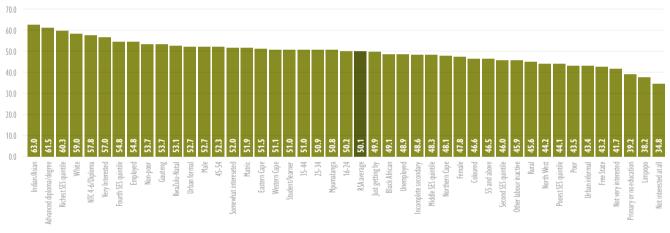


Figure 1: Interest in the environment, by select socio-demographic attributes (2022, mean score based on 0-100 scale)



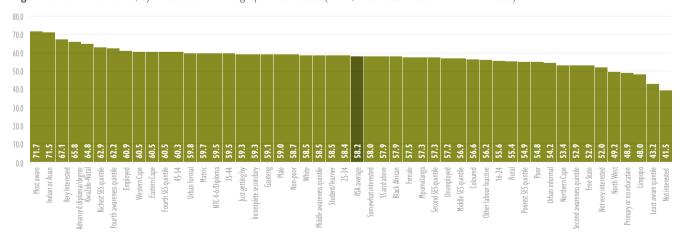
Source: DFFE-HSRC-CSIR CEAI survey 2022

Figure 2: Level of awareness, by select socio-demographic attributes (2022, mean score based on 0-100 scale)



Source: DFFE-HSRC-CSIR CEAI survey 2022

Figure 3: Level of concern, by select socio-demographic attributes (2022, mean score based on 0-100 scale)



AQUIFER MAPPING TO BOOST WATER SERVICE DELIVERY IN NORTHERN CAPE

he Northern Cape province's town of De Aar will become one of the very few in South Africa to drill and pump its boreholes strategically using scientific maps of underground aquifers. Dr Harrison Pienaar, a hydrogeological expert at the CSIR, is calling on all South African waterboards, mayors, municipal managers and communities to conduct cost-effective groundwater surveys, ensuring compliance with the national directive to diversify municipal water supply.

Like the rest of the Northern Cape, the parched and sunbaked town of De Aar in the Emthanjeni Local Municipality relies almost entirely on groundwater.

"Remember that surface water like dams or rivers are not in abundance there, because the Northern Cape is primarily a semi-arid region, with some areas classified as arid," says Pienaar, who leads smart water use studies at the CSIR Water Research Centre.

Some rain does fall; however, most seeps into the earth to recharge its underground water channels.

"When you have, say, five or six aquifer systems next to one another, some of these are horizontally linked and some are vertically linked, meaning that the water interacts and exchanges in both directions," Pienaar explains. "We need to study the relationship between these aquifer systems and their characteristics to understand which one will run dry and when, if they are all pumped for water at a certain rate."

Over the past two years, local farmers and municipal officials hosted Pienaar and a team from the CSIR, the University of the Western Cape and the Northern Cape branch of the Department of Water and Sanitation (DWS) as they worked to



During 2024, Dr Harrison Pienaar and a team from the CSIR, the University of the Western Cape and the Northern Cape branch of the Department of Water and Sanitation used modern, cost-effective hydrogeophysical methods to map the aquifer systems of De Aar. Often working day and night on local farms, they pinpointed the location, extent and thickness of groundwater channels and measured the quality of groundwater in terms of acidity, flow, temperature and potential harmful contaminants.

map the aquifer systems below the surface. Often working day and night, they pinpointed the location, extent and thickness of groundwater channels and measured the quality of groundwater in terms of acidity, flow, temperature and potential harmful contaminants. The joint research team together with local stakeholders, such as municipal officials and farmers, assess how much water the aquifer system receive, how much they yield over time, and their sustainable yield.

The researchers shared the outcomes and recommendations of this hydrogeophysical survey directly with the South African Local Government Association (SALGA) in the Northern Cape.

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This research forms part of a collaborative study between the CSIR, the University of the Western Cape and the DWS and it is co-funded by the Department of Water and Sanitation. It addresses SDG 6, SDG 11 and SDG 13.

Pienaar says one of the immediate goals is to enable the municipality to better manage aquifer recharge (refilling from rainfall), as this will lead to better decisions on groundwater usage, monitoring and management. He says municipal managers can use the aquifer maps to schedule and switch borehole pumping in a way that will not deplete aquifers during, for instance, the dry season.

At the same time, the water quality data they have provided can inform water treatment measures that will ensure sustainable, clean and safe drinking water for their communities.

Unfortunately, says Pienaar, despite enough groundwater being available to supply its citizens, most municipalities in South Africa are not yet using cost-effective hydrogeophysical technologies, systems approaches or catchment-wide studies for groundwater allocation and management.

"Groundwater is not being looked at strategically," says Pienaar, emphasising that the result is ultimately poor service delivery.

"It's just a shame when you drive through small towns in South Africa and people don't get even the most basic of services. As researchers, we come from the very same communities, so it hits home when we see people who don't get services."

To make matters worse, he says, South Africa is now overreliant on surface water consumption, with the DWS urging diversification of water sources as a national imperative.

But it is not just a matter of drilling boreholes. "We need to consider the strategic points that we can point out to municipalities through these studies, to make sure that there's meaningful supply of water to the population that they serve," says Pienaar.

He says it is time to adopt newer, faster and cheaper hydrogeophysical methods to study aquifer systems because traditional approaches are invasive and expensive.

"The old approach involved drilling and taking soil samples from the site, which can disturb the study site, cost too much time or money, or expose researchers and people to harmful chemicals and contaminants," says Pienaar, adding that these methods cover only small, localised areas, rather than the large-scale underground maps required by municipalities.

In De Aar, scientific support from the CSIR and partners is ongoing, and SALGA expressed gratitude to Pienaar following his detailed presentation in December 2024 on the survey

results and other smart technologies that will ensure efficient groundwater management and service delivery in the region.

Pienaar says successes in De Aar have led to another similar project approach for Lepelle Northern Water (a Limpopobased waterboard) as part of its systems approach to water management.

"I want to urge other municipal managers, including waterboards, to equally consider strategic mapping and characterisation of aquifers to unlock the potential of groundwater as an important source of water supply," says Pienaar. "This will reduce our overreliance on surface water, which is already overstressed due to increasing water use demands."



CSIR researchers are using modern hydrogeophysical methods to map aquifer systems below the ground in De Aar, Northern Cape. The results of such a survey allow municipal managers to strategically manage groundwater by scheduling and switching borehole pumping in a way that will not deplete aquifers. At the same time, the water quality data these surveys provide can inform water treatment measures that will ensure sustainable, clean and safe drinking water for their communities.

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A BIODEGRADABLE RAPID TEST TO DETECT E. COLI IN WATER

he CSIR has developed a biodegradable device that can detect *E. coli* in water within two hours. It works faster than similar existing lateral flow detection devices, is easy to use by non-experts and circumvents the need for lengthy laboratory testing processes.

Dr Vusani Mandiwana, a pharmaceutical scientist at the CSIR, says: "This technology matters because clean water is an essential commodity for human life." She explains that the technology will be especially useful in areas affected by untreated human waste contaminating groundwater and surface water used for drinking, irrigation bathing or other household uses.

"This *E. coli* detection device is convenient and requires no technical knowledge to use," she says.

The device is particularly suitable for use by municipalities, as they oversee precipitation ponds containing sewage, which must be treated before the water is released back into river systems.

"Water can only be released back into river systems once it meets the specification in terms of *E. coli* bacteria counts," explains Dr Mandiwane. She says it is usually a time-consuming process for water samples to be collected, filtered and placed on petri dishes for multiplication in preparation for laboratory analysis.

The project is co-funded by the CSIR and Department of Science Technology and Innovation. It addresses SDG 3 and SDG 6.





nents of the CSIR-developed E. coli detection device (above). CSIR senior ner Dr Vusani Mandiwana (top) inspects an assembled E. coli detection device.

"It takes days before the results are made available. If users opt for this quick test instead, they can determine *E. coli* levels and release the water back into river systems on the spot, within two hours – this is a big advantage."

This technology builds on existing lateral flow devices (similar to pregnancy tests) developed by Dr Amanda Skepu's team at the CSIR, in that it uses paper strips to detect the presence of biological markers – in this case, the *E. coli* pathogen.

"The challenge is that it is difficult for lateral flow device strips to get bacteria to multiply as they do in a petri dish – the device



is not sensitive enough to detect just a few of the bacteria," she says. "To address this, we developed a system that filters the water and incubates the bacteria so they multiply to a detectable level."

She adds: "We have taken our solution one step further by putting all of this technology into one system that is biodegradable." This approach was designed by CSIR technician Masibulele Kakaza and has been patented.

The uniqueness lies not in the lateral flow strip itself, but in the combination of the strip, the filtration mechanism, the mechanical method of engaging the filter and opening of a port that allows the lateral flow strip to come into direct contact with the growth medium in the filtration chamber. The technology has a minimum bacteria load requirement for *E. coli* detection, so it is not designed for household use, but rather for industrial water treatment plants.

Mandiwana says that the technology has been tested and that a prototype is available. The CSIR now plans to issue a call for interested parties to license and commercialise the technology.

The technology will help industries and authorities ensure that communities do not develop illnesses like diarrhoea, which can occur when contaminated ground or surface water is used for drinking, irrigation, bathing or other household activities.







SCHOOLS URGED TO COLLECT RAINWATER TO AVOID CLOSURES AND LEARNING DISRUPTIONS

f public schools in South Africa used their roof surfaces, netball courts, soccer fields and other large surfaces to catch rainwater, thousands of hopeful matriculants could continue with lessons and exams uninterrupted by municipal water cuts and droughts.

Add greywater recycling, water-saving fittings and dry toilets, and schools could go virtually off the water grid.

This is according to Dr Jeremy Gibberd, an expert on sustainable built environments and education infrastructure at the CSIR. He says the latest research challenges the myth that rainwater harvesting is too expensive or too difficult to implement at schools.

His team of researchers conducted cost analyses and water consumption modelling at one school in the Eastern Cape and one in Gauteng, which showed that an investment of just R2 500 per learner in rainwater harvesting could make a huge impact.

"The myth is that you can't go off-grid, but the research says you can. Our modelling and calculations also show that it doesn't have to be incredibly expensive," he says, adding that there will be an even bigger cost to society if schools don't act.

"During a water disruption, if these kids in the Eastern Cape, for example, miss three or four weeks at a crucial period leading up to matric, they could fail."

Gibberd says schooling is disrupted most for children suffering irregular municipal water supply, as well as children in areas experiencing droughts made worse by climate change.



"The fundamental thing is to have drinking water to cool down, and if people don't have plentiful, easily accessible water, very quickly health problems multiply. Especially if you've got toilets that can't flush," he says. "And so, in terms of the Constitution, you're not fulfilling children's rights to education and health."

The advantage that large public buildings like schools have, is an abundance of catchment surfaces. Taking schools off grid for water helps reduce the pressure on municipalities to meet demand. This could also be done with a range of other public buildings such as TVET Colleges, government offices, depots and police stations.

Unfortunately, Gibberd says much of the guidance available to the public interested in going off-grid focuses on rainwater harvesting water tank sizes, rather than the catchment area and consumption factors that may be more important in determining feasibility.

He therefore hopes that municipalities and the Department of Basic Education will take note of the CSIR's recommendations for the two study schools as a proof-of-concept for what can be done to improve water supply cost-effectively, based on the individual needs of a particular school.

"The two schools we modelled are very different. The one in Gauteng is a typical model-c school, as they used to be called, where they use a municipal water supply for a swimming pool, irrigation and to flush toilets," says Gibberd. "We contrasted this with a school near Hankey, in the Eastern Cape, where there had been serious water shortages, resulting in very high tariffs."

He says the CSIR's modelling is sophisticated enough to take these water consumption differences into account, as well as local rainfall patterns and other seasonal weather conditions.

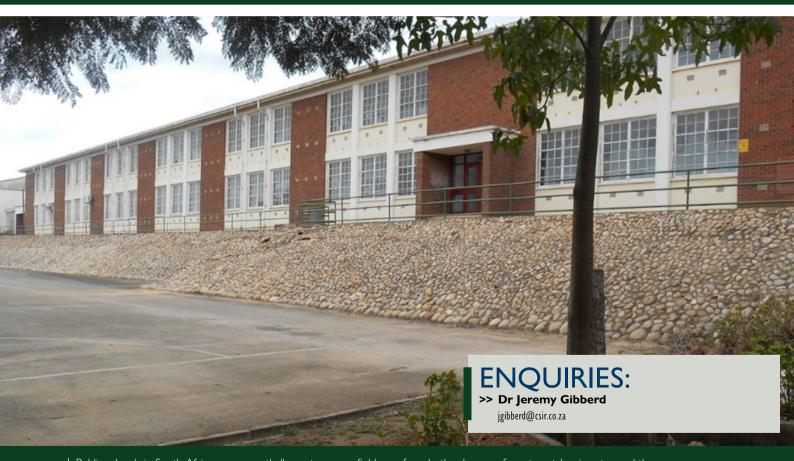
If the funds were made available, the two schools could implement the water-wise solutions recommended by the CSIR's study.

Ideally, says Gibberd, national and provincial education bodies should also draw on these case studies and the latest research and technologies to earmark funding for a rainwater harvesting programme at public schools in water-scarce areas.

He says the CSIR's role is to provide the scientific and technical expertise to support such programmes, and to offer innovations that will ensure water resilience in schools and other public infrastructures.



Seen from above, public schools have large surface areas that can be used to collect rainwater, such as roofs and sports fields. Dr Jeremy Gibberd, an expert on sustainable built environments and education infrastructure at the CSIR, says cost analyses and water consumption modelling at one school in the Eastern Cape and one in Gauteng showed that an investment of just R2 500 per learner in rainwater harvesting and water-efficiency measures can reduce or prevent water shortages and school closures caused by municipal water cuts and droughts.



Public schools in South Africa can use netball courts, soccer fields, roofs and other large surfaces to catch rainwater, and they can implement grey water recycling, water-saving fittings and dry toilets to prevent water shortages. Dr Jeremy Gibberd, an expert on sustainable built environments and education infrastructure at the CSIR, says this can help reduce learning disruptions at schools exposed to irregular municipal water supply or those located in areas experiencing droughts due to climate change.





SCIENTISTS CLOSE TO 86% REDUCTION IN HYDROGEN CYLINDER STORAGE PRESSURE

SIR researchers are at an advanced stage of developing a technology to compact one kilogram of hydrogen into a 20-litre cylinder at just 100 bars – 86% less pressure than current compression technology allows for. This technology, which is currently under development and is expected to be demonstrated in the coming months, will make it possible for hydrogen-powered vehicles to store the fuel at reduced pressures, thus enhancing the technology's safety and affordability.

Principal researcher at the CSIR, Dr Mike Masukume, says hydrogen has been identified as a viable clean energy source for the transportation sector.

"Fuel cells and hydrogen represent the practical solution for decarbonising trucks, buses, ships, trains and large cars, with commercial vehicles being considered the early adopters," he says. "But with current compression technology, it would have to be stored at a very high pressure of 700 bars, which is costly and unsafe."

The CSIR is one of 13 international collaborators developing the world's first one kilogram low compression hydrogen storage

This innovation is funded by Horizon Europe, the technology development consortium consists of the CSIR, Environemp (Spain), Contactia (Spain), Cidetec (Spain), Consejo Superior de Investigaciones Científicas (Spain), Spike Renewables (Italy), Edag Engineering (Germany), Nanolayers (Estonia), the University of Nottingham (UK), Peugeot Citroen Automotive Portugal (Portugal), LKR Leichtmetallkompetenzzentrum Ranshofen GmbH (Austria) and the University of Pretoria (South Africa). It addresses SGD 7.

device, with a target of 100 bars or lower. The collaboration, known as Mast3RBoost, is funded by the Horizon Europe programme.

"As the CSIR, we are leading the work package that is responsible for developing ultra-porous materials known as metal-organic frameworks (MOFs) at scale, as well as their composites," says Masukume. "The porosity allows the material to store more hydrogen, thereby achieving hydrogen storage below 100 bars."

In parallel, his team also synthesised MOFs using metals recovered from waste, like packaging materials, to enhance their cost-effectiveness and eco-friendliness.

"The CSIR has made tremendous progress on the Mast3RBoost project, which is in its third year of four," explains Masukume. "We have synthesised the best-performing MOFs in the laboratory and scaled production up to 1 200-litres capacity."

He adds that the team densified the pristine MOF materials and their composites into granules and pellets, and characterised them in terms of surface area, mechanical strength, porosity, bulk density, thermal conductivity and hydrogen uptake at one bar.

"Due to the unavailability of high-pressure hydrogen testing equipment at the CSIR and within the country, selected samples have been sent to the University of Nottingham, a member of the consortium, for hydrogen uptake measurements at 100 bars," he says.

Other members of the Mast3RBoost consortium are also exploring other porous materials, such as activated carbons, and applying machine-learning algorithms to enhance their performance. They are also designing and fabricating the cylinder, developing compatible coatings for its lining and testing the final cylinder in a stationary testing rig.

"We are excited to be just months away from demonstrating the storage of one kilogram of hydrogen in a 20-litre tank at 100 bars," says Masukume. "This will be revolutionary for the transportation sector and we look forward to the adoption of clean alternative fuel sources throughout the world as a result of this project. If the technology is successfully demonstrated in the European Union, it will also be localised for South Africa and will have a major impact on global transportation."



CSIR chemical engineering intern, Zandile Mabasa, displays the final granulated metal-organic framework product.



CSIR chemical engineering intern, Zandile Mabasa, and chemical engineering graduate trainee, Simphiwe Ncwane, collect a slurry product from a reactor.



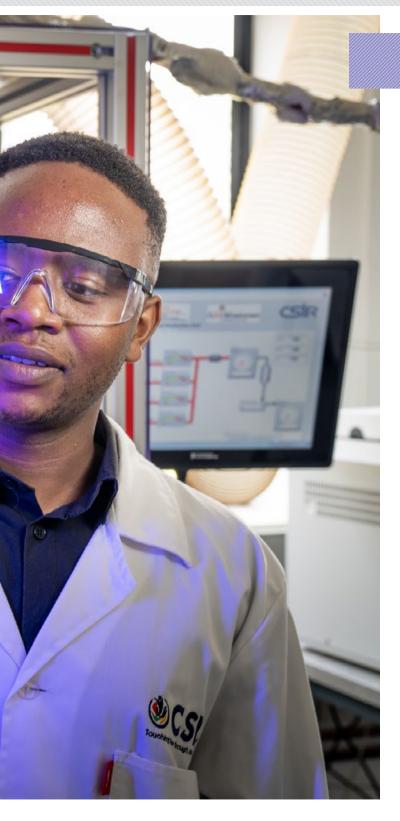
Metal-organic framework cakes are collected after mechanical dewatering using a pilot-scale filter press.







This research is co-funded by the CSIR and the Royal Society-Foreign, Commonwealth and Development Office Africa Capacity Building Initiative Programme and the Department of Science, Technology and Innovation. It addresses SDG 7 and SDG 13.



CARBON DIOXIDE POLLUTION CONVERTED INTO GREEN METHANOL FUEL

esearchers at the CSIR developed a catalyst that converts carbon dioxide (CO₂) into ecofriendly methanol. The technology is poised to help stimulate South Africa's green methanol economy.

Methanol is an essential component in various industries, including plastics manufacturing and chemical synthesis. It can also be used as a potential fuel in maritime travel, says CSIR researcher Zama Duma.

Duma says the ability to produce green methanol from captured CO_2 represents a crucial step towards achieving the United Nations Sustainable Development Goals (SDGs) around climate action and clean energy.

"The primary issue this research seeks to address is global warming, which is primarily caused by the accumulation of greenhouse gases such as CO₂ and methane in the atmosphere," he says. "These gases trap heat, leading to erratic climate patterns, severe droughts and more frequent flooding."

Industrial sectors, including power generation, oil and gas production, cement manufacturing and steel production, are among the largest contributors to carbon emissions.

The CSIR's innovation was supported by the Department of Science, Technology and Innovation-funded Hydrogen South Africa programme and seeks to target emissions from both anthropogenic (manmade) and biogenic (natural) point sources and convert them into valuable chemicals. This would reduce their negative environmental impact.

Thus, the innovation aims to mitigate greenhouse gas emissions while contributing to global efforts for cleaner, more sustainable energy sources. The study also aligns with South Africa's green

(continued overleaf)

energy policies and international carbon reduction strategies, such as the United Nations SDGs.

"The key breakthrough in this research lies in the catalyst design," says Duma, adding that the findings have been published in various scientific journals, reinforcing South Africa's position as a leader in sustainable energy innovation.

"The CSIR has used its proprietary metal-organic frameworks to enhance the conversion efficiency of CO₂ into methanol. This process not only repurposes waste gases but also produces a sustainable alternative to fossil fuel-based methanol, which is currently derived from natural gas," he adds.

While the catalyst was shown to be active towards methanol production and the process technically feasible, it still requires further optimisation, says Duma.

In the broader context, the economic viability of green methanol remains a challenge. The current cost of methanol derived from fossil fuels is between US \$303 to US \$824 per ton, and current techno-economic evaluations indicate that the cost of methanol derived from renewable, low-carbon hydrogen and captured CO_2 may be two to three times higher.

"Clean energy technologies are still in their infancy, making them more expensive than conventional fossil fuels. To address this, the CSIR is working with policymakers and industry stakeholders to make green technologies more competitive," says Duma.

The research has gained recognition, with a presentation made to the Southern African German Chamber of Commerce in November 2023, where project developers introduced the market to a planned green methanol corridor.

"One of the most exciting applications of this technology could be in the proposed Green Methanol Corridor in the Vaal Special Economic Zone. This initiative aims to use wastewater treatment plants to produce green hydrogen, which, when combined with captured CO_2 , will generate methanol for local use and export. The corridor is envisioned to run from the Vaal region to the Port of Durban, establishing South Africa as a key player in the global green methanol market," he says.

The success of this innovation hinges on collaboration among governments, industries and research institutions. The CSIR has partnered with international organisations, including entities in France, to advance this technology beyond the laboratory and into industrial-scale production.

Despite the promising advancements, significant hurdles remain. The cost of scaling up green methanol production and the











need for policy support are critical factors in determining the widespread adoption of this technology. Public awareness and industry buy-in are also crucial to ensure a just transition away from carbon-intensive fuels.

The CSIR is advocating for increased funding, both domestically and internationally, to drive further research and commercialisation. The hydrogenation of CO₂ into green methanol represents a transformative step in the fight against climate change and provision of clean technologies.

While challenges persist, the CSIR's pioneering research has the potential to reshape the energy landscape, reduce carbon footprints and create economic opportunities through sustainable innovation.

"If supported by appropriate policies and investments, this technology could play a crucial role in South Africa's transition to a greener economy and contribute to global climate goals," says Duma.

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balone farmers along South Africa's coast are now using ocean colour maps to track marine algal blooms that could harm their export molluscs. CSIR scientists made ocean colour and temperature data from satellites easy to access in an online tool as part of the country's ocean economy plan to boost aquaculture jobs.

The younger creatures look like tiny blue snails, clinging in bunches to specially designed black cone hideouts in tanks stationed nearest the waves below.

Further up the farm, beneath row after row of solar panel shelters, mature molluscs bathe and crawl, now pearlescent and heavy in the careful hands moving them from tank to tank.

The roughly 400 staff who tend to about 15 million of these animals at the Abagold aquaculture facility, which is perched on the rocks of Walker Bay in Hermanus, often spot whales nearby, feeding on plankton in the Atlantic waves.

The farm's 650 tonnes of abalone, famed for their umami flavour profile, grow through various stages of life in the very same

OCIMS was developed by the Department of Forestry, Fisheries and the Environment and partners through Operation Phakisa, a government initiative to drive South Africa's ocean economy. The CSIR supports OCIMS by making ocean colour data from satellites available to the public through the Fisheries and Aquaculture Decision Support Tool, thereby contributing to SDG8, SDG9 and SDG13.

seawater – intake pipes fill 5 000 tanks directly from the ocean below.

Marius Hugo, Abagold's COO, says this massive biological stock has taken years to rebuild.

"In 2017, we had an algal bloom that we were unprepared for. We had mortalities of about 40% in that year," he says.

Millions of abalone in the Walker Bay area of South Africa were killed as phytoplankton numbers got out of hand, producing toxins that caused a harmful red tide throughout nearby bays.

The CSIR's Dr Marié Smith, a marine Earth observation expert, says the combination of upwelling, followed by calm conditions

or marine heatwaves, can cause these microscopic algae to proliferate.

Abalone can be sensitive to certain species of bloom-forming algae.

"There are different mechanisms of harmful algal blooms – some cause toxins, and some toxins are harmful to certain species but not to others. Some blooms are harmful in that they cause mechanical damage – they might be spikey and stick in fish gills, for instance," explains Sarah Halse, Research and Sustainability Manager at Abagold.

Red tides are not new; an abalone farm's scientific team will routinely check for signs of harmful algae in incoming seawater.



But now, it is possible to use ocean colour maps from satellite data to track algal blooms before they even reach an aquaculture facility.

"The nice thing about satellite information is that it provides you with a much larger spatial scale of information than you could get with simply taking a single sample at the farm at the intake pipe," says Smith.

Smith is a lead expert behind the Fisheries and Aquaculture Decision Support Tool of the National Oceans and Coastal Information Management System (OCIMS). The free, easy-touse tool interprets ocean colour and temperature data from the Copernicus Sentinel-3 polar-orbiting satellite so that abalone farmers can monitor approaching harmful red tides in near real time.

Smith says that if this imagery had been available in 2017, abalone farmers would have had more time to take protective measures like closing their intake pipes, changing their filters and adjusting feeding schedules to preserve the water quality for their animals.

Hugo says Abagold and other aquaculture facilities nearby have since learnt to anticipate harmful algal blooms using the OCIMS tool, along with ongoing support from Smith and the CSIR.

"The aquaculture industry is really integrated in the community," he says. "It's a large provider, a driver of the economy and the small local economy. A lot of the jobs that were dependent on the fisheries and the ocean have transferred to the aquaculture sector."

Smith says past, present and future satellite data is critical to safeguard these jobs, particularly in the context of the climate crisis where frequent and intense environmental hazards like marine heatwaves could worsen red tides.

"In terms of climate change adaptation and being able to prepare for climate change impacts, satellite data are very valuable because the satellites have been up there for a long time," she says. This means ocean colour and temperature data trends can be analysed and used to model future scenarios.

"We can see if there's more variable conditions or if the red tides have been increasing," says Smith.

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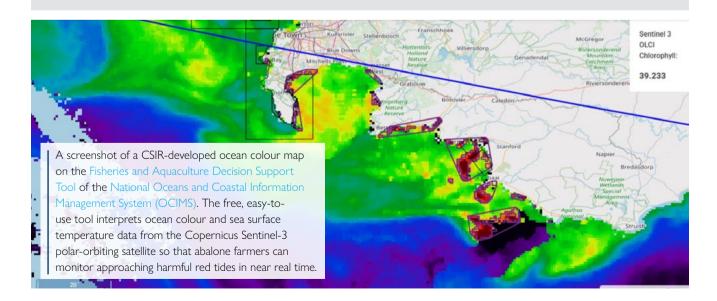


An abalone farm's scientific team routinely checks for signs of harmful algal blooms in incoming seawater. But now, it is possible to use ocean colour maps from satellites to track these blooms before they reach an aquaculture facility.



SATELLITE OCEAN COLOUR MAPS WARN ABALONE FARMERS OF HARMFUL ALGAE

Abalone farmers along South Africa's coast are now using ocean colour maps to track marine algal blooms that could harm their export molluscs. CSIR scientists made ocean colour and temperature data from satellites easy to access in an online tool as part of the country's ocean economy plan to boost aquaculture jobs. The near-real-time maps are available freely to the public through the Fisheries and Aquaculture Decision Support Tool of the National Oceans and Coastal Information Management System (OCIMS). OCIMS was developed by the Department of Forestry, Fisheries and the Environment and partners through Operation Phakisa.





DIGITAL PERMITS FOR ABNORMAL VEHICLES REDUCE ROAD DAMAGE



This technology forms part of collaborative work between the CSIR, South African municipalities and SADC Countries such as Namibia. It addresses SDG 8, SDG 9 and SDG 11.



Large trucks carrying abnormally large loads, like harvesters, industrials machines or power station equipment, put extra stress on the tarmac of national roads.

Khangwelo Muronga, a CSIR research group leader at the CSIR, says abnormal loads can't be divided into smaller parts, so these vehicles must comply with strict legal standards.

"For example, an Eskom power transformer cannot be cut in half; you need to transport it as it is, and it needs to be transported with a specialised vehicle," he says.

"With the new automated, digital system developed by CSIR researchers, drivers transporting cargo that exceeds standard dimensions or weight limits can now register their vehicles and present their permits at checkpoints, particularly those on national roads connecting neighbouring countries," says Muronga.

The system also calculates the appropriate permit fees, which are then used to fund road maintenance.

"The heavy vehicle will cause road damage, but the entity transporting the goods will pay for damaging the road, which is the reason the system is there – to make sure that they are charged accordingly," says Trevor Nkuna, a CSIR technologist involved in developing the system.

Muronga says abnormal load transportation contributes to the economic development of Southern African Development Community (SADC) regions. For instance, South Africa's national power utility, Eskom, which has a power purchase agreement with Namibia, needs to transport large equipment from South Africa to Namibia. There are also many instances of mining machinery being delivered to other parts of Africa from South Africa, he says.

"This means all of us benefit as the SADC countries," he says, referring to the new permit system that enables more efficient cross-border cargo transport. "We are not just developing these technologies for ourselves; we are developing our neighbouring countries at the same time."

In her recent keynote address at the launch of the World Bank Driving Inclusive Growth in South Africa report, South Africa's Transport Minister, Barbara Creecy, confirmed that the government is prioritising efficient logistics to support inclusive and sustainable economic growth.

"A healthy transport sector is the lifeblood of a vibrant economy," Creecy said, adding that South Africa has a competitive advantage as the logistics hub of the subcontinent.

She said current logistical inefficiencies increase road accident fatalities, freight transportation costs, the cost of doing business and ultimately the cost of living for the average citizen.

The CSIR is well placed to assist the government with finding solutions to these problems. Muronga says its experts previously provided guidelines to assist the government with developing standards for cargo loads, so this digital permit system for abnormal vehicles was the next step.

CSIR senior technologist and project manager at the CSIR, Lydia Kwange, says the system development was motivated by the vision of driving Africa's digital transformation. "This is a move from manual processes to a fully automated, cloud-based system, contributing to a connected Africa where digital solutions enhance efficiency in government services, logistics and trade," she says.

Nkuna adds that this kind of digital technology is already transforming industries. "The abnormal load system is a perfect example of how software engineering meets transport logistics to enhance efficiency, safety and compliance," he says.

"The challenge of digitising complex permit processes excites me, as it presents an opportunity to create a seamless, automated system that eliminates delays, prevents road damage and facilitates smoother cross-border travel," he says.

Muronga says the entire team is glad to see their work applied in the real world. "When you are out and see an abnormal vehicle on the road with an abnormal load, you know they are there because the CSIR system produced a payment system or a licence for them. So, whatever we are doing, is something that adds value and improves the quality of life for South Africans."

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The CSIR-hosted Circular Innovation South Africa (CISA) programme is funding a one-hectare demonstration and experimentation urban farm in Potsdam as one of eight DSTI Circular Economy Demonstration Fund grants. It will feature circular and regenerative technologies such as agrivoltaics (3), where solar panels generate electricity while protecting plants and animals from harsh sunlight or severe weather conditions. The farm will also use black soldier fly larvae (1) to assist in recycling organic waste and in generating animal feed, as well as vertical gardens and hydroponics, which are water-efficient and space-saving methods of growing food crops (2).





CAPE TOWN TURNS ABANDONED PLOT INTO URBAN FARM

esearchers and City of Cape Town officials are transforming an abandoned piece of land into a circular economy urban farm and learning hub. It will feature circular and regenerative technologies such as agrivoltaics, hydroponics, vertical gardens, a seedling nursery and zero-till agriculture, and it will test local, community-based solutions for organic waste treatment.

"We're funding the one-hectare demonstration and experimentation urban farm in Potsdam as one of eight Circular Economy Demonstration Fund grants," says Prof. Linda Godfrey, a sustainability and circular economy expert leading the CSIR-hosted Circular Innovation South Africa (CISA) programme.

CISA administers the Fund on behalf of the national Department of Science, Technology and Innovation (DSTI).

The Potsdam urban farm project is being implemented by Stellenbosch University, in partnership with the City of Cape Town's Urban Regeneration Department, and an urban sustainability network called ICLEI Africa. The farm will form part of the city's Potsdam Sustainability Campus, nestled inbetween its public transport interchange and waste facility.

"This project will demonstrate not only how the large volumes of organic waste produced within our cities can be managed, but also how to improve urban food security and regenerate open spaces in urban areas that are often misused, for example, for illegal dumping," says Godfrey.

The public will be able to visit the farm to explore and receive training on its sustainable urban farming technologies.

"Take zero-till agriculture, for instance – that's a regenerative form of agriculture where you don't plough the land. You only plant what you need, and you don't till or turn the soil, which maintains the soils integrity and health," she explains.

Agrivoltaics is another example, combining efficient land-use with renewable energy generation.

"Farmers can install solar panels and continue to use the land underneath for livestock grazing, aquaculture or shade crops," says Godfrey. Solar panel shade can reduce water evaporation and therefore irrigation requirements and it can protect both plants and animals from harsh sunlight or severe weather conditions.

Vertical gardens and hydroponics are also water-efficient and space-saving methods for growing food crops.

Godfrey says the farm site has been secured, the black soldier fly service provider has commenced the installation of a modular facility and two farmers and a site manager have been appointed to ensure implementation of the various circular technologies. Black soldier flies can assist in recycling organic waste and in generating animal feed.

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This project is supported by the Circular Economy Demonstration Fund, which is administered by the CSIR-hosted Circular Innovation South Africa programme on behalf of the Department of Science, Technology and Innovation. It addresses SDG 2, SDG 7, SDG 9, SDG 11, SDG 12, SDG 13 and SDG 17.





"We had a soft launch of the farm in November 2024, where City of Cape Town officials and researchers explored some of the technologies that will be installed on-site, including aspects of vertical faming, poultry farming, anaerobic digestion, hydroponics, fertiliser production, black soldier flies, worm farming and more," she says.

"The City of Cape Town has indicated that once this pilot is shown to be successful, there is the opportunity to replicate it in other open spaces within the city."

"The Circular Economy Demonstration Fund, the first of its kind in South Africa, brings our national system of innovation, including our universities and science councils, closer to the private sector," she says. "The aim is that these collaborative demonstration projects will help South Africa to de-risk and to scale circular interventions."

She explains that the CSIR, through CISA, gives effect to the government's circular economy, science, technology and innovation aspirations.

"It's the hosted programme's mandate to drive the strategic direction and investment in circular economy science, technology and innovation, and to play a facilitating and catalytic role within the national system of innovation, with the funding provided by the DSTI," says Godfrey.

Because CSIR scientists have a wealth of expertise in areas like sustainable building technologies, smart agriculture, waste repurposing and climate resilience, she says it is well-placed to identify deserving circular economy projects to fund and to act as project manager.

"The eight demonstration fund projects have been awarded to researchers at science councils, including the CSIR, and various South African universities. We make sure they deliver on the project, but they undertake the research," she says.

During 2024 and early 2025, CISA also launched the South African Circular Minerals and Metals, Circular Agriculture and Circular Manufacturing initiatives. "These three initiatives speak directly to the DSTI's White Paper and 10-year Decadal Plan to modernise mining, agriculture and manufacturing, and look at how these priority economic sectors interface with the circular economy."

Godfrey says the circular economy is a development opportunity for South Africa and Africa, and therefore these projects, including the Potsdam circular agriculture demonstration project, are ultimately about creating more sustainable, resilient and thriving cities.

"We are in desperate need of building our infrastructure as a continent for the future," she says. "We can either build that infrastructure the same way the global north has, which is highly resource intensive and unsustainable, or we can build it in a more regenerative, sustainable, low-carbon and circular way that meets the needs of all Africans, within planetary boundaries."

ENQUIRIES: >> Prof Linda Godfrey

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At a soft launch of the Potsdam circular economy urban farm and learning hub in November 2024, City of Cape Town officials and researchers explored some of the regenerative technologies that will be installed on-site. These include agrivoltaics, hydroponics, vertical gardens, a seedling nursery and zero-till agriculture and community-based solutions for organic waste treatment. From left, Alderman Eddie Andrews, Liezel Kruger-Fountain, Sue van der Linde and Joy Solomons.





























CAN WE TURN PRAWN SHELLS INTO FIREFIGHTER **GEAR?**

ithin the next three years, CSIR researchers want to close the recycling loop on chitinous waste by turning scraps from lobster, prawns and other shellfish into eco-friendly products.



Prof. Suprakas Sinha Ray is a CSIR chief researcher and the Director of the Centre for Nanostructures and Advanced Materials hosted by the CSIR and the Department of Science, Technology and Innovation. His team's circular economy research on chitin waste repurposing forms part of the national Waste RD&I Roadmap. It addresses SDG 12.

Green materials expert Prof. Suprakas Sinha Ray says one of the most promising applications for chitin derivatives is in fireproof fibres and plastics, which could be incorporated into firefighter gear and building materials.

Chitin is a hardy biological molecule that fortifies the exoskeletons of crustaceans and insects.

"South Africa's seafood industry processes tons of shellfish every year, producing mounds of chitinous waste that could be absorbed into our circular economy and repurposed," says Ray.

Through chemical engineering, chitin can be converted into chitosan, a polymer that can be woven into other common synthetic polymers, such as those used to produce fabrics or PVC pipes.

Ray says the chemical conversion of chitin to chitosan is wellestablished and that scientists already know about chitosan's fire deterrent properties: its unique structure can block oxygen and therefore combustion, and when it does burn, it turns into char, stopping fire in its tracks.

What the CSIR is working on now is what happens before and after the chemical conversion; how to extract chitin from shellfish waste and how to incorporate chitosan into useful products.

Dr Lucia Steenkamp's team at the CSIR's Industrial Biocatalysis Hub in Pretoria has developed a method to isolate chitin from waste collected at seafood production facilities. They have also optimised a commercial method of chitosan production using less chemicals, with less waste and ten-fold less water.

"We already have some samples produced from shellfish, using crustacean waste received from Mozambique," says Steenkamp. "We first made the chitin and then different chitosans. Langoustines, for example, yield a slightly different product than prawns, and the down-stream process yields different chitosans."

Over the next three years, the CSIR, in collaboration with other research institutes and industry, plans to develop chitosan-based products and seek approval for viable ones from the South African Bureau of Standards.

One of the products they are exploring is fire-retardant materials. Ray says they will test the market for fire-retardant products, but he is confident that sustainable alternatives to existing products are in demand.

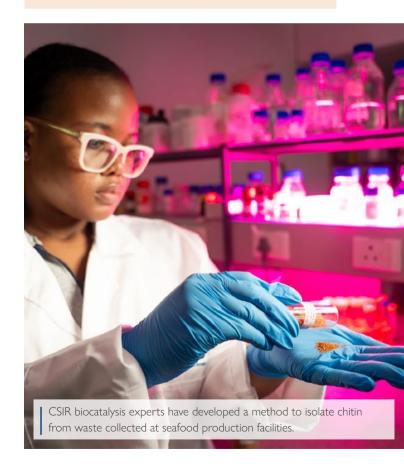
"In most countries, conventional chemicals used in fire retardants, like bromide, are banned," he says. "But our challenge here is that there is no alternative yet. So, our goal is to develop a local, high-value product that is produced cleanly from waste streams and does not harm human health or the environment."

While Ray describes chitosan-based fireproofing as a circular economy project that is still in its infancy, many other green materials developed by the CSIR, including an agricultural mulch film, antimicrobials and bio-packaging for foods, are already at advanced stages for commercialisation.

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SINGLE-USE BIOMEDICAL KITS AND APRONS THAT ARE COMPOSTABLE

he CSIR has developed single-use medical diagnostic kit cassettes and surgical aprons that are compostable. This innovation solves a major environmental pollution challenge: traditional cassettes and aprons, used daily in large quantities in the medical industry, are made from petroleum-based plastics that do not biodegrade.

The new cassettes and aprons are made of biopolymers and bio-based additives, and they comply with international biodegradation standards.

Dr Maya Mathew, an advanced polymer and composites scientist at the CSIR, says these products meet technical specifications and can be composted under industrial conditions. Tests conducted at the CSIR's biodegradation testing laboratory, the only such facility in Africa, found that the materials exhibit 90% biodegradation within 120 days in industrial composting conditions.

"Biodegradation can only be claimed if we outline the conditions and timeframes of biodegradation, which is determined by the type of material used for the formulation," she explains. According to the standards set by the American Society for Testing and Materials (ASTM) and the International Organization for Standardization (ISO), biodegradability can be claimed if 90% of a product's carbon is converted into carbon dioxide within six months for industrial composting conditions.

"Apart from these technical specifications, we have conducted industrial trials of our devices at two medical facilities in Cape



Town and another in Gqeberha. We also tested them with a medical device manufacturer that manufactured HIV and pregnancy lateral flow test kits using the CSIR-developed cassettes," she says. "The test outcome was positive in the sense that the composition of the cassettes did not have adverse effects on the test outcomes."

Mathew says hospitals, clinics and medical device manufacturers are the intended beneficiaries of this technology, due to the high production and usage rate of single-use medical diagnostic kits and surgical aprons.

"Within the biomedical sector, there are several singleuse products that are not recycled due to contamination with biomedical waste, and most of the products are made from petroleum-based plastics, which are non-biodegradable," she says. "These are discarded into landfills where they remain there and persist for more than 100 years."

She says the novel cassettes and aprons biodegrade to non-toxic residues like carbon dioxide and water.

The two products were developed using the CSIR's state-of-the-art processing and characterisation equipment. "Our pilot scale processing facility allows us to manufacture specimens at optimum processing conditions, so that the products have a balance of properties such as strength, toughness and flexibility," says Mathew.

"Our materials meet the technical requirements of the medical community, while addressing the challenges of sustainable sourcing, recyclability and compostability, and mass production using conventional industrial sites."

Mathew explains that biopolymers and biobased additives have a lower carbon footprint generally, so any material based on this technology will help increase resource efficiency, reduce the harmful impacts of littering, and help businesses meet market needs that are aligned to environmental legislations.

"Our work is focused on developing novel materials with added functional properties, but in the long run, the work that we do provides solutions to plastic pollution and climate change by reducing greenhouse gas emissions," she says.





A researcher demonstrates the test kit before (top) and after 60 days (above) of disintegration under controlled composting conditions, as per standards set by the American Society for Testing and Materials.



CSIR developed biopolymers and biobased additives pellets used to produce biodegradable test kit cassettes and surgical aprons, which are an environmentally friendly alternative to current petroleum-based plastics.





The Southern Ocean Carbon-Climate Observatory's ocean science human capital development and technological infrastructure development programmes are funded by the CSIR and the Department of Science, Technology and Innovation. This work addresses SDG4, SDG 5, SDG 9, SDG13 and SDG 14.







A NEW GENERATION OF OCEAN EXPERTS TO TACKLE CLIMATE CHANGE

ore than 80 ocean climate scientists, engineers and technicians are now skilled in advanced robotics, modelling, satellite remote sensing, ocean chemistry and more, thanks to over a decade of investment in Southern Ocean climate research by the CSIR and the Department of Science, Technology and Innovation (DSTI).

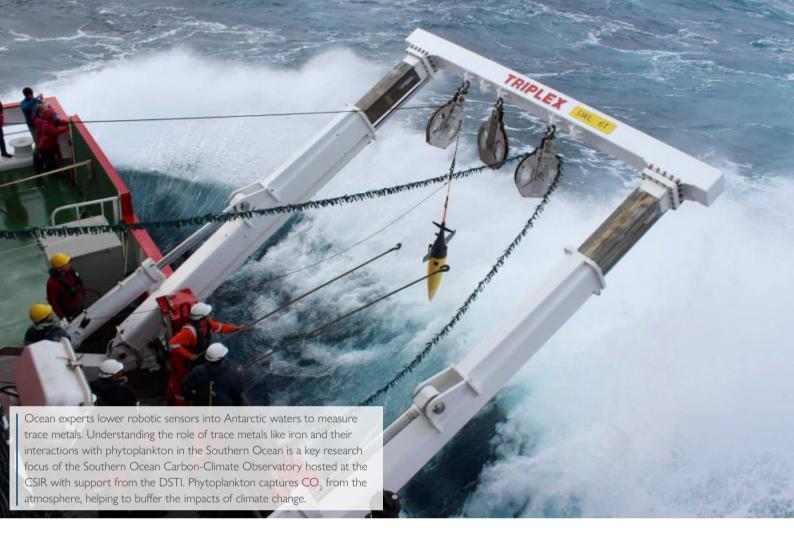
South Africa today boasts very mature capabilities to understand the Southern Ocean and how it impacts climate. "This understanding is implemented into Earth systems models, and with better Earth systems models, we can feed back into society by supporting policy and governance around adaptation and mitigation strategies," says Dr Sandy Thomalla. Thomalla, a career oceanographer, currently leads the Southern Ocean Carbon-Climate Observatory (SOCCO), which is hosted at the CSIR with support from the DSTI.

When SOCCO was first conceptualised in 2010 by her predecessor, Prof. Pedro Monteiro, South Africa had almost no ocean research infrastructure (although a new polar research vessel was on the horizon). It was also clear at the time that the country needed an ocean-climate research programme, and a new generation of ocean scientists would face what Thomalla calls the biggest challenge of the 21st century: climate change.

"The Southern Ocean takes up 50% of the ocean's carbon dioxide (CO₂) uptake and 75% of the heat that is being generated by the excess CO₂ that remains in our atmosphere. So, it is a disproportionately more important ocean when it comes to buffering the impacts of climate change," says Thomalla.

Since South Africa has the geographical advantage in terms of accessing the Southern Ocean for scientific observations via the polar research vessel, each SOCCO student has an opportunity

(continued overleaf)



to join expeditions and gain hands-on scientific experience in a suite of disciplines that span physical and biogeochemical oceanography, ocean robotics and sensor development. One of SOCCO's very first graduates was Dr Thato Mtshali, now a specialist scientist at the Department of Forestry, Fisheries and Environment.

Thomalla says Mtshali's journey is a prime example of how SOCCO equips experts to make tangible contributions to climate action and research worldwide, as he now applies his expertise in government and still collaborates with the CSIR.

"Within government, I am focusing mostly along the west coast, trying to understand the impact of climate change there," says Mtshali. "The outcomes we produce provide advice to the fisheries and the communities along the coast."

Mtshali helped develop SOCCO's capability to accurately sample, analyse and interpret trace metals in the ocean.

"Understanding the role of trace metals like iron and how they interact with phytoplankton in the Southern Ocean is a key component of SOCCO's research," says Thomalla. "It is very difficult to measure a trace metal on a metal ship, so Thato had a long learning curve with all of us on how to do the measurements accurately."

She explains that phytoplankton, which is at the base of the ocean food chain and thus critical for underwater life, captures CO₂ from the atmosphere during photosynthesis, just as trees on land do.

"Our work in trace metal chemistry and other areas has helped reduce the uncertainty of global CO_2 For example, SOCCO has developed a machine learning global CO_2 flux data product that is one of six global machine-learning models used to reconstruct global ocean CO_2 flux for the Global Carbon Budget," says Thomalla.

This research formed part of the most recent Intergovernmental Panel on Climate Change assessment report, the current global benchmark, which was published in 2023.

She says SOCCO's contribution to local and global climate action is built on human capital development. The people trained there, 50% men and 50% women, hail from all over South Africa.



A NEW GENERATION OF OCEAN EXPERTS TO TACKLE CLIMATE

More than 80 ocean climate scientists, engineers and technicians are now skilled in advanced robotics, modelling, satellite data, ocean chemistry and more, thanks to over a decade of investment into Southern Ocean climate research by the CSIR and the Department of Science, Technology and Innovation. "We now have these very mature capabilities in South Africa to understand the Southern Ocean and how it impacts climate," says Dr Sandy Thomalla, who leads the Southern Ocean Carbon-Climate Observatory (SOCCO), hosted at the CSIR. One of SOCCO's very first graduates was Dr Thato Mtshali, now a specialist scientist at the Department. His journey is a prime example of how SOCCO equips experts to make tangible contributions to climate action.

"They are not only focusing on the community that is close to the coast; they also go inland to previously disadvantaged universities like those in Limpopo and the Free State," says Mtshali.

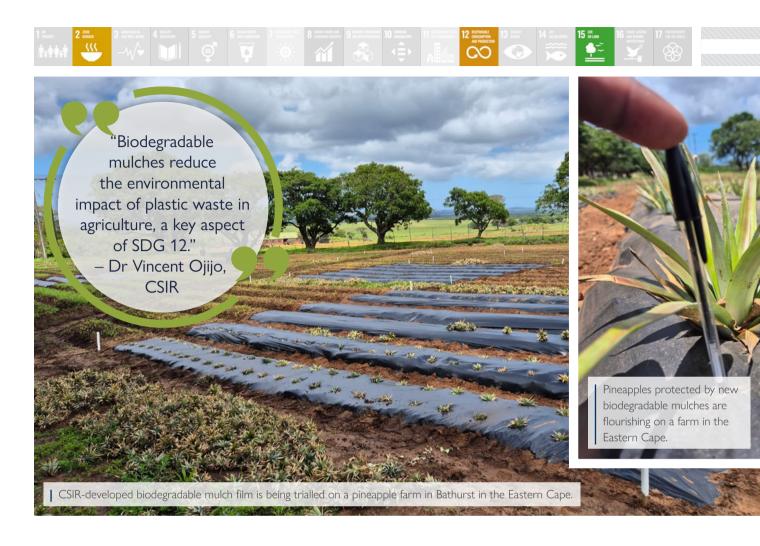
"I come from the Free State, you know, so I wasn't exposed to the ocean and SOCCO is one of the groups that can give you that opportunity to explore. There are a lot of opportunities in terms of internships and postgraduate studies, and the group also employs its own students," he says.

Thomalla says many SOCCO graduates are already applying their skills in robotics, chemistry, high-resolution modelling, machine learning, big data analysis and satellite observations towards South Africa's national STI decadal plan, to support

global climate research and response, as well as to further their own careers.

"When it comes to ocean science, you cannot mention it without including SOCCO," says Mtshali. "The skills that I got from SOCCO made me who I am today, and I can now apply all that knowledge anywhere in the ocean."





PINEAPPLES GROW FASTER UNDER CSIR BIO-MULCH COVER

which o

ineapple farmers in the Eastern Cape are trialing a new biodegradable mulch film developed by the CSIR, which can be used as an alternative to conventional plastic soil covers.

Early results from both trials in Ghana and the Eastern Cape, representing two different climatic zones, suggest that the mulches improve the growth rate of pineapples, potentially leading to early harvest.

Dr Vincent Ojijo, a polymer expert at the CSIR, says the biodegradable mulch film is designed to fully decompose into carbon dioxide, water and biomass, so it does not pollute the environment like traditional plastic films.

These films are made of up to 40% locally sourced natural materials, which reduces costs compared to commercially biodegradable mulches. Farmers will be able to use the biodegradable film for short-term mulching of vegetable crops, as well as long-term mulching for crops like strawberries and pineapples.

"Different crops have distinct life cycles, requiring specific solutions," says Ojijo. Our biodegradable mulch films retain moisture, control weeds and enhance crop growth, just like

This agricultural innovation is co-funded by the CSIR, Department of Science, Technology and Innovatio and the Foreign Commonwealth Development Office of the United Kingdom. It addresses SDG 15, SDG 12 and SDG 2.





conventional plastic mulches. However, they offer the added benefit of fully breaking down without leaving microplastic residues."

The CSIR is conducting extensive field trials of the new mulch film in South Africa and Ghana. Earlier trials in Nigeria demonstrated higher tomato yields and superior weed control when compared to un-mulched fields. The current South African trials are supported by the Department of Science, Technology and Innovation (DSTI), focusing on pineapples and greenhouse vegetables.

"In our Eastern Cape pineapple trials, the difference is already clear," says Ojijo. "Within three months, the mulched plots exhibit significantly healthier crops compared to the un-mulched ones."

Ojijo says the agricultural sector is facing increasing pressure to adopt sustainable practices, especially from export-driven markets in Europe that demand environmentally friendly farming methods. Biodegradable mulch films offer a solution that aligns with these sustainability goals while reducing the costs associated with plastic waste disposal.

"The problem with conventional plastic mulches is their disposal," he says.

"Farmers often burn them, releasing harmful fumes into the atmosphere. Additionally, these plastics disintegrate into microplastics, degrading soil quality and contaminating water sources."

Despite the advantages, biodegradable mulch films currently cost two to three times more than conventional plastic mulches. However, Ojijo emphasises that conventional plastics carry hidden environmental costs that are not factored into their market price.

"Plastic pollution imposes severe economic and environmental costs. If policymakers recognise these externalities, regulatory measures such as differentiated levies that account for cost of externalities could help level the playing field," he says.

Researchers at the CSIR are now exploring ways to improve cost-effectiveness, including testing reuse models for short-term mulches in greenhouse farming. Collaboration with local plastic manufacturers is also underway to refine production processes and to scale up the technology.

While biodegradable mulch films show great promise, Ojijo says more research is needed to assess long-term soil health impacts. His team at the CSIR is also advocating for further studies on the environmental effects of burning plastic mulches and potential policy interventions to address this.

"We aim to provide farmers with practical, sustainable solutions," he says. "By promoting biodegradable alternatives and influencing policy, we can drive the transition towards more sustainable agriculture."

As the world moves towards greener farming practices, innovations like biodegradable mulch films represent a step in the right direction – one that benefits farmers and the environment.











This research was a collaboration with Delft University of Technology in the Netherlands, South Africa's Transnet National Port Authority and UNEP's Nairobi Convention Secretariat. It addresses SDG 3, SDG 8. SDG 9. SDG 11. SDG 13. SDG 14. SDG 15 and SDG 17.





GREEN SCORES FOR AFRICAN PORTS AND BLUE ECONOMIES

oastal scientists at the CSIR assisted the Port of Ngqura in South Africa and Port Victoria in the Seychelles in assessing their ports' sustainability performance using a new tool developed by the research team.

Susan Taljaard, a coastal water quality expert at the CSIR's Coastal Systems Earth Observation research group, explains that while international sustainability assessment tools exist, they are not locally relatable for application at the port level and are often too scientifically complex for port operators to use.

To address this challenge, the team developed a Port Sustainability Performance Index, which has the flexibility of being globally comparable, but locally relatable. The tool was piloted at the two ports as part of a UN Environment Programme (UNEP)-funded project focused on sustainable port development to stimulate a regional blue economy.

The index measures economic, social, environmental and governance sustainability in line with the United Nations' 17 Sustainable Development Goals. Following its successful application at the Port of Ngqura and Port Victoria, plans are in place to roll out the tool to all commercial ports in South Africa, as well as ports across the Western Indian Ocean region.

Steven Weerts, a coastal ecologist in the same research group, highlights the growing need for good environmental stewardship in ports, with increasing requirements for formal sustainability reporting.

He says that the overall score provided by the new tool is valuable for comparing performance across ports within the same country, or at the same port over time.

The CSIR has also demonstrated the index to the Port of Rotterdam and, more recently, to a smaller municipal port in the

Netherlands. "We are also in the initial phases of rolling it out in the wider Western Indian Ocean region," says Weerts.

Taljaard says that although sustainability performance assessments are not yet a legal requirement, ports are increasingly under pressure to demonstrate environmentally and socially responsible practices to secure their future 'licence to operate'.

"When we piloted the index at the Port of Ngqura, which is the head office of Transnet National Port Authority, it was inspiring to observe the buy-in from different departments and across management levels", she says. "We were pleasantly surprised by how quickly the engaged with the index because we made it accessible in a language they could understand."

She explains that other existing international tools are often difficult for port staff to interpret and apply, so the team worked hard to simplify and localise highly scientific concepts. "We didn't want to make it a more complex process and that's one of the main reasons we insisted the index be locally relatable," says Taljaard.

Ports can use a simple spreadsheet to populate the index with their own data to obtain port-specific performance scores. These scores could reflect, for example, how well ports manage waste, whether they account for cultural and heritage protection, and how satisfied their employees are.

Weerts says an incentive system based on sustainability scores could be considered. "There are examples of where such assessment tools are used to award and certify a port's sustainability status."

A good sustainability status could reward ports in several ways, including financial, operational and reputational benefits. "There are already tangible benefits in shipping companies prioritising ports with green initiatives, such as reduced emissions and efficient waste management," says Weerts.

Weerts says that the Port Sustainability Performance Index, together with the Port Sustainability Toolkit for the Western Indian Ocean developed by the research team, will ultimately serve the port sector that supports national and regional economies.

"Ultimately, the sustainability agenda is an economic agenda because it improves port efficiency and competitiveness," he says.

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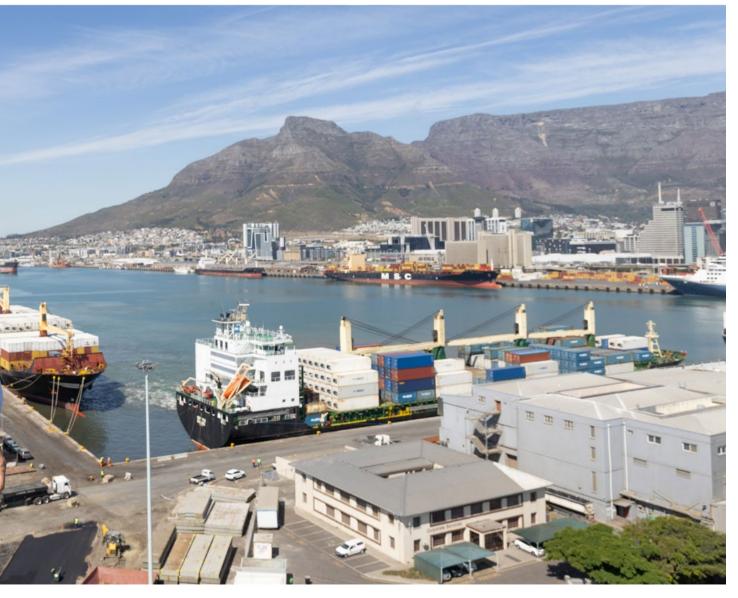
>> Dr Susan Taljaard staljaard@csir.co.za











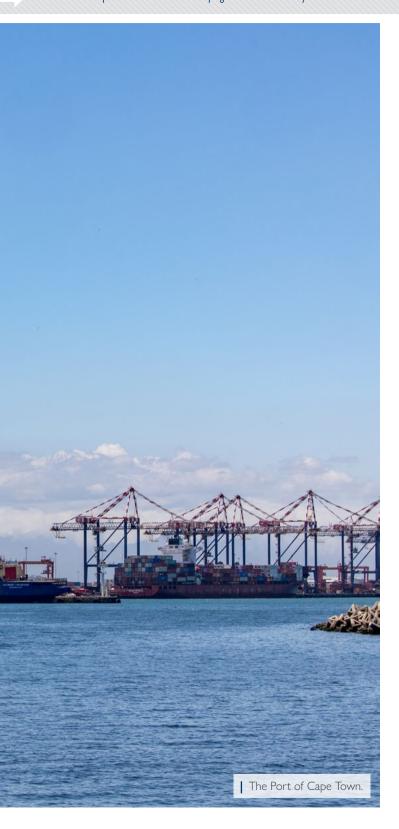


SCIENTISTS CALLED IN AS WIND DISRUPTS FRUIT EXPORTS IN CAPE TOWN

trong summer winds can disrupt shipping operations and cargo handling activities at Cape Town's port, causing delays in the shipping of containers destined for export markets. CSIR researchers are collecting data to help predict disruptive winds in the short and long term, and they are also studying the economic costs of disruptive harbour winds. The research outputs will enable exporters to plan better ahead of wind delays and will inform the Transnet National Port Authority on potential layout and structural changes that will divert disruptive winds.



This research forms part of the CSIR-hosted ACCESS programme and is funded by the National Research Foundation and the Belmont Forum. It addresses SDG9, SDG11 and SDG13.



At the peak of the fruit picking and packing season, it is normal for Cape Town's gusty summer southeaster to swirl over and around Table Mountain and Devil's Peak.

It is normal for that strong Cape Doctor wind to then blow down to the bay, focusing, as if through a lens, onto container ships and cranes moving in the port.

It is *not* normal, however, for the port to experience extreme winds that are more frequent and intense than before. "This is our concern, especially when demand for marine services in the port is increasing," says Dr Neville Sweijd, the director of the CSIR-hosted Alliance for Collaboration on Climate and Earth Systems Science (ACCESS) programme.

If these amplified harbour winds exceed about 80 kilometres per hour, port operations need to shut down to avoid safety risks from swinging containers and the potential collapse of cranes.

Sweijd says such wind disruptions are causing logistical headaches and financial losses for fruit exporters.

"Occasionally, fruit companies have to put their fruit on a truck and get it to Durban so that they can get it to their market on time," says Sweijd.

His team, along with other CSIR researchers and partners, is currently assessing the economic impacts of wind disruptions, and they are supporting the Transnet National Port Authority (TNPA) and its clients with short- and long-term wind predictions.

"We provide them essentially with weather parameters that inform their port operations," says CSIR engineer Vuyo Ndayi. He says the CSIR's wind anemometers and sensors provide wind speed, wind direction and wind gust data that allow for hourly and daily operational decision making.

"We need to get a good handle on understanding the wind, how it will trend going forward, and what measures we can actually then put in place to try to reduce the effects on port operations," says Magenthran Ruthenavelu, technical director at TNPA.

Ruthenavelu adds that the research will inform potential changes or additions to the port layout and structures to divert wind away from the operational area of the terminals.

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Zelde Kennedy, spokesperson for major fruit exporter Fruitways, says the data will also help exporters plan around anticipated wind delays. "It will definitely have an impact on our cost, and I think it will be better for the whole industry," she says.

Sweijd says extreme wind disruption of fruit exports is an example of how the negative impacts of climate variability and change manifest in day-to-day life.

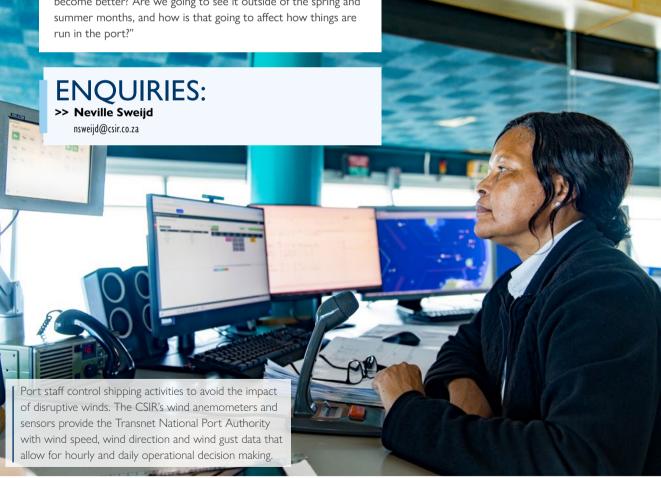
"Climate change is not some phenomenon of the future and it's not something that happens on average – it impacts people at the weather scale, not just at the long-term climate scale. It impacts them with extreme weather events, not as an average," he says.

"We're seeing a trend in the extreme events that are happening more frequently and that are happening with longer duration. They are more intense with bigger magnitude," says Sweijd.

For the windy Cape Town port, Ndayi says long-term predictions and climate modelling will try to answer the question of how the wind will change. "Is it going to become worse? Is it going to become better? Are we going to see it outside of the spring and summer months, and how is that going to affect how things are run in the port?"

The CSIR's wind anemometers and sensors provide the Transnet National Port Authority with wind speed, wind direction and wind gust data that allow for hourly and daily operational decision making. If harbour winds exceed about 80 kilometres per hour, port operations shut down to avoid safety risks from swinging containers and the potential collapse of cranes.







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HOW INVASIVE WATER PLANTS ARE STRESSING SOUTH AFRICA'S ESTUARIES

outh Africa's estuaries are home to a unique mix of plant and animal life and provide vital ecosystems services. However, a new study by CSIR researchers has revealed that some nuisance water plants are throwing these delicate ecosystems off balance – literally.





New research shows that invasive plants in South Africa's estuaries cause extreme swings in water pH from day to night, potentially creating stressful conditions for fish and other aquatic life

CSIR senior researcher Aadila Omarjee says that estuaries on South Africa's subtropical east coast are especially vulnerable to invasive water plants. Many of these estuaries naturally close off from the sea during dry seasons, leaving them more exposed to pollution-driven plant growth.

This pollution, often from agricultural and urban runoff as well as the lack or failure of sewerage systems, leads to eutrophication — a condition in which excess nutrients supercharge plant and algae growth. While plants may seem like a good thing, too much of the wrong kind can cause serious problems.

A CONTROLLED EXPERIMENT TO UNCOVER THE PROBLEM

To better understand how nuisance plants impact estuary health, Omarjee and her team conducted a controlled outdoor experiment at the CSIR in Durban, KwaZulu-Natal. They studied two problematic species: water lettuce (*Pistia stratiotes*), a floating invasive alien plant, and filamentous algae (*Rhizoclonium riparium*), a cosmopolitan species that reaches nuisance levels when it grows excessively. By simulating real estuary conditions, the researchers measured how these plants affected pH levels during the day (when photosynthesis happens) versus at night (when respiration takes place).

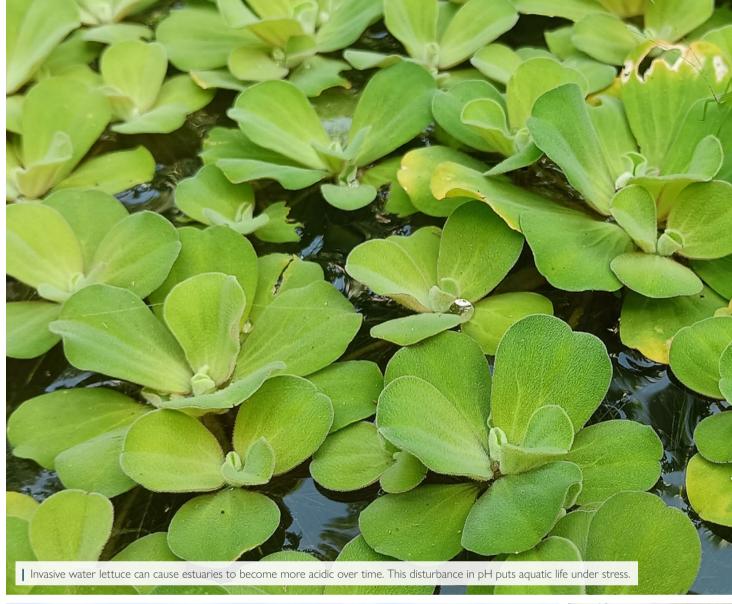
"We simulated natural estuarine conditions specifically to see how aquatic plants affect daytime and nighttime pH levels," says Omarjee. "Our question was: How does the pH of the water that the animals live in change on a daily basis?"

Omarjee's pH study forms part of the CSIR's extensive research on estuaries to assess their health, identify threats and develop strategies for sustainable management and restoration.

EXTREME PH SWINGS EQUAL STRESSED ESTUARIES

The results demonstrated how aquatic plants can absorb carbon dioxide and hydrogen carbonate from the water during daytime photosynthesis, thereby raising the pH (lowering acidity). At night, however, they release the carbon dioxide back into the water, lowering the pH again (increasing acidity).

(continued overleaf)











The submerged algae caused the biggest pH swings between day and night, while water lettuce made the estuary more acidic over time. This happens because submerged algae absorb carbon dioxide from the water during the day, raising the pH, and release it at night, making the water more acidic. In contrast, floating water lettuce releases its photosynthesis byproducts into the air. However, over time, water lettuce also contributes to increased acidity in the water.

"This balance between photosynthesis and respiration drives daily pH changes," explains Omarjee. While natural pH fluctuations in estuaries are normal and important for biological and chemical processes, she says an overload of nuisance plants due to eutrophication can push the limits leading to extreme day-night shifts in pH or long-term acidification. This, in turn, can increase the toxicity of metals to animals and plants living in the water.

Omarjee highlights that this study is the first to show how South Africa's estuaries — especially smaller, temporarily closed ones — are particularly vulnerable to these disruptions. Most previous research has focused on larger, permanently open estuaries in the northern hemisphere, which behave differently.

"South Africa's estuaries provide essential ecosystem services and support rich biodiversity, so understanding threats like eutrophication is critical," says Omarjee.

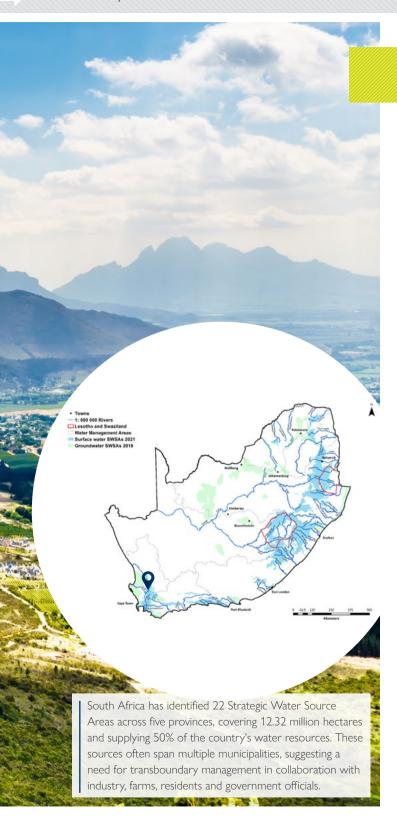
"Ultimately, the proliferation of nuisance water plants is linked to global environmental change, particularly pollution from agriculture, industry and urban development that dumps excessive nutrients into our water systems."

Omarjee's research underscores the need for better estuary management, pollution control and strategies to restore natural balance to these vital ecosystems.

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MUNICIPAL GUIDELINE FOR SUSTAINABLE WATER PLANNING

he CSIR, the Water Research Commission and two Western Cape municipalities have co-created a step-by-step guide, or framework, to help cities across South Africa manage their water resources in partnership with citizens, industry and neighbouring municipalities.

Dr Ilse Kotzee, an ecosystem services and geographic information system (GIS) expert at the CSIR, says the new Strategic Water Source Areas Framework draws on water-related opportunities and challenges identified in the City of Cape Town Metropolitan Municipality and the Witzenberg Local Municipality, as well as international best practice and spatial data resources.

"In the City of Cape Town, for instance, 36% of the land area is classified as protected. The rivers running through these conserved areas are usually pristine and clear, but as soon as they flow through urban developments and informal settlements, the water quality deteriorates significantly," she says.

"This is not just a phenomenon unique to South Africa. The issues and challenges observed are those typical of urban catchment river systems, where there is a decline in water quality due to pollution from stormwater, agricultural runoff and industrial discharge."

She explains that surface and groundwater quality and quantity are further impacted by development in wetland areas, the transformation of natural vegetation into hardened or paved surfaces and the spread of invasive alien vegetation. "Infrastructure and urban expansion also lead to increased erosion, sedimentation and the disruption of natural river flows, all of which pose significant challenges for municipalities, especially those that are under-resourced."

Since rivers traverse municipal boundaries and flow across farms and through cities, Kotzee says a key finding of the research

underpinning the framework is that greater cooperation is needed between municipalities, landowners, farmers and industries to align water priorities and pool resources.

The framework, published in May 2025, therefore guides municipalities towards improved governance and protection of Strategic Water Source Areas. The research outputs were designed to serve as a structure and user-friendly guideline for municipalities and to demonstrate practical ways of using spatial data and mapping.

"We want to encourage municipal officials, local stakeholders, Non-Governmental Organisations (NGOs), civil society organisations and officials in provincial and national government to use this framework as a basis for developing municipal strategies to protect and manage their water resources. Some of these strategies include restoring wetlands, regularly testing and monitoring water quality and diversifying water supply," says Kotzee.

She adds that the research team also found that although municipalities are mandated to manage water resources, they often lack access to dedicated GIS specialists, hydrologists or environmental planners that can integrate advanced mapping techniques into their management plans. They may also be unaware of spatial data resources that are already publicly available, such as the CSIR Green Book and the National Freshwater Ecosystem Priority Areas.

Kotzee says the research also suggests that environmental bylaws need stricter enforcement, that limited finances need to be strategically allocated to holistic water resource management within integrated development plans, and that more consistent data collection and monitoring of water quality and quantity, land-use impacts and ecosystem condition are needed.

Cities and districts can address many of their complex water challenges through low-cost, high-impact interventions like nature-based solutions, sustainable agricultural practices, green infrastructures and integrated water and land management.

For example, says Kotzee, instead of building culverts to channel floodwaters away from urban settlements, a municipality can restore wetlands and harness their natural ability to absorb and slow floodwaters.

"It costs much less and has a much higher impact because ecosystem services often have more than one benefit. If you restore a wetland, you're not only getting water purification — you get flood attenuation; people can use the reeds growing in the wetland for thatching, basketry and other crafts; and it serves as a recreational area," says Kotzee.





She explains that the framework will help capacitate municipalities facing financial, technical or human resource challenges so that they do not have to prioritise service delivery over environmental challenges, but rather tackle both holistically.

"As a collective we used the City of Cape Town and Witzenberg as case studies – we worked with them to identify their needs and to apply strategic planning to achieve their vision for the protection of Strategic Water Source Areas," says Kotzee.

Importantly, strategic planning looks not just at obstacles, but at existing opportunities. In Witzenberg, for instance, established partnerships between the municipality, businesses and NGOs such as the World Wide Fund for Nature South Africa (WWF-SA) could be further expanded, while ongoing water recycling and desalination initiatives in Cape Town could be further developed.

"Any local municipality can now use this structured framework and introductory guide to identify clear goals and strategies to ensure that everyone within its boundaries has a secure source of water, that ecosystem services are protected and that land is used sustainably," says Kotzee.

The research team hopes to refine and expand the Strategic Water Source Area Framework for different municipal contexts, such as rural or coastal, and to engage further with a range of stakeholders.

Researchers conducted in-person workshops with municipal officials from the City of Cape Town and Witzenberg. This ensured that the strategic water resource management guidelines were co-created and considered the unique water challenges and opportunities faced by decision-makers.







"We want to encourage municipal officials, local stakeholders, NGOs, civil society organisations and officials in provincial and national government to use this framework." - Ilse Kotzee, CSIR

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