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Partnering for world-class research, development and innovation

The CSIR mandate encourages the organisation to harness its multidisciplinary skills to foster industrial and scientific development, and to cooperate with entities in the public and private sectors in doing so. This edition of *ScienceScope* features a small selection of work done in partnership with others. In all CSIR focus areas – energy, health, industry, the natural and built environments, and defence and security – we work with state-owned entities, tertiary education institutions, local and international research and technology organisations, as well as the private and public sectors.

THE REASONS TO COLLABORATE are widely recognised in the scientific community – improved creativity, rapid learning through others, generating critical mass in specific fields, improved funding opportunities, as well as access to networks, knowledge and experts.

Arguably, the necessity to collaborate is even more important today than when the CSIR mandate was first formulated more than 70 years ago. With the rapid advances in technologies and the emergence of new specialist areas, it has become increasingly important to also collaborate across disciplines. The scenario of a researcher doing ground-breaking work in isolation has become almost unimaginable. Partnerships, collaborations, alliances and teamwork have become as necessary an ingredient in the formula for success as people, infrastructure and funding.

In the South African context, there are many compelling reasons to collaborate. With a modest percentage of gross domestic product (GDP) allocated to the science budget, South African researchers have to make the most of the national investment in scientific infrastructure. An example is high-performance computing capabilities, established through national funding, that are accessible to the wider research community and industry.

Innovation occurs at a rapid pace across the globe, with significant breakthroughs from around the world, notably from economically advanced countries who invest significant portions of their GDP into research and development (R&D). Collaboration with these countries provides an opportunity to access the knowledge and to adapt it to local problems.

The pooling of skills to address a common set of national priorities is now more important than ever before. The CSIR has prioritised partnerships with state-owned companies, noting the role they play in national economic development through industrialisation. In these cases, strategic partnerships that require a joint investment in infrastructure, human capital development and intellectual property, are being formed.

The collaboration between Transnet and the CSIR is such a partnership. Transnet now not only shares its strategic priorities with the CSIR, but has also located its R&D facilities at the CSIR in Pretoria and continues to invest in our hydraulics laboratory in Stellenbosch.

The CSIR and Eskom signed an agreement in May 2016 in which the organisations agree to synergise their research capabilities in support of Eskom's strategic and operational needs.

Another form of partnering that should be singled out, is that with tertiary education institutions. The CSIR remains committed to making a contribution to the development of human capital development in science, engineering and technology.

Ultimately, the CSIR's ability to draw from and contribute to the collective abilities of Team Science South Africa will help determine whether or not we succeed in addressing today's complex research challenges and meet our mandate to improve the quality of life of all South Africans and the region.

Dr Sibusiso Sibisi,
CSIR CEO

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Dr Thokozani Kanyerere of the University of the Western Cape, Dr Sumaya Israel of the CSIR and Nicolette Vermaak of the Department of Water and Sanitation in the Western Cape undertaking a routine monitoring of an aquifer.

COLLABORATING FOR A BETTER UNDERSTANDING OF COASTAL AQUIFERS

By Reyhana Mahomed

Experts from three organisations in the Western Cape are collaborating to improve the knowledge and understanding of coastal aquifers – underground natural freshwater reservoirs – in the province.

EFFORTS TO ESTABLISH a coastal groundwater centre of excellence in the Western Cape have been boosted through collaboration between the CSIR, the University of the Western Cape and the Department of Water and Sanitation in the Western Cape (DWS). This collaboration will bring about an enhanced understanding of groundwater resources in the Western Cape.

Until recently, investigations of three aquifers in the Western Cape, namely the Cape Flats Aquifer, Atlantis Aquifer and Langebaan Road Aquifer, have been conducted independently by the three organisations. To improve data collection and collation and to share knowledge on the aquifers, the organisations agreed to combine their hydrogeological expertise and establish a coastal groundwater centre of excellence.

"The links between these organisations also make it possible to expand the routine monitoring networks across the Cape Flats Aquifer area, and enable the supervision of students who require the experience and learning from researchers in the field," says Dr Sumaya Israel, CSIR hydrogeologist.

Alternative water sources

Considering the country's current water availability challenges, the City of Cape Town is looking for alternative sources of water for the city.

"Understanding the groundwater systems in terms of quality, availability and required infrastructure to enable use, is of utmost importance," explains Israel.

Accordingly, the project team will conduct a full hydrocensus in the Langebaan Road Aquifer area and study the groundwater recharge of the Cape Flats Aquifer and Atlantis Aquifer.

"The coastal aquifer in the Cape Flats is a possible water source that may in future provide water to areas in the Western Cape. However, the aquifer is vulnerable to pollution, which is why we need to monitor water levels and quality on a regular basis," says DWS geohydrologist, Nicolette Vermaak, who oversees data collection and storage.

Vermaak says the shallow and sandy nature of the aquifer makes it more vulnerable to pollution, for example by sewage, pesticides and hydrocarbons such as petrol and oil, than a deeper or secondary aquifer. Pollution also originates from cemeteries and landfills in the area.

Israel says, "The partners now work together to formulate joint funding proposals. Strengthening the knowledge of these coastal aquifer systems will inform decision-makers on the availability of alternate water resources of good quality."

Way forward

The new collective approach to funding could unlock new opportunities and research that will benefit water-sensitive urban design, sound water resource planning and options for dwindling surface water supplies in areas along the coast.

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FAST FACT

What is an aquifer?

An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand or silt) from which groundwater can be extracted using a water well. The study of water flow in aquifers and the characterisation of aquifers is called hydrogeology.

CSIR researchers are comparing how much more water high-yielding apple orchards require compared to lower yielding orchards measured in previous studies.

Water use by smaller trees is measured using Granier Probes.

Despite a higher crop load, scientists found that the leaves account for most of the transpiration.

Water use by larger trees are measured using the heat-ration method of the heat-pulse velocity sap flow technique.

Combining efforts to investigate how much water Cape apple orchards use

CSIR scientists partnered with peers in other research organisations and tertiary institutions to refine estimates and reduce uncertainties in estimating the water requirements of apple orchards in the Western Cape.

THE EXPERTISE OF HORTICULTURALISTS, soil and irrigation scientists, hydrologists, eco-physiologists and remote sensing specialists was called upon to refine estimates of the water requirements of high-yielding apple trees in the Western Cape.

The study was commissioned and funded by the Water Research Commission (WRC), the South African Apple and Pear Producers' Association through HortGro Science, and Parliamentary Grant funding to the CSIR and the Agricultural Research Council. The universities of Pretoria and Stellenbosch also form part of this partnership, which enables all aspects of water management and fruit production practices to be comprehensively addressed in estimating the water use of these apple orchards.

"Previous studies on tree water use quantified the water requirements of apple orchards, but these were not exceptionally high-yielding orchards. In this study we are looking at a broad range of methods, drawn from the various partner organisations, to refine estimates of water use and to reduce uncertainties in the estimates of the water requirements of apple orchards," says Dr Sebinasi Dzikiti, an agro-meteorologist and project leader from the CSIR.

For many years, apple orchards bearing between 60 to 80 tonnes of fruit per hectare per season (ha/season) were considered to be economically viable. "But yields of up to 120 tonnes/ha/season, are now the norm," explains Dzikiti. This raises alarm bells regarding the sustainability of these production practices given the increasing pressure on the availability of irrigation water in South Africa.

The first part of the study, entitled *Quantifying water use by high performing commercial apple orchards in the winter rainfall areas of South Africa* was done in two full-bearing orchards planted to the 'Cripps' Pink' and 'Golden Delicious' cultivars; and two non-bearing orchards planted to the 'Golden Delicious' and 'RosyGlo' cultivars in the Koue Bokkeveld region of the Western Cape.

The apple industry plays an important role in contributing towards the South African agriculture sector, says Dr Sylvester Mpandeli of the WRC. "This sector needs to be supported by technical information and other means. We are happy with the deliverables submitted so far as well as the knowledge generated through the study."

Measuring water use

The first phase of the four-year study showed that trees with larger canopy sizes tend to use more water regardless of crop load. According to Dzikiti, these preliminary results fail to show a clear relationship between crop load and transpiration. The project team measured water use on five different trees of varying stem sizes in each of the full-bearing orchards using the heat-ratio method of the heat-pulse velocity sap flow technique. Water use by the smaller trees was measured using Granier Probes. Additional data included the orchard microclimate, irrigation volumes, and tree and orchard leaf area indices. Soil water content was measured using up to 30 soil moisture probes in the root zone of a single tree in the two 'Golden Delicious' orchards to ensure an accurate soil water balance assessment.

"The purpose of the first phase was to determine how much more water the high-yielding orchards require, compared to lower yielding orchards measured in previous studies," explains Dzikiti. "The canopy size was found to be a strong factor influencing tree water use in this study. You may have a high crop load, but the leaves do most of the transpiration."

Managing the size of the transpiring leaf area is thus critical in optimising water use; therefore the project team will follow up on this observation to gain improved insights on how high crop load influences tree water use.

"This will be done through a targeted study which will directly monitor the amount of fruit on a tree and the amount of water transpired by that tree, while at the same time taking into account the different canopy sizes," says Dzikiti.

The next phase of the project is being conducted in similar orchards in the Vyeboom and Villiersdorp growing regions of the Western Cape.

Tree water requirements data generated in this study will be used for irrigation system design, irrigation scheduling (deciding when to irrigate and with how much water), and for water allocation and licensing purposes.

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The CSIR and various partner organisations are refining estimates of the water requirements of high-yielding apple orchards in the Western Cape.

CSIR PARTNERS WITH DEPARTMENT OF WATER AND SANITATION TO DETERMINE WATER REQUIREMENTS OF KZN FARMERS

The CSIR has partnered with the Department of Water and Sanitation (DWS) to determine how much water is being used by farmers in KwaZulu-Natal (KZN) and how much they require for irrigation, commercial forestry and other activities. This is necessary in light of past and current water challenges, exacerbated by a projected increase in temperatures over Africa that is threatening agricultural activities.

COMBINING THE REMOTE SENSING, hydrology and agricultural meteorology expertise of the CSIR and the water resource management capabilities of the DWS, the partners will produce a series of maps detailing water use by farmers in KZN.

"The aim of this partnership is to establish how much water is being used for irrigation in commercial farms in the province, given that agriculture uses more than 60% of the country's water resources. The information will be used by the DWS to update the Water Use Authorisation Registration Management System," says CSIR agricultural meteorologist, Dr Sebinasi Dzikiti.

The *Validation and Verification of Lawful Water Uses for KZN* project commenced in 2012, with an initial focus on validation as a precursor to the process of water use verification.

Dr Evison Kapangaziwiri, CSIR hydrologist and team leader of the hydrology component of the project, says validation involved the CSIR generating a database of crop types and their water requirements on each identified property before requesting users to submit further information to validate the data. Information required included types of crops or forest land uses on each property, the extent of each land-use type, total irrigated area for each crop type, whether users have reservoirs and the amount of water currently being used.

Dr Abel Ramoelo, CSIR researcher and team leader of the remote sensing component, says the team used earth observation technologies to determine the extent and types of crops and plantations as well as reservoir areas for the current and historical periods.

Agricultural activities, such as those undertaken on this farm in Underberg in KwaZulu-Natal, consume more than 60% of the country's water. The CSIR and the Department of Water and Sanitation are investigating how much water KwaZulu-Natal farmers require.

Stakeholder engagement sessions were held to verify information collected on the water use of KwaZulu-Natal farmers.

CSIR hydrologists and remote sensing specialists engage with two farmers on the crops they grow and the reservoirs located on their land.

Kapangaziwiri says, "The data tells us what crops the users have. Then, with the expertise of our hydrologists, we are able to determine how much water that crop requires. We are also able to estimate the capacity of reservoirs on farms using remote sensing data."

In 2015, the project team commenced with the verification of information collected in the province. CSIR project manager, Mark Naidoo explains: "The verification component involved hosting three stakeholder sessions in the province. We invited users to assist us in verifying the information collected through the validation component."

The first set of stakeholder engagement sessions were held within the boundaries of the Mgeni River Catchment, providing all users an opportunity to interact with the DWS. "This is an important exercise for the department, and will help us understand irrigation water requirements and stream flow reduction activities through forestry," says DWS Acting CEO: Proto-Catchment Management Agency, Jay Reddy.

"This is a big project and the DWS has been instrumental in facilitating interaction with users," says CSIR catchment hydrologist, Dr Jean-Marc Mwenge Kahinda.

"During the stakeholder engagement sessions, CSIR and DWS experts responded to technical queries from water users in the respective project areas. If the farmers have any disputes with what we retrieved from the remote sensing data, our researchers were readily available to address those issues."

Naidoo says that the next step is to host public consultation meetings and roll out further stakeholder engagements for the rest of KwaZulu-Natal. This will aid in the production of a series of maps detailing water use by farmers in the province.

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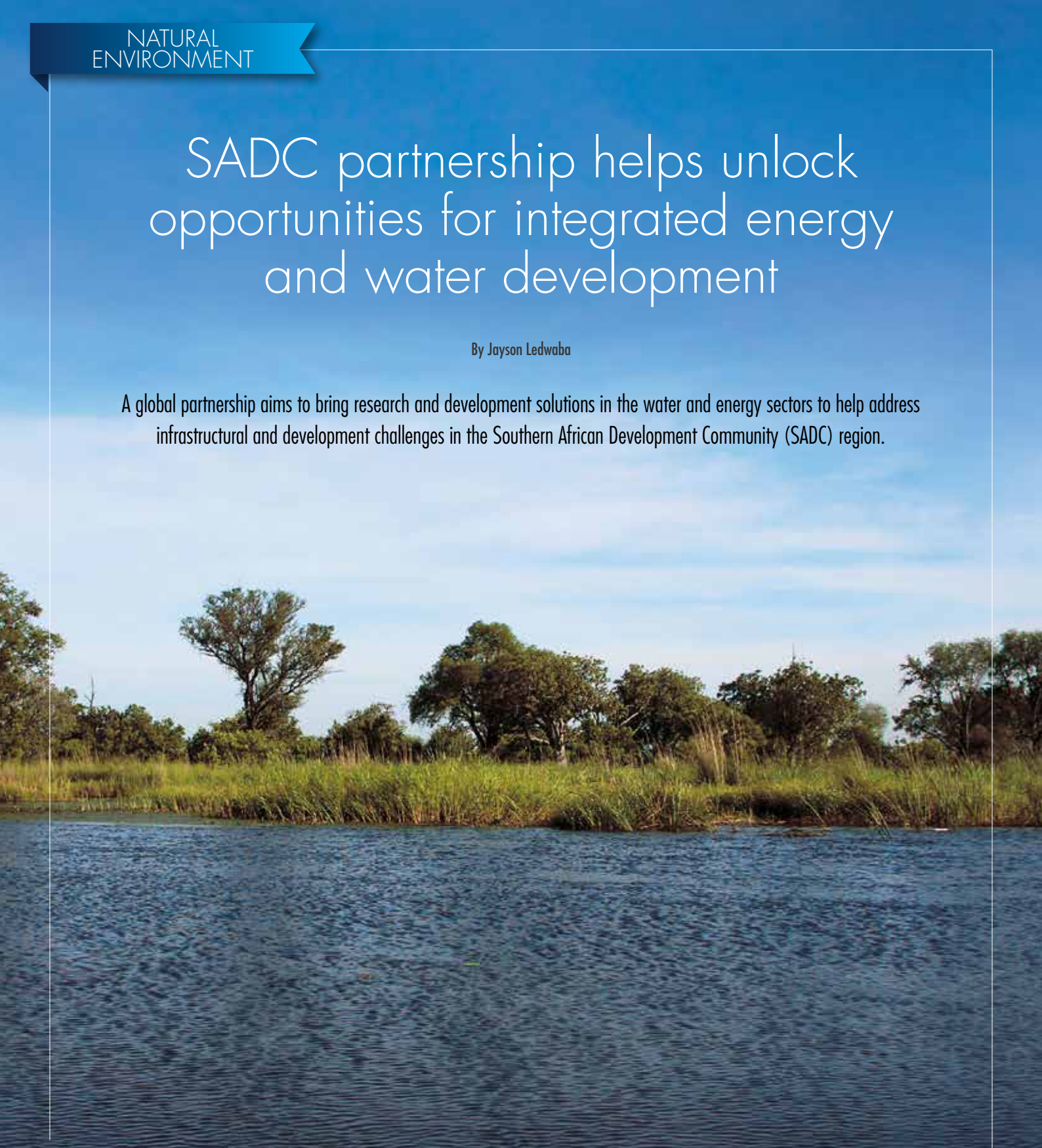
SADC partnership helps unlock opportunities for integrated energy and water development

By Jayson Ledwaba

A global partnership aims to bring research and development solutions in the water and energy sectors to help address infrastructural and development challenges in the Southern African Development Community (SADC) region.



The SADC region has potential for hydropower, despite physical and economic water scarcity. The Okavango Delta in the north of Botswana is created through seasonal flooding.

REGIONAL COOPERATION and integration in water and energy planning and development are essential to unlocking the potential for economic development in southern Africa. The SADC region needs to invest in water and energy infrastructure at the appropriate scale to develop economically and provide better livelihoods to enhance the quality of life of its citizens.

The CSIR, the Stockholm Environment Institute (SEI), the South African Institute of International Affairs (SAIIA), the Global Water Partnership Southern Africa and the Stockholm International Water Institute (SIWI) aim to provide scientific evidence to enhance regional cooperation and integration in water and energy planning and development.

CSIR research group leader, Dr Marius Claassen, says, "Development aspirations in SADC countries are high, with an ambitious agenda of industrialisation as a means to build robust economic growth to improve livelihoods. Access to water and energy is critical to achieve this agenda and to alleviate poverty. Coal is the primary source of fuel for power-generation in SADC, but the region has potential for hydropower, as well as solar and wind-generated power. The region experiences physical and economic water scarcity. Much of the region's water resources are transboundary, originating from non-SADC regions. Climate change is making matters worse."

"Water and energy have become limited resources in the region. The CSIR's strength in this project lies in climate and adaptation experience, as well as strategy development, in addition to the core research in water resources management," says Claassen.

Dr Jakob Granit, Centre Director at SEI says, "The project partners are generating solid evidence and facts on climate change, ecosystem functions, water resources and regional institutions. Together, this multidisciplinary research approach sets the scene for work that will contribute to a policy agenda that will enhance cooperation in SADC."

Anton Earle, SIWI Director: Africa Regional Centre, says, "SIWI's role is to better understand the multiple connections that add up to regional integration. These go beyond the formal state-to-state interactions and include the private sector, civil society and the media – all making a contribution to regional water and energy management. By better understanding who these actors are and what role they can play, the governance of regional water and energy resources can be improved and it will bring development to the region."

Dr Agathe Maupin, researcher at SAIIA, says, "This project is of particular interest to us as it speaks to the development and implementation of inter-sectorial policies for water and energy resources."

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> Much of the region's water resources are transboundary, originating from non-SADC regions.
>
> Dr Marius Claassen, CSIR

Collaborative research to aid decision-making on the use and protection of sandy rivers

By Arno de Klerk

The CSIR has partnered with Argentina's National Institute of Limnology (INALI), combining the two countries' expertise in water quality monitoring to deliver better water quality to communities. The collaboration will result in the development of new tools to evaluate the impact of certain types of human-induced pollution on the Berg River in South Africa and the Paraná River in Argentina, which both deliver water to a number of communities.

RESEARCHERS IN SOUTH AFRICA and their counterparts in Argentina are studying the links between human-induced pollution, the interaction of river streams and landscapes, and specific groups of organisms in sandy rivers.

The research will fill the gap of knowledge pertaining to sandy bedforms like bars and dunes and their relationship to macroinvertebrates and human-induced pollution in both countries. Macroinvertebrates are organisms that lack a spine and are large enough to be seen by the naked eye, and they are useful indicators of the health of water bodies. Specifically, a macroinvertebrate index will be compiled for sandy bottom rivers, based on the information gained from the two rivers.

Christoff Truter, an aquatic scientist from the Stellenbosch University, and a member of the CSIR project team, says it is important to understand the potential impact of land-use activities adjacent to these rivers in terms of chemicals that could affect the organisms in a number of ways. "Thus, these bedforms provide strategic locations to investigate different types of pollution and to determine its risk in terms of environmental toxicity."

The Berg River

The Berg River catchment covers an area of almost 9 000 km^2 in the Western Cape province. The river runs in a northern direction for some 285 km and a big part of the catchment is relatively flat. Ultimately, the Berg River discharges into the Atlantic Ocean. The main source of pollution in the Berg River comes from informal settlements located in close proximity to the river and from raw sewage originating from sewage treatment works that often end up in the river. Due to the fact that the upper and middle river catchments support intensive agricultural activities, which in turn also have the potential to cause pollution, the ecological integrity of this river is of extreme importance.

The Paraná River

Argentina's middle Paraná River is the sixth longest river in the world. It is surrounded by agricultural activities as well as densely populated urban areas. The study area is in a floodplain area and as such, is a massive suptropical wetland system, explains Arno de Klerk, CSIR aquatic scientist. The Paraná River has a drainage area of more than 2.5 million km^2 and has an average discharge of approximately 17 000 m^3 water per second. Understanding the hydrology of the middle Paraná floodplain system, especially flood pulses, is crucial.

"Although the two river systems differ dramatically in terms of size, the ecosystem processes occurring within these systems are similar," says De Klerk.

The Berg River under the microscope

In the Berg River, longitudinal patterns in invertebrate assemblages are primarily the result of the geomorphology of the different reaches, which reflect the morphology, sediment and hydrological regime, as well as water quality changes along the length of the river. The total irrigated area under control of the Berg River Main Irrigation Board is approximately 23 000 ha. Therefore, it has a large associated agricultural export market estimated at around R950 million. Due to the poor water quality in the Berg River and stringent water quality regulations imposed by the European Union, many farmers

Expected outcomes

The aim of the study is to develop a novel molecular marker technique aimed at speeding up the process of identifying specific organisms that live on or in the bottom of water bodies (called benthic fauna) through the use of specific genetic markers, says De Klerk. These tools will aid in making informed decisions regarding the state, use and protection of sandy rivers. The ultimate goal is that these tools be rolled out nationally through specific case studies in other parts of South Africa.

opt to treat the water themselves prior to use. In addition, the upper Berg River supplies most of Cape Town and its suburbs with fresh water. Nutrient enrichment is one of the major problems associated with the Berg River, as increasing evidence has highlighted its sensitive trophic status. An important source of nutrients is an increase in urban runoff, overloaded and/or dysfunctional municipal wastewater treatment plants and informal human settlements with none to limited sewerage infrastructure.

"The lack of proper monitoring techniques for sandy rivers such as the Berg River makes the monitoring and management of such rivers extremely difficult. Especially in the lowland part of the river, changes in flow result in a high diversity of sandy biotopes. Current monitoring techniques such as the South African Scoring System (SASS) are unable to properly deal with such sandy rivers. The predicted narrowing of the active channel in summer also tends to result in a reduction in the extent of marginal biotopes such as slack waters and backwaters. This makes monitoring more difficult, especially when using the SASS methodology," says De Klerk.

The Paraná River under the microscope

"It is critical to understand the different linkages in the complex system of the Paraná River to determine the ecosystem services it provides," explains De Klerk, "especially its role in mitigating pollution."

In 2015, South African scientists visited sites in the Paraná River under the guidance of Dr Martin Blettler, INALI biological scientist and Prof Mario Amsler, INALI water resources engineer. Amsler is also associated with the Faculty of Engineering and Water Sciences of the National University of the Littoral and a key member of the collaborative research project. Amsler is devoted to research on the mechanics of sediment transportation in rivers.

"Historically, pollution is not regarded as a problem in the Paraná River, mainly as a result of its size, but we were able to start exchanging knowledge with our Argentinian counterparts about the risk of pollution to humans and wildlife," says Truter.

Dr Paul Oberholster, CSIR chief researcher, says the results of the analyses from the samples collected in the middle Paraná River will be of great value to the Argentinians in informing assumptions made about pollutant levels in the river."

"This project will provide information from different environments and at different scales, which will aid in predicting the impact of pollutants in sandy rivers," says De Klerk.

The results of the first leg of the study have already helped water resource managers in the Western Cape province to improve their monitoring programme by incorporating the developed tools into their monitoring exercises. "To be able to make informed decisions and develop suitable tools to improve water management in both South Africa and Argentina, we need to properly study the different variables in these ecosystems, and base the development of methods for solving the problems identified on the use of morphodynamic, hydraulic, biological and chemical data," Oberholster says.

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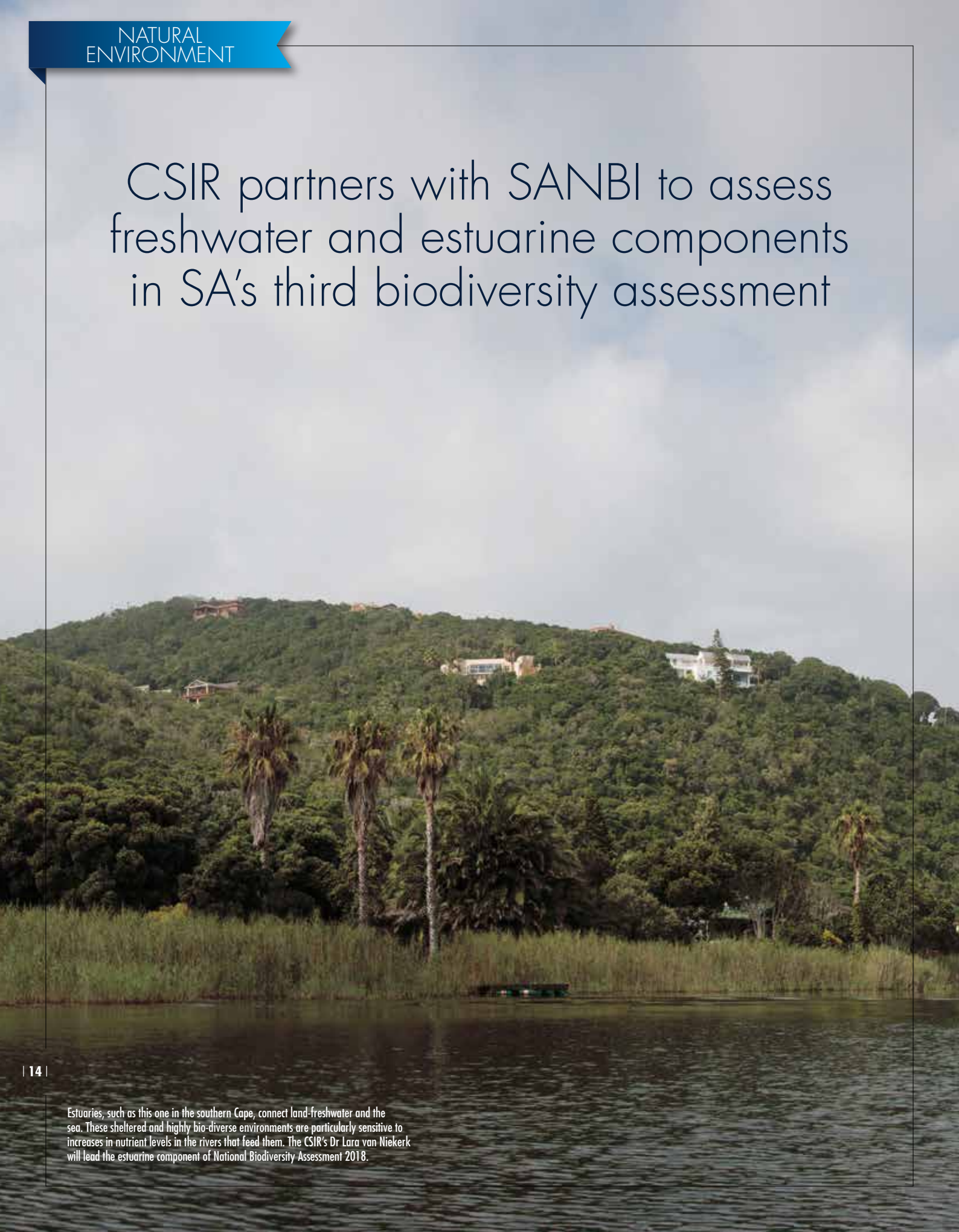
Getting wet at one of the study sites in the Berg River are, from left, Arno de Klerk of the CSIR, Christoff Truter of Stellenbosch University, Dr Paul Oberholster of the CSIR and Prof Mario Amsler of Argentina's National Institute of Limnology.

CSIR partners with SANBI to assess freshwater and estuarine components in SA's third biodiversity assessment



Estuaries, such as this one in the southern Cape, connect land-freshwater and the sea. These sheltered and highly bio-diverse environments are particularly sensitive to increases in nutrient levels in the rivers that feed them. The CSIR's Dr Lara van Niekerk will lead the estuarine component of National Biodiversity Assessment 2018.

THE CSIR IS COLLABORATING with the South African National Biodiversity Institute (SANBI) on the country's next National Biodiversity Assessment 2018 (NBA 2018).

The CSIR and SANBI have a history of working together and had collaborated on the first two national biodiversity assessments for South Africa, the National Spatial Biodiversity Assessment of 2004 and the NBA of 2011, as well as the 2011 National Freshwater Ecosystem Priority Areas.

The purpose of a national biodiversity assessment is to assess the state of South Africa's biodiversity, based on best available science, with a view to understanding trends over time and informing policy and decision-making across a range of sectors. In NBA 2018, the CSIR will lead two main ecosystem components: Dr Heidi van Deventer will lead the freshwater component and Dr Lara van Niekerk will lead the estuarine component, while SANBI will lead the terrestrial and marine components.

Collaborating for biodiversity: (From left, back) Andrew Skowno, SANBI; Dr Heidi van Deventer, CSIR; Tsamaelo Malebu, SANBI; Smiso Bhengu, SANBI; Heather Terrapon, SANBI; Namhla Mbona, SANBI. (From left, front) Dr Jeanne Nel, CSIR; Mandy Driver, SANBI; Maphale Matlala, SANBI; Anisha Dayaram, SANBI; Fahiema Daniels, SANBI and Dr Sebataolo Rahlao, SANBI.

The freshwater component will consist of a wetland sub-component, led by Van Deventer and a river sub-component, led by the CSIR's Lindie Smith-Adao. NBA 2018 will also expand on themes related to indigenous species, genetic diversity of species, pressures, including climate change and invasive species, as well as benefits.

The NBA is a policy tool that provides a platform for synthesising existing information on South Africa's biodiversity, publishing new scientific findings and binding results to policy and managerial responses in government. It also provides an opportunity for setting the scene for biodiversity research for the next five to seven years to address oversights in future assessments.

NBA 2018 is led by SANBI's National Biodiversity Assessment Lead, Andrew Skowno.

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FAST FACT

The National Biodiversity Assessment…

…deals with all three components of biodiversity: genes, species and ecosystems.

…assesses biodiversity and ecosystems across terrestrial, freshwater, estuarine and marine environments.

A global collaborative effort to integrate ecological infrastructure into national planning

Scientists from South Africa, Vietnam, Chile, and Trinidad and Tobago combined their expertise in a global collaborative effort to enhance the integration of ecological infrastructure and ecosystem services into development planning and policy.

THE GLOBAL PROECOSERV programme looked at how mainstream biodiversity and ecosystem services can best be integrated into multi-sectoral planning processes across scales.

The South African component of the project was structured as a partnership between the South African National Biodiversity Institute (SANBI) and the CSIR, with the Department of Environmental Affairs chairing the project steering committee.

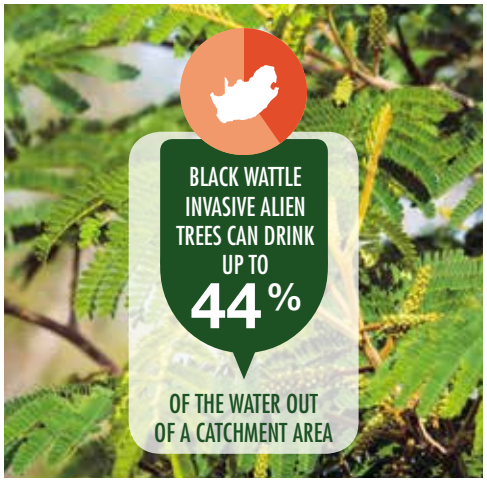
The programme was funded by the Global Environment Facility and United Nations Environment Programme (UNEP).

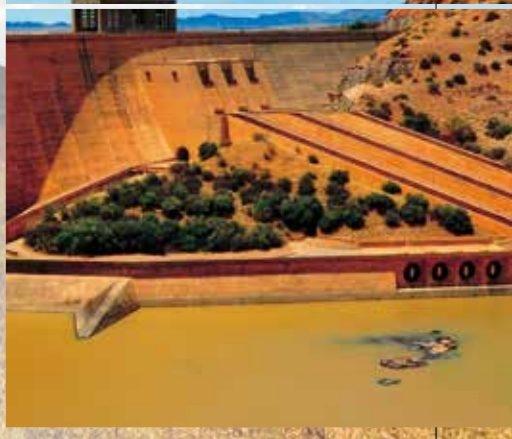
"ProEcoServ looked at how we can integrate mainstream biodiversity and ecosystem services into multi-sectoral planning processes across scales," says Dr Nadia Sitas, CSIR senior researcher for the South African component of ProEcoServ.

"In South Africa we engaged with a variety of role-players involved in ecosystem governance — from local to national scales, and including the public and private sector — to highlight the importance of ecological infrastructure for South Africa's development," Sitas says.

The programme involved partners from sectors such as agriculture, urban development, water management, insurance and mining during its four-year period. Sitas says the programme focused on integrating ecosystem-based solutions for disaster risk reduction at a local level; integrated water resource planning at a catchment level; and identifying key policy intervention points at a national level through targeted mainstreaming strategies.

As part of the project, scientists and policy makers in South Africa worked together to ensure that ecosystem services were embedded in national policy. In the October 2015 edition of *Time Magazine,* Achim Steiner,





Executive Director of UNEP was quoted as saying that through ProEcoServ, UNEP identified almost $1 billion worth of ecosystem benefits in only four test countries. “In South Africa, a map of strategic water source areas indicated they make up only 8% of the land area, but provide a staggering 50% of the water, collectively contributing to over half the national economy,” he said. This statement is based on the work by CSIR principal scientist Dr Jeanne Nel.

ProEcoServ-SA engaged with key decision-makers and facilitated the inclusion of ecosystem services concepts in the National Development Plan, the National Water Resource Strategy, the Disaster Management Act, and the Norms and Standards for Biodiversity Management Plans for Ecosystems.

The concept of ecological infrastructure

Ecological infrastructure refers to functioning ecosystems like wetlands, coastal dunes, rivers and estuaries that deliver valuable services to people.

Ecological infrastructure plays as crucial a role in a country’s development as built infrastructure like roads and railways. South Africa’s wealth of ecological infrastructure – viewed as a nice-to-have for decades – is increasingly proving to be the cornerstone that underpins urban and rural economies. This ecological infrastructure provides us with many benefits (called ecosystem services) including fertile soil for agriculture, and protection from extreme events – floods, droughts and fire. This is increasingly relevant in the face of the mounting risks of climate change.

16%

OF SOUTH AFRICA IS COVERED

by invasive alien plants

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Climate models and the Centre for High Performance Computing

Research Manager at South Africa's Centre for High Performance Computing (CHPC), Werner Janse van Rensburg, says high performance computing typically refers to the use of a very large computer with many central processing units (CPU) that one wants to use in parallel. Instead of running a task on one CPU, it is run on 1 000 CPUs, thereby drastically increasing the speed of calculation.

The CHPC is able to contribute to the development of climate models. Such models are systems of differential equations based on the basic laws of physics, fluid motion, and chemistry. To 'run' a model, scientists divide the planet into a three-dimensional grid, apply the basic equations, and evaluate the results.

CSIR researcher Precious Mongwe, who is doing his PhD on the Southern Ocean carbon cycle and Werner Janse van Rensburg, research manager at the Centre for High Performance Computing discuss a set of maps resulting from the use of high-performance computing.

A COLLABORATIVE EFFORT TO DEVELOP AN AFRICAN-BASED EARTH SYSTEM MODEL

The CSIR and its international partners in Australia, Japan and France are combining their supercomputing infrastructure and expertise, along with their climate modelling expertise, to develop reliable projections of future climate change over Africa and the Southern Ocean. The collaborators are contributing to the development of the first African-based earth system model.

THE CSIR AND ITS INTERNATIONAL counterparts will develop downscaled climate projections – derived from global climate models – to help South Africa and Africa understand and plan for the greatest collective challenge ever faced by mankind: climate change.

This multidisciplinary effort is driven by CSIR experts in the fields of global change, high-performance computing and modelling and digital science.

"Only one of the about 30 coupled ocean-atmosphere global circulation models and earth system models suitable for the projection of future climate change, has its origin in the southern hemisphere, developed at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia," says CSIR principal researcher, Prof Francois Engelbrecht.

"However, southern hemisphere and African climate issues differ from those that drive the research and modelling efforts in the north. In particular, oceans dominate the southern hemisphere and the land is largely occupied by semi-arid systems and tropical forests," he says.

CSIR researchers are working closely with international partners in Australia, Japan and France, who are making key contributions to the development of this new model.

What projections tell us about climate change in Africa

Temperature increases are projected to range between 4 and 7°C over subtropical southern Africa under low mitigation. CSIR researchers project that Africa may experience more extreme weather events resulting from climate change, such as intense thunderstorms, heat waves and droughts. An increase in tropical storms and cyclones that reach land are also projected for the northern parts of neighbouring Mozambique. Many sectors, including the insurance industry, are likely to be increasingly affected by the costs associated with high-impact climate events.

Real-world applications of the CSIR's climate models

In agriculture, research has shown that a 4 °C temperature increase can significantly reduce maize harvests over southern and east Africa.

"In a worst-case scenario where global climate mitigation fails, temperature increases of 6 to 8°C are plausible over parts of Africa. International crop modelling studies show that no current maize varieties can withstand such drastic temperature increases, and failure of the maize crop in southern and east Africa may reach drastic proportions under such a scenario," says Engelbrecht.

Researchers from the University of Pretoria have used the CSIR's models to project the future of potato farming in South Africa. They have found that the increase in carbon dioxide levels might boost potato harvests, but this benefit will be lost if there is not enough water for irrigation due to projected decreases in rainfall.

Tomato farmers in the north-eastern parts of South Africa are reporting that it has already become too hot to grow tomatoes in mid-summer in parts of Limpopo. They are foreseeing a shift of tomato production, at least to some extent, to farms in cooler Gauteng where winter frost is likely to occur less frequently under climate change.

Eskom currently uses the CSIR's downscaled climate models to inform its adaptation strategies in terms of the effects of high-impact climate events on Eskom infrastructure and household demand for energy.

The CSIR research on climate change also informs national policy-making. Recently, the CSIR climate change projections formed an integral part of the Long-Term Adaptation Scenario Project of the Department of Environmental Affairs (DEA) and related CSIR research informs the position of the DEA on aspects of the climate negotiations of the United Nations Framework Convention on Climate Change.

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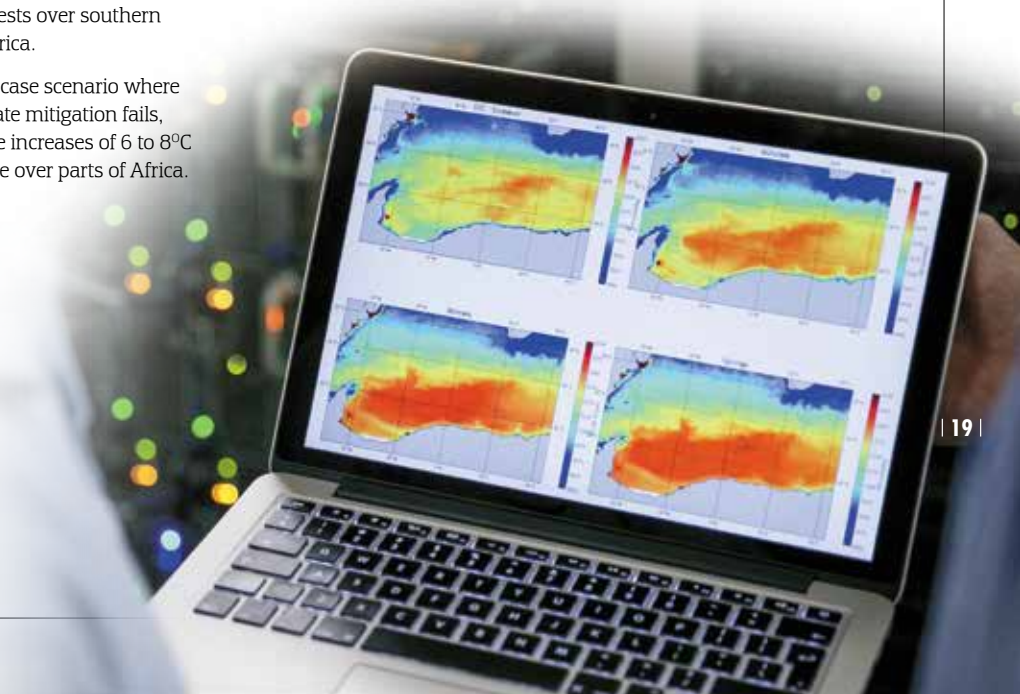


A collaboration to improve air quality in the City of Johannesburg

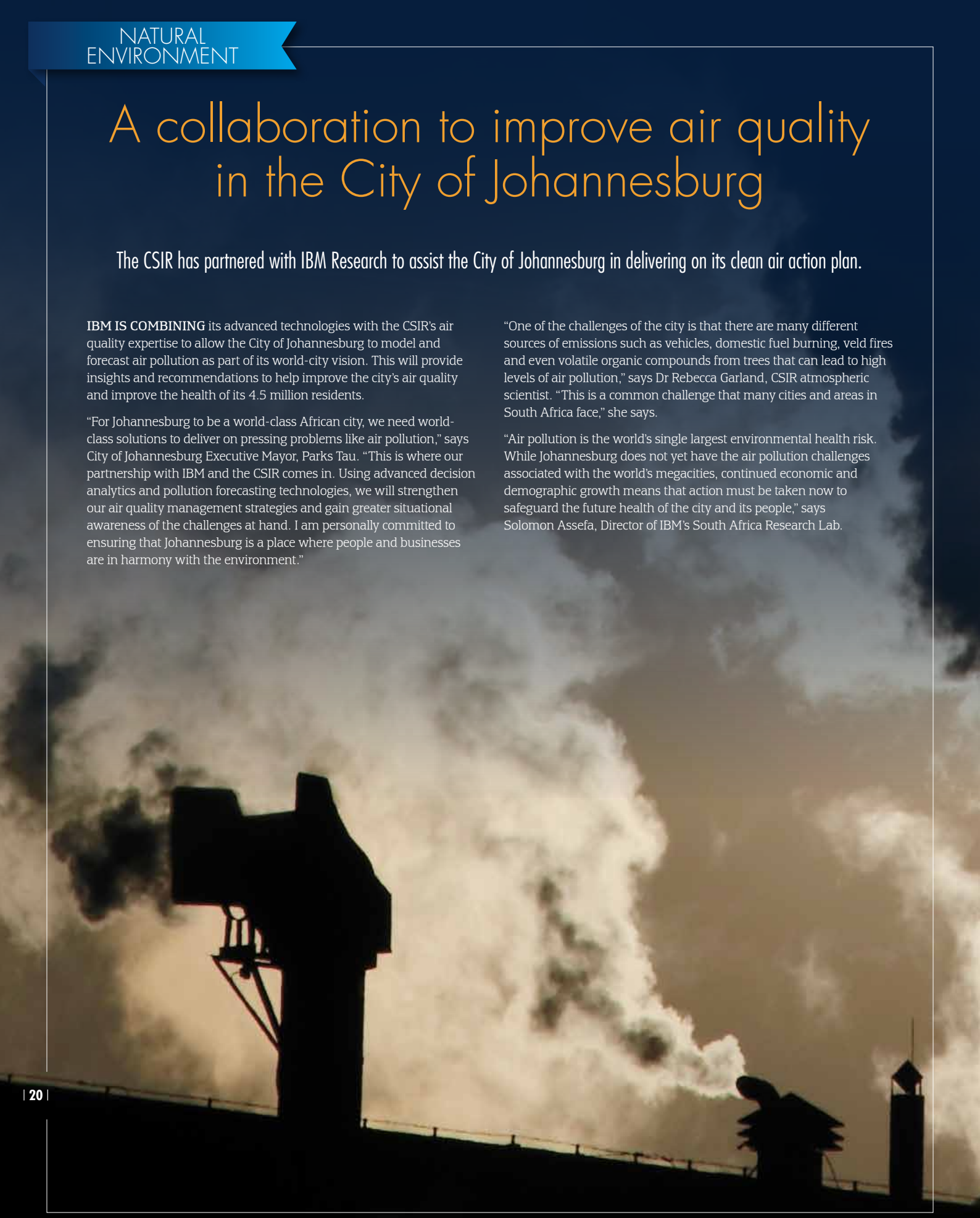
The CSIR has partnered with IBM Research to assist the City of Johannesburg in delivering on its clean air action plan.

IBM IS COMBINING its advanced technologies with the CSIR's air quality expertise to allow the City of Johannesburg to model and forecast air pollution as part of its world-city vision. This will provide insights and recommendations to help improve the city's air quality and improve the health of its 4.5 million residents.

"For Johannesburg to be a world-class African city, we need world-class solutions to deliver on pressing problems like air pollution," says City of Johannesburg Executive Mayor, Parks Tau. "This is where our partnership with IBM and the CSIR comes in. Using advanced decision analytics and pollution forecasting technologies, we will strengthen our air quality management strategies and gain greater situational awareness of the challenges at hand. I am personally committed to ensuring that Johannesburg is a place where people and businesses are in harmony with the environment."

"One of the challenges of the city is that there are many different sources of emissions such as vehicles, domestic fuel burning, veld fires and even volatile organic compounds from trees that can lead to high levels of air pollution," says Dr Rebecca Garland, CSIR atmospheric scientist. "This is a common challenge that many cities and areas in South Africa face," she says.

"Air pollution is the world's single largest environmental health risk. While Johannesburg does not yet have the air pollution challenges associated with the world's megacities, continued economic and demographic growth means that action must be taken now to safeguard the future health of the city and its people," says Solomon Assefa, Director of IBM's South Africa Research Lab.



The partnership builds on an IBM-CSIR collaboration framework agreement that was signed in January 2015. It also builds on the global Green Horizon initiative of IBM Research, leveraging Internet of Things technologies combined with the analytical power of cognitive computing.

"There is an increasing focus on energy and environmental issues in South Africa and around the world leading to new streams of investment and opportunities for innovation," says Dr Sibusiso Sibisi, CEO of the CSIR.

"Working together, the CSIR and IBM will explore how advanced technologies can help to better understand and improve society's relationship with the environment, bringing to bear local talent and best practices from some of the most environmentally challenged places on the planet."

The CSIR, IBM and the City of Johannesburg will work together to analyse historical and real-time data from environmental monitoring stations across Gauteng, also including the City of Tshwane and the Vaal Industrial Triangle. The objective is to uncover greater insight about the nature and causes of air pollution and model the effectiveness of intervention strategies.

In a second phase, the programme will be extended to include high-accuracy air pollution forecasting for planning and decision support and to enable proactive approaches to air quality management.

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Improved baseline emissions data and models will help improve regulation and management of industrial and other man-made emissions.

GROW, an interactive board game, teaches rural farmers to consider the environment, their neighbours and economic sustainability when making decisions about farming.

DEVELOPING A GAME TO HELP COMMUNITIES WITH LAND-BASED DECISION-MAKING

The CSIR has collaborated with the Serious Games Institute of North-West University (NWU), the Institute for Rural Development of the University of Venda, the Vhembe District Municipality and the Makhado Local Municipality to creatively address challenges around land-based decision-making in communities living on restitution land, by developing a game called GROW.

AN INTERACTIVE BOARD GAME – which teaches rural farmers to consider the environment, their neighbours and economic sustainability when making decisions about farming – has been developed by drawing on the expertise of a range of role players.

The knowledge and experience of participating municipalities and the Institute for Rural Development of the University of Venda was the first vital component. It was complemented by the CSIR's knowledge on decision-making related to the use of land for agricultural purposes and the game development skills of The Serious Games Institute at NWU.

The game facilitates and teaches sound decision-making. It illustrates systematic and transparent group decision-making which involves all role players and equally considers social, economic and environmental factors.

CSIR senior researcher and GROW project leader Dr Constansia Musvoto says the main cause of damaging agricultural practices in the context of communities living on restitution land, is fragmented and uncoordinated decision-making processes with a dominant focus on immediate livelihood needs.

"GROW is more than a game," says Musvoto, "It is a process for decision-making where once a decision is reached, everyone involved can see how the decision was reached."

The Serious Games Institute brought its expertise in refining the mechanics of the game, making sure that the objectives were clear and that the game succeeded in encouraging transparency.

"The game lacked elements of excitement and anticipation, so they introduced unknown variables, such as hail which threatens crops," says Musvoto.

"Since each scenario offers a range of pros and cons, it is important that each decision within the game is thought through extensively," says Irma Myburgh of the Serious Games Institute, adding that the board game goes a long way in teaching individuals to debate and investigate opportunities and alternatives.

Myburgh says the board game represents a culmination of empirical research data and infotainment, the latter referring to a type of media which provides a combination of information (in this instance, research outcomes) and entertainment (the joy derived by playing the game).

Musvoto says: "The game ensures that a decision is balanced and that unintended consequences stemming from focusing on only one aspect when making land-based decisions are avoided. For example, decisions based purely on profit can harm the environment and people, while decisions that only consider social needs could result in financial losses and harm the environment."

The decision-making process taught by GROW aims to protect people, the environment and the economy.

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The Serious Games Institute played a big role in refining key elements of the game, such as adding elements of excitement and anticipation.

The game assists in facilitating coordinated and integrated decision-making involving different people with different interests and objectives.

Pooling scientific expertise for national assessment of shale gas development

The CSIR leads a project to undertake, together with the South African National Biodiversity Institute (SANBI) and the Council for Geosciences (CGS), an independent scientific assessment which will feed into the Strategic Environmental Assessment (SEA) for shale gas development in South Africa, commissioned by the Department of Environmental Affairs in partnership with the Interministerial Committee on Shale Gas development and the affected provincial environmental departments.

THE CSIR'S EXPERIENCE in best-practice scientific assessment theory and implementation is complemented by that of SANBI, which is responsible for coordinating research and reports on biodiversity. In turn, the CGS provides a wealth of research experience into geoscience aspects such as groundwater and geophysics. Over 150 independent experts from around the world support the core team in author and peer-review capacities.

The scientific assessment has as its departure point a commitment to transparency and participatory processes. Project co-leader Prof Bob Scholes, a systems ecologist from the University of Witwatersrand and CSIR research associate, explains, "It is important to satisfy the principles of legitimacy, saliency and credibility, to ensure that the results of the assessment carry authority, highlight the most important and relevant aspects, and are believable."

Project co-leader Paul Lochner from the CSIR says, "The scientific assessment forms the basis for the scrutiny of the exploration and production-related activities of shale gas development which encompasses the entire life-cycle, including closure of facilities and restoration of sites."

All the material issues are assessed as part of the scientific assessment, identifying both the risks and opportunities of the shale gas development across various development scenarios. This includes detailed assessments into social fabric, air quality and greenhouse gases, visual, noise and electromagnetic interference, heritage resources, tourism, waste management, sense of place values, agriculture, national energy planning, spatial planning and infrastructure, economics, geophysics, water resources and terrestrial/aquatic diversity.

SANBI CEO Dr Tanya Abrahamse says, "The work done so far in the biodiversity component demonstrates the power of collaboration. Going into this scientific assessment we were well aware of the data and knowledge gaps on much of the Karoo landscape. Close collaboration with scientific institutions has provided the opportunity to gain a better understanding of the state of our collective knowledge and to improve our information on habitats and species distributions within the Karoo. This will benefit not only this assessment, but assessments for other developments in the Karoo. Overall, this will boost our biodiversity knowledge for South Africa."

To tackle each of these critical and highly diverse issues, multi-author teams with both local and international contributors have been assembled. The teams each produce chapters, to be reviewed in turn by expert independent local and international reviewers, the latter from Canada, the United States, Japan, Australia, the United Kingdom and other European countries.

The scientific assessment and the overall SEA process are also open to the general public through established communication forums such as the website and public briefing sessions which are undertaken in the study area. Intern and stakeholder communication officer on the assessment, the CSIR's Andile Dludla, says, "The stakeholder engagement process is important as it allows the general public to comment on each chapter in its draft format in the same way that the peer reviewers will be doing. We have registered around 500 stakeholders as part of the process who all have the opportunity to give input."

Why does this all matter? Scholes explains, "If we are to give government the tools to make the right decisions, we must deliver on a number of results and tools. Maps, management tools, frameworks, best practice, and development monitoring requirements are important to shape the process going forward."

The anticipated completion date of the scientific assessment is September 2016 and the overall SEA process, March 2017.

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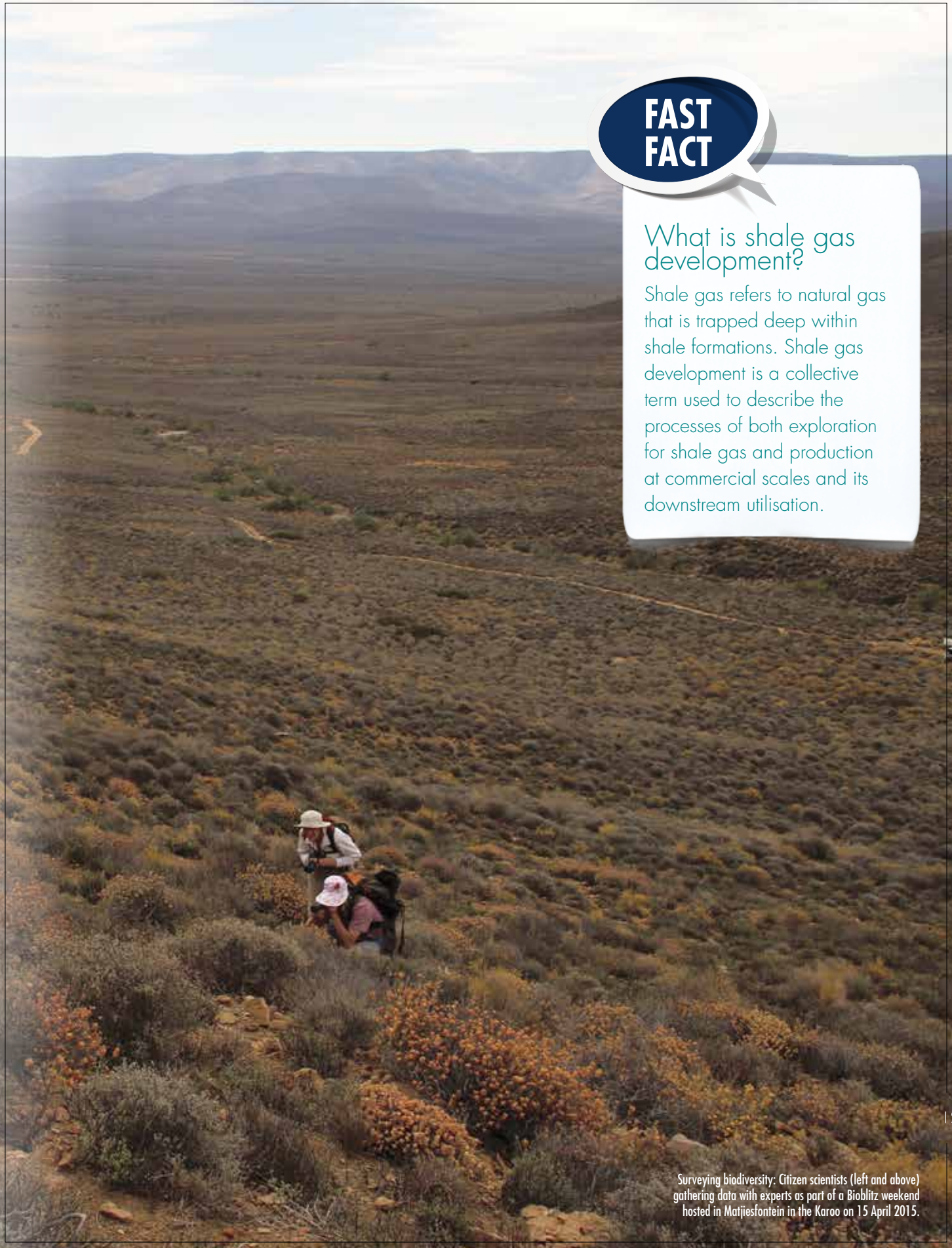

FAST FACT

What is shale gas development?

Shale gas refers to natural gas that is trapped deep within shale formations. Shale gas development is a collective term used to describe the processes of both exploration for shale gas and production at commercial scales and its downstream utilisation.

Surveying biodiversity: Citizen scientists (left and above) gathering data with experts as part of a Bioblitz weekend hosted in Matjiesfontein in the Karoo on 15 April 2015.

WORKING WITH ESKOM TO BETTER THE LIVES OF SOUTH AFRICANS

South Africa's economy and the quality of life of its people rely on an efficient electricity system. The CSIR and Eskom have a long history of working together. Now the two organisations are expanding their collaboration through a new agreement.

A NEW PARTNERSHIP AGREEMENT between Eskom and the CSIR seeks to synergise the research capabilities of the two state-owned organisations in support of Eskom's strategic and operational needs. The agreement covers the next five years and is aimed at aligning and enhancing interaction between the organisations in support of national goals.

Eskom's Group Chief Executive Brian Molefe says: "The partnership provides for a long-term relationship to perform scientific and operational research and evaluation tasks and provide scientific decision support in the context of Eskom's strategic and operational needs."

"We look forward to collaborating with the CSIR as we forge ahead with delivery on our mandate of ensuring reliable power to stimulate economic growth for our country and address socio-economic challenges faced by our people. We will prioritise projects that will ensure our operational and financial sustainability as we refurbish our current plant and deliver on new infrastructural projects to provide much-needed electricity," says Molefe.

CSIR Chief Executive Officer, Dr Sibusiso Sibisi says energy is one of the CSIR's areas of focus. The CSIR's vision in this area is to help the country achieve an energy-secure and low-carbon national economy.

"Together, Eskom and the CSIR can come up with innovative solutions for current and future energy issues, determine what the new electricity system will look like and what the plans and responses should be that need to be put in place to build the future South African energy system," he says.

To address its short-term requirements, Eskom has identified three imperatives that have been expanded to identify new and existing technologies and capabilities that can address specific challenges.

The first imperative relates to the availability and reliability of the existing asset base. The organisations will work together on extending the lifespan of the electricity infrastructure, through, among others, predictive maintenance; real-time grid monitoring using the Advanced Fire Information System; laser-based refurbishment of

high-value components; development of a joining technology and non-destructive testing centre to improve build and maintenance quality; analytical testing to ensure environmental compliance; and robotics and unmanned air vehicles for maintenance.

The second imperative is aimed at safely delivering on the new build programme and capacity management. Research and development will focus on, among others, the reduction of water consumption; development of advanced emission control technologies; development of components for use in advanced high-temperature gas reactors and modelling of associated technologies; load forecasting; and smart energy management systems.

The third imperative focuses on financial sustainability. Aspects to be jointly investigated include security risk management solutions to prevent theft and safeguard high-value assets; cable and infrastructure theft detection and prevention; smart meter protection; and detection and prevention of illegal connections and revenue theft.

In the long term Eskom is also facing significant challenges from fundamental shifts in the electricity and energy system that is becoming more distributed and flexible due to the increasing contribution of renewable technologies as well as the future focus on new build. Thus the agreement includes the intention to collaborate strategically on flexibility requirements in the future power system; implications of higher penetration of (fluctuating) renewables; establishing new build capabilities and capacity; integrated foresight studies and energy scenario planning; establishment of a joint centre of advanced manufacturing and repair technologies; a national centre of expertise for non-destructive testing and evaluation; skills development and job creation.

Eskom and the CSIR have therefore jointly approved the elevation of the current partnership to a strategic partnership that can support both strategic decision-making and assist with operational issues so as to address both the short- and long-term challenges of Eskom and the country's electricity system.

The partnership will enable the CSIR and Eskom to garner more value from the relationship that is also increasingly being promoted by the principal stakeholders of the two organisations, the Department of Science and Technology and the Department of Public Enterprises.

A history of working together

Historically the CSIR has been able to deliver technological solutions that helped Eskom overcome select operational challenges, but now the value of the partnership will be further enhanced through this new Memorandum of Agreement.

Barry MacColl, General Manager of the Research, Testing and Development unit at Eskom says: "The CSIR has highly skilled, experienced scientists and engineers with access to the latest equipment and facilities. Although Eskom has its own teams of such people, we do not have the desire or resources to grow in areas where the CSIR is already very competent and so it makes absolute sense to work in partnership and to share the costs of the projects."

CSIR Group Executive: Strategic Alliances and Communication, Dr Rachel Chikwamba says that while historically the CSIR has been able to deliver technological solutions that helped Eskom overcome select operational challenges, the value of the partnership will be further enhanced when the two organisations fully understand one another's strategies. "Our hope is for the partnership to develop joint foresight studies to anticipate sector challenges. Ultimately, we believe that a joint national response rooted in joint national capabilities will benefit South Africa."

(Continued overleaf)

The Group Chief Executive of Eskom, Mr Brian Molefe and the Chief Executive Officer of the CSIR, Dr Sibusiso Sibisi, signed a Memorandum of Agreement between the two entities on 23 May 2016.

The CSIR has assisted Eskom to overcome select operational challenges in recent years. Some of this joint work is featured here.

Sealing of cracks using a laser beam.

The CSIR has skills in the development of software to detect network intrusions.

LASER-BASED REFURBISHMENT

Eskom needs to keep its ageing infrastructure operational for the foreseeable future to meet the energy requirements of the country. As a result, the utility faces challenges in terms of unplanned shut-downs and a high incidence of faults detected during scheduled maintenance. Delays in obtaining parts and the associated replacement or repair costs add to the operational challenges.

The CSIR assisted Eskom to avoid replacement costs and shut-down time through the sealing of cracks in two large stainless steel water tanks at the Koeberg Power Plant and significantly extended the service life of the tanks.

"These tanks are an important safety feature of the nuclear reactor and need to be properly maintained to ensure that Koeberg retains its operating licence. They are filled with borated water which can be injected into the reactor coolant system to cool down the nuclear reactor and act as a neutron absorber to shut down the reactor," says Francois Prinsloo, CSIR key account manager for Eskom.

"The technique developed by the CSIR drew on its knowledge of laser cladding and surface engineering and involved the deposition of a specific metal powder on the surface of the tanks using a laser beam, creating a metallurgical bond."

The CSIR and Eskom then formed a laser beam welding work-group that meets regularly, and established an Eskom laser research cell at the CSIR using equipment from the Koeberg project. "This has led to additional collaborative projects on the refurbishment of steam turbine blades and rotor journals which can save costs and down-time."

SECURITY

Eskom has a significant problem with non-technical energy losses, typically caused by theft through illegal connections, meter tampering and illegal vending of pre-paid electricity; and network equipment theft including conductor or copper theft. The CSIR and Eskom are currently investigating using the CSIR's expertise in shared awareness platforms, cybersecurity, predictive modelling, network security and information security to assist Eskom in combatting these non-technical losses by evaluating and addressing these risks.

SMARTER DECISIONS ON ENERGY

The CSIR and Eskom collaborated on projects on smarter demand-side energy management. One project resulted in the capability to monitor and control energy usage of individual appliances as opposed to monitoring a home as a single entity. Devices were successfully installed in Eskom customers' homes and linked to a CSIR platform as part of a trial for the Testbeds for Reliable Smart City Machine to Machine Communication (TRESCIMO) project. Eskom's customers were provided a mobile application, which enables them to monitor and control individual appliances. Such smart energy systems could be commercialised in future. The TRESCIMO project also involved the University of Cape Town and international partners such as Eurescom, Technische Universität Berlin, Fraunhofer, Airbase Systems Ltd and I2CAT.

Eskom and the CSIR collaborated to develop a solution to visualise corona discharges on power distribution networks.

Using satellite data, the Advanced Fire Information System detects fires in real-time and issues automatic warnings to the cell phones or tablets of users such the managers of Eskom's electricity transmission lines.

SPOTTING DEFECTS ON TRANSMISSION LINES

Engineers need to conduct regular inspections of the electrical insulators on Eskom's transmission lines to avoid costly breakdowns. The aim is to extend their design life with timely repairs rather than having to replace such components because of a lack of maintenance.

Collaboration between the CSIR and Eskom of over 15 years resulted in the development of a world-first inspection camera that allows engineers to see defects on transmission lines before they are visible to the human eye.

"The CoroCAM provides video images of corona discharges on high-voltage equipment that are a precursor of a possible breakdown and a warning to Eskom to do preventative maintenance," says Francois Prinsloo, the CSIR's key account manager for Eskom.

CoroCAM resulted in a spin-off company, UVIRCO Pty Ltd, from which the CSIR and Eskom receive on-going royalties and which is considered a commercial success. The successful implementation of this technology has also led to new proposals on further imaging technology, including the use of robots and unmanned vehicles for high risk maintenance, augmented reality cameras and devices that can detect gas leaks at an early stage.

FIRE WARNING SYSTEM

Wildfires hold significant risk for Eskom. These fires cause faults on the approximately 28 000 km of high voltage transmission lines which can lead to outages that affect the power utility's customers. The life of equipment, such as transformers, is also drastically reduced by fires.

Over the past 10 years, Eskom and the CSIR have tested and proven the efficacy of a satellite-based wildfire monitoring system, called the Advanced Fire Information System. Using satellites, this technology determines the exact location of active wildfires and sends a text message to users, such as Eskom, empowering the electricity provider to respond timeously to reduce damage and power supply disruptions.

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THE FUTURE POWER SYSTEM

Eskom will need to incorporate alternative energy sources such as solar photovoltaic (PV), wind and biogas systems into the national grid as it moves away from fossil-based energy generation. However, the flexibility requirements in the system will increase, because solar PV and wind are weather-dispatched and not system operator-dispatched. The CSIR can assist Eskom in determining the system and business requirements for such systems by working closely with the Eskom teams.

The CSIR is assessing the impact of dust and dirt build-up on the photovoltaic panels' ability to yield power in one of the studies conducted at the CSIR plant.

Sharing lessons in becoming energy-autonomous

The CSIR constructed its first solar photovoltaic (PV) power plant on its Pretoria campus as part of investigations into technologies and policies to support the increased use of renewable energy in South Africa and to study aspects of distributed energy generation. It follows the earlier formation of the CSIR Energy Centre. It also marks the start of the journey to a carbon-neutral campus. Under a bilateral agreement, the CSIR and Eskom will share knowledge and expertise related to the technical aspects and business models of solar farms.

AS A RESULT OF the energy challenges faced by South Africa, many businesses and private households have already started to look at alternative sources of energy, for example solar power. This trend is expected to continue in future with energy consumers also becoming small-scale energy producers.

The CSIR wants to become energy-autonomous – generating significant amounts of renewable electricity and consuming minimally from the national electricity grid while also feeding its surplus energy into the grid. The CSIR's campus programme, which is in its early stages, falls under an Eskom-CSIR bilateral agreement.

Solar plant built

As part of these plans, the CSIR's first PV power plant was constructed between June and August 2015 on its Pretoria campus.

"CSIR researchers hope to share knowledge and expertise with Eskom to solve technical questions related to solar farms and to better understand what the business model for a utility such as Eskom should look like in the future in such a distributed energy world where everybody will have their own generators," says Dr Tobias Bischof-Niemz, manager of the CSIR energy centre. He is also a member of the Ministerial Advisory Council on Energy, which advises the Minister of Energy, Tina Joemat-Pettersson, on long-term strategic plans relating to the energy sector in South Africa.

Plant capacity

The solar array consists of a total of 1 800 PV modules with a total surface of 3 493 m^2. Power generated feeds directly into the CSIR's campus grid, therefore no energy storage is needed.

"The facility will have an annual yield of close to 1 200 MWh, about 4% of the CSIR's electricity needs on its Pretoria campus. This is the equivalent of the electricity needed to power 200 middle-income households in South Africa," says Bischof-Niemz.

"We have achieved a lifetime energy cost of 83 cents per kWh, which compares favourably with existing utility-scale solar PV plants in the Northern Cape and is cost-competitive compared to other methods of electricity generation."

South African designed and made solar tracking system

The panels are controlled by a single-axis solar tracker that allows the modules to tilt and follow the movement of the sun from east to west. This tracking system is generally more expensive to install and maintain, but has a higher energy yield as opposed to a fixed-tilt system. "The CSIR's 1-axis tracking PV facility is the first of its kind in the country with a 100% South African designed and made tracking system and substructure, including the control algorithms."

Research

Dust and dirt build-up can impair the PV panels' ability to yield power, but the cost of regular cleaning will ultimately increase the price of energy generated. To assess the impact of the dust and dirt build-up on yield, CSIR researchers have divided the arrays into different blocks with some of the modules being routinely cleaned, while others are left uncleaned. The purpose is to derive a cost-optimal operational plan for the cleaning of the modules.

Benefits

"The CSIR campus will balance supply and demand with other campuses that are connected to the South African grid in a 'virtual power plant' approach, says Bischof-Niemz. "This means that during times of oversupply at the CSIR campus we will supply that excess to another campus anywhere in South Africa that is experiencing undersupply at that time."

The facility has an expected lifespan of at least 25 years. The solar power generated will equate to an annual carbon dioxide saving of approximately 1 200 tons, which will significantly reduce the CSIR's carbon footprint.

The facility will also be used to train PV engineers and technicians.

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Construction workers installing solar photovoltaic modules at the CSIR in Pretoria.

South African-German collaboration on energy: Dr Stefan Bofinger, Fraunhofer IWES; Joanne Calitz, CSIR; Crescent Mushwana, CSIR; Sipho Mdhluli, Eskom; Terence van Zyl; Eugéne Mabille, CSIR; and Nicolene Botha, CSIR.

> The potential to produce electricity from wind turbines in South Africa is significantly greater and much more widely spread than initially thought.
>
> Joint CSIR-Fraunhofer study.

Quantifying the combined effect of wind and solar power in South Africa

South Africa has abundant wind and solar energy resources, but these have not been fully exploited for the country's economic benefit. The CSIR partnered with Germany's Fraunhofer Institute for Wind Energy and Energy System Technology (Fraunhofer IWES) to quantify the combined effect of these two energy sources.

SOLAR AND WIND POWER naturally and continuously fluctuate – wind speeds vary greatly from minute to minute and cloud cover continuously changes. It is important to understand this variability in the context of a stable power system for the country.

"Eskom had done previous studies to look at the output of solar photovoltaic (PV) power in the whole of South Africa, for example on how the output is influenced by weather and cloud patterns, but we needed to understand the spatially aggregated wind and solar PV profiles for the country," says CSIR principal engineer Crescent Mushwana, who leads research into the planning and operation of energy systems.

The CSIR consulted with Eskom, the Department of Energy, the South African Photovoltaic Industry Association, the South African Wind Energy Association and the South African National Energy Development Institute (SANEDI) to study this aspect.

"The researchers at Fraunhofer IWES had done a similar study in Germany before. As part of the project, CSIR researchers had visited the institute in Kassel and were trained by experts in energy modelling, renewable energy forecasting, information, communication and technology for renewable energy power plants, as well as micro-scale wind modelling."

The Fraunhofer IWES researchers used existing solar and wind data from satellite and ground measured data in combination to assess the combined output from the two sources when they are spatially dispersed. The raw wind data used are the output of the Wind Atlas South Africa programme in which the CSIR played a part and which is run by SANEDI on behalf of the Department of Energy, with support from the Danish government.

"The results indicate that wind and solar PV installations provide smooth power output when the power plants are dispersed over a large area. It also indicates that power output from wind and solar PV plants do not happen at the same time; they complement each other, which is good for the power system. Solar PV output is higher during the day and wind output is higher in the evening, which is ideal for meeting the evening peak load," says Mushwana. "Short-term fluctuations in the combined aggregated power output produced every 15 minutes can be avoided almost entirely by spreading solar PV and wind power plants across the country."

"Additionally, we found that the wind resources in South Africa are excellent, not only in the coastal areas, but literally across the entire country, with only a few exceptions. The reality is that wind farms can be economically built across almost all of South Africa, which again helps to make a widespread spatial distribution of wind generators economically feasible."

Mushwana says the datasets produced by this study can be used for a variety of further studies to quantify the amount of renewables that can be integrated into South Africa's power system.

"The study is a good basis for future collaboration with Fraunhofer IWES on renewable energy technologies and energy-system integration," he says.

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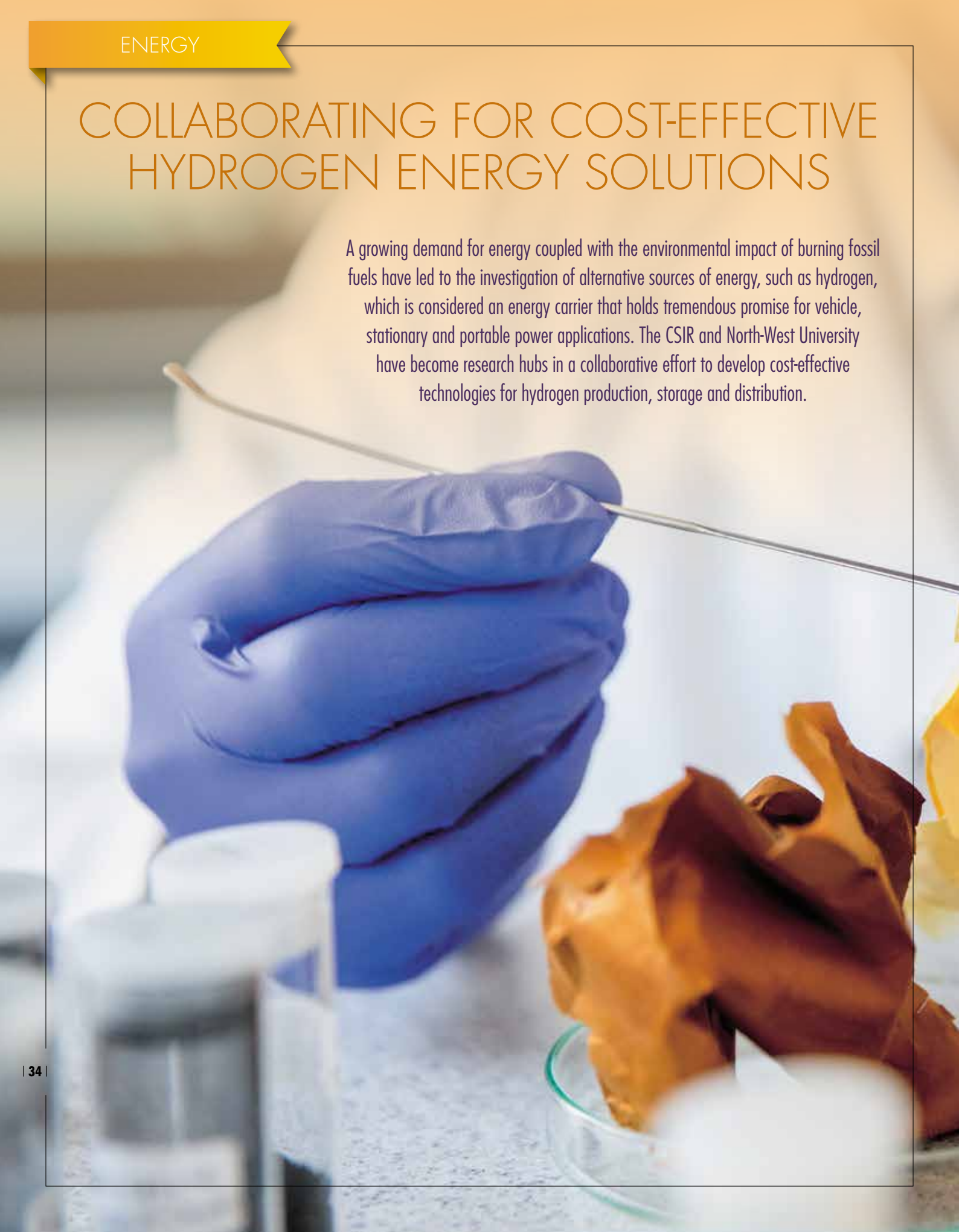
A CSIR-Fraunhofer study found that South Africa exhibits low seasonality in both wind and solar PV supply.

COLLABORATING FOR COST-EFFECTIVE HYDROGEN ENERGY SOLUTIONS

A growing demand for energy coupled with the environmental impact of burning fossil fuels have led to the investigation of alternative sources of energy, such as hydrogen, which is considered an energy carrier that holds tremendous promise for vehicle, stationary and portable power applications. The CSIR and North-West University have become research hubs in a collaborative effort to develop cost-effective technologies for hydrogen production, storage and distribution.



The CSIR's Dr Henrietta Langmi and Director of the HySA Infrastructure Centre of Competence, Dr Dmtri Bessarabov, at the electrolyser testing and benchmarking facility at HySA Infrastructure at the North-West University (left). The testing station is a vital component of electrolyser development. On the right they are seen at the solar-to-hydrogen facility. This pilot plant is capable of producing 2.5 kg high-purity hydrogen per day.

HYDROGEN IS THE third most common element in the Earth's crust although less than 1% occurs in its free form as molecular hydrogen gas. It can be generated from clean and renewable sources, for example, by electrolysis of water linked to renewable energy like solar energy. It is considered clean because when combined with oxygen in fuel cells to generate electrical energy, the only by-product is water. Hydrogen has a high-energy density on a mass basis, which is about three times higher than that of other liquid hydrocarbon fuels like petrol. However, there are still technical challenges associated with the efficient production, storage and utilisation of hydrogen in fuel cells.

Collaboration hubs

The Department of Science and Technology (DST) developed South Africa's national hydrogen and fuel cells strategy, branded Hydrogen South Africa (HySA), which aims to develop and guide innovation along the value chain of hydrogen and fuel cells nationally.

The HySA Infrastructure Centre of Competence, which is jointly hosted by the CSIR and North-West University (NWU), is tasked to deliver cost-efficient technologies for the production, storage and distribution of hydrogen.

The storage of hydrogen in the form of chemical carriers is examined at both the CSIR and NWU. The CSIR is also examining storage in high-pressure gas cylinders and in porous materials.

These storage solutions will be integrated with the renewable hydrogen production at NWU, which has already seen the construction of the first solar-to-hydrogen plant in South Africa.

Dr Dmtri Bessarabov, Director of the HySA Infrastructure Centre of Competence, is based at NWU and has overall responsibility and accountability.

"The commercial-scale system capability of the solar-to-hydrogen plant has been upgraded from 6 kW PV to 15 kW PV, 30 kWh to 90 kWh battery storage and 0.56 kg to 2.5 kg production of high-purity hydrogen per day. Additionally, an air-driven hydrogen booster provides filling pressures up to 200 bar with upgrade capability to 400 bar," Bessarabov says.

"HySA Infrastructure also has a vision of preparing South Africa to participate in hydrogen-related applications by beneficiating the country's own resource base, specifically the plantinum-group metals, in becoming a significant supplier of material, components, products, sub-systems and systems. These include polymer electrolyte membrane electrolyser systems and hydrogen storage systems for export," he says.

The CSIR's Dr Henrietta Langmi is programme manager at the HySA Infrastructure Centre of Competence. "It is great to work with the NWU as co-host of HySA infrastructure, and together I believe we can accomplish our mission of hydrogen generation, delivery and storage, which would be a significant contribution towards hydrogen and fuel cells technology in South Africa and worldwide," says Langmi.

"Fuel cells and associated hydrogen infrastructure represent an exciting new market which could drive growth for platinum, a key component of polymer electrolyte membrane fuel cells and electrolysers as well as spark significant new opportunities internationally and locally in SA," she says.

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A fibre mat incorporating hydrogen storage material. The hydrogen storage material is incorporated into nanofibres to impart application-specific properties.

A new tariff concept to stimulate South Africa's rooftop solar PV market

The National Renewable Energy Laboratory (NREL) in the United States of America and the CSIR are collaborating to develop an innovative tariff concept to stimulate the market for embedded photovoltaic (PV) power generation.

ROOFTOP-MOUNTED solar PV panel technology has become an attractive option for electricity generation due to better affordability and the significant increase in electricity tariffs in South Africa over the past five years.

"However, a large uptake of this technology might have negative financial implications for electricity distributors, while many individual investors are still uncertain about the long-term return on such an investment, says Dominic Milazi, who heads research into energy policy at the CSIR.

"Distributors also have safety concerns about the lack of standards for connection of these systems to South African distribution grids, while the appropriate regulatory frameworks are not yet in place to effectively measure actual on-site electricity consumption across all households with embedded generators, a challenge for future energy planning."

CSIR researchers are developing a concept to address these challenges. They suggest the creation of a central power purchasing agency to compensate municipalities for all lost revenue resulting from consumers who have their own solar PV panels, which has resulted in them buying less energy from municipal utilities.

The idea is to have the new proposed agency offer to buy back the part of the PV energy that PV owners don't consume, which feeds back into the national electricity grid. This will be measured by a bi-directional electricity meter that measures incoming and outgoing electricity in two separate registers.

"The idea is to make the municipalities financially indifferent to customers using embedded generators and to make the investment in PV systems less risky at the same time," says Milazi. "This combination will lead to lower

costs to the potential solar PV owners deploying this technology as part of the power-generation fleet."

The NREL has, under the 21st Century Power Partnership, sponsored an international expert, Toby D. Couture, founder and director of the independent renewable energy consultancy E3 Analytics in Berlin, to review the CSIR's concept.

"South Africa is a fascinating electricity market in many ways," says Couture. "The sector has undergone a number of challenging years with frequent power outages and rapid rate increases, but taking a step back, the market as a whole seems to have turned a corner and is now making some impressive strides forward.

"Power reliability is up, private sector investment is increasing, and the share of renewable energy from both wind and solar power continues to grow. In that regard, South Africa carries a number of important lessons for other major markets across the continent, for example Ghana, Tunisia, Kenya and Zambia," he says.

CSIR Energy Centre manager Dr Tobias Bischof-Niemz says: "The country has the chance to put policies in place that are developed on a clean sheet with the recently achieved cost-competitiveness of solar PV in mind. This is unlike scenarios in the USA and Europe, where solar PV is also becoming cost competitive, but still has the historic notion of requiring subsidies and related structures around subsidy schemes already in place. The international experts therefore have the opportunity to possibly see what the real effects of a 'clean' policy intervention would be, rather than just the theoretical."

Work on the development of the concept is ongoing.

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A solar photovoltaic installer converts a household rooftop area into a small-scale generation unit.

TECHNOLOGY PARTNERS IN THE FIGHT AGAINST RHINO POACHING

The CSIR and StopRhinoPoaching.com signed a partnership agreement in 2016 aimed at supporting security groups working towards the protection of wildlife in southern Africa. Testing interventions to equip rangers (names withheld to protect their identity) are Chris Serfontein of the CSIR and Elise Daffue of StopRhinoPoaching.com.

One of the first outcomes of a partnership between the CSIR, not-for-profit organisation StopRhinoPoaching.com and Seecrypt is a secure communications system for counter-poaching groups.

The CSIR and StopRhinoPoaching.com aim to establish and support counter-poaching capabilities to combat wildlife crime within South Africa and southern Africa.

StopRhinoPoaching.com was founded by Elise Daffue in 2010. What started as an effort to raise awareness for the growing threat to South Africa's rhinos has since grown into one of the leading organisations supporting counter-poaching efforts in southern Africa. Since signing a Memorandum of Understanding with the CSIR in 2014, both parties have brought complementary skills to a wide range of projects.

Securing communications between counter-poaching groups

Poaching syndicates are well-organised and well-equipped criminal organisations with advanced technologies at their disposal. Communications between groups working on counter-poaching activities may be vulnerable to interception, which made secure communications an important first objective of the partnership.

In September 2014, Seecrypt, a provider of encryption technologies for ultra-sensitive to secret voice and messaging applications, signed a partnership agreement with the CSIR and StopRhinoPoaching.com to deliver military-grade secure communications to counter-poaching groups. Seecrypt provided licences for its secure communications software. The company relied on the CSIR to customise the encryption technology to meet the operational requirements for counter-poaching activities. The technology is currently being used by various groups working on counter-poaching activities.

"To be successful in the ongoing battle against poaching, Seecrypt will continue to supply the latest technology to ensure that sensitive and vital information is shared securely among the anti-poaching group in real-time," says Mornay Walters, Seecrypt founder.

Technology interventions to equip rangers, integrate systems

The CSIR Technology for Special Operations group has extensive knowledge in aspects such as tactical ranger technology, operational concept development and strategic risk analysis. Manager of the group, Chris Serfontein, says: "We are currently looking at technology development, integration and support of operational systems. This includes tactical equipment for rangers, command and control systems, optimisation of investigations, tracking systems and tactical ranger trailers that could sustain a team of rangers in an area without any infrastructure."

Another key area of collaboration is the development of environmental asset protection doctrine which looks at counter-poaching operations, air support for counter-poaching activities and support for canine units, as rangers' dogs remain key in the tracking of poachers in certain conservation areas.

"StopRhinoPoaching.com's main focus is on the security domain, which made a partnership with the CSIR a perfect match. The CSIR has a way of repackaging ideas, creating structure and leading when necessary. Their sharing of knowledge and expertise has given us – and the trusted network within which we work – strategic direction," says Daffue.

Developing strategy and technology to counter environmental crimes, such as wildlife trafficking, poaching and illegal trade in animal products, has become a priority focus area for the CSIR. With more than 100 stakeholders involved in different roles, a multidisciplinary approach was needed.

"Knowing that a partner of the CSIR's calibre is actively working towards solutions across a range of focus areas brings much needed peace of mind. Working with like-minded people who are motivated and passionate has forged a team of rhino guardians who stand together to fight for their survival. We cannot thank them enough," concludes Daffue.

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POWERFUL PARTNERSHIP TO COUNTER POACHING

Dr Sibusiso Sibisi and members of CSIR Executive travelled to the Kruger National Park as first visitors to the Mission Area Management Centre that forms the backbone for intelligence gathering, decision-making and rapid responses in the fight against rhino poaching. (Left) Welcoming Dr Sibisi was Head of Special Projects for the South African National Parks Board, General (retired) Johan Jooste.

To counter the onslaught on South African natural resources such as rhino horn and ivory, South African National Parks (SANParks) needed access to experts in a variety of technical fields, such as radar technology, tactical operational planning and doctrine development. The CSIR stepped up to the challenge and became a formal SANParks partner in 2013.

THE CSIR'S ROLE in the war on rhino and elephant poaching is to impartially evaluate, adapt and develop technologies and equipment needed to counter poaching activities in South Africa's national parks – the hardest-hit being the Kruger National Park in the Mpumalanga province.

SANParks rangers and staff who work in counter-poaching have a range of needs that include operational-level rapid response, transport, forensics, communication and detection systems. Charl Petzer, programme manager at the CSIR, outlines the support to SANParks: "Operationally, we need to understand how to manage the life cycle of SANParks' resources and optimise capabilities to be effective for the challenges the organisation faces. For example, we assisted with the establishment of a command centre for real-time surveillance, data collection and analysis, as well as decision-support modelling. We evaluated the technologies used for sensors, gunshot detection, detection of human movement in border zones, weaponry, as well as aerial and land transport modes."

The CSIR provides science, engineering and technology support in areas of national importance. Increased incidents of environmental crime called for an increased involvement in environmental asset management – a multidisciplinary domain focusing on safeguarding all natural riches.

With more than 100 stakeholders involved in counter-poaching initiatives, managing these stakeholders is an important aspect that influences effective decision-making. CSIR systems engineer Duarte Goncalves, who uses whole-of-society approaches to combat wildlife crime, says, "A complex problem such as rhino poaching requires multiple levels of simultaneous intervention on international, national and organisational levels across various geographical areas. Alignment of these efforts is required to ensure success. One way of achieving this is to work with individual groups, ensure their buy-in to potential solutions and to then bring different groups together to form a larger group that can have a significant impact."

SANParks Head of Special Projects, General (retired) Johan Jooste says, "We see the CSIR not as a consultant or merely a service provider, we see the organisation as an integral part of the project team. They physically go into the field with us, they learn from the rangers; they are colleagues."

SANParks is funding the CSIR's development work through funding by the Howard G. Buffett Foundation, while some aspects of the work are also funded by the Peace Parks Foundation.

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Head of SANParks Scientific Services, Danie Pienaar, welcoming members of the CSIR executive team during a visit to the counter-poaching operation base in Skukuza.

Tactical counter-poaching teams prepare for departure in response to threats being detected.

The CSIR and the South African Police Services work together to prevent crime

The CSIR and the South African Police Services (SAPS) signed a Memorandum of Agreement in 2014 and the organisations are working together to optimise science, engineering and technology for national safety and security.

"The SAPS has communicated its national crime-prevention intervention requirements to the CSIR. These requirements form the foundation of the operational strategy guiding the CSIR to support the SAPS in the national interest," says Braam Greeff, the CSIR key account manager for the strategic relationship with the SAPS.

"The intention with the agreement was to create the institutional framework for the SAPS to access scientific, engineering and technology support for both the operational and strategic components of its duty towards national safety and security. This will enable the SAPS to operate as a smart buyer, user and manager of technology."

The agreement stipulates six leading intervention programmes, namely situation awareness and command and control; information and communications technologies (ICT); integration and interoperability support; operational quick reaction tasks; science and technology capability development; as well as strategic and operational decision support.

More about the programmes

The first programme will address situation awareness, command and control solutions including technologies such as sensors, data fusion, intelligence and information gathering, display and dissemination, and associated information technology infrastructure, as well as operational command and control systems and infrastructure.

In the ICT domain, the CSIR will be focusing on optimising systems within the SAPS to improve efficiency and cost effectiveness.

Integration and interoperability are key means of optimising existing infrastructure and resources in defence and security. This entails finding ways for the smarter use of existing equipment and systems and avoiding new investments, the pitfalls of vendor lock-in, and the risks of costly, yet soon obsolete systems.

Operational quick-reaction tasks are critical in agile law enforcement. This includes the ability to rapidly design, engineer and create a custom solution to an urgent operational need.

The programme to drive science and technology capability development is set to bring skills and capabilities to the SAPS to support systems and product evaluation, acquisition, product deployment or customisation, and to establish new technical capabilities.

In the area of strategic and operational decision support, activities will focus on the establishment of a scientific decision-support base for the SAPS for operational and strategic needs.

The CSIR and the SAPS are conducting mutual requirements elicitation workshops with the objective to elicit the SAPS' future operational requirements in the domain of public-order policing.

"The CSIR has already provided strategic decision support to the SAPS on various key tender requirements and was involved in the testing of electronic equipment required by the SAPS in future crime preventions," says Maj. Gen. Charl Annandale, component head of specialised operations at the SAPS.

The CSIR and the SAPS will also do research and development focused on enhancing required policing technologies to enable a more pro-active policing capability. The establishment of a Safety and Security Research and Evaluation Institute, with this objective in mind, is in the planning stages. This forum will provide a platform for the SAPS and the CSIR to perform co-research in the fields of forensics, language learning technologies, cyber security, human behaviour, smart-policing and crime analysis. The research will also focus on human capital development to enable the SAPS to utilise technologies in its endeavour to be more pro-active, leading to a safer society for all South Africans.

CSIR CEO, Dr Sibusiso Sibisi, signs a Memorandum of Agreement with the South African Police Services that established the institutional framework for collaboration between the two organisations.

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POLICE
SOUTH AFRICAN
POLICE SERVICE

The CSIR and Cybicom Atlas Defence developed a simulator to help train marine helicopter pilots

The CSIR and Cybicom Atlas Defence have jointly developed a prototype helicopter simulator primarily to help the South African Navy with helicopter flight deck training.

THE HELICOPTER FLIGHT DECK trainer is designed to provide training for flight deck controllers and marine helicopter pilots. It provides a safe, cost-effective solution to train personnel in a realistic and controlled environment. The flight deck trainer is a flexible, modular system that can be supplied in various levels, from a simple, portable, desktop trainer, to a multichannel, high-performance tracking system that can accommodate multiple trainees and provide a 360-degree, high-fidelity simulation with full-environment simulation.

The distributed simulation environment integrates three man-in-the-loop simulator stations, namely; a helicopter flight simulator with pilot interface that models the helicopter, the airflow over the deck and the ship interaction dynamics complete with an image-generation system that displays the external world view to the pilot; a ship bridge simulator that includes sea-state, rain, and cloud-cover models with a bridge interface for the captain; as well as a deck landing officer station.

"The success of this project illustrates the advantages of the collaboration between industry and the CSIR – the team operated as a single entity with a common purpose. Each role-player brought its own expertise to the project and the team was able to ensure seamless integration between hardware and software as well as between image generation, control software and highly realistic flight dynamics," says Dave Viljoen, Managing Director of Cybicom Atlas Defence.

"The South African aerospace industry can only benefit from the introduction of Cybicom Atlas Defence as a new manufacturer of locally developed simulator products. We have also succeeded in replacing an imported component through the local manufacture of the display cladding and mounting," he says.

Cybicom Atlas Defence and the CSIR are also working on industrialising the training system. The product envisaged will be suitable for small-scale production and will cater to both the commercial and defence markets. The work is being undertaken with the support of the Aerospace Industry Support Initiative (AISI). The AISI is an initiative of the Department of Trade and Industry and is hosted and managed by the CSIR.

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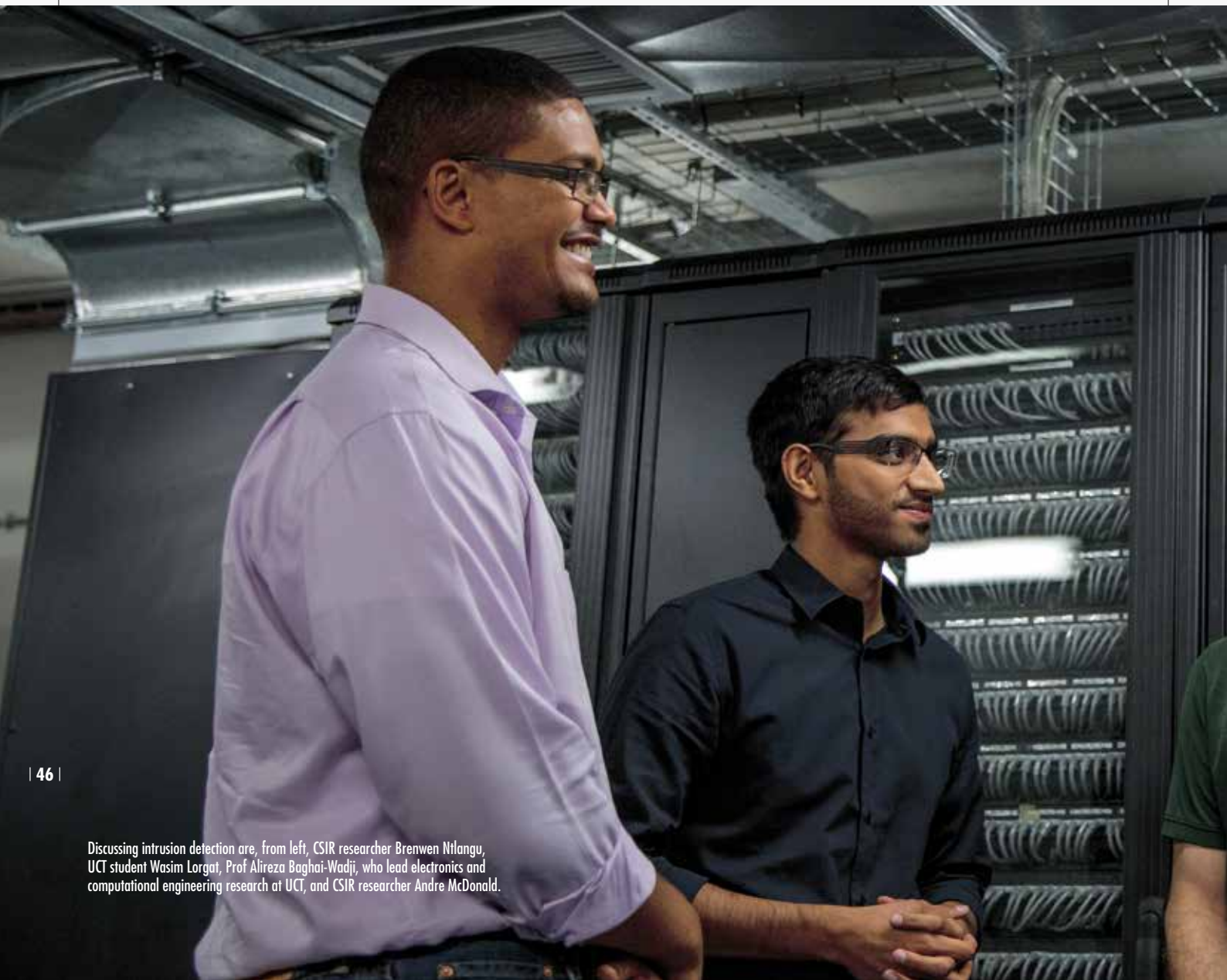
The helicopter flight deck trainer is used to provide training for flight-deck controllers and marine helicopter pilots, primarily those in the South African Navy.

PARTNERING WITH THE UNIVERSITY OF CAPE TOWN TO IMPROVE NETWORK INTRUSION DETECTION

CSIR researchers have partnered with experts from the University of Cape Town (UCT) to create a virtual laboratory where they use advanced computational techniques to improve a network intrusion detection system that the CSIR is developing.



Discussing intrusion detection are, from left, CSIR researcher Brenwen Ntlangu, UCT student Wasim Lorgat, Prof Alireza Baghai-Wadji, who lead electronics and computational engineering research at UCT, and CSIR researcher Andre McDonald.

SOUTH AFRICA'S GROWING reliance on information and communications technology (ICT) to provide access to information and services has exposed individuals and business to increasingly sophisticated cyber security threats, including identity theft, fraud and extortion. CSIR researchers have partnered with Prof Alireza Baghai-Wadji and his research group from the Faculty of Engineering and the Built Environment at the University of Cape Town to undertake joint research on network intrusion detection.

"Our goal is to create more reliable and accurate algorithms for detecting novel threats to computer networks and to develop and commercialise a software platform for deploying these novel detectors in a network," says CSIR researcher, Andre McDonald.

He says that existing anomaly detection systems often exhibit unacceptably high false positive rates, which limits their practicality.

Multiresolution analysis techniques show promise in suppressing false-positives and this is where the expertise of Baghai-Wadji, who leads a strong electronics and computational engineering research group, provides valuable support. He also has extensive experience with the product development chain and commercialisation.

"The CSIR's initial work has led to a prototype system that is able to detect threats in real-time by scanning for unusual or unexpected network traffic patterns. The joint research involves the application of advanced computational techniques to develop a range of detectors that operate in synergy to suppress false positives, thereby improving the performance of the prototype," says McDonald. The CSIR and UCT are exploring partnership options with industry towards the further development and commercialisation of the system.

The initiative will be part of the Cybersecurity Centre of Innovation planned for the Western Cape and involving other universities in the area.

"Besides joint supervision of postgraduates and organising seminars for cultivating an environment conducive for rigorous research, our virtual laboratory has been positioning itself as a platform for actively pursuing breakthrough discoveries where we employ techniques stemming from seemingly diverse areas," Baghai-Wadji says.

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JOINING FORCES TO OPTIMISE TRANSNET'S POSITION IN AFRICA

CSIR firmware engineer, Lorinda Brazzoli; executive manager for research at Transnet Engineering, Andy Mabaso; and Transnet engineer Thibedi Matjila discussing a control module of the train control and monitoring subsystem.

The CSIR and Transnet have partnered in an effort to streamline transport operations and boost transport-related manufacturing in South Africa. Research, development and technology are being employed in a bid to move the country from an importer of equipment used in this sector, to an original equipment manufacturer.

THE SOUTH AFRICAN transport sector faces multiple challenges that adversely affect socio-economic development in the country. These include high transport logistics costs, skills shortages and limited local manufacturing capability, which result in the country importing the components and skills needed to create railway equipment, trains and infrastructure.

The CSIR and Transnet have collaborated for many decades, but renewed their agreement with regards to specific projects that aim to address these problems.

Localising technology

"Our biggest challenge is to localise technology that we would otherwise import," says Andy Mabaso, executive manager for research at Transnet engineering.

The CSIR and Transnet are working on a locally designed locomotive control system and the aim is to become an original equipment manufacturer that also exports to the rest of Africa.

"During the last few years, Transnet has acquired 1 064 locomotives at a cost of R50 billion, money that in future could be spent on a local product to strengthen the economy," adds Charl Harding, strategic business development manager at the CSIR.

Advantage of localising

"Localisation will have an impact in other parts of industry by creating a local need for maintenance and materials or parts production, thereby using and retaining local skills," says Mabasa.

"Also, when we design a component locally, we can customise it to our own specifications and environment, instead of importing and modifying parts."

Streamlining and refining

Other collaborative work between the CSIR and Transnet includes refining laser refurbishment to increase the lifetime of components, the refining of manufacturing processes for locomotive and wagon components and improving the monitoring of components, for example axel corrosion.

"We are also working towards streamlining operations at ports. One example is the creation of a sensor network to improve the turnaround time for the loading and off-loading of containers. This could result in huge logistics cost savings," says Harding.

"The reduced cost of logistics will also have a ripple effect as efficiently transported goods would cost less."

Skills to the table

About 50 young Transnet engineers are based at the CSIR in Pretoria, collaborating with senior CSIR engineers in an effort to build the local skills capacity.

"It is crucial that we develop experts in South Africa, and Transnet selected the cream of the crop at South African universities," says Harding.

"These engineers are vibrant and energetic. They work in the railways and factories and therefore bring real-world problems to the table, while the CSIR engineers share their research and design experience. We have also placed some CSIR researchers at Transnet operations."

Mabasa says the Transnet engineers appreciate the CSIR's neutral perspective. "CSIR engineers have expertise in the military and aviation domain and that helps us to tackle railway engineering problems in new ways. In this technology age, where there is rapid innovation, our young engineers have the agility and curiosity to try new things."

Lorinda Brazzoli, CSIR firmware engineer and project manager, says that the young engineers benefit from the sound system engineering approach of the CSIR.

The future

Harding and Mabasa say the way forward is to partner more extensively, also in their efforts to build a locally designed high-speed train which is currently under discussion.

"There is no industry for high-speed trains in the country at the moment. We have the Gautrain that goes at 160km/h, but high-speed for us is 300km/h," says Mabasa.

Harding says the partners are building a long-term roadmap to improve the competitiveness of Transnet in the African space.

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A team of young Transnet engineers is based at the CSIR where they are collaborating with senior CSIR engineers to build the local skills capability.

Partnering to prevent derailments caused by broken rails

In the late 1990s, Transnet began investigating ways to detect breaks on railway tracks, automatically and in real-time. The state-owned entity's challenge was the almost impossible task of manually checking 860 km of railway track renowned for derailments of trains carrying iron ore. The Institute for Maritime Technology (IMT) conceptualised a rail monitoring system and approached the CSIR to help develop the system because of the organisation's sonar transducer expertise.

THE CSIR WAS subcontracted by IMT, a division of Armscor, to assist with the research, development and manufacture of an ultrasonic transducer to detect rail breaks. This was the beginning of an innovation journey and partnership between these institutions, leading to a ground-breaking Ultrasonic Broken Rail Detection (UBRD) system.

The UBRD is a solution that is able to detect rail breaks remotely and in real-time, a significant improvement over manual inspection techniques. The system works by sending and receiving low-frequency ultrasound along the rails and, through signal processing techniques, reliably detecting rail breaks as they occur, and wirelessly alerting a control centre.

IMT Chief Design Engineer for the UBRD, Francois Burger, says, "The IMT and the CSIR worked well together as a team over many years, starting in 1998, to achieve the current status, which is a field-trialled and tested UBRD system that has proven itself on Transnet's Orex line by having already detected a number of rail breaks. These breaks would most likely have resulted in costly derailments."

"The value of our collaboration lies in supporting an existing industry, developing human capital, and making an impact by saving lives and resources," says Burger.

"This is a good relationship in that we have complementary skills, and we value one another's skills," says Dr Philip Loveday, the project leader at the CSIR.

In 2013, the National Science and Technology Forum, in partnership with BHP Billiton, awarded the CSIR and the IMT for outstanding contributions to science, engineering, technology and innovation for work done on the URBD system.

The collaboration has also drawn international attention. The Indian Railways company is in talks with Armscor, seeking ways to roll out this technology on the Indian continent.

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Ultrasonic Broken Rail Detection Systems are extensively tested.

An Ultrasonic Broken Rail Detection System transducer undergoing lab testing.

Full manufacturing and inspection procedures, here undertaken by Gail Marrian, are developed at the CSIR prior to technology transfer to a licensee.

Studying the correlation between road quality and damage to fresh produce during transportation

Top-notch road infrastructure helps ensure that fresh produce makes it to markets while still fresh. In a research collaboration to improve the quality of fresh tomatoes in California in the USA, the CSIR, the universities of Pretoria (UP) and California, Davis (UC Davis), teamed up to identify factors that render fruits susceptible to injury during transportation.

Studies conducted by the CSIR and partners have shown that there is a correlation between road quality and damage to fresh produce during transportation from the farms to the marketplace.

IN A PILOT STUDY in California, researchers from the CSIR, UP and UC Davis evaluated the effects of riding quality on low-volume roads when transporting tomatoes from farms to processing plants.

In addition to the field evaluation, laboratory tests were conducted under the leadership of Prof Wynand Steyn, head of the civil engineering department at UP, to replicate the dominant vibrations of the trucks, and to measure the stresses that tomatoes typically undergo at these vibration levels, and their associated deterioration.

The damage and failure levels of the tomatoes during transportation were determined, and these damage levels were used to calculate typical costs to the agricultural suppliers due to road conditions.

CSIR project leader and engineer, Louw du Plessis, says that in this pilot study it was demonstrated that an important interaction exists between pavement roughness, vehicle behaviour, freight damage and logistics considerations.

"We also demonstrated that pavement maintenance activities potentially affect freight operations and logistics," he notes.

On the logistics side, the CSIR contributed to an investigation on how California road infrastructure and regulations affected the daily supply chain management practices within specific economic sectors.

Du Plessis says that the partners have developed a sound working relationship and that they hope to continue to jointly study aspects of the correlation between the quality of roads and damage to fresh produce during transportation.

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Tomato grading after transportation.

CSIR AND PARTNERS STEP UP SPATIAL AND TEMPORAL EVIDENCE FOR PLANNING IN SOUTH AFRICA

A CSIR-led multi-stakeholder research and development initiative is developing evidence and capabilities to profile and simulate the spatial implications of growth and development in cities, towns and regions in South Africa.

THE SPATIAL AND TEMPORAL Evidence for Planning in South Africa (stepSA) initiative has its origin in research and development collaboration between the CSIR, the Department of Science and Technology (DST) and the Human Sciences Research Council (HSRC). Since its inception in 2008, the initiative has made major breakthroughs in identifying regional interactions between urban and rural South Africa and modelling the spatial implications of urban growth.

CSIR stepSA project leader, Elsona van Huyssteen, says the project has evolved into a multi-stakeholder initiative that works with municipalities and policy makers to conduct and disseminate research on population movement as well as trends and the possible implications thereof for service delivery, housing and infrastructure investment in fast-growing cities and towns.

"The initiative laid the foundation for the establishment of a new modelling centre by the Gauteng Department of Transport, aimed at more effective infrastructure investment. The innovative urban simulation capability will enable integrated demand projections as well as transportation and land-use modelling between the three metropolitan municipalities and seven municipalities in the province," she says.

Valuable and widely used outputs have been developed through stepSA with collaborators such as the National Planning Commission, South African Cities Network, the Department of Co-operative Governance, The Department of Rural Development and Land Reform, as well as various metropolitan, district and local municipalities.

Through collaboration with government, stepSA has been producing a growing set of innovative and highly relevant spatial indicators and profiles. The Department of Rural Development and Land Reform successfully used the fine-scale population distribution indicators to profile growth nodes in distressed and growing rural regions to support government and municipalities in prioritising catalytic infrastructure investment projects in South Africa's priority rural districts.

Van Huyssteen says, "Research provides evidence of the increasingly important role that towns and cities play in South Africa's development trajectory, with evidence of more than 80% of the South African population already concentrated in cities, towns and rural settlements. In partnership with the South African Cities Network (SACN), the CSIR team has used temporally aligned spatial indicators to track spatial change in the country's biggest cities. The findings highlight challenges associated with spatial transformation, higher numbers of young South Africans and increased poverty in cities.

Profiling the growth of the 115 medium to large towns and more than 500 small towns in South Africa forms a key building block for collaborating with the South African Local Government Association to support municipalities in strategy development for town regeneration, service provision and economic development.

The CSIR has played a major role in developing innovative technologies to support decision-makers to understand the implications of projected urban and town growth as well as planned housing and transport investments. Within growing city regions this enables smart urban governance and investment choices that can support better access for poor households to job opportunities and social services.

The role of the HSRC in the partnership primarily focuses

Partners in the stepSA initiative at the SA Science Forum's Urban Science discussion are, from left, Johan Maritz, CSIR; Catherine Cross, HSRC; Ivan Turok, HSRC; Elsona van Huyssteen, CSIR; and Pravesh Debba, CSIR.

on research exploring policy implications of changing settlement and population dynamics, urban-rural interactions with a specific focus on migration, the labour market and location choices of the youth and urban poor.

The DST has played a lead role in the conceptualisation and funding of the original initiative, and is still involved as a key partner in driving priority research and development components to support government in targeting high-impact investment.

Van Huyssteen says, "The stepSA collaborative initiative has over the years proven itself to be much more than the presentation of improved and systematic evidence on the spatial implications of town and city growth. It is in the context of ongoing collaboration in policy workshops and discussions, as well as in specific projects with municipalities, that such evidence adds significant value to support decision-making."

SACN Executive Manager: Programmes, Dr Geci Karuri-Sebina, says the value of stepSA collaboration is aptly illustrated in the 2016 State of Cities Report and government's Integrated Urban Development Framework development processes, in which evidence regarding city and town growth, migration and urbanisation patterns helped to inform decision-makers, parliamentary committees, and Cabinet about the need for government-wide coordination to acknowledge and better manage urbanisation realities across South Africa.

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AEROSPACE PARTNERSHIPS TAKE OFF

In 2015, the CSIR signed agreements with three European organisations, Airbus DS GmbH (Airbus DS), Surrey Satellite Technology Limited (SSTL) and the Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR – the German aerospace organisation), to promote cooperative research and development. The focus of the joint research ranges from aeronautics, space, energy, light metals, transport and mobility, to military aircraft, space systems, electronics and communications, intelligence and security.

THE CSIR'S TRACK RECORD of over 70 years and its past successes in aerospace ideally positions it for research, development and innovation in aerospace. CSIR key account manager for aerospace Marié Botha wears a second hat, that of Manager of the Aerospace Industry Support Initiative (AISI), a Department of Trade and Industry initiative at the CSIR. She plays a critical coordination role as the CSIR expands its involvement in the aerospace industry, and nurtures its relationships with key local and international partners.

"The CSIR, as a contributor to the National System of Innovation (NSI), and in terms of its mandate, undertakes industrial and scientific development in areas that it deems important, ensuring co-operation with public and private sectors. In this specific area, the CSIR is coordinating a South African offering to Airbus Defence and Space, aligning and coordinating priority areas of South African entities for national benefit. The CSIR aims to utilise the strengths of the NSI to leverage international market opportunities."

The CSIR and Airbus DS signed a research collaboration framework agreement in Berlin, Germany, in August 2015. This agreement heralded the start of a formal relationship between Airbus DS, SSL and the CSIR. The organisations now have the opportunity to expand their knowledge and expertise through cooperative activities.

"Subsequent engagements include a visit by the Airbus DS team to the CSIR in October 2015 to participate at the CSIR Conference. A workshop between Airbus DS and the CSIR to explore and define collaborative research and development activities relating to the International Space Station sloshing experiment was held at the CSIR in February 2016.

CSIR Group Executive Strategic Alliances and Communication, Dr Rachel Chikwamba, centre, flanked by the Airbus Defence and Space delegation in Bremen, Germany, from left, Airbus representatives Guido Schwartz, Cora Schumacher, Matthias Holzwart, Andreas Schuette and Magdalene Rossmann and, right, Ludger Froebel, Manfred Jaumann, Marié Botha and Dr Kaven Naidoo of the CSIR; and Joachim Schneegans of Airbus.

This followed the success of the fuel sloshing experiment carried out by Denel Aerostructures, the CSIR and the University of Pretoria, which is supported by the AISI. Sloshing is defined as the movement of liquid inside another moving object. It is an important aspect of aerospace fuel tank design. Botha says, "The CSIR has been appointed as the design authority on this joint international project, a feather in our cap. It bodes well for the future of this relationship."

The CSIR and DLR signed a Memorandum of Understanding framework for cooperation in the areas of aeronautics, space, energy, light metals, transport and mobility, in Cologne, Germany, in August 2015.

In addition to the commitment to areas specified for joint research, the DLR and the CSIR are exploring, promoting and developing their cooperation through visits by, and interchange of, PhD students, researchers and other staff.

Key to the future success of these relationships is the utilisation of world-class capabilities at the CSIR. These include aerospace systems, radar and electronic warfare, sensor science and technology, and laser materials processing.

"The CSIR's expertise covers aerospace and space applications," Botha explains. "The CSIR is strong in this field and our expertise is recognised locally and internationally."

"For Airbus Defence and Space, the CSIR is the centre of excellence for aerospace research in South Africa. We are looking forward to investigating numerous opportunities of mutual interest, one of them being the investigation of sloshing on board the ISS," says Jan van Toor, Airbus Defence and Space: Vice President and Head of Disruptive Innovation.

Guido Schwartz, Senior Innovation and Business Development Manager of Airbus Defence & Space; Marié Botha, CSIR key account manager: aerospace; Dr Rachel Chikwamba, CSIR Group Executive: Strategic Alliances and Communication; Jan Van Toor, Vice President and Head of Disruptive Innovation of Airbus Defence and Space; and Laurens Cloete, CSIR Group Executive: Operations.

The CSIR's unique infrastructure is made available to industry through the facilitating role of the AISI, thereby allowing industry to improve its competitiveness and offerings.

Botha views the role of the CSIR as pivotal in ensuring that strong partnerships between government, industry, academia and science councils are maintained. "The CSIR plays an essential role in ensuring that strategic guidance from government and insight from the manufacturing sector is made available to the benefit of the entire aerospace industry," she says.

"Our partnerships are extremely important," Botha concludes. "It is only by working together both here at the CSIR and in South Africa, that we are able to realise our potential to create a globally competitive aerospace industry."

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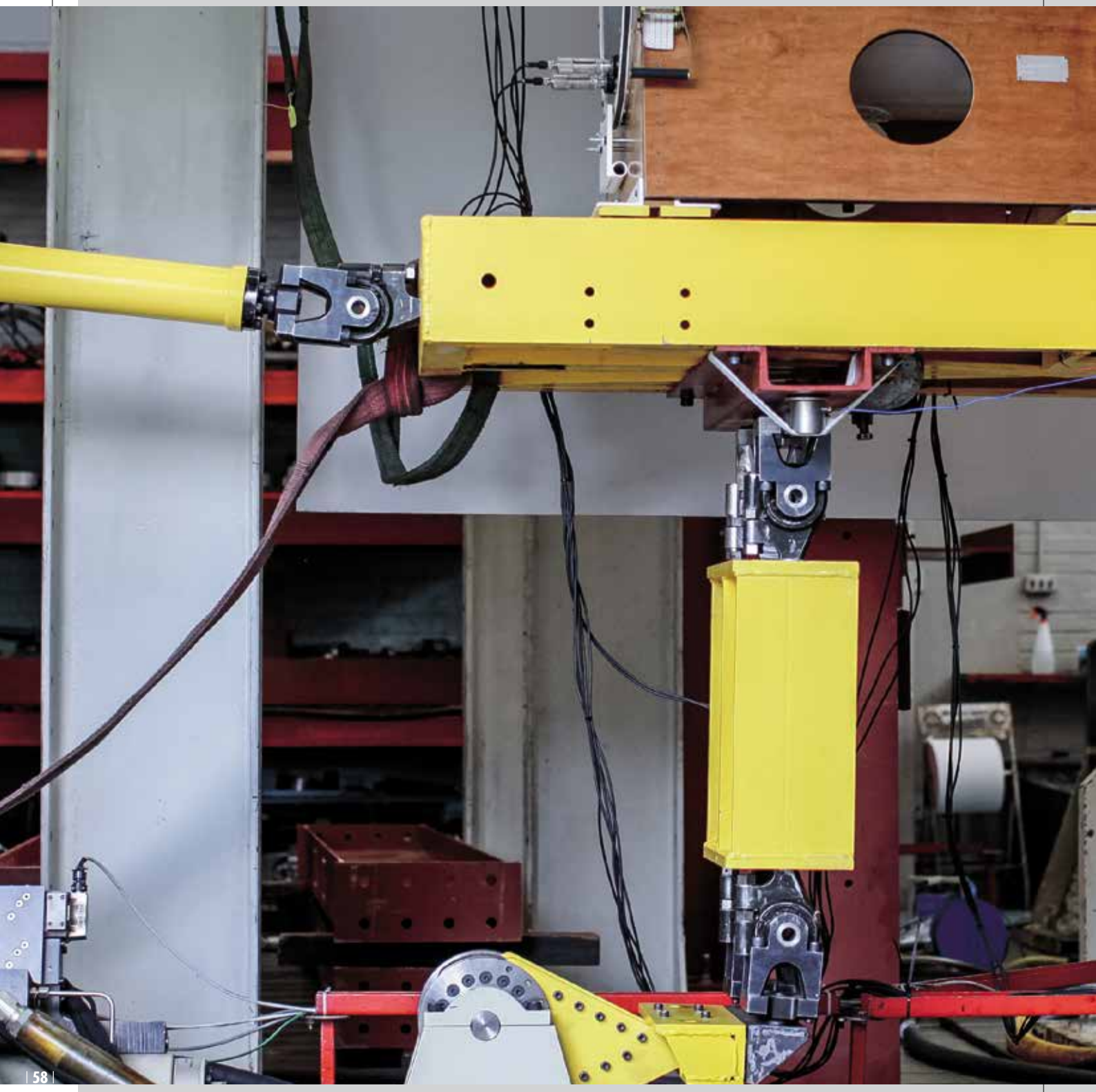

Denel Aerostructures, the CSIR and the University of Pretoria aim to establish a specialised local capability to analyse the loads of aerospace fuel tank structures. The load and movement of fuel can threaten the dynamic stability of aircraft and is therefore a crucial safety consideration. The project encompasses an extensive range of large-scale laboratory tests on realistic fuel tanks as well as the numerical simulation of the experiments for validation of the laboratory results.

THE CSIR AND DENEL
A long-standing collaboration

The CSIR has been collaborating with Denel, South Africa's state-owned aerospace and defence technology company, for decades, as it did with the companies that preceded Denel. New prospects for collaboration include work on non-defence projects such as the development of a concept for a local passenger and cargo aircraft.

FOCUSING ON THE DEFENCE ARENA, the CSIR has in the past contributed expertise to support various Denel projects, including the development of the Rooivalk attack helicopter and technology related to it, as well as various missile projects. The Rooivalk project began in early 1984 under the auspices of the Atlas Aircraft Corporation, a predecessor of Denel Aviation.

The South African Air Force has been deploying these helicopters on peace keeping missions since 2011. One of the CSIR's contributions includes the development of infrared heat suppressors that were fitted on the exhausts. This airframe modification protects the aircraft in an infrared threat situation by making it more difficult to detect.

Decades of work on the Rooivalk resulted in the export of various systems that were developed for the helicopter as well as the establishment of a strong skills and technological capability in South Africa. The CSIR and Denel have the expertise to contribute to the development of a Rooivalk Mk2, should such a project get the green light in future.

Denel has a five-decade history of aircraft development and innovation. After these technological successes, Denel identified future aircraft development opportunities that can be unlocked with its national design capability.

"Our partnership with the CSIR is vital to remain in touch with technology evolutions and to drive innovation in the local aerospace industry," says Theo Kleynhans, CEO of Denel Aerostructures.

The CSIR and Denel are also well-positioned to expand their involvement to projects in the non-defence arena, for example the development of Denel's Small African Regional Aircraft (SARA), a concept for a locally designed regional passenger and cargo aircraft.

"Such an aircraft could fly between regional centres, such as Umtata and Polokwane, reducing travel times significantly, bypassing current hubs like Johannesburg, Cape Town and Durban, and helping to unlock the economic potential of these towns. An independent feasibility study indicates that there is a market for this aircraft in Africa," says Reshen Nair, the CSIR's key account manager: Denel.

> Our partnership with the CSIR is vital to remain in touch with technology evolutions and to drive innovation in the local aerospace industry.
>
> Theo Kleynhans, CEO of Denel Aerostructures.

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Dutch-South African collaboration on diesel emissions in mines

The Netherlands Organisation for Applied Scientific Research – The Toegepast Natuurwetenschappelijk Onderzoek (TNO) – and the CSIR are renewing their partnership in the study of diesel emissions and diesel particulate matter in South African mines. Both pose serious health risks to mine employees in the South African mining industry.

Cecilia Pretorius of the CSIR's air and dust laboratory, confirms, "A baseline study was completed and methodologies for testing are being developed." The CSIR will work in partnership with TNO on this project funded by the Mine Health and Safety Council.

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A demonstration at the Kloppersbos research and development facility, where full-scale surface tests for fires and explosions are undertaken to help ensure safe working conditions for South African industries at risk of such events. The facility is managed by the departments of Mineral Resources and Public Works.

CSIR leads the development of a national mining research and development strategy

The CSIR, in collaboration with various government departments, universities and state-owned entities, led the development of a consolidated national mining research and development (R&D) strategy that focuses on extraction. The strategy – the South African Mining Extraction Research, Development and Innovation Strategy – was adopted as the baseline document for the Mining Phakisa discussions, which in turn contributed to developments around the establishment of a mining research and development hub.

THE CSIR HAD BEEN TASKED by the Department of Mineral Resources (DMR) to take the lead in developing a consolidated strategy to rebuild mining R&D capacity and provide solutions to current urgent sectoral problems. It followed earlier stakeholder discussions, led by the Deputy Minister of Mineral Resources, Mr Godfrey Oliphant, during which the necessity was expressed for a single, consolidated strategy.

Oliphant said, "The well-being of the people of our country is dependent on our mineral resources and the extractive industries are key to future prosperity."

The vision of the consolidated strategy is to maximise the returns of South Africa's mineral wealth through collaborative, sustainable research, development, innovation and implementation of mining technologies in a manner that is rooted in the well-being of local communities, the environment and the national economy.

"The strategy aims to modernise the mining sector, with resulting improved productivity as well as occupational health and safety, while minimising the impact on the environment and a constant focus on the socio-economic externalities," says Navin Singh, CSIR manager for mining and mineral resources and author of the strategy.

Prof May Hermanus, CSIR Executive Director for Natural Resources and the Environment, says, "We have to start focusing on new technologies across the value chain and strengthen our research environment to support technical, environmental and social innovation."

Mining and Operation Phakisa

The need to revitalise the mining sector was a strong focus of the Mining Phakisa, given the difficulties facing the sector, such as depressed commodity prices, increased costs and the call for improved health and safety in mines. There is a need to change the processes, technologies, skillsets and social and environmental impacts associated with current mining practices.

Mining R&D hub

Modernisation of mines via mechanisation and automation, and ultimately, fully autonomous operations, is the envisaged path that will bring change to processes, technologies, skill sets and social and environmental impacts associated with current mining practices.

The CSIR, via the Department of Science and Technology, has since been appointed to lead the establishment of a mining research and development hub. The function of the hub is to coordinate research activities toward the revitalisation of mining for South Africa's mining operations through the development of next-generation mechanised mining systems. The Department of Science and Technology intends to fund the Johannesburg-based facility and make space available at no cost to participants of the mining hub. The hub will host researchers and mining staff from 44 organisations including the Chamber of Mines, Anglo Platinum and Wits University. The facility will also be made available for technology demonstrations on site.

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Deputy Minister of Mineral Resources, Mr Godfrey Oliphant, is greeted by CSIR Group Executive: Research and Development, Dr Molefi Motuku, at a stakeholder workshop.

CSIR Executive Director: Natural Resources and the Environment, Prof May Hermanus, greets officials from the Department of Mineral Resources at a workshop at the CSIR.

Microbes from the Agricultural Research Centre in Egypt and the CSIR are used to inoculate the compost.

CSIR and eThekwini Municipality explore the valorisation of biowaste

The CSIR and the eThekwini Municipality collaborated in a pilot project in which compost was successfully generated from municipal biowaste.

BIOWASTE COLLECTED through the eThekwini municipality's garbage collection service was identified and characterised by the CSIR to potentially generate products such as biogas, lactic acid and amino acids. The pilot project successfully generated compost from biowaste. Biowaste is a form of biomass – it is waste material capable of decomposing under anaerobic or aerobic conditions.

The collaboration between the CSIR and eThekwini is part of a broader European Union collaboration initiative, called Biowaste4SP, which aims to develop environmentally appropriate and socio-economically feasible technologies for conversion of biowaste in developing countries.

"The first phase of the project, concluded in October 2015, saw the production of compost-derived fertilisers from two tonnes of sugarcane bagasse and vegetable waste," says Neville Tawona, University of KwaZulu-Natal PhD student, supervised by CSIR researcher, Prof Bruce Sithole.

"The CSIR's contribution was to identify and characterise biowaste collected within the municipality and some parts of the country," says Tawona. The biofertiliser was produced using different strains of microorganism. It was then supplied to farmers within the eTthekwini municipality.

"Food security is important for the country and the municipality," says John Parkin, eThekwini Municipality solid waste deputy head responsible for engineering, "If we can improve the quality of the soil, the quality of vegetables will also improve."

A key focus of Biowaste4SP is to pinpoint and use the right technology for the most significant raw materials identified in each of the participating five African countries: Ghana, Egypt, Kenya, Morocco and South Africa. The objective is to generate bioethanol, biogas, biofertiliser, lactic acid, protein and amino acids from biowaste.

"These products can substitute fossil-based chemicals and energy products and turn a waste problem into a wide range of valuable products," says Tawona.

"Food security is important for the country and the municipality. If we can improve the quality of the soil, the quality of vegetables will also improve."

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Integrating the informal waste sector into municipal waste management

The Department of Environmental Affairs (DEA), in partnership with the Coca Cola Company and its bottler, Amalgamated Beverage Industries (ABI), and the CSIR aim to bring solutions to the waste sector by integrating informal waste cooperatives into the municipal waste management system.

A PARTNERSHIP LED BY

DEA provided recommendations on how to integrate the informal waste sector and small, medium and micro enterprises (SMMEs) into municipal solid waste management in South Africa. The CSIR's role was to provide research and development insight on waste management challenges. ABI, through its commitment to sustainable development, conducted a study to establish best-practice business development support with the objective of increasing the number of SMMEs in the waste sector.

"South Africa has a high unemployment rate. To add to this, some 60% of the unemployed have a qualification lower than grade 12 (StatsSA 2012). The waste sector can support low-skilled workers and it can also create opportunities to deal with waste as a secondary resource, for example through recycling and manufacturing," says CSIR principal scientist Prof Linda Godfrey.

"The informal sector has been active in the South African waste economy for more than two decades and plays an important role in diverting recyclables away from landfill towards recycling. However, in most cities and towns in South Africa, the sector is marginalised and operates at the fringe of municipal solid waste management systems," she says.

Some of the major challenges highlighted in the sector include a lack of infrastructure, specifically transport, equipment and premises to keep collected waste, as well as a lack of capacity in terms of training, knowledge and skill.

Despite these challenges, Mamosa Africa, Director in General Waste at the DEA, says that there is significant value locked in waste that can be derived from the work of waste pickers.

Godfrey says cooperatives require long-term support and investment from all relevant role-players in the sector.

Elizabeth Thabethe, Deputy Minister of Small Business Development, says, "It is good to have these types of collaborations, taking into consideration South Africa's high unemployment rate. The Department of Small Business Development believes that small business can address this bleak situation."

An African-European research and innovation partnership to address waste management

Combined research from Europe and Africa will advance research, development and innovation (RDI) for waste management on both continents.

By Reyhana Mahomed

AS PART OF AN INTERNATIONAL working group supported by the European Commission and the African Union, the CSIR has contributed to a Joint European and African Research and Innovation Agenda on waste management, which provides a platform for addressing waste management practices on the partner continents.
The partnership identified two thematic areas for cooperation: Recycling and the recovery of raw materials from solid waste.

While the partnership acknowledges that individual European and African countries may have their own waste research and innovation agendas, roadmaps and research priorities, Prof Linda Godfrey, CSIR principal researcher and manager of the Waste RDI Roadmap Portfolio Management Unit, says, "The intention of this partnership is to support existing agendas and find synergies for research and innovation between the continents, building on existing mechanisms and structures in individual countries." Godfrey was part of the development of the partnership and co-editor of the strategy.

"Europe has the know-how, technology and legislative experience that could be of value to African countries as they build up their recycling structures, frameworks and value chains," says Reinhard Bütikofer, member of the European Parliament, in his foreword to the strategy.

By leveraging institutional, technical and financial resources to strengthen waste-related research and innovation capabilities on the continents, the partners hope to unlock the social, environmental and economic potential of waste to grow the African and European secondary resources economies.

"The African-European research and innovation partnership provides the foundation for proactively and strategically strengthening science and technology partnerships between South Africa and the European Union, as well as its member states, and between South Africa and other African countries. This is something we have identified as being crucial as we implement South Africa's 10-Year Waste (RDI) Roadmap," says Godfrey.

The CSIR's Prof Linda Godfrey engaging with partners at an African Union-European Union workshop.

Participants of the Joint European and African Research and Innovation Agenda on waste management.

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AGRI-PARKS:
Providing comprehensive agri-business services for emerging and established farmers

Smallholder farmers in South Africa require a range of agri-services. The Agri-Park Initiative featured prominently in the State of the Nation Address of 2014 and 2015 and has the potential to provide enhanced access to these services.

UNDER THE UMBRELLA of its Memorandum of Agreement with the CSIR, the Department of Rural Development and Land Reform (DRDLR) worked with the CSIR, the World Bank, provinces and district municipalities on the design and planning of the Agri-Parks initiatives. Joint workshops and review sessions led to the development of decision tools to aid effective deployment of agri-services, human resources, equipment and infrastructure in targeted districts.

A gap exists between the local, rural needs of emerging farmers for agri-services – specifically agri-business services – and the extent to which these services are currently provided for by the departments of Rural Development and Land Reform, Agriculture, Forestry and Fisheries, as well as business support and development agencies such as the Small Enterprise Development Agency.

The CSIR was tasked to review and enhance the initial Agri-Park model and thinking. The organisation provided guidance and decision-support tools from the initial inception of the Agri-Park initiative in a specific district to initial construction and implementation.

"The benefits of using a guide-pack to support a common national approach are significant," says Clinton Heimann, Chief Director Rural Infrastructure Development Service Delivery Co-Ordination. "This means that agri-parks can be effectively planned by the DRDLR in districts throughout South Africa with relative ease."

The CSIR interrogated the establishment and support process required at district municipality level in detail, and recommended two types of decision-support tools: spatial data-based tools and value chain-based tools. Spatial data tools identify geographic location of features and boundaries whereas value chain tools explore the relationships between the pre-production, production, processing and marketing activities of agricultural commodities.

"These tools are essential to enable municipalities to arrive at sustainable business models and plans, which are aligned to national guidelines and initiatives," says Rensie van Rensburg, CSIR Initiative Manager for rural enterprise and economic development.

The CSIR also organised review sessions with two district municipalities, Vhembe in Limpopo and Namakwa in the Northern Cape, to test the agri-park development process with the decision-support tools produced by the CSIR. The outputs of the Namakwa review session led to an initial business plan framework for the Namakwa Agri-Park.

The CSIR is using these guidelines to develop business plans for agri-parks in the following eight district municipalities: Fezile Dabi and Lejweleputswa in the Free State; Amajuba, uMgungu Ndlovu, uMzinyathi and uThungulu in KwaZulu-Natal; and Alfred Nzo and Chris Hani in the Eastern Cape.

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Rensie van Rensburg (right) with the team of Infopreneurs® from the Vhembe district who are in the process of implementing components of the Vhembe District Agri-Park. They are, from left, Braam Cronje, Pinkie Maingo, Shumane Tshamano, Robert Tshikwama, Phophi Marageni and Joel Malitsha.

Improving water resource management in Richards Bay through scientific and technological collaboration

The deteriorating quality of raw water in South Africa, coupled with current water shortages, has created a need to protect the country's water resources and ensure effective water and wastewater management. The CSIR and the City of uMhlathuze (CoU) have partnered to improve water resource management across the city's jurisdiction through the application of scientific and technological solutions.

Real-time data presented by the water quality monitoring system dashboard enable the city to make informed decisions for improved wastewater management.

THE PARTNERSHIP BETWEEN the CSIR and the municipality is viewed as a valuable approach to addressing water-related service delivery issues. "The municipality welcomed the opportunity to partner with a public sector institution with a sound reputation. The bilateral agreement has afforded the council the opportunity to unlock possibilities with a fellow public sector partner committed to improve the lives of the people through the use of science, engineering and technology," says Neeran Maharaj from the CoU.

Projects undertaken were aimed at identifying and addressing issues relating to various aspects of water provision and management. The primary issues pertained to improving natural resource management whereby the municipality enforced pollution prevention, water resource protection and rehabilitation measures as recommended by the CSIR. For instance, the CSIR developed a lake management plan for Lake Mzingazi as well as a rehabilitation plan for a compromised stream within the municipality.

Secondary-level issues in the city include ageing and insufficient infrastructure. Breakdown of equipment at treatment plants in the city has led to poor water quality and increased treatment costs. Furthermore, leakages in water pipelines resulted in water shortages and unnecessary wastage.

By assessing treatment works and developing better bulk sewer and bulk water master plans, the CSIR has contributed to the improvement of water and wastewater reticulation and management. The use of a CSIR-manufactured water quality monitoring system has helped the city to effectively manage water quality levels (in real-time) at both water and wastewater treatment plants.

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On-site calibration of a water quality monitoring system unit at a wastewater treatment plant in the City of uMhlathuze.

The CSIR and its counterpart in Botswana collaborate on dynamic spectrum access

By Bandile Sikwane

The CSIR and the Botswana Institute for Technology Research and Innovation (BITRI) are collaborating on dynamic spectrum access, a new approach to managing spectrum. The two organisations have participated in numerous workshops to share knowledge and build capacity in dynamic spectrum and broadband access. The capacity-building workshop organised by the CSIR in Botswana was attended by the University of Botswana, the Botswana International University of Science and Technology, Botswana Fibre Networks and the Botswana Regulatory Authority.

A CSIR-developed white spaces spectrum database can efficiently allocate usable spectrum. The television white spaces can then be used without interfering in any way with adjacent primary licensed services.

Agreeing to collaborate on dynamic spectrum access are, from left (back), Kagiso Keatimilwe, CSIR; Sikhonzile Sikhosana, DST; Nakale Kelapile, BITRI; Moshe Masonta, CSIR; Dr Fisseha Mekuria, CSIR; Dr Ephraim Gower, BITRI; Moses Tsalaile, BITRI; and Dr Aubrey Mokotedi, BITRI. From left (middle) are Dr Ntsibane Ntlatlapa, CSIR; and Kagiso Chikane, CSIR. From left (front) are Dr Quentin Williams, CSIR; and Prof Thato Tsalaile, BITRI.

A valuable and finite resource

Spectrum is the medium over which all wireless communications devices (televisions, mobile phones, tablets, radios, micro-phones and more) communicate. It is also vital for a wide variety of other devices, technologies and industries that are critical to the economic wellbeing of countries. It is a finite resource.

Innovative techniques like dynamic spectrum access make it possible to efficiently allocate usable specrum. Currently, spectrum management uses what is referred to as a static licensing regime, meaning that spectrum is licensed for a fixed period to a primary user. Often, the users – for one reason or the other – cannot use the entire spectrum allocated to them. This leads to tracks of unused, but licensed spectrum. Dynamic spectrum access proposes that this available spectrum be shared either by accommodating different types of uses or by accommodating multiple user groups.

Current research on the dynamic spectrum access has focused on the unused spectrum between television channels. Television broadcasters leave 'white spaces' to avoid interference in adjacent channels. The CSIR has experience in building networks using these TV Whites Spaces (TVWS), without interfering in any way with adjacent primary licensed services. This allows for different types of uses in the same band – one for television broadcasting and the other for communication networks.

This harmonious co-existence is made possible through a technology called 'white spaces spectrum database'. The database carries out the appropriate calculations and authorises the white space devices to operate on specific channels. This is a fully automatic process, which ensures that no interference is caused by the white space device to any television broadcasting. Thus spectrum is assigned dynamically and automatically, as needed.

Dynamic spectrum access research in Botswana

BITRI is collaborating with the CSIR in building its own TVWS experimental network as well as building an instance of a white spaces spectrum database to harness its national spectrum resources. The CSIR team had been approached to assist in the design and deployment of the Botswana TVWS network test-bed. It is this network that will be used by the two entities for collaborative long-term research on dynamic spectrum access and sharing on the TV-band frequencies.

The joint BITRI and CSIR delegation will be scouting for sites in Gaborone, Botswana for the network infrastructure. Five schools and two clinics have been targeted as the TVWS trial sites for the research project.

"We have earmarked sites where there will be guaranteed usage of broadband. We have chosen schools because they are centres of innovation. They would also benefit from having high-speed internet connection, which aids e-learning. The research will also help formulate regulations and policies around TVWS utilisation," says BITRI's Dr Ephraim Gower.

Moshe Masonta, senior researcher at the CSIR, adds, "There is a high demand for spectrum below 5 GHz band, especially in developing countries, where there is a challenge to connect over one billion people."

"The CSIR brings its research experience and intellectual property in smart spectrum management to develop an instance of the CSIR spectrum database for TVWS network operation in Botswana," says chief researcher Dr Fisseha Mekuria.

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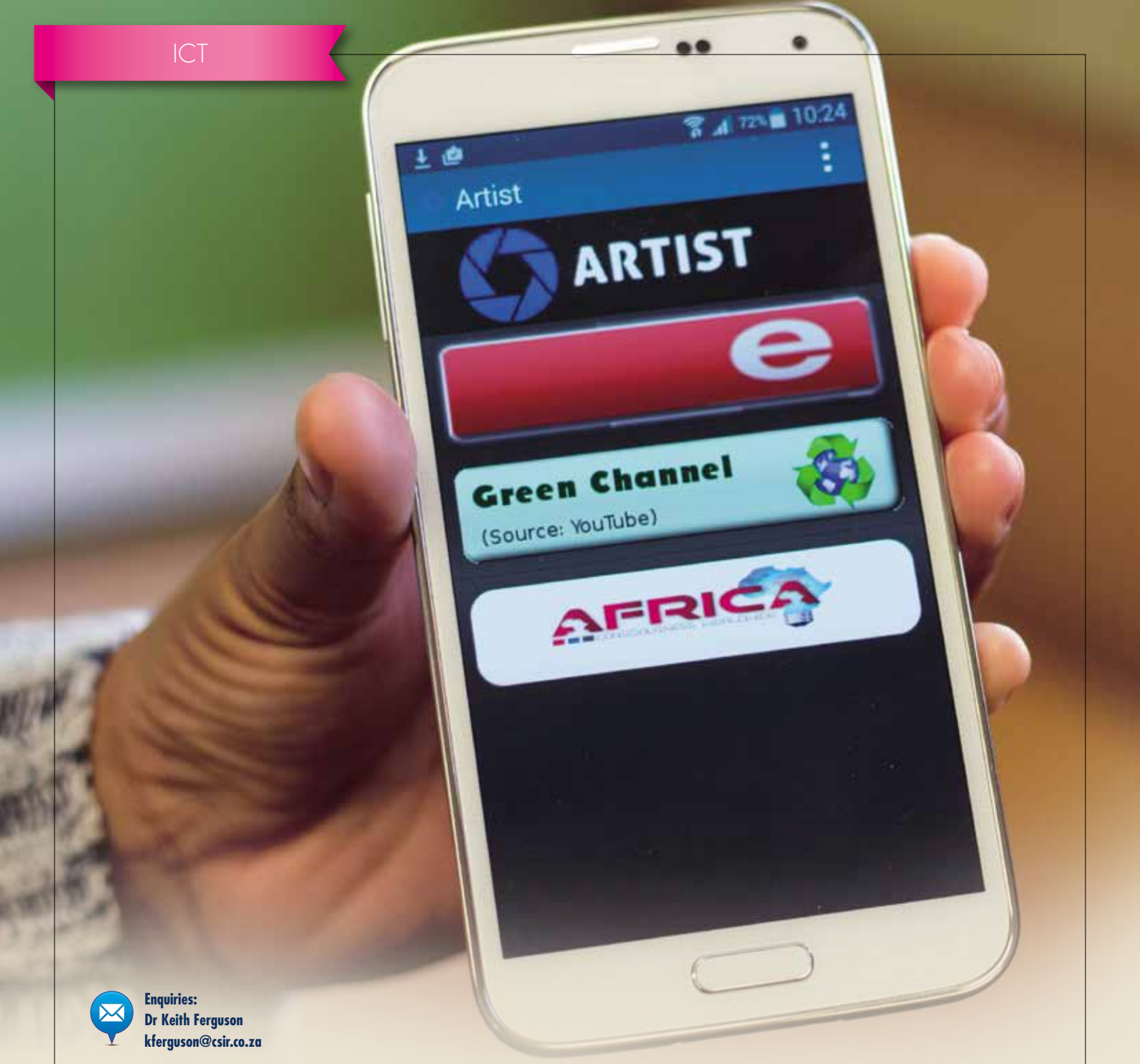

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CSIR technology equips young filmmakers to run mobile TV channels

By Ntombi Dyosop

The CSIR has partnered with the Big Fish School of Digital Film Making to include rural and urban youth in the formal digital economy through a technology platform that makes it possible for entrepreneurs to operate their own television stations using a mobile internet protocol television platform.

The CSIR's Dr Keith Ferguson and CEO of the Big Fish School of Filmmaking, Dr Melanie Chait.

THE COMMERCIAL TELEVISION INDUSTRY is dominated by large regional monopolies that own high-cost delivery mechanisms such as satellite and terrestrial TV and act as the only current gateway for content distribution. Film and television producers who wish to broadcast to their desired audiences have to sell their content to these industry players. They risk producing content at high cost and still be rejected. Another challenge is that despite several government and non-government initiatives to address film school graduate unemployment, significant numbers of media graduates have no outlet for their talent if they are not absorbed into such large media production houses.

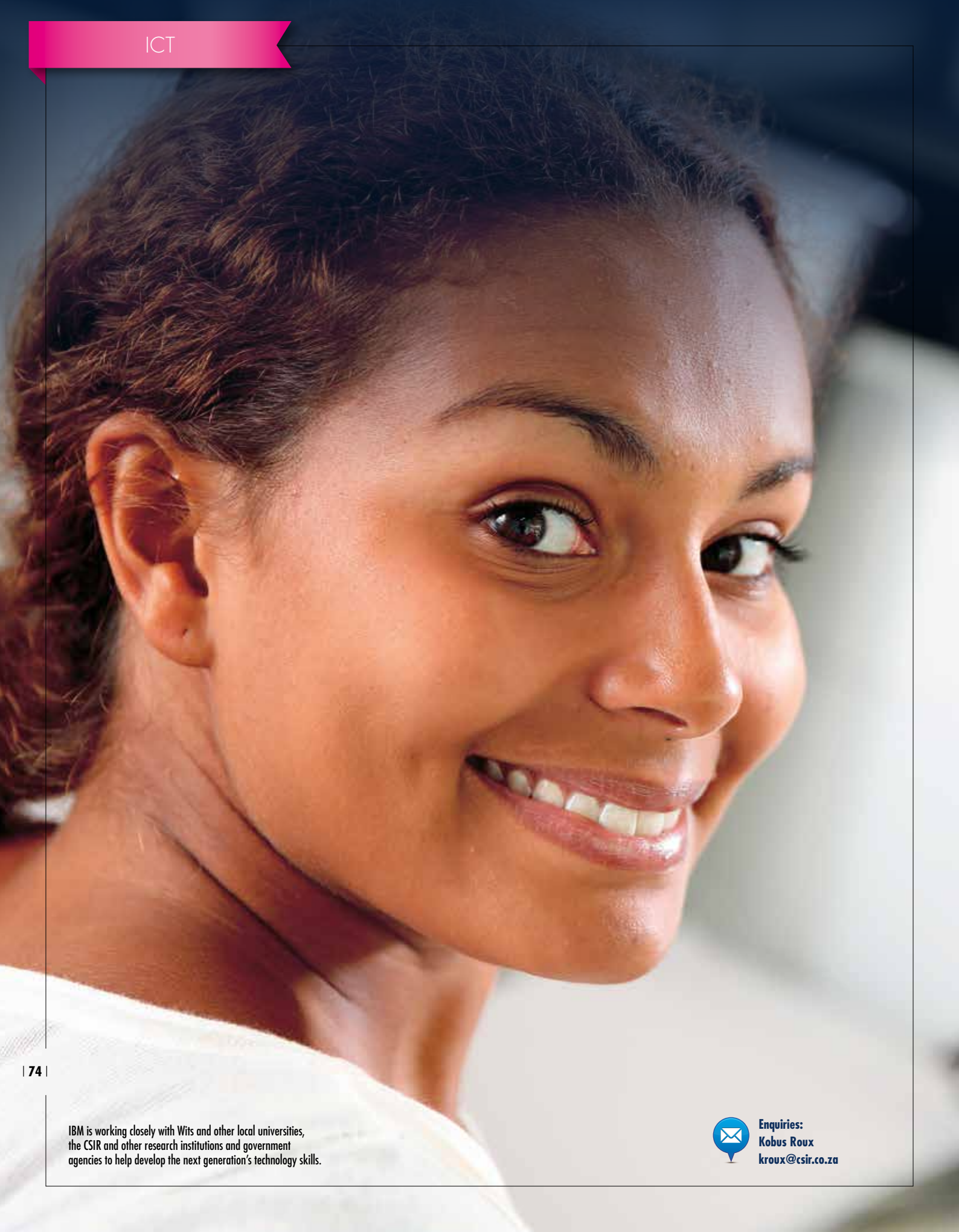
In an effort to mitigate these challenges, the CSIR is setting up a studio and full mobile internet broadcasting capability at the Big Fish School of Digital Film Making, under the guidance of experienced media training personnel. The partners will employ young people to develop several mobile internet protocol television platform youth channels. The objectives are for the youth to not only film the content but also to engage in the conceptualisation, planning, editing and scheduling, thereby managing the entire media production chain. Big Fish will run the educational operations of the project and the CSIR will implement the technology software development. Big Fish will also provide in-house employment opportunities for young people who graduate from recognised education institutions in South Africa such as universities, FET colleges and other training organisations. Only unemployed youth will be targeted for these roles.

"Who better to understand a young audience than the youth themselves? By expanding the video content production into the international arena, particularly across the African continent, we can all start to understand each other better," says Dr Keith Ferguson, the project leader at the CSIR.

"This project should not be considered a trial, but as seeding the actual implementation where the effectiveness will grow over the project period as the new software components are completed and come online," he says.

The introduction of new low-cost mobile internet protocol television technology will disrupt the traditional chain by bringing the media producers and their global audiences into direct contact and in so-doing, widen the scope for participation by micro-enterprises and individuals as micro-workers. "The new technology enables open access where the global delivery platform becomes a service to television producers and not a stranglehold," says Ferguson.

The CSIR team are Moipone Ramokone, Thierry Luhanjula, Dr Keith Ferguson, Siveshnee Moonsamy, Ralf Globisch, Tebogo Rens, Riette Pretorius and Louis Joubert.



IBM is working closely with Wits and other local universities, the CSIR and other research institutions and government agencies to help develop the next generation's technology skills.

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The CSIR partners with IBM, Wits and **the dti** to help develop the next generation's technology skills

By Bandile Sikwane

In 2015, IBM partnered with the CSIR and the University of the Witwatersrand (Wits) to establish an IBM research laboratory to accelerate skills development and innovation-based economic growth. The laboratory is located inside Braamfontein's new 3 000 m^2 software hub, Tshimologong Precinct – which is also the home of the Wits Joburg Centre for Software Engineering (JCSE).

OVER THE PAST YEAR, the three-way partnership between government, academia and industry has ensured progress in research on advancing big data, cloud computing and mobile technologies. IBM's South African researchers are working closely with Wits and other local universities, the CSIR and other research institutions, innovation centres, start-ups and government agencies to bolster South Africa's emerging innovation ecosystem as well as help develop the next generation's technology skills.

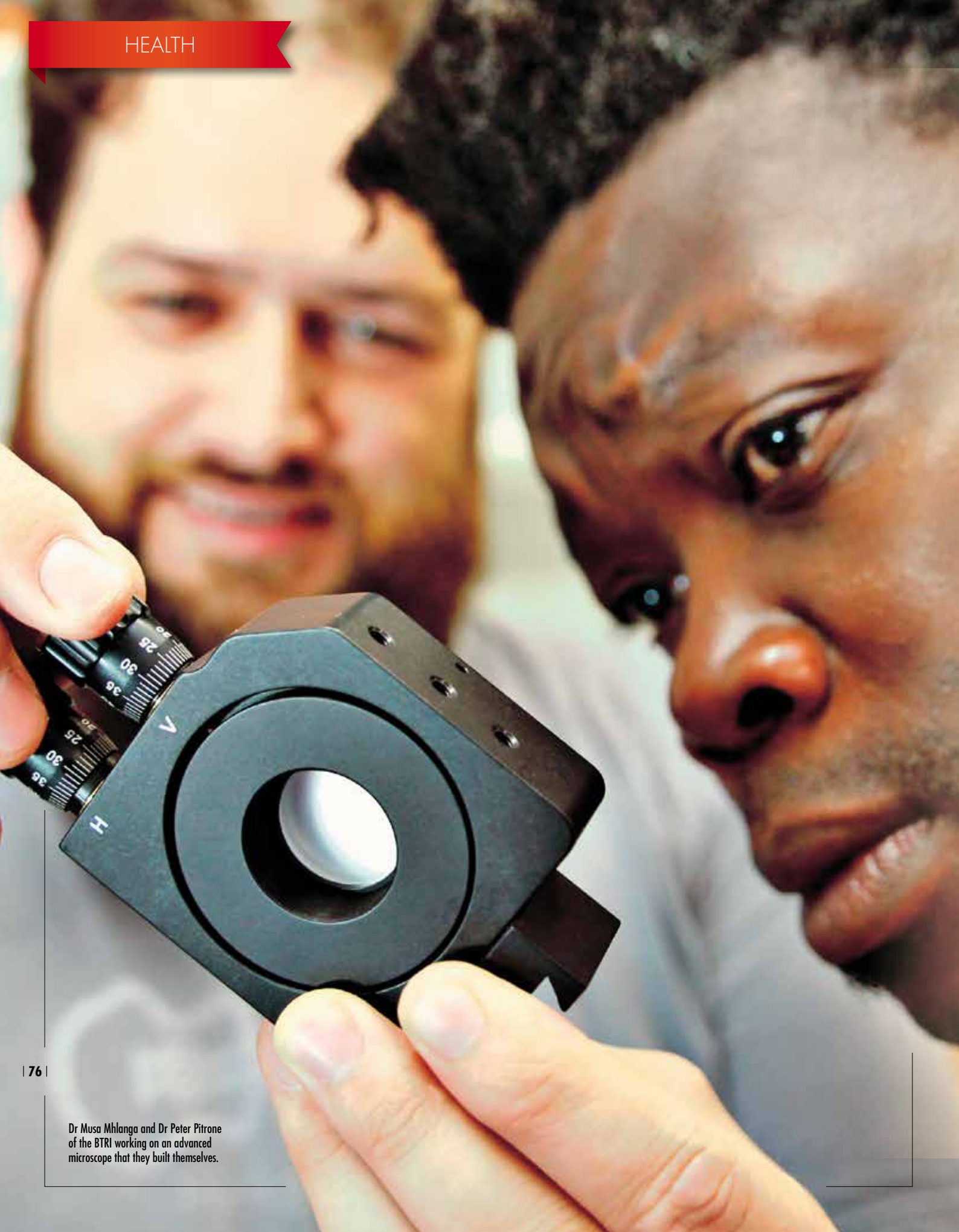
One example project is the collaboration between the city of Johannesburg, IBM and CSIR to apply advanced technologies to help the city deliver on its air quality management plan.

Under the 'Global Green Horizons' initiative of IBM and the CSIR, this partnership with the City of Johannesburg will leverage the 'Internet of Things' combined with the analytical power of cognitive computing to provide insights and recommended actions to improve air quality and better protect the health of Johannesburg citizens.

IBM already has twelve labs across the world, including one in Kenya. The South African lab forms part of a 10-year, R700-million Broad-Based Black Economic Empowerment (B-BBE) Equity Equivalent Investment Programme instituted by the Department of Trade (**the dti**). The Equity Equivalent Investment Programme requires all entities operating in the South African economy to make a contribution towards the objectives of B-BBEE.

These equity equivalents are expected to contribute towards the achievement of enterprise creation and development, foreign direct investment, accelerated growth and development of black rural women and youth, sustainable growth and development, human development with a focus on education and skills development, and infrastructure investment with emphasis on developing the country's research and development infrastructure.

The IBM investment includes sponsorship of an academic programme for under- and postgraduate students in disruptive technologies, a research programme, and an enterprise development programme.



Dr Musa Mhlanga and Dr Peter Pitrone of the BTRI working on an advanced microscope that they built themselves.

BATTLING CANCER WITH PRECISION MEDICINE

In an effort to improve the survival of cancer patients, the CSIR has teamed up with the University of Cape Town to understand the genetic mutations that characterise some cancers and use this to identify chemotherapeutic agents that will provide the best clinical outcomes.

CHEMOTHERAPEUTIC DRUGS are the heavy artillery in the fight against cancer, but they are still highly toxic to all rapidly-dividing cells in the body, leading to immune suppression, hair loss, and inflammation. According to the CSIR's Dr Musa Mhlanga, chemotherapy drugs vary in their ability to target specific cancer cells.

"That means most people need to have two or three rounds of chemotherapy, because the first round kills those cancer cells that are susceptible to the drug, but allows the others to escape," he says. "You actually establish a new set of stronger tumour cells that you have to target differently, and it increases the risk of the cancer spreading."

Traditionally, doctors have used cellular anatomy and molecular markers to choose between the many first-line chemotherapeutic drugs available to treat tumours. Now, genomic advances are making it possible to improve the survival rate of cancer patients by selecting the most efficacious drug.

New tools, new treatment options

"The tools of cell biology, such as imaging and stem cell biology, are making it possible to diagnose and identify treatment options for cancer. To make the most of these advances, the CSIR has teamed up with the University of Cape Town (UCT) to establish the Biomedical Translational Research Initiative (BTRI). Based at UCT's Institute for Infectious Diseases and Molecular Medicine (IDM), the BTRI will work with clinicians to understand the genetic variations that characterise a particular cancer and tie these to effective chemotherapeutic agents, in order to recommend better treatment approaches to doctors.

"The idea is to use some of the molecular tools that we've been working on and developing at the CSIR – aspects of stem cell biology, imaging and microscopy – to provide molecular diagnostics and targeting of tumours in clinical contexts where they can be highly effective," explains Mhlanga, who is BTRI Technical Manager and has a background in molecular biophysics and molecular genetics. "Our research informs us what mutations or variants are driving a tumour, and allows us to prescribe specific drugs that are tailored to work against those mutations."

Team BTRI

The BTRI has been in development since late 2013, when the CSIR first identified the need to link its work in synthetic biology with academia and translational medicine. It will initially focus on cancer, but in future the BTRI will work on other aspects of translational medicine, including stem cell biology.

The BTRI is an initiative of the CSIR and UCT funded by the Department of Science and Technology. Mhlanga was also appointed as an Honorary Professor in the newly created Department of Integrative Biomedical Sciences at the UCT Medical School. The BTRI has adopted a hub-and-spoke operational model with a dual footprint at both UCT and the CSIR, while the spokes will include other universities and industry partners.

"The initiative also has Frank Brombacher and Professor Stephan Barth of UCT as principal investigators. Their labs retain their independence, but we work together and share funding for some projects," explains Mhlanga. He also plans to work with surgeons from Groote Schuur Hospital, the study hospital attached to UCT's Medical School.

"We are happy to start an intensive collaboration with Dr Mhlanga on the topic of precision medicine through the establishment of the BTRI. This new structure will allow us to expand our applied research activities and we are looking forward to a sustainable partnership," says Prof Stephan Barth.

A cancer biobank

Mhlanga has ambitious plans to turn the BRTI into an invaluable resource for clinicians, researchers and pharmaceutical companies. Perhaps the most noteworthy of these is the concept of a living cancer biobank, which will hold a large number of tumour samples that are genetically and physically well-characterised, and will be accessible to researchers, pharmaceutical companies and biotech startups.

Mhlanga goes on to explain that a biobank would hold value for a pharmaceutical company developing cancer drugs. "Using the biobank, they can know which drugs work for which type of tumour, and the genetic sequences of those tumours," he says, adding that it will also benefit preclinical drug trials. "If we identify a mutation that is unresponsive to current drugs, researchers could use the biobank to test a new drug against that specific variant, which might occur primarily or exclusively in SA."

The BTRI aims to attract young researchers from around the country to receive training in translational medicine, further showing that its establishment is an important step towards improving South Africa's competence in this field and reducing the impact of cancer on the South African population.

The BTRI is funded by the DST and implemented by the CSIR.

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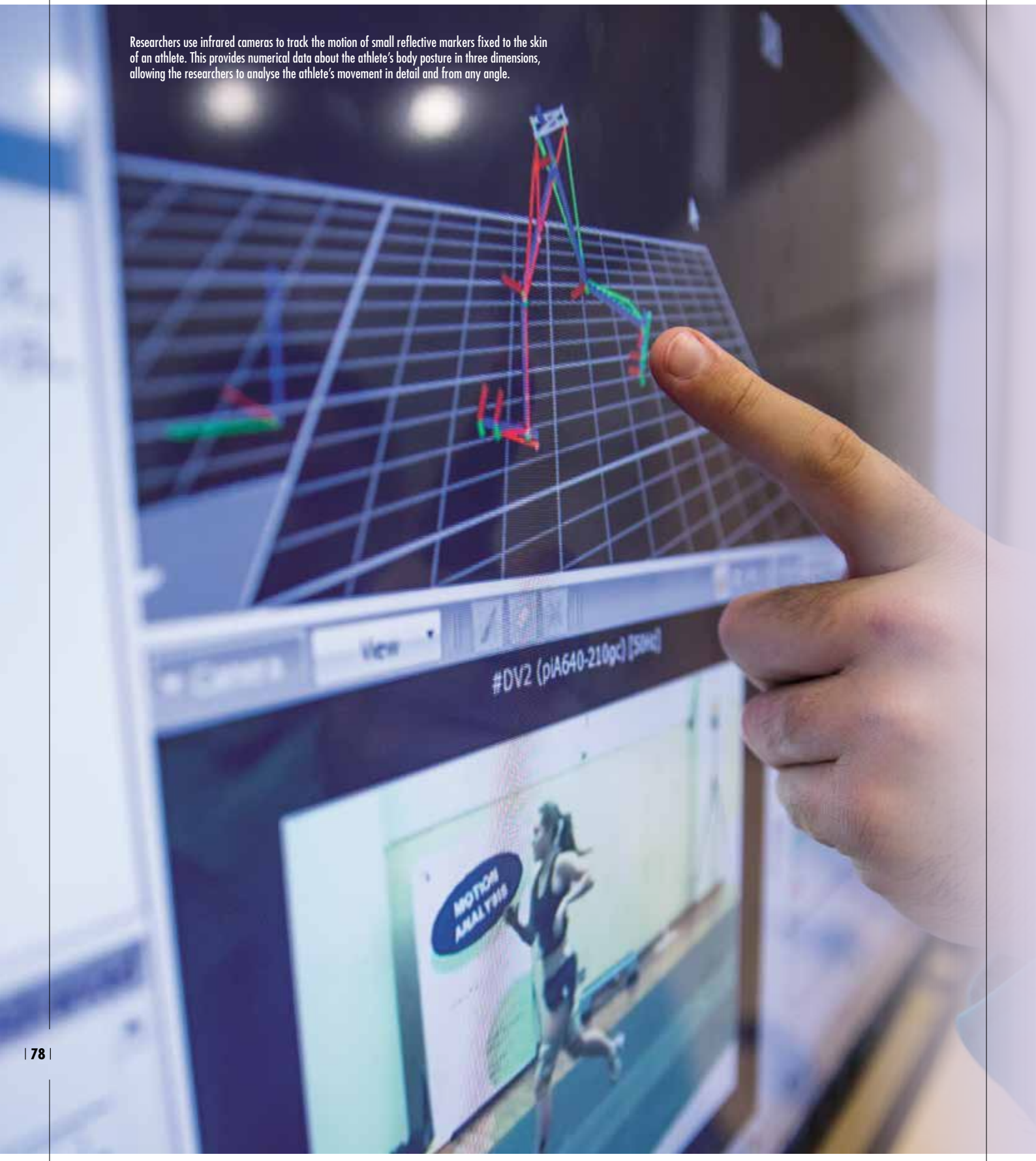

Researchers use infrared cameras to track the motion of small reflective markers fixed to the skin of an athlete. This provides numerical data about the athlete's body posture in three dimensions, allowing the researchers to analyse the athlete's movement in detail and from any angle.

PARTNERING TO STUDY MOVEMENT ANALYSIS DATA

A better understanding of the nature and causes of problems relating to human movement may help researchers to develop optimal treatment methods for people with disabilities and injuries. Statisticians from the CSIR and the University of Calcutta in India are collaborating with physiotherapists at a Stellenbosch University movement analysis laboratory in the Western Cape to find out how advanced mathematical modelling can help to analyse the vast amounts of data that the laboratory's advanced equipment collects.

DISABILITIES OR INJURIES that hinder people's ability to move freely may significantly impact their ability to be economically active, especially in poorly resourced communities where they do not have easy access to medical treatment, physiotherapy or optimal prosthetic aids.

Even those who have access to good medical treatment, such as professional athletes, may suffer career-limiting or career-ending injuries.

The Central Analytical Facility for Human Movement Analysis at Stellenbosch University's Tygerberg campus uses advanced motion analysis technology to evaluate sports, neurological or other movement problems people experience.

"We are able to collect vast amounts of data, but need to have the data thoroughly analysed to understand how abnormal movement patterns are associated with specific conditions," explains Prof Quinette Louw, who founded the laboratory in 2009.

Getting statisticians on board

John Cockcroft, managing staff scientist at the laboratory, met CSIR statistician, Dr Sonali Das, by chance while he was working on a robotics project with the CSIR and introduced her to Louw. Prof Bhaswati Ganguli, a statistician from the University of Calcutta, also became involved to investigate how the latest data modelling techniques could be applied to movement analysis research.

"Earlier, Ganguli introduced me to functional data analysis. This is a branch of statistics that analyses data that provide information about curves, surfaces or anything else varying over a continuum," says Das.

"It basically substitutes a data series or a part of the data series by a mathematical function and then explores various aspects of that function rather than the raw data. We were keen to test this technique on new datasets."

Runner's knee

Cockcroft and Louw realised that the statisticians might have the expertise to provide the crucial numerical modelling needed to interpret the laboratory's movement data and provided them with a set of data to do some preliminary tests.

The data were collected from a group of people suffering from iliotibial band syndrome, one of the leading causes of knee pain in runners and cyclists, together with the data from a control group.

"We measured their running patterns using eight infrared cameras, which track the motion of small reflective markers fixed to the skin," Cockcroft explains. "This system gives us numerical data about body posture in three-dimensions, allowing us to analyse the movement in detail from any angle. It is a big volume of data and the idea was to see how those with knee problems move differently to those in the control group."

The statisticians are still working with the data, testing different analytical models.

Future applications

"It has been a very successful pooling of resources, with the laboratory providing a very sophisticated dataset, while we could share our statistical expertise. We are keen to explore further collaborations, especially with departments whose research involves gait analysis, signal processing and image analysis," says Ganguli.

"In the future, advanced data modelling techniques could be applied to inform the development of artificial intelligence or products to reduce disability and optimise function in people of all ages," says Louw.

"It may also improve access to healthcare by using advanced algorithms, for example, for diagnostic purposes. In our resource-constrained healthcare system, where difficult decisions need to be made about medical interventions, movement analysis might provide better data for a surgeon to prioritise patients and to more accurately target interventions."

Louw believes the laboratory's link with the CSIR could also facilitate product development, which is not well supported at higher educational institutions. She has also put the researchers at Calcutta in contact with the biostatistics unit at her faculty as she believes they could help with skills development and training of local statisticians.

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Prof Dean Brady, Head of the School of Chemistry at the University of Witwatersrand (Wits), Wits PhD student Peter Wanyama and Varsha Chhiba, CSIR researcher and Wits PhD student.

Pooling resources in advanced biotechnology

Since 2002, the CSIR has partnered with several South African universities and research organisations to establish and strengthen the African Centre for Gene Technologies, an initiative that aims to boost biotechnology capacity in the country. Today the partners continue to work on joint projects on natural products, biocatalysis, genetic modification and bioinformatics.

ALL LIVING ORGANISMS rely on genes that make proteins to enable them to grow and function. These genes are passed on from one generation to the next and determine aspects of appearance such as colour, structure and size, as well as movement, reproduction and organisms' resistance to diseases.

Scientists have developed techniques to manipulate these genes looking at ways to protect people, plants and animals from diseases, to protect the environment and to improve agricultural crop production for food security.

In an effort to boost South African research in this field, the CSIR and the University of Pretoria (UP) established the African Centre for Gene Technologies (ACGT) in 2003. The University of the Witwatersrand (Wits), the University of Johannesburg (UJ) and the Agricultural Research Council (ARC) later joined the initiative.

Reaching a critical mass

"At that stage, biotechnology research was still in its infancy in South Africa and researchers realised that by working together a critical mass of expertise could be created to make real breakthroughs," says the CSIR's Dr John Becker, who was appointed to manage the ACGT in 2011.

The individual institutions have their own activities in the biosciences field, but by sharing expertise and equipment they can unlock larger opportunities and be more competitive as a world-class platform in advanced biotechnology with

Researchers at the University of the Witwatersrand set up a lipase enzyme reaction.

increasing involvement by other organisations.

Natural products

One of the centre's successes is the establishment of the Southern African Biochemistry and Informatics for Natural Products (SABINA) initiative, which is training the next cadre of academics in this field. SABINA proactively implements postgraduate chemistry and biochemistry programmes. Through these programmes, the initiative strengthens networks that integrate chemical and biological sciences in key Southern African Development Community (SADC) universities.

"This project is funded by the Carnegie Corporation of New York and co-funded by the Department of Science and Technology (DST) and is in its third phase. We have established a network of natural products researchers across southern Africa to focus on postgraduate education and shared expertise and infrastructure," says Becker.

The CSIR's Dr Dashnie Naidoo has been part of the SABINA network for several years. She has helped to train students in natural products chemistry and bioprospecting and supervised PhD students from southern African countries such as Tanzania, Malawi and Zimbabwe.

"Two of the students (from Tanzania and Malawi), who studied at South African universities and trained at the CSIR, have secured positions at other African institutes in their home countries. A third student (from Zimbabwe) is doing a PhD," Naidoo says.

Biocatalysis for greener processes

The CSIR and Wits are hubs for the DST-funded National Biocatalysis Initiative, the establishment of which the Centre contributed to through coordination and facilitation. The Biocatalysis Initiative aims to help maximise the potential of biocatalysis in the manufacture of commodity and value-added products in South Africa by sharing expertise and facilities as well as developing human capital in this field.

"Biocatalysis is the biological transformation of chemical molecules. For example, we could use micro-organisms or enzymes to catalyse chemicals in industrial processes for the production of medicines. In this way materials that are in abundance in South Africa can be transformed into valuable compounds," says Becker.

Prof Dean Brady, who heads the Wits School of Chemistry, says biocatalysis has a number of commercial advantages, such as reduced production costs by involving fewer process steps, improved yields due to reduced by-product formation and reduced capital costs as a result of low temperature and pressure reactions.

"Biocatalysis is also a major contributor to green chemistry technology as it can readily utilise chemicals derived from biomass such as inedible plant material as a waste by-product of agriculture. Typical current products include bio-diesel, bio-ethanol and lactic acid."

Genetically modified food

The ACGT also manages a programme on assuring the agricultural and food safety of genetically modified organisms in southern Africa – called GMASSURE – which is funded by the European Union and the DST.

SADC needs to maximise food production for food security, while simultaneously safeguarding the environment through sustainable agricultural practices.

"The focus of this programme is to develop capacity in agricultural biotechnology in SADC, but we also work closely with scientists, government officials and policy makers, farming communities and the general public to share information about the solutions that agricultural biotechnology can provide to boost agricultural production," says Becker.

The project is coordinated at UP and the other partners include UJ, the CSIR, the ARC, the Technical University of Denmark and the universities of Zimbabwe and Namibia.

The centre has also initiated a bioinformatics training programme in 2013, building capacity in the partnership and country through workshops facilitated by world-leading experts in the field.

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The CSIR's Tshidi Moroka; Adv Leslie Sedibe, CEO of Proudly SA; Mrs Naledi Pandor, Minister of Science and Technology; Dr Sibusiso Sibisi, CSIR CEO; Dr Shadrack Moephuli, ARC CEO; Dr Astereda Mnkeni, Manager, Vegetable Processing Unit of Agri-Park project and Ravi Pillay, Corporate Affairs Director, Nestlé South Africa.

A NEW FOOD PRODUCT MAKES IT TO MARKET

A partnership that draws on food science, agricultural science, consumer science and indigenous knowledge led to the development of a new Maggi 2-Minute noodles product.

AFTER THREE YEARS of extensive research on various indigenous South African edible plants, collaboration between the CSIR, Nestlé South Africa and the Agricultural Research Council resulted in a new food product on the shelves of South African food retailers. Maggi 2-Minute Morogo-flavoured Noodles was launched during the CSIR's Ideas that Work Conference in 2015.

The partners in this endeavour started working together in March 2012, following earlier research and development (R&D) work based on South Africa's biodiversity and indigenous knowledge to evaluate the potential use of novel ingredients that have known health benefits.

Tshidi Moroka, who heads the CSIR's bioprospecting and agroprocessing research efforts, says, "A team of scientists from Nestlé visited the CSIR in 2011 looking for potential collaborative projects. We soon found common ground."

Dr Nomusa Dlamini, CSIR principal researcher, says, "Our research at the time focused on identifying indigenous edible plants with health benefits and was funded by the Department of Science and Technology. Various leafy green vegetables, including Cleome, Cow Pea and *Amaranthus* (popularly known as Morogo) were screened to assess nutrient bioavailability during digestion."

Product development and launch

After conducting thorough research and consumer studies, Amaranthus was chosen because of its robust growth potential and health benefits – which stem from the presence of beta-carotene, minerals and protein. Morogo refers to a group of green leafy vegetables found throughout southern Africa and harvested for human consumption. It has long been considered a traditional South African dish and forms an important part of the staple diet in rural communities.

The selected Amaranthus vegetable became an ingredient (used as a dried material) in Nestlé's Maggi 2-Minute Noodle product.

Outlining the CSIR's role in the partnership, Moroka says: "We provided our expertise in the processing of indigenous products to jointly develop this innovative product with Nestlé. Producing the vegetable ingredients would provide an opportunity for small-scale farmers and we teamed up with the ARC to make the most of this opportunity."

The CSIR team transferred the knowledge relating to processing to staff at the University of Fort Hare Agri-Park, who in turn ensured the production of a safe and high-quality powdered product to Nestlé. Commenting on their involvement in the partnership, Chief Executive Officer of the ARC, Dr Shadrack Moephuli says, "Through this partnership, we were able to develop best practices and farming guidelines for Morogo. We evaluated the commercial viability of producing African leafy vegetables in a sustainable manner for commercial smallholder farmers under irrigated conditions."

Nestlé says the partnership demonstrates the company's shared-value business principle which states that for a business to be successful, it must create value for the communities in which it operates.

"We believe that through partnerships such as this one – in which we are able to collaborate with experts in agricultural and food science and share our consumer understanding and product development – we continue to demonstrate this business principle," says Ravi Pillay, Corporate Affairs Director for Nestlé South Africa."

Ravi Pillay, Corporate Affairs Director at Nestlé SA with the innovative product.

The partnership supports the country's National Development Plan which aims to grow South Africa's economy through public-private partnerships. It is envisaged that this project will contribute towards much-needed rural development and the revitalisation of rural communities through job creation particularly for emerging farmers.

Amaranthus, commonly known in South Africa as Morogo.

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Dried, blanched Cleome leaves and (right) a sample in an amber high-performance liquid chromatography vial ready for analysis. Top: A sample extract.

COLLABORATION TO PROMOTE THE CONSUMPTION OF INDIGENOUS EDIBLE PLANTS

The CSIR first partnered with the University of Venda and the Agricultural Research Council (ARC) in 2011 to conduct research and development on nutraceutical products based on indigenous edible plants. Such food products not only provide nutrients to the diet but also contain biologically active components that assist in preventing life style diseases, by providing health benefits associated with high antioxidant properties.

A COLLABORATION BETWEEN the CSIR, the University of Venda and the ARC is targeting the development of nutraceutical products based on indigenous edible plants.

"South Africa is blessed in terms of edible indigenous plants, and yet their use as food is limited. With this partnership we hope that scientific research will contribute to motivating people to consume these vegetables by creating awareness about the nutritional value and other health benefits," says Dr Nomusa Dlamini, CSIR principal researcher.

The collaboration covers the complete value chain, from indigenous biodiversity and knowledge from the communities that the University of Venda interacts with, to scientific evaluation at the CSIR, the development of cultivation methods by the ARC and process and product development at the CSIR.

"Our role in this collaboration is to identify and liaise with these communities that will supply plant material and advice on the indigenous uses of these plants," says Dr Lindelani Mushaphi, senior lecturer and head of the department of nutrition at the University of Venda.

The ARC trains and assists communities in cultivating and harvesting plants, and the CSIR conducts research and development on these plants. This includes nutrient analysis and product development. Moreover, the CSIR trains the communities on how to process the plants.

One of the outcomes of the project is a booklet on indigenous edible plants with health benefits in the Vhembe district of Limpopo province.

As part of the community training in food-processing practices, the Makonde community was trained in the preparation of vegetable-fermented products. CSIR interns in food-plant analysis assisted with this process.

In addition, an exchange of skills in this domain resulted in Daniso Beswa, a staff member of the University of Venda, in 2015 graduating with a PhD under the co-supervision of Dlamini, who is also currently supervising PhD student, Vanessa Mbhatsani.

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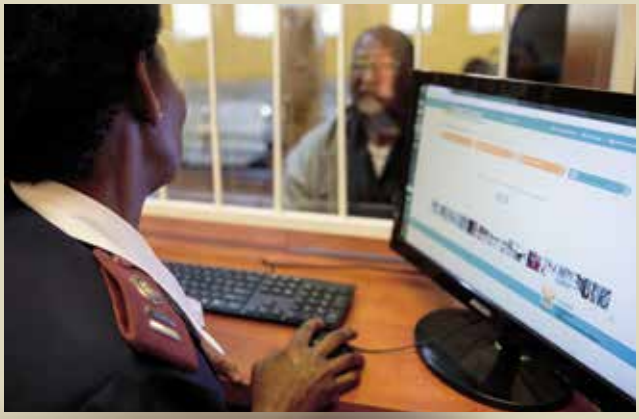
A researcher filters a sample for high-performance liquid chromatography analysis and (right) dried Cleome leaves being extracted in an amber vial. Researchers use amber vials to minimise the dried leaves' exposure to light.

CSIR PARTNERS WITH HEALTH DEPARTMENT ON E-HEALTH INTEROPERABILITY

The CSIR has partnered with the National Department of Health to help the department strengthen South Africa's health system in a bid to improve healthcare for all citizens. Key to this initiative is the department's 2012 National eHealth Strategy. The main aim of the strategy is for South Africa to have a comprehensive, integrated ICT solution for health by 2017.



THE CSIR'S WORK in e-health began with a contract with the department to develop a set of standards for interoperability of e-health systems. The Health Normative Standards Framework for eHealth interoperability was gazetted in April 2014. It serves as a critical building block towards health systems interoperability by establishing standards for health data exchange to which all health systems in the country must conform.

The department and the CSIR also partnered to develop the Health Patient Registration System, which enables the electronic registration and lookup of patients on a national database. The system is now deployed in approximately 650 clinics across the country. To date, there are in excess of a million patients registered on the system.

In 2015, the CSIR's final report and recommendations regarding the assessment of primary healthcare patient information systems were accepted by the National Health Council. The CSIR is engaging with provinces and municipalities to implement comprehensive patient information systems in clinics. The National Health Council has also tasked the CSIR to conduct an assessment of hospital information systems.

Continued engagement

In November 2015, the CSIR and the department hosted over 130 delegates at the inaugural eHealth Interoperability Workshop. The aim of the workshop was to bring together stakeholders with an interest in the implementation of the Health Normative Standards Framework for interoperability.

"This workshop afforded us the opportunity to engage and learn," said Dr Gail Andrews, Chief Operating Officer at the National Department of Health.

"This event contributed significantly towards enabling us to take full advantage of the many benefits that eHealth will bring towards strengthening the national health system," Andrews noted.

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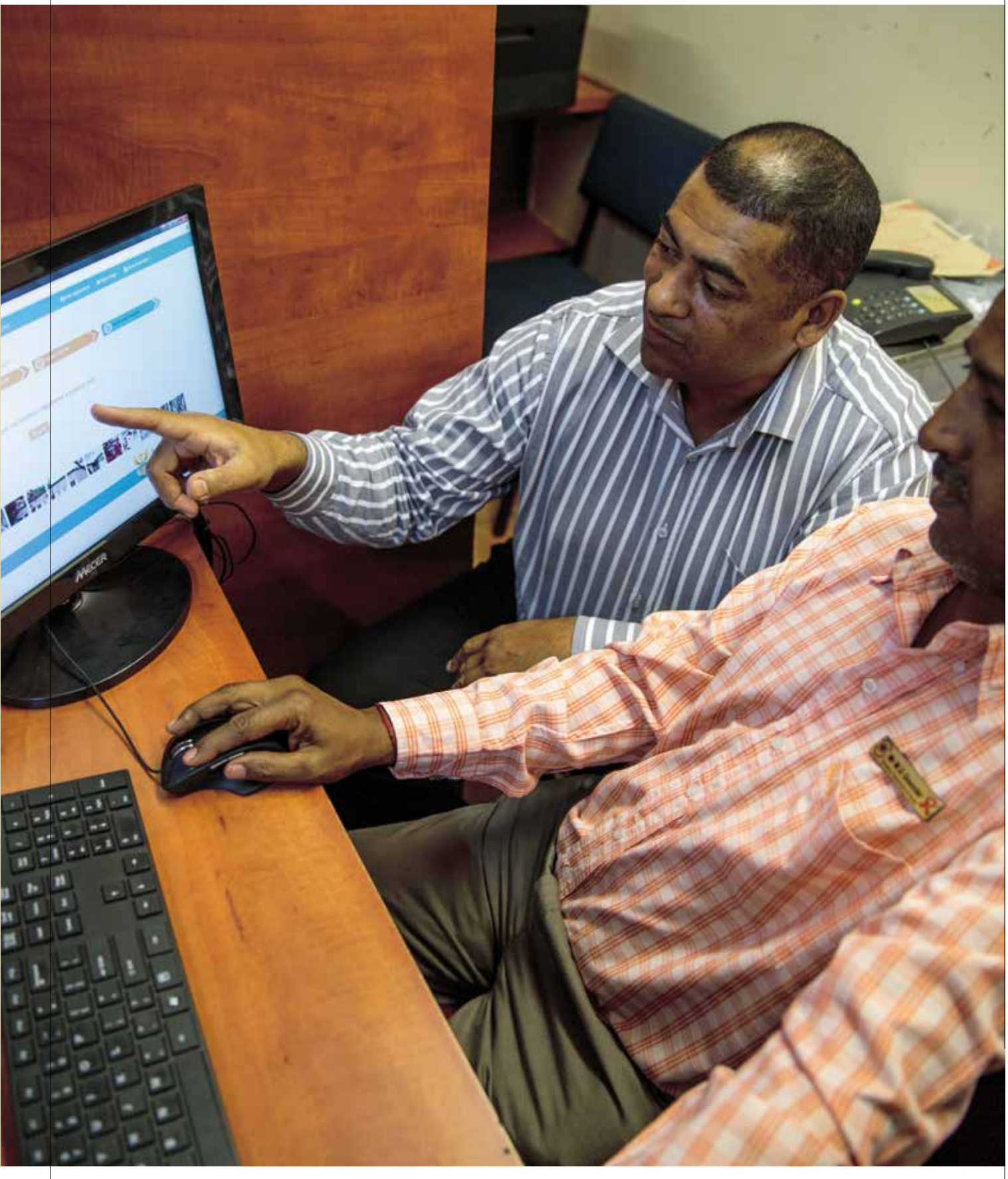
(Top) A healthcare worker captures patient information on an electronic database at a community health centre in Laudium, Gauteng. The CSIR's Paul Geldenhuys (left) was one of a team of researchers who visited several clinics (right) to understand the requirements for a national patient registration system.




NEW
GROWTH
FORMULA
ANTI-HAIR LOSS SERUM

CSIR and Afriplex partner for health solutions

The CSIR signed an agreement with Afriplex, a South African manufacturer of nutraceutical and healthcare products, to carry out biological evaluation studies on herbal extracts that may be beneficial in the management of colds and flu, allergies, male pattern baldness and hair loss.

AN AGREEMENT BETWEEN the CSIR and Afriplex is creating opportunities for the marketing and distribution of herbal products that are based on South African plants and indigenous knowledge.

"The CSIR's collaboration with traditional health practitioners on the use of medicinal plants has led to the identification of a number of traditional remedies," says the CSIR's Prof Gerda Fouché, principal investigator of the project.

"South Africa has a long tradition of the medicinal use of plants, with an estimated 80% of South Africans consulting one of more than 200 000 traditional healers. Despite the country's rich biodiversity of more than 24 500 plant species, there are only a few registered herbal medicines that have been derived from these plants," she says.

The CSIR and Afriplex focus on the plant *Elephantorrhiza elephantina*. This plant, which is commonly known as Elandsboontjie (Afrikaans) and Intolwane (Nguni languages), is found in grassland areas in large parts of the country. Extracts and compounds of *Elephantorrhiza elephantina* have been developed and produced at the CSIR, including formulations such as treatment capsules, shampoos and scalp massage serums for topical application.

"The roots of this plant are commonly used by indigenous people for a wide range of ailments including diarrhoea and dysentery, stomach disorders, haemorrhoids and perforated ulcers, and as emetics. It is also popular for the treatment of skin diseases and acne. CSIR research has shown significant activity of the extracts and compounds against the enzyme steroid 5-alpha reductase. This enzyme – which converts testosterone to dihydrotestosterone (DHT) – is seen as a causative factor in the progression of benign prostatic hyperplasia (BPH) and also male pattern baldness. The extract also showed potent anti-oxidant activity that was greater than that of green tea extract when tested," she says.

Both organisations prefer clinical evaluation of extracts of the plant as the preferred route to the commercialisation of products derived from the plant. This aspect of the work is being funded by the Technology Innovation Agency and specifically focuses on the management and treatment of BPH. A patent has been filed by the CSIR for this specific use. To commercialise this product, the CSIR has partnered with Afriplex to complete the remaining development programme and to market and distribute the product.

"This partnership demonstrates that South African organisations can produce registered herbal medicine derived from the botanical specimens available in this country, instead of importing products. By adding value locally and through the application of South African know-how and technology, a solid platform is created to present effective products," she says.

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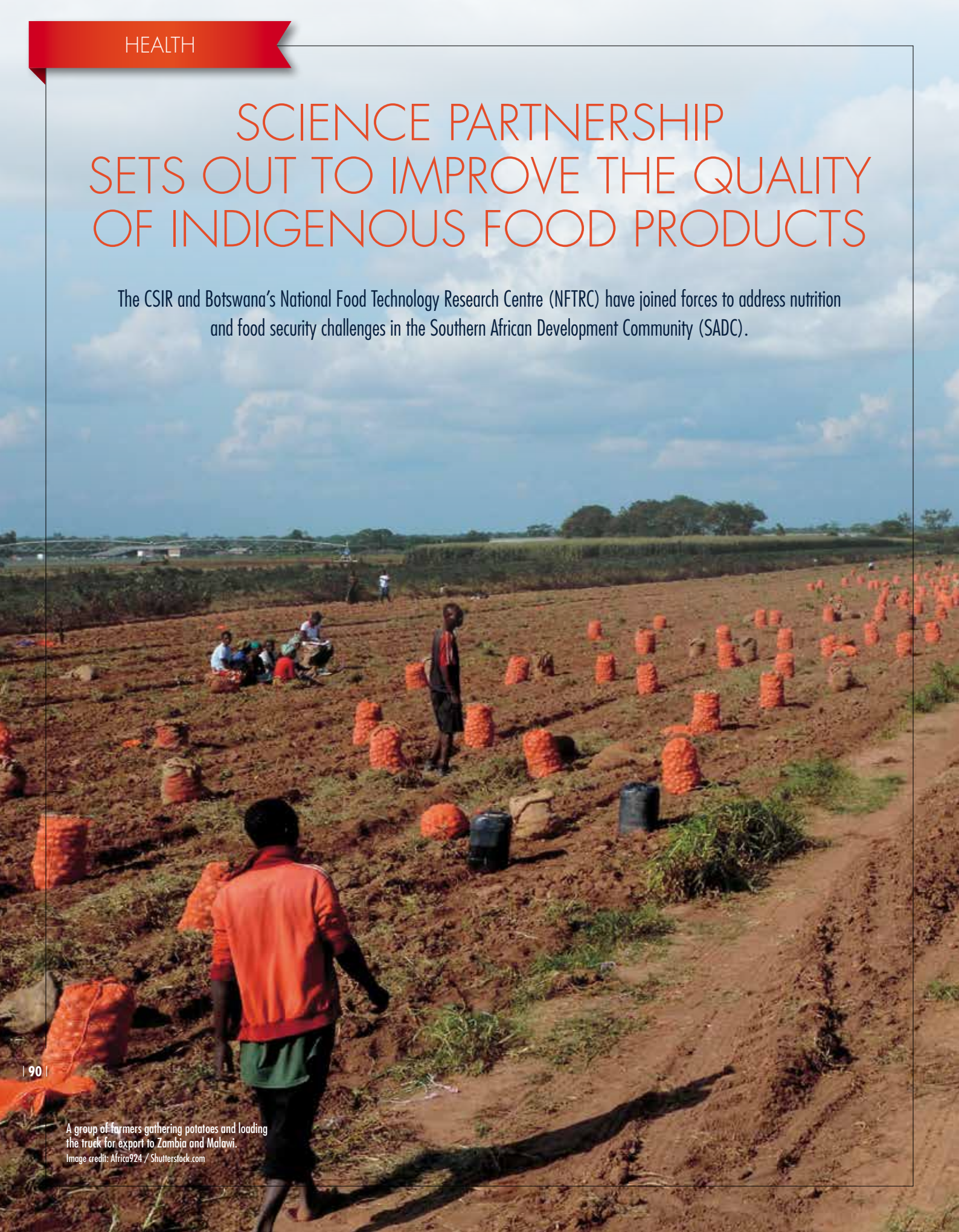
SCIENCE PARTNERSHIP SETS OUT TO IMPROVE THE QUALITY OF INDIGENOUS FOOD PRODUCTS

The CSIR and Botswana's National Food Technology Research Centre (NFTRC) have joined forces to address nutrition and food security challenges in the Southern African Development Community (SADC).



A group of farmers gathering potatoes and loading the truck for export to Zambia and Malawi.
Image credit: Africa924 / Shutterstock.com

THE CSIR AND THE NFTRC in Botswana have signed a memorandum of understanding to develop a strategic partnership to guide their collaboration. The CSIR is the hub of the Southern Africa Network for Biosciences (SANBio), a NEPAD flagship programme implementing the African Union's Science, Technology and Innovation Strategy. Botswana is a member of the SANBio Network.

Dr Boitumelo Semete-Makokotlela, Executive Director: CSIR Biosciences, says great value can be derived by fostering partnerships across the continent and joining efforts to address food security and malnutrition challenges faced by SADC and the rest of Africa.

"It is critical to us to foster partnerships across the continent because we appreciate the value that can be derived from working together. It is also important to collectively address imminent challenges that are faced by the continent," says Dr Semete-Makokotlela.

Acting managing director for the NFTRC, Dr Martin Kebakile emphasised the importance of collaboration.

"We may have ideas, but for us to come up with great ideas we have to work with other research institutions to identify better products, approaches and programmes that can go a long way in solving the continent's challenges in food science and technology," he says.

The agreement focuses on food science and technology research to support the development of novel and nutritious food ingredients, as well as product prototypes using indigenous knowledge and biodiversity. It also includes developing competencies to facilitate the creation of high-quality natural product prototypes based on commonly found and used edible plant species.

The two organisations will provide training and capacity-building support to communities in agro-processing, post-harvest technologies and development of processes and products. Dr Ereck Chakauya, acting network manager for SANBio, says one of the objectives of the network is to encourage institutions within the SADC region to collaborate.

"I believe the CSIR and the NFTRC have the resources and capabilities to make an impact in the areas of collaboration for the benefit of SADC. Ultimately, the success of the partnership will be jointly developed food ingredients and products," says Chakauya.

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CSIR Biosciences Executive Director Dr Boitumelo Semete-Makokotlela and Botswana's National Food Technology Research Centre Acting Managing Director Dr Martin Kebakile during the signing of an agreement to jointly address food and security challenges in the Southern African Development Community.

CSIR PhD and Master's support: Dr Sello Manoto, a CSIR expert in the fields of biophotonics, tissue engineering and medical diagnostics and (inset) Arno de Klerk, an expert in the field of aquatic ecotoxicology.

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Supporting young bright minds in partnership with SA universities

Since 2003, the CSIR has partnered with several South African universities to establish a scholarship programme that aims to develop high-level scarce skills in selected fields of science and technology, while providing much needed financial relief to students.

THE LINK BETWEEN a country's investment in research and development and its economic growth and prosperity is widely acknowledged. The ability to innovate will continue to be a key derminant of the global competitiveness of nations and requires a sound science, engineering and technology capability. The number of PhD graduates per million of a population is often used as one of the indicators of this capability. The National Development Plan 2030 proposes that South Africa produces at least 100 PhD graduates per million per year by 2030, which will be an increase from 1 420 new PhDs in 2010 to over 5 000 per year.

The CSIR and several South African universities have collaborated to establish a scholarship programme to help top science, engineering and technology students to reach their full potential.

The need for support

"There is a significant scarcity of high-level skills in science, engineering and technology and these skills are often the ones that drive innovation," says Pinda Sifunda, manager of human capital development at the CSIR.

"Many students do not have sufficient financial support and this difficulty causes many promising candidates to abandon their studies. We can't afford to lose them, especially because the pool is so small."

The aim is to support students who work in joint projects between universities and the CSIR and in research areas aligned with the CSIR's priorities. Since 2008, the scholarships have funded more than 280 postgraduate students.

The partnership

"The CSIR contributes 50% of every scholarship and the funds are exclusively used to support students that are enrolled for honours, Master's and PhD studies in specific areas identified in the memorandums of agreement with each university," says Sifunda.

These scholarship agreements are renewed every year, depending on the progress of each student. The funds also provide students with access to CSIR research facilities in order to support their research projects.

She says the programme has been very successful in addressing the objectives of building strategic partnerships with universities, while researchers at the CSIR and universities have strengthened their networks.

Current partners include the Tshwane University of Technology, the University of Cape Town, the University of Johannesburg, the University of the Western Cape, the University of KwaZulu-Natal, Stellenbosch University and the Nelson Mandela Metropolitan University.

Realising a dream

Thanks to a scholarship, the CSIR's Dr Sello Manoto obtained a PhD in biomedical technology from the University of Johannesburg. His areas of expertise include biophotonics, photodynamic therapy, ozone therapy, tissue engineering, regenerative medicine, and medical diagnostics.

"I wanted to further my studies immediately upon the completion of my MSc degree, but did not have adequate funds. Obtaining the scholarship enabled me to enrol for a PhD and become a specialist in photodynamic therapy.

"In the 10 months that I have been employed by the CSIR, I have written three publications that are due for inclusion in international peer-reviewed journals. The aspect that I feel most encouraged about, is the use of photonics for HIV/Aids research. We are currently investigating point-of-care technologies using lasers in HIV/Aids diagnostics. Being involved in research that is directly impacting the health of communities similar to the one I come from, is dear to my heart," he says.

A great start

Arno de Klerk, CSIR researcher in the field of aquatic ecotoxicology, completed an MSc in aquatic health thanks to a scholarship that he received in 2008 to study at the University of Johannesburg.

"I study the effects of pollution on biological organisms, especially at the population, community and ecosystem level within inland freshwater systems. Ecotoxicology is a multidisciplinary field, which integrates toxicology and ecology. An example of this was an in-depth study in the Waterberg Region of South Africa in which we assessed pollution in the surface waters in the rivers and its implications for aquatic ecosystem health."

The scholarship enabled him to get involved in research projects, to go on field trips and to interact with senior researchers during his studies. "This enabled me to broaden my field of expertise and to publish numerous articles early in my career, which gave me a great start."

Benjamin Rosman, senior researcher at the CSIR and visiting lecturer at the University of the Witwatersrand says it is not hard to find talented young researchers.
(Middle) Dr Benjamin Rosman, CSIR; Wits lecturer and one of Rosman's PhD students, Pravesh Rachod; Orry Messer and MSc student Ntokozo Mabena.

COLLABORATIVE ROBOTICS RESEARCH

Dr Benjamin Rosman believes that ideas are for sharing. This belief formed during his MSc and PhD studies in robotics at the University of Edinburgh in the United Kingdom where he experienced a degree of knowledge sharing that he had not been exposed to before. Today Rosman has the opportunity to impart and share knowledge in his role as visiting lecturer at the University of the Witwatersrand (Wits), where he supervises 20 postgraduate students.

Scoping and lecturing an honours robotics course

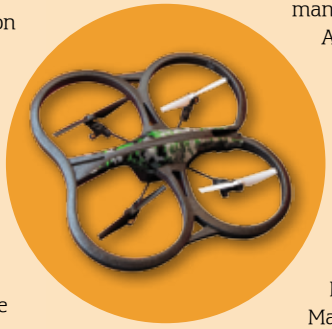
Rosman is a senior researcher at the CSIR, where he leads numerous collaborative robotics research projects. His passion for collaboration happens to be in a field in which South Africa desperately requires a critical mass of highly skilled researchers. Fresh from his six-year stint at the University of Edinburgh, Rosman set about ploughing back his recently acquired knowledge and experience.

Together with Wits lecturer, Pravesh Ranchod – who is also one of his PhD students – he proposed a robotics course at honours level, based on the MSc courses he had taken at Edinburgh. "Scoping and then lecturing this course essentially meant that somebody coming out of this course has the exact skills that we are looking for in prospective CSIR robotics researchers."

Rosman relishes his role as supervisor, lecturer and mentor. "It's a win-win scenario," says Rosman. "While the students have access to a lecturer who has worked with the best in the field, I am contributing to a solid, viable, international-standard robotics research community here. I find that this kind of collaboration is essentially a multiplier of my time as it gives me ideas for some of the other projects I am working on and helps me to filter research questions which ultimately helps me do better science."

For many of his top students Rosman strives to secure co-supervision from universities around the world. He says while the quality of the students is not a concern, "the country still has long way to go in terms of the scale of collaboration and sharing techniques and results."

"We do not have sufficient information exchange and enough of a collaboration mentality in South Africa. We don't see the same level of sharing that exists in the East-West academic trade route in the northern hemisphere – there is a continuous two-way flow of visiting academics from America, Canada, the UK, East and West Europe, India, China and other parts of Asia. In the field of robotics, research work in South Africa is still too fractured," he says.



As part of his effort to get experts across different research entities together to collaborate, Rosman has also started a weekly machine learning reading group within the CSIR. "Once people acknowledge that the problem is more likely to be solved by working together than working individually, their resistance to collaborating and their fears about giving away intellectual property generally subsides." He says he has found that the CSIR represents neutral ground and has a role to play in facilitating collaboration, also between universities.

Linking up with global leaders in the robotics field

Rosman's network spans many continents. A collaborator at Duke University in the USA co-supervises PhD student Pravesh Ranchod, while CSIR researcher Ndivhuwo Makondo is being co-supervised at the Tokyo Institute of Technology. He continues to work with the University of Edinburgh and has published a joint paper with collaborators at Yale University in the United States. Through his many co-supervision roles, he has interacted and collaborated with institutions such as the University of Waterloo in Canada and the Washington State University, resulting in numerous co-authored peer-reviewed papers. He is savouring the prospect of new collaborations resulting from a new group of students about to sign up and agreed co-supervision by the Universities of Sheffield, Leeds, and Edinburgh in the United Kingdom.

Rosman was named principal investigator of one of the first research projects funded as part of the Robotics Strategy of South Africa. The project will look at the limitation of robotic tools to perceive and understand natural, cluttered environments during decision-making processes. Ultimately, it will help to develop robotic systems that can operate under conditions of high uncertainty, for example in mining environments. While three PhD and three MSc students will be involved during every year of the three-year project, Rosman has also secured co-supervision from existing international collaborators, including Prof George Konidaris of Duke University, Dr Subramanian Ramamoorthy of the University of Edinburgh, Prof Matthew Taylor of Washington State University, and Dr Andrew Saxe of Harvard University.

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PARTNERING TO DEVELOP OUR FUTURE COASTAL AND PORT ENGINEERS

The CSIR and Stellenbosch University (SU) are jointly investing in the development of South African coastal and port engineers.

IN THE SOUTH AFRICAN CONTEXT, coastal and port engineers are highly sought after, as their skills are invaluable to the South African economy. With 90% of South Africa's trade passing through its harbours, their structural stability is vital. Coastal and port engineers have a key role to play in this regard.

Typically, coastal and port engineers are involved in building mathematical, as well as scaled, physical models of ports to allow them to determine how coastal structures will withstand the constant assault of wind and waves. A long-standing partnership between the CSIR and the Stellenbosch University (SU) aims to create opportunities for skills development and knowledge generation in this field.

Dr Patrick Hlabela, CSIR manager for hydraulic infrastructure engineering, says, "The partnership is about creating a pipeline of skilled professionals to enhance the ability of South African ports to compete with the best in the world. It is mutually beneficial by its nature."

The university benefits by exposing its students to real-life scenarios to ensure that its training is relevant, while the CSIR benefits from the knowledge generated by Master's and PhD students and ultimately, from a pipeline that is equipped to join the profession.

However, the biggest challenge for the CSIR is the fact that the university can only accommodate a small number of undergraduate students. SU registered 24 students for the coastal and ports engineering course last year.

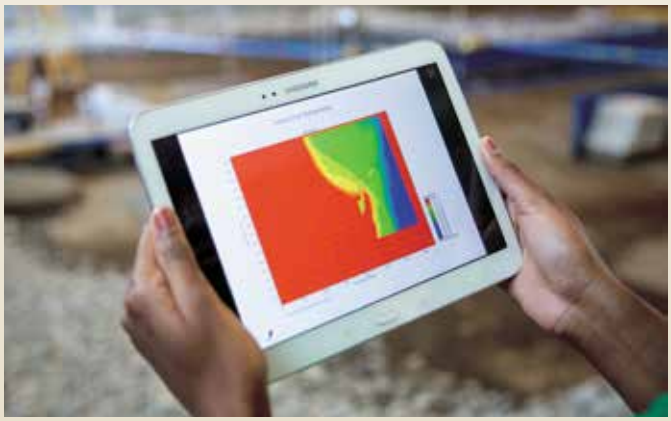
"Only a few of these undergraduate students end up pursuing postgraduate studies, which contributes to the scarcity of researchers in this field," he says.

Hlabela says the CSIR provides a good training ground. "This development route helps ensure that well-rounded, suitably equipped coastal and ports engineers are ready to be taken up by the sector. By contributing to the quality of the approximately 12 Master's produced per annum, we are able to help ensure that our ports, and ultimately the country's trade, benefit."

He says that other Southern African Development Community ports are also in need of suitably qualified coastal and ports engineers.

"The CSIR's extensive collaboration with state-owned entity, Transnet, also extends to the efficient operation of its ports. We believe that our partnership with SU to help shape our future coastal and ports engineers also helps Transnet achieve its mission."

Hlabela says SU is the only institution in the country that offers the coastal engineering programme and that it is no co-incidence that the CSIR hydraulics laboratory is situated a stone's throw away from the university.



A modelled bathymetry for the Port of Durban.

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From left, the CSIR's Johan Kieviet, Mogau Sebopa, a coastal engineering Master's student with specialisation in numerical modelling and Kishan Tulsi.

The CSIR, here represented by Dr Abel Ramoelo, (centre), regularly hosts University of Limpopo students to expose them to the latest techniques and technologies in earth observation science.

The CSIR and University of Limpopo collaborate to build capacity in remote sensing

The CSIR has partnered with the University of Limpopo (UL) to build capacity in remote sensing in South Africa. The partnership was motivated by the shortage of capacity and skills in spatial analysis at the CSIR and in southern Africa.

THE SOUTH AFRICAN Risk and Vulnerability Assessment Centre (SARVAC), a research centre for spatial analysis and modelling, has been established as a result of the partnership between the CSIR and the UL. The centre, based at the university, provides up-to-date data and information through its links with the CSIR.

The role of the CSIR in the partnership is to accelerate capacity building and develop innovative technological tools for remote sensing. The partnership will support strategy development and decision-making in areas of risk and vulnerability.

"This partnership makes significant contributions to supporting South Africa's resilience to the effects of climate change," says Prof Kingsley Ayisi, SARVAC Manager and programme coordinator at UL.

Dr Abel Ramoelo, a CSIR expert in remote sensing, is a research associate at the centre and currently co-supervises UL remote sensing students. Ramoelo's research interests are in vegetation quality and quantity estimation; improving and developing techniques to extract vegetation parameters using remote sensing technologies; and assessment, tree species identification, estimation and validation of leaf area index.

"One of the contributions of the CSIR's earth observation research group has been to assist several universities with the development of the remote sensing curriculum and information technology infrastructure requirements," says Ramoelo.

This collaboration provides university students with an opportunity to visit the CSIR regularly to download remote sensing data and learn about new techniques and technologies.

"With the expertise from the CSIR, we have experienced an increase in the number of postgraduate students for this programme," says Ayisi.

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Prof Sisa Pityana, a CSIR expert in the field of laser materials processing, supervises TUT graduate Thabo Lengopeng using laser cladding equipment at the CSIR. "Laser cladding describes the process where we use a laser to melt certain types and combinations of metal powders onto steel to cover it with a layer that will make the surface harder and more resistant to corrosion and wear," says Lengopeng.

The researchers use a vernier caliper to measure the thickness of a metal layer deposited through laser cladding and (right) studying a sample in front of a robot arm.

Working with TUT to train young experts in laser materials processing

The CSIR is collaborating with the Tshwane University of Technology (TUT) in the field of laser materials processing. Through this partnership, students at the institution also get valuable workplace experience.

THE FAILURE OF A SINGLE COMPONENT as a result of wear or corrosion can result in the scrapping of entire pieces of industrial equipment. This may have costly consequences, for example when it halts a manufacturing process and if the new part is subject to a long lead time from overseas suppliers. This is why training experts in the field of laser materials processing – as the CSIR is doing in collaboration with TUT – will benefit South African industry.

"In engineering, materials are fundamental. We are the so-called doctors of materials who choose which materials are suited for which applications and to find ways to make them harder, more corrosion and wear-resistant and change them to fit different applications," says Dr Patricia Popoola, senior lecturer and researcher at the Department of Chemical, Metallurgical and Materials Engineering of TUT's Faculty of Engineering and the Built Environment.

The CSIR's Prof Sisa Pityana, an expert in laser materials processing, was Popoola's supervisor when she worked on her Doctor Techologiae degree, which she completed in 2011.

They continued to collaborate and since then many TUT students have completed the practical components of their Baccalaureus, Magister's and Doctors Techologiae degrees in the field of laser materials processing at the CSIR, supervised by Pityana.

"The exposure that our students get at the CSIR brings them closer to a real-life research environment. They are exposed to the latest technology and expertise that they would not get anywhere else," says Lerato Tshabalala, a senior technologist at TUT who is doing her Doctor Technologiae under supervision of Pityana.

Thabo Lengopeng is another TUT student who is now working towards his Magister Technologiae at the CSIR. "I see myself doing industrial research one day. Working at the CSIR gives me the opportunity to get the necessary experience," says Lengopeng.

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Naleli Matjelo, a PhD student in laser physics, (left) and Dr Ncamiso Khanyile who is doing his post-doctoral studies in laser physics, both at the Stellenbosch University, look on while Dr Hermann Uys adjusts the cooling laser for their ion trap experiment.

Single ytterbium ions are confined in the ion trap pictured in the vacuum chamber. The gold-coated electrodes are visible in the centre of the image.

Deploying the best in quantum physics to help South Africa compete

Internationally, research organisations are deploying teams of top quantum physicists in a quest to develop a next generation of computers and instruments that are predicted to reach unprecedented computational capacity and unrivalled levels of measurement sensitivity.

CSIR PHYSICIST, Dr Hermann Uys, has been appointed as a research chair in quantum, optical and atomic physics at Stellenbosch University's Faculty of Science, as part of a collaboration between the organisations to boost local training of experts and to tackle some of the fundamental aspects of research in this field.

"A quantum physicist studies nature at its most fundamental level, at the level of atoms and molecules. There are many applications that are already exploiting quantum effects, for example, the atomic clock, which provides very precise standards of time and frequency. Every global positioning system satellite has more than one atomic clock on board to keep track of its whereabouts while orbiting," Uys says.

His research focuses on trapped ions that are a leading contender in the race towards quantum computers.

"Conventional computers use electrical signals as bits, a unit of data with a value of 0 or 1, which are used to represent information in binary code. These new computers would run on quantum bits, called qubits. Trapped ion qubits consist of single ionised atoms, suspended in oscillating electric fields under vacuum and cooled to extreme temperatures using lasers. Due to their quantum nature, a qubit can occupy a superposition state, so that it is simultaneously in both 1 and 0, and it is this property that ultimately leads to the speeding up in certain computational algorithms."

"We would like to develop quantum technologies for precision measurement instruments that rely on so-called quantum feedback loops. However, the kinds of measurements typically used by quantum physicists strongly disrupt the ions, making it difficult to preserve their superposition states so they lose their 'quantumness'. We are trying to find ways to overcome that by extracting only small amounts of information from the qubits at a time, therefore disturbing them less."

According to Uys, it will take years for this type of technology to reach the market, which is why it makes sense for the CSIR to work closely with the university where there is a strong interest in the fundamental aspects of this work that still needs to be done. In the meantime, they also work to develop more conventional technologies that advance their research field in a short space of time.

He also lectures and supervises students. "It is a complex field and not a one-man job. At the university, I benefit through having access to highly trained people in this field."

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Above: Students hosted by Imfuyo Projects in Benoni are (left) Nozipho Mabaso, Jan Legodi, and (right) Khosi Shabalala and Mandy Rasemphe. Busisiwe Zondi, (centre) is the Project Manager: TLIU Science, Engineering and Technology Industry Internship Programme.

Students hosted by Silverton Engineering in Pretoria are (left), Emmanuel Tebo, Mduduzi Ndlangamandla, and (right), Patience Hlungwani and Alfred Randima. Busisiwe Zondi, (centre) is the Project Manager: TLIU Science, Engineering and Technology Industry Internship Programme.

INDUSTRY INTERNSHIPS GAIN MOMENTUM

A programme to develop human capital in science, engineering and technology through an industry internship programme has benefited over 200 students. The programme is the outcome of a partnership between the Technology Localisation Implementation Unit (TLIU) and the Southern African Society of Cooperative Education (SASCE).

SOUTH AFRICAN ENGINEERING students completing a National Diploma are taking the plunge into the world of practical work for a year, thanks to the Science, Engineering and Technology Industry Internship Programme (SETIIP). The Department of Science and Technology formed the TLIU to implement aspects of its technology localisation plan. One of these deliverables is human capital development, in the form of an industry internship programme, the SETIIP. The programme caters for students in various engineering disciplines, notably mechanical, electronics, electrical, industrial, civil and metallurgical engineering. The TLIU is hosted by the CSIR.

The partnership between the TLIU and SASCE is critical to the growing success of the internship programme, which commenced in 2014 and is gaining momentum. SASCE is a body formed by the universities of technology, colleges, the National Skills Authority (NSA) and industry with a board of directors representing universities, the NSA, the Quality Council for Trades and Occupations, the Department of Higher Education and Training, Skills Education Training Authorities, public and private Technical Vocational Education and Training colleges, and industry.

Shakeel Ori, President of SASCE, says, "Through the partnership with the TLIU, we are able to utilise our database to identify students for placement in the various engineering disciplines in at least five South African provinces."

"We place students with companies that have benefited from the Firm Technology Assistance Packages of the TLIU." These packages are interventions to assist companies to achieve higher levels of competitiveness in industry. Many students have been successfully placed upon completion of their practical training.

The TLIU's Busisiwe Zondi, who oversees the internship programme, is enthusiastic about the programme's progress. "To date, our programme has benefited over 200 students. The mentorship provided by SASCE has helped to ensure the ongoing viability and success of the internship programme," she says.

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Learning from the experts: Architecture student Silindzile Shongwe puts his work on display for the scrutiny of Llewellyn van Wyk, CSIR; and Graham Young, University of Pretoria.

IMPARTING KNOWLEDGE ON SUSTAINABLE DESIGN

A good working relationship between researchers at the CSIR and their counterparts at the University of Pretoria (UP) ensures that architecture students at the university benefit from lectures that focus on the latest practice and development relating to sustainable design.

CSIR EXPERTS PARTICIPATE in an annual Earth Sciences: Sustainable Design Workshop, which forms part of a module for third-year students in architecture, landscape architecture and interior architecture at UP. The workshop helps students understand and apply the key concepts of sustainable design.

Sustainable design in the context of the built environment requires of students to understand the role of the built environment in climate change adaptation and mitigation strategies. The CSIR's multidisciplinary skills base makes the organisation a valuable partner in conveying different aspects of sustainable design including energy, water, emissions, waste and ecology.

The course features an introductory talk on urban ecological landscape design by the university's Graham Young. CSIR experts are then able to share their expertise: Llewellyn van Wyk on resilience in the built environment; Dr Dirk Conradie on design for climate change; Tobias van Reenen on indoor environmental quality; Steve Szeczuk on energy considerations; Coralie van Reenen on green materials; Cathy Mphahlele on high-performance building envelopes and Louisa Duncker on water and sanitation.

"Under typical lecturing circumstances, there aren't courses that cut across a range of different disciplines. It's a classical dilemma in lecturing – you appoint someone for their expertise, but the increasing multidisciplinary skills needed to address society's challenges, also necessitates knowledge about other aspects. This module manages to do exactly that. By bringing in the different CSIR experts, the university brings a cross-cutting dimension that benefits the students," says CSIR principal researcher Llewellyn van Wyk, an expert in the design and implementation of high-performance green buildings using innovative technologies.

The students have access to the CSIR researchers, who work at the edge of innovative building technologies. "At the CSIR, we typically do evaluations of some of the latest technologies available and match these to design problems in the built environment. We match technologies to problems, make recommendations, oversee implementation and undertake post-occupancy evaluation to determine how it's working. We also assess the learning outcome to determine whether there is a policy gap that should be passed on to policy makers. This means that we continuously have fresh case studies to draw on when engaging with students," says Van Wyk.

He says sharing knowledge is rewarding. "In 2015, we've participated in and taught at the sustainable design workshop for the fifth time and we will do so again in 2016. Ultimately, we want students to go into practice not just having come across some of the concepts, but actually having implemented these. The practical component of the sustainable design workshop does just this."

Van Wyk does not think that South Africa has sufficient knowledge sharing and transferring partnerships of this nature. He says that resource constraints hamper such undertakings, but, "if we don't do this, the students are not going to get it anywhere else."

This thought is enough to continue to mobilise the group of CSIR researchers to continue rendering this public-good service.

Angelique Ingabire from the Rwanda Agricultural Board and the CSIR's Simone Hammersley preparing samples for real-time polymerase chain reaction during a training course at the CSIR for laboratory staff from African countries participating in the programme. The course was funded by South Africa's Department of Science and Technology, the National Research Foundation and SANBio.

Jointly fighting foot-and-mouth-disease

Foot-and-mouth disease affects livestock across Africa. In an effort to address this problem through a collective approach, the CSIR is leading a Southern African Development Community (SADC) programme, in collaboration with the University of Pretoria (UP) and the Agricultural Research Council, and with collaborators from Zambia, Namibia, Botswana, Rwanda and Mozambique.

"LIVESTOCK FARMING is a way of living for many people in the SADC region. Outbreaks of a viral disease not only affect the health of the animals, but also result in stringent food safety regulations, preventing the export of animals and animal products to lucrative foreign markets. Diseases such as foot-and-mouth disease debilitate the economic viability of rural areas – typically areas where it is already difficult to achieve economic sustainability," says Dr Phiyani Lebea, CSIR research group leader for molecular diagnostics.

One of the aims of the programme is to develop skills in this domain. "It's a disease that knows no borders. If it breaks out in Namibia, it's just a matter of time before it is in Pretoria. We can only contain it through meaningful collaboration. It will be of no use for South Africa only to have the knowledge and the infrastructure. We need highly skilled and sufficiently resourced biotechnologists and biochemists in the SADC countries to fight the disease," he says.

To do this, Lebea, who lectures a biochemistry honours course at the University of Johannesburg, also lectures in Rwanda through a formal collaboration agreement with the University of Rwanda. In addition, he advises and mentors PhD students that are registered either with UP (veterinary science) or the North-West University (molecular biology and biochemistry). Currently, two South African students are enrolled for Master's degrees and two for PhDs. Six PhD candidates from the collaborating African countries will enrol in 2017. A further 30 personnel are trained as part of the programme through annual training interventions.

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