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CSIR
Touching lives through innovation

FOREWORD

CELEBRATING OUR WOMEN

Every year in August, South Africa celebrates its women. This year is no different. And yet it is.

The Covid-19 pandemic, with its relentless, devastating impact is contributing to even higher levels of poverty, unemployment and gender-based violence. Factors that are dealing a relentless blow to efforts worldwide to achieve gender equality.

It is hard to comprehend that, although women make up half of the world's population, they hold only 20% of its leadership, according to the United Nations (UN) Economic and Social Council. The World Economic Forum estimates says that, on average, around 30% of the world's researchers are women.

Recently, the UN said that global efforts to recover from the Covid-19 pandemic are under threat because women are being excluded from critical decision-making roles. The organisation says that only 6% of Coronavirus task forces, which are responsible for co-ordinating government responses to the deadly virus, have equal numbers of men and women, while 11% have no women at all. I agree with the UN that "sustainable recovery is only possible when women are able to play a full role in shaping a post-Covid-19 world that works for all of us."

In 2020/21, some 36.4% of the CSIR's science, engineering and technology base was female – a slight increase from the previous year's 35%. At leadership level, three out of the seven executive committee members are women. The organisation has implemented a number of human capital development programmes with a sizeable cohort of women participating, and we are confident that this will help us grow the number of women scientists, engineers and technologists.

We know that the gap begins in education; that not enough girls are encouraged to select mathematics and science as school subjects. Often girls don't see and encounter enough role models in science, technology, engineering and mathematics. In the people section of this edition of *ScienceScope*, we hope to contribute, in a small way, to efforts nationally to reverse this scenario. Meet some of the CSIR women in our multidisciplinary teams. Some of them have many years of experience, and accolades to show for it, others started their career journeys fairly recently.

Some of the women featured are very closely involved in Covid-19-related research, while others are working, alongside their colleagues – the men and women of the CSIR – to continue with work that will help make South Africa more competitive, despite a world pandemic. I salute every one of our researchers for their dedication throughout the pandemic.

A *ScienceScope* would not be complete without also including some of our latest work, so also read about a device that warns officials of airborne transmission risk inside health facilities; and how we have helped a local steel pipe manufacturer develop a composite material to replace the material used to coat its steel pipes. Enjoy these and other stories.

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Dr Thulani Dlamini
CSIR Chief Executive Officer

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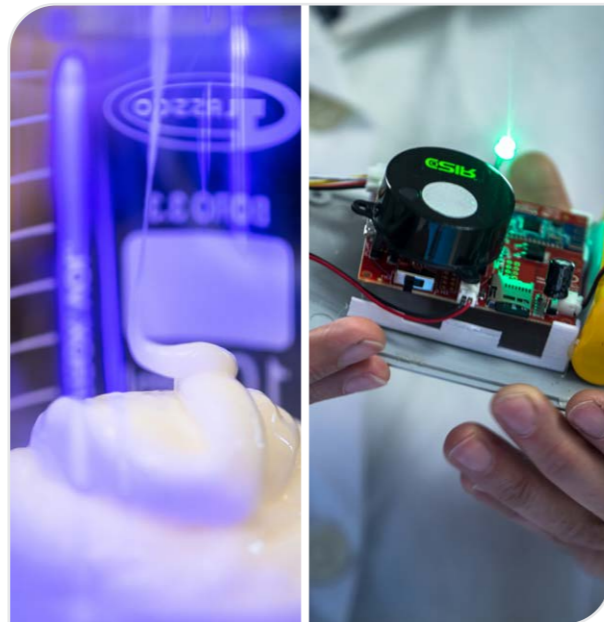
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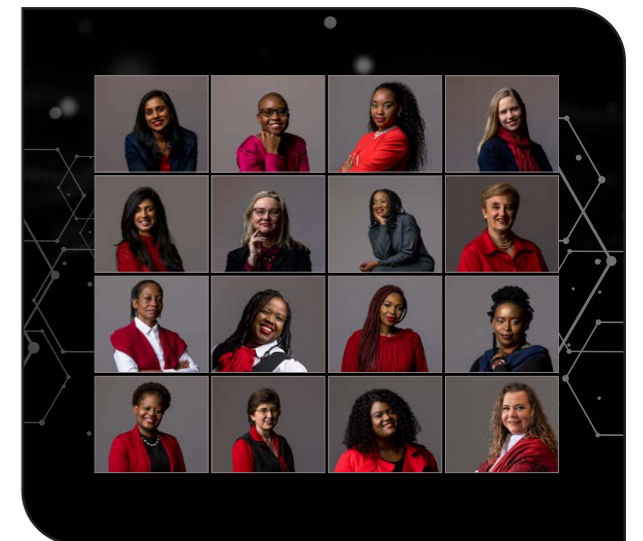
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OUR PEOPLE

The CSIR's dynamic team of experts in environmental assessment has been actively involved in environmental planning for South African renewable energy and electricity grid infrastructure. This included three new renewable energy development zones and two expanded power line corridors, gazetted in April 2021.

Four members of the team are, from left, Abulele Adams, Paul Lochner, Kelly Stroebel and Luanita Snyman-Van der Walt. Adams, Stroebel and Snyman-Van der Walt first joined the CSIR as interns in 2014. Adams has an MSc in geography from Nelson Mandela University and Stroebel is completing an MSc in remote sensing through Stellenbosch University. Snyman-Van der Walt is finalising her second MSc, which is in geo-design, through the Vrije Universiteit Amsterdam, the Netherlands. Adams is a lead author of the national Ecosystem Environmental Assessment Guideline that is currently being finalised in collaboration with the South African National Biodiversity Institute. Lochner is the research group leader of the CSIR's environmental management services research group.



Each one, teach one: Ghaneshree Moonsamy's recipe for **empowered future scientists**

Dr Ghaneshree Moonsamy is a biotechnologist who uses her technical expertise to develop impactful and sustainable technologies for small, medium and micro enterprises and industry partners, driven by her passion for science. But she is equally driven by her passion for people – drawing on her personal career experiences to mentor and motivate young people to take on careers in science and technology.

Dr Ghaneshree Moonsamy started her career at the CSIR in 2006 as an in-service trainee of the bioprocessing development research group. With grit and passion, she progressed to the position of senior researcher in bioprocess development in 2016. Her research interest in the development of production technologies for bio-based products led her to pursue a Master's degree in biotechnology with the Durban University of Technology. Her thesis, which focused on the development of a bioprocess technology for the production of *Vibrio miodae*, a probiotic of value in abalone aquaculture, was converted to a doctoral degree – a first for the university.

This achievement is one of many accolades. Other notable milestones include developing several licensed technologies and commercially available products that have been taken up by the market and are generating royalties for the CSIR. She also counts working with small, medium and micro enterprises (SMMEs) in developing suitable technologies for market to support their business growth, as a milestone.

"Finding ways to develop sustainable technologies for SMMEs and our industry partners is one of our main objectives. As we know, the human population has overexploited natural resources. As a result, part of our research and development activities explore how micro-organisms can be suitably applied so that we live more sustainably. One such approach is how agricultural biological agents may be applied to reduce the use of chemical pesticides for better crops, with less disease and carry-over of chemical products to human consumers."

Another avenue is the development of human and animal probiotics. Moonsamy adds that the CSIR probiotic technology development approach is not only aimed at improving the livelihoods of humans, but it also explores a more sustainable way of producing animals for human consumption. So, as part of driving the

development of circular technologies and an economy that drives this agenda, the CSIR team grows micro-organisms using waste feedstocks from other industries in order to generate probiotics and agricultural biological agents, as well as other products of value, from these waste substrates.

Years of experience in research, working with industry, and her passion for mentoring young people have made her the ideal candidate to transfer her knowledge to learners and postgraduate students. As an advocate for young people taking on careers in science, she has volunteered her time to a number of educational media programmes for children."

"My career journey has not been easy; it has been a mixed bag of ups and downs, and a balance between work, my postgraduate studies and being a mother. As a result of my experiences and personal journey, my idea of success is not just about the impact of my academically inclined science outputs on society, but it is also about finding meaningful ways to use my experience to help nurture the skills of those around me," says Moonsamy.

"I consider myself to be very blessed to have a career that is so fulfilling. When I look back, I realise that all I have achieved thus far is something to be proud of, and all that I have learnt throughout my journey, I ought to share with young people who are aspiring scientists. I believe that if each one could teach one, our personal successes could contribute to empowered and knowledgeable future scientists," concludes Moonsamy.

Current position: CSIR senior researcher

Career type: Biotechnologist

Education: PhD (Biotechnology), Durban University of Technology, 2019



Above: Dr Ghaneshree Moonsamy and former colleague Arvesh Parsoo set up lab-scale bioreactors to conduct microbial cultivations.

CSIR senior researcher Dr Ghaneshree Moonsamy

Conversing with **microbes** in the search for **solutions**

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The better we understand how the virus behaves and the areas that are prone to change during replication, the easier it is to design and produce a vaccine that not only protects against specific current strains, but also the myriad of emerging ones.

- Dr Tovhowani Ramulongo, CSIR

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aving a knack for understanding biological systems but hating the sight of blood might not make for a good medical doctor; however, as Dr Tovhowani Ramulongo is finding out, nothing stands in her way of being an excellent molecular biologist.

Dr Tovhowani Ramulongo credits the CSIR for her decision to become a researcher, “During my final undergraduate year, I developed a significant interest in molecular biology. A CSIR bursary enabled me to be part of Stellenbosch University’s Molecular Biology Honours Programme. During my internship year at the CSIR, I was exposed to experts in the field and I realised that I love research – and that I am even pretty good at it!”

Ramulongo joined the CSIR in May 2020 and immediately immersed herself in the diagnostic processing of Covid-19 samples, looking at ribonucleic acid (RNA) extraction and reverse transcription polymerase chain reaction (RT-PCR), and analysing results, managing data and doing research on the virus’ evolution.

“Most of my time is spent in the lab, having conversations with microbes. But there are days where I must read articles, design experiments, do computer-based analysis and write reports,” she says.

Understanding the virus

Apart from the socioeconomic chaos brought about by the Covid-19 pandemic, global concern has also focused on the rate at which the virus strain changes. Ramulongo’s current focus is to understand exactly that.

She explains, “The global Covid-19 pandemic has raised the awareness about the danger posed by coronaviruses. We have seen how easy such viruses change. Just a minor change in the genomic information can have a drastic impact on the protective immunity that might have been conferred through infection or vaccination. I am specifically looking at how this happens during the course of infection in an individual and/or as the virus spreads between individuals.”

The potential impact of this research is obvious. “The better we understand how the virus behaves and the areas that are prone to change during replication, the easier it is to design and produce a vaccine that not only protects against specific current strains, but also the myriad of emerging ones.” Her dream is to be able to do such life-changing research, without financial constraints.

Meaningful life skills

Ramulongo lists completing her PhD as her greatest achievement thus far. She is quick to add that the process also presented her with an unexpected obstacle and invitation to stretch her perseverance muscles.

“I did not expect the process to be so frustrating,” she admits. She completed the experimental part of the work in four years, but writing the thesis and publishing took another two years. “I was completely dependent on someone for input and had to learn to endure the process.”

As a female researcher, she has learnt – and offers this advice to others – that “the people around you are watching. Staying focused is important, and obviously, always giving your best.” She also believes in being kind, eager to learn, and knowing how to make your voice heard. Working together is essential, “You can never go far on your own, you need others to lift you up.”

Ramulongo deals with bias philosophically, “We are inclined to prefer some individuals over others. Sometimes it has nothing to do with what they can bring to the table. It is hard to be overlooked, but when that happens you must not let other people’s shortcomings hold you back.”

Current position: CSIR senior researcher

Career type: Microbiologist

Current research: Mutation rate of SARS-CoV-2 in infected individuals

Education: PhD (Microbiology), University of Pretoria, 2020



Above: Dr Tovhowani Ramulongo studying genetically engineered bacteria expressing recombinant proteins.

CSIR senior researcher Dr Tovhowani Ramulongo

“

Being a woman comes with gifts: we are born with a special amount of resilience, gentleness and empathy. Often one has to tap into all of that to overcome inevitable obstacles.

– Dr Bolelang Sibolla, CSIR

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CSIR researcher Dr Bolelang Sibolla

Pursuing research with measurable impact

As an ambitious child, Dr Bolelang Sibolla thought of becoming a medical doctor. Soon, however, her strengths pointed her to geomatics, at the time a relatively unknown study area. The geomatics field appealed to her because it is a niche area that provides specialised solutions, while catering for her inherent interest in the physical aspects of the environment. During her studies, she became particularly interested in monitoring wide geographic areas, and portraying these through digital media.

Dr Bolelang Sibolla joined the CSIR in 2010 and is currently a researcher in spatial information systems. “We develop bespoke geospatial systems that address a specific need and inform decisions. Our systems are based on open-source software. We use international geospatial standards that allow for interoperability and accessibility by other geospatial systems, whether open source or proprietary, if they adhere to international spatial data and infrastructure standards,” she explains.

Focusing on technology, Sibolla splits her activities between front-end software development for web-based geospatial applications, and researching the latest and best geospatial technologies, analysis methods and standards that can enhance the team’s technology offering.

Sibolla explains that location data were traditionally provided by the Earth observation community using Earth observing satellites from space. Now the number of players in this field has increased significantly, resulting in many other types of sensors that provide location-based information – think about mobile phones and vehicle trackers – at varied frequencies, spatial resolutions and at much larger data volumes.

While great news for the growth of Earth observation systems, the challenges come in developing a system that can accommodate all these types of data and portray these seamlessly and sensibly to the end user, and sharing large data volumes with others. To help address this challenge, Sibolla is looking at ways to enable geospatial data discovery and accessibility using data-sharing standards and interfaces.

“The relevance of our work is evident from the type of technology solutions we provide,” Sibolla says. “For example, our National Oceans and Coastal Information Management System provides decision support for the effective governance of South Africa’s oceans and coastal. For the National Department of Health,

we assisted with the development of services and infrastructure monitoring during the early onset of the Covid-19 pandemic, and with the analysis of data for the National Health Insurance programme.”

Making it worthwhile

Although completing a PhD and working full time while raising a young family is already impressive, a particular career highlight was when her PhD, assessed by international experts and professors in the geospatial domain, was passed without any corrections.

Following her own advice

To girls wanting to pursue careers in the sciences or technology fields, she says, “Anyone can achieve great things. Dedication and hard work are key, but also to believe in yourself and respect everyone you encounter.”

And bias? “I have been fortunate to have had a lot of mentors throughout my career, across the gender and race spectrum, and have not necessarily felt any specific prejudice or bias. One must, however, always stay positive, set goals, and remain focused. I would like to think that success is the sum of the impact you have had on others and society through your work.”

Current position: CSIR researcher

Career type: Geomatics engineer

Current research interest: Geovisualisation, geovisual analytics, spatiotemporal analysis and geospatial systems development

Education: PhD (Geoinformatics), University of Pretoria, 2020



Above: The National Oceans and Coastal Information Management System provides decision support for the effective governance of South Africa’s oceans and coasts.

“

These soldiers keep us safe and I enjoy the opportunity to help them do their jobs and contribute to improving their quality of life.

– Anria Clarke, CSIR

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CSIR mechanical engineer Anria Clarke

Helping those who keep us safe

As a mechanical engineer specialising in vehicle dynamics (how vehicles move) at the CSIR, Clarke retrofits existing vehicles with weapon systems and mounts that they were not originally designed for, but in a way that doesn't compromise the integrity of the vehicle.

Anria Clarke has had a glimpse of the grueling life that South African National Defence Force (SANDF) foot soldiers face in the theatre of war. During a visit to a training camp at the South African Army Infantry in Oudtshoorn in 2018, she witnessed the toll that training takes on their bodies, and developed a deep sense of empathy for the people who put their lives on the line to protect South Africa.

“It is a difficult life. I think that we would all be shocked if we knew the sacrifices that our foot soldiers have to make to defend our country.” She says budget cuts at the SANDF mean that foot soldiers increasingly have to make the most of what they have, including weaponised vehicles.

She's always loved mathematics, physics and design, and the retrofits she undertakes on existing vehicles used by the SANDF, satisfy her curious and creative sides. Before university, she considered a career in astrophysics because of her fascination with the night sky, and she even looked into becoming an interior designer.

“Something that put me off that path was that interior design has a lot to do with taste. And I thought I may end up working on something, and not believing in the project because it's not to my taste.”

Her father, an electronics engineer, had always encouraged her curious young mind and was always able to explain how things work. So she settled on engineering, graduating from the University of Pretoria in 2009.

She has since further specialised in vehicle suspension. She looks specifically at the physics of additional weight on military vehicles, and also at the comfort and safety of the soldiers who use the system.

“We need to consider the trade-offs in crew capacity and the inclusion of sacrificial components, meaning the parts of the vehicle that will not last as long as originally

designed,” she says. “These soldiers keep us safe and I enjoy the opportunity to help them do their jobs and improve their quality of life.”

Clarke's career highlights include graduating with a distinction for her Master's in Engineering, and winning the best student paper award at the American Society of Mechanical Engineers Advanced Vehicle Technologies conference in 2014.

She says other young women planning a career in science, technology, engineering and mathematics should leverage their interest in science and their creativity to take up this rewarding career because they will always be intellectually stimulated in mechanical engineering.

“Don't let people discourage you by telling you that it is a male-dominated field. It is your life and you have to do what makes you happy!”

Current position: CSIR engineer

Career type: Mechanical engineer

Education: Master's (Engineering), University of Pretoria, 2013.



Above and below: CSIR engineers assist the country's armed forces with novel alterations to commercially available vehicles, to match their intended use, for example, as field ambulances and troop carriers.



Building an equitable future for women in artificial intelligence

Engineer, volunteer, meditator. Loves the space where technology and innovation coincide. Passionate about tech capacity building...dabbles in guitar playing.

- Dr Reevana Balmahoon in 160 characters.

The World Economic Forum's 2021 Global Gender Gap Report shows that just 32% of professionals in data analysis and artificial intelligence are women. The report identifies some of the major challenges as encouraging interest in the field among girls, and convincing women in engineering to take up emerging roles in the technology space. Dr Reevana Balmahoon aims to change that. She leads the CSIR's group for artificial intelligence and augmented reality and wants to enhance the experiences of women and young people in this space.

Dr Reevana Balmahoon is on a mission, along with WomEng, to help encourage one million girls around the world to take up careers in science, technology, engineering and mathematics (STEM). She is a research leader in what the tech world calls the 'jobs of tomorrow' and she is the tech lead at WomEng, a multi-award winning social enterprise developing high-skilled girls and women for the engineering and technology industries.

A curious mind brought Balmahoon to this point in her career; she acknowledges the role her parents played in helping her decide which career options were available to her in Grade 12. "At the time, I felt this was extremely confusing, but I am grateful to have been able to make an informed decision about pursuing engineering during my tertiary studies. I have not looked back."

However, her journey has revealed the need for transformation and inclusivity for women who want to pursue this field. "This is a global issue – I remember visiting Microsoft in the United States of America in 2017 and was surprised to see that less than 40% of their tech positions were held by women." She says the reason for the shortage of females in STEM careers is two-fold: the lack of female role models, and the stereotype that suggests that women cannot be engineers. Balmahoon has resolved to change this reality by encouraging more women to take up space, and has started and contributed to multiple initiatives that intentionally focus on the recruitment of young women into the engineering fraternity.

She leads a dynamic team of researchers who produce cutting-edge research and working solutions across industries in the artificial intelligence (AI) environment. She looks at ways of mobilising the emerging

technology of augmented reality (AR), so as to enhance the insights formulated by AI methodologies. "Some believe that AI poses threats to humankind and others believe it is the best possible way forward. We are working on finding patterns in all types of data, which can be used to make better quality decisions, so that the value of AI and AR can be realised," she says.

As a researcher in an evolving technology, Balmahoon is constantly looking for new applications of AI and their relationship to enhance how humans experience the world. To keep abreast of the latest advancements, she ensures that her finger is on the pulse of the industry.

"In June 2021, Google and Harvard University unveiled the most detailed image of the human cerebral cortex, with approximately 130 million synapses. With this amazing achievement, the complexity of the human brain is highlighted. Our contributions serve to enhance the decision-making power across industries, while delving deeper into the human mind and understanding how to use these AI algorithms for good."

Current position: CSIR research group leader for artificial intelligence and augmented reality

Career type: Researcher in artificial intelligence and augmented reality

Education: PhD (Engineering), University of the Witwatersrand, 2015

MBA, Gordon Institute of Business Science, 2017



Above: Facilitating a workshop in artificial intelligence and cybersecurity in partnership with the Royal Academy of Engineering.

“

With perseverance and solidarity, the future is full of promise for women in science, and there are excellent prospects for us to play meaningful roles crafting the smart towns and cities of the future.

– Peta de Jager, CSIR

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CSIR impact area manager Peta de Jager

A career dedicated to smarter buildings

P

eta de Jager works with teams that apply science, innovation and technology to make buildings better in as many ways as possible.

Who could have guessed that a child's bus trip into the centre of Johannesburg, meandering through streets flanked by the impressive facades of large buildings, would set the scene for a successful career as an architect decades later?

Yet, Peta de Jager was hooked. She says, "I was held captive by the mysteries concealed behind the glamorous granite lobbies of these tall structures. When I found out these were created by architects, I knew that was what I would do one day." She never doubted her decision and admits that she still loves the smell of new concrete.

She started as an architect-in-training in 1991 and worked as an architect in other firms and her own practice before joining the CSIR in 2007. She excelled. Besides publishing extensively, providing strategic leadership and mentoring students, being the CSIR convener for continuous professional development short courses on 'Building Design and Engineering for Airborne Infection Control' and the 'International Clinician's Course for TB Management in South Africa' counts among her many diverse achievements. De Jager also led the 'Innovation for Inclusiveness: Science Technology and Innovation for Sustainable Human Settlements Roadmap', which is currently entering a 10-year implementation phase.

Despite these and other feathers in her cap, De Jager considers the variety of people she gets to meet a main career highlight. "I consider it a privilege and a wonder that my vocation has enabled me to interact and work directly with ministers, a Zulu king, a Nobel laureate, electricians, plumbers, plasterers, cleaners and professors."

More than concrete

Far from only being concerned with the aesthetic qualities of a building, De Jager says she works with teams that apply science, innovation and technology to make buildings better in as many ways as possible.

"We endeavour to make the insides of buildings healthier, for example, by looking at how design and

engineering can minimise the spread of diseases. We look at how to diminish the environmental impact of the extracted materials used for our structures. We look at how data and information can be harnessed to be good stewards of our existing infrastructure and to plan our new infrastructure."

She explains that while we spend nearly all of our time in environments modified through human endeavour, "We mostly fail to appreciate the significant effect of the built environment on our quality of life, productivity, health and wellbeing. We are also often unaware of the effects of construction activities on our human habitats, our resource endowment and the ecology."

De Jager says, success to her is functional building infrastructure in which structures, features and facilities are fit for purpose and service. In other words, "They are conceived, executed and managed with multidisciplinary ingenuity. They host the full range of human endeavour, consistent with the aspiration of achieving 'smart places'. In my version of success, all citizens attach a sense of belonging to what we build; and the way we exploit and transform our landscapes is meaningful and responsible, in other words, 'smart'."

Current position: CSIR impact area manager for functional building infrastructure

Career type: Architect

Current research interest: Science, technology and innovation for smarter built environments

Education: Bachelor of Architecture, University of the Witwatersrand, 1995 and Master in Applied Ethics for Professionals, University of the Witwatersrand, 2010



Above: Peta de Jager with a CSIR-designed sustainable modular clinic model.

The road less taken: Lydia Kwange's determination to make a **difference** in the **transport sector**

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Every woman is meant to shine; we all have something special to offer.

- Lydia Kwange, CSIR

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L Lydia Kwange's story is one of grit and determination. It's the ultimate proof of what is possible through sheer willpower. It's the story of a switchboard operator who invested every ounce of energy left after a full day of work, into her studies. Today, she works as a transport technologist alongside some of the country's brightest minds.

Lydia Kwange specialises in transport economy. Her research interest lies in addressing the challenges that South African passengers face.

But to live out this passion, took drive and will power. Kwange was first hired as a switchboard operator at the CSIR in 2006. After three years, she asked to be moved, "I requested my then manager to consider moving me because I had learned so much. I was transferred to the CSIR's call centre, where I took calls from users across the CSIR's Pretoria campus who were experiencing information technology and other systems problems. I spent 11 years at the CSIR in this role," Kwange says.

While working as a call centre agent, Kwange studied towards a diploma in electrical engineering. She needed to do a six-month in-service training stint to move on to do her N6 qualification. While looking for training opportunities at the CSIR, she was referred to an operating unit at the CSIR that focused on the built environment and transport technologies.

Here, she encountered CSIR impact area manager, Dr Mathetha Mokonyama, who advised her to get involved in a project that focused on cross-border road transport. "I started seeing transport from a different angle. People from Zimbabwe bought food, clothes and furniture in South Africa and transported it to their families in Zimbabwe. I realised that transport is vital to an economy's well-being. It's such an important sector; one that influences the competitiveness of our industries and our society. I also observed that it was a male-dominated sector, and I wanted to make a difference," says Kwange.

Kwange's job focuses on finding solutions that can be used in transport systems and operations. She is involved in the collection, validation and analysis of data.

The transport research team of which Kwange is part, was called upon by the Gauteng Department of Roads and Transport during the first lockdown of the

Covid-19 pandemic in South Africa. The department required an in-depth analysis of pre-identified public transport hotspots in Gauteng to assist in combating the pandemic by identifying vulnerable commuters and areas of mobility. This was done using spatial data relating to the dynamics of passenger travel patterns, public transport networks and modes of public transport. The datasets were generated from earlier surveys conducted on behalf of the department. The information was used to geographically prioritise areas of intervention based on trip densities and route volumes. The team also made inputs regarding possible approaches of compensating minibus taxi operators, given the limitation on the number of passengers they could carry under lockdown regulations, which was informed by a thorough understanding of cost drivers in the minibus taxi industry.

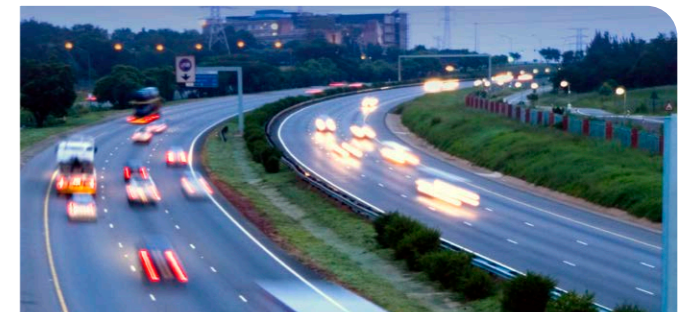
One of her career highlights was when she worked closely with the Gauteng MEC for Roads and Transport, Jacob Mamabolo, during a project to understand transport usage in Gauteng – and finding solutions to improve it.

Kwange says, like many other women, she initially battled to strike a work-life balance. Now, she knows how to manage her life. Her message to women is that it is never too late to make a difference in society. "Change begins with you."

Current position: CSIR technologist

Education: Advanced diploma in transport management, University of Johannesburg, 2020

Currently pursuing a B Comm (Hons) in transport economy, also through the University of Johannesburg.



South Africa's 750 000 km road network facilitates economic growth, local economic development and job creation.

CSIR technologist Lydia Kwange

A pioneer in producing greener technologies

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The aim of my work is to produce products with green technologies and develop technologies that are techno-economically feasible, resulting in products with the correct purity and that can be commercialised. That is success.

- Dr Lucia Steenkamp, CSIR

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CSIR principal researcher Dr Lucia Steenkamp

With biology always being a firm interest, Dr Lucia Steenkamp wavered between becoming a medical doctor or a researcher. Her fondness for cooking and baking also had her consider opening a wedding venue. Fortunately for South Africa, aptitude test results gave the required nudge to become a researcher in biochemistry.

More than 20 years after her decision to become a researcher, with 5 patents, 5 technology packages and more than 10 technology demonstrators in the bag, Dr Lucia Steenkamp is an expert in the field of biocatalysis. In 2018, her work earned her the *Distinguished South African Women in Science Award* for Research and Innovation. Other career highlights include being a finalist in the 2013 and 2019 *National Science and Technology Forum Awards for SMMEs*, and in 2020, for *Corporate Organisations*; and leading the Industrial Biocatalysis Hub for South Africa for the next three years.

“The latter gives us the opportunity to really advance biocatalysis research and commercialisation in the country and contribute to the bio-economy. This may also result in the development of skilled jobs in the manufacturing sector,” she says.

She explains, “Biocatalysis is the ultimate green technology. Through biocatalysis we identify and optimise microorganisms and/or enzymes to accomplish specific reactions and produce certain desired molecules, instead of using classical chemical technologies. The technologies we develop do not require harsh chemicals or high temperatures; they consume little energy, and normally generate little to no waste.”

“Consumers are demanding greener technologies. By using biocatalysis, the environment does not encounter the same waste load. Also, products from this process are classified as ‘natural’, meaning that the commercial partner can ask a higher price for the product compared to products produced via classical chemical methods.”

A day in the life

Passionate about hands-on research, Steenkamp spends about 75% of her time in the laboratory. She engages with and identifies the needs of potential commercial partners, writes the necessary proposals,

and once approved, work starts with screening for microorganisms and/or enzymes that can give the desired bioconversion.

“We optimise the technology at laboratory scale, including the up- or downstream process for the product to result in the required purity. Scale-up to a measure agreed with the client follows, and a market sample is produced for the client to test and verify. Once we have our technology demonstrator, we decide whether the technology will be patented.”

The rest of her time is spent on the students under her wing working towards their MSc and PhD degrees and other administrative and project-related activities.

Steenkamp’s projects span from developing products for the food, flavours and fragrance industries, to cosmetics, pharmaceuticals and veterinary products. Among other clients, she has worked on the formulation of biocides for Biodx (Pty) Ltd. These were registered on 23 June 2021 as the only type 2 and 4 biocides from Africa in the European Union. These types of biocide refer to products used as surface disinfection for food contact and general surface disinfection, respectively.

“These two products have also been tested against Covid-19 and have a kill rate of 99.987% within seconds of application. The commercial partner has already sold ton quantities of the products to different local and international markets.”

Current position: CSIR principal researcher
Career type: Biochemist specialising in biocatalysis
Education: PhD (Biochemistry), University of Johannesburg (former Rand Afrikaans University), 1991



Above: Dr Lucia Steenkamp preparing for the demonstration of a newly developed technology on large scale.

Exploring much more than treats for tastebuds

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A key to success is collaboration with industry, academia and communities. Be hungry for knowledge. Talk to people; and attend scientific and technology conferences and meetings. These days it's even easier with online events, which are a click away.”

– Dr Nomusa Dlamini, CSIR

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CSIR principal researcher Dr Nomusa Dlamini

Inspired by Hippocrates' saying, "Let food be thy medicine, and let medicine be thy food", Dr Nomusa Dlamini, herself a food fundi, is quick to emphasise that her field of expertise, food science, has little to do with culinary conquests and everything to do with understanding the makeup of food from a nutritional, technological and safety perspective.

CSIR principal researcher Dr Nomusa Dlamini understands that to get to a safe, nutritious food product, one has to understand the chemical changes that food undergoes during cooking. "An example is the development of flavours as you fry a piece of meat or the structural changes that enable digestion, as well as the absorption of important nutrients and how these are assimilated into the body through various biochemical pathways," she says.

Her research in this field, she says, is important because it does not only lead to products that bolster healthy living, but also to job creation through cultivation and processing opportunities, and poverty alleviation from the commercial activities that have a ripple effect on employment and raising people's income brackets. The research also encourages the conservation of biodiversity and innovation.

At university, her desire to help humankind led her to study biochemistry, which allowed her to branch into food sciences and nutrition. "Considering that food intake affects our wellbeing, I felt I could make a real contribution, especially as the aspect of food safety is still overlooked, but is key to achieving good health and food security, not to mention its importance in overall human development," she adds.

Leveraging what nature has to offer

Dlamini's current research focuses on product and process development of nutritious food products and nutraceuticals. Her research also contributes to the country's Bio-economy Strategy that aims to address issues of job creation, poverty alleviation, and reducing malnutrition. "I work with small, medium and micro enterprises (SMMEs), communities and industry in trying to address the question of how to effectively use indigenous biodiversity, and creating value-added products that have health benefits."

She elaborates, "I explore how indigenous edible plants that show health benefits can be formulated into

innovative products. These plants are analysed for basic nutrient content, and extracts are prepared so that their chemical profile can be determined. For this aspect, I work with chemists who have the analytical tools and high-end equipment. I also work with botanists to confirm the identity of the plants. Usually, the edible plant will be formulated to a nutritious food product or used as an ingredient. However, in the case of health benefits, extracts are prepared to concentrate those components that are beneficial."

Illustrating the multidisciplinary nature of her work, Dlamini explains that once the beneficiation of extracts reach pilot scale, her team works with chemical engineers and process engineers to optimise the process of extraction. "In all those cases, the products must be safe for the consumer and, thus, we do safety studies, including toxicity and microbial safety, for which microbiology and pharmacology are other important disciplines."

Dlamini also helps SMMEs with product and process development. "They might have an idea and we help bring it to life, using our skills in product development and formulation, which include stability and safety tests." Once the development is complete, the technology is transferred and the SMME either receives training to be able to produce the product or is enabled to engage a contract manufacturer to help with production.

Current position: CSIR principal researcher

Career type: Food scientist

Current research interest: Addressing the issue of food safety along the food value chain, starting from primary production and processing, up to the food reaching the consumer (farm to fork)

Education: PhD (Food Science and Technology), Texas A&M University, United States of America, 2007



Above: Developing a nutritious drink formulation, based on indigenous ingredients, to help alleviate malnutrition in children.

Computational modelling and role modeling – the passions of Dr Rosinah Modiba

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We will have succeeded when gender is no longer an issue in certain career types and positions.

- Dr Rosinah Modiba, CSIR

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CSIR senior researcher Dr Rosinah Modiba

Dr Rosinah Modiba knew that she wanted to be a scientist from a very young age. “I believe it was my childhood environment, growing up in Soshanguve,” she says. “Even though I was young, I quickly became cognisant of the challenges that were surrounding me, and, in my mind, science was going to be a catalyst for change,” she adds.

Dr Rosinah Modiba develops shape-memory alloys for the medical and aerospace industries. Shape-memory alloys are metals that, even if they become deformed below a certain temperature, can regain their original shape when heated at a high temperature.

Using computational modelling techniques as opposed to traditional experimentation, Modiba can predict the properties and behaviour of shape-memory alloys at the development and composition stage.

“Recently, there has been an upswing in the demand for production and commercialisation, Modiba explains.

“The need to combine both computational modelling techniques and traditional experimentation to speed up the process has become a reality.”

“Computational models typically use observation and manipulation in the same way as traditional experimentation to predict the stability of materials – but at a lower cost and with minimal waste. The major advantage of computational modelling is the increased productivity that is achieved through the synthesis and characterisation procedures within a short period,” Modiba says.

Modiba forms part of the 23% of women in science, technology, engineering and mathematics (STEM), according to Statistics South Africa, a number that has grown since her student days. After completing her BSc degree at the University of Limpopo, Modiba was uncertain of the steps she needed to follow to become a scientist. Fortunately, she was recruited into an initiative that was offering STEM career empowerment and financial support to young women of different backgrounds.

She completed her Master’s degree *cum laude*, and obtained her doctoral degree in 2015. Her career journey is an inspiring story to many young women and Modiba is determined to share her story and uplift

as many young women as she can reach. She has partnered with Women in Physics in South Africa, an initiative that intends to bridge the gap between universities and schools through empowerment programmes.

Now a senior researcher at the CSIR and receiver of multiple grants, including from funding initiatives such as the CSIR’s Young Researcher Establishment Fund and the National Research Foundation’s Thuthuka, Modiba says young women should keep a positive mindset and work on their dreams throughout the challenges they encounter. “It might seem impossible at the beginning, but it’s doable. Young women must not let their background or challenges discourage them from achieving their goals,” she concludes.

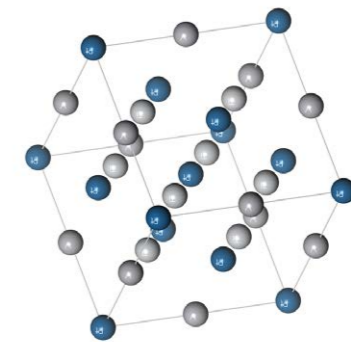
Modiba and her team are also working on harnessing the properties of the shape-memory alloys required for sensors and actuators in various industries, and modelling is playing a critical role at this stage.

Current position: CSIR senior researcher

Career type: Computational materials scientist; physicist

Current research interest: Development of alloys using computational modelling techniques

Education: MSc (Physics) (cum laude), University of Limpopo, 2010 and PhD (Physics), University of Limpopo, 2015



Above: A model used for the prediction of shape memory alloys.

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My advice to girls who would like to enter the sciences, is that everything is in their capable hands, to make or break, regardless of gender.

- Dr Lindiwe Thete, CSIR

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CSIR senior researcher Dr Lindiwe Thete

Following her heart for a healthy society

Dr Lindiwe Thete (née Nkabinde) joined the CSIR in 2004, left for academia in 2017, and returned in 2020 to throw her weight behind the organisation's drive to improve healthcare in South Africa. From her résumé, it is easy to find the golden thread she refers to as her heartbeat: to help people who are in need.

Dr Lindiwe Thete's desire to help people explains why medicine was her first career choice, even as a child. "My childhood painted a picture of an educated person, either as a medical doctor, lawyer, teacher or nurse. Medicine has been the centre of my core," she says.

When entry level marks precluded her from becoming a medical doctor, she opted for a biochemistry degree, something she has not regretted once. "This field painted a much clearer picture of how I can best contribute to the healthy lives of people through scientific research."

She quotes Lao Tzu when asked what success would look like, "He said, 'A journey of a thousand miles starts with a single step'. To me, success is the accomplishment of set goals and making a worthwhile contribution to the organisation and society."

In the lab

Instead of diagnosing and prescribing medicines for patients, her work takes her to the drawing board of how cells co-operate with pharmaceutical materials. This enables her and her team to contribute to the manufacture of the best course of treatment for diseases, varying from HIV/Aids, malaria and cancer to the current SARS-Cov-2 viruses, from both an efficacy and safety perspective.

Thete explains, "I am a cell biologist. Cell biology studies the structure and function of cells, and our interest lies specifically in the behaviour of cells when interacting with a pharmaceutical ingredient. Currently, we focus on the development and screening of drug-like candidates against various ailments, using high-throughput screening platforms, including toxicity screening."

To ensure that all the principles of the required standards for evaluation of biologics are met, her work also includes the development or amendment of standard operating procedures, and accreditation methods earmarked to support and strengthen her department's sustainability.

She emphasises that working diligently and observing all set protocols are key factors for success in this field. "People's lives are dependent on the outcome of our laboratory investigations," she says.

Memorable moment

As a favourite, she highlights a Department of Science and Innovation-funded project on nutraceuticals, which are products from food sources that provide nutritional and medicinal benefits. "We studied food ingredients with the potential of meeting the nutritional needs of impoverished children in South Africa and further afield in southern Africa. We used state-of-the-art technology that simulates human gastro-intestinal digestion. I received training for this at TNO-Triskellion in the Netherlands. This project aimed to alleviate poverty and targeted malnutrition in children, especially those younger than five. It had a great impact on my scientific world because I had to learn to communicate science to a society that is not necessarily science-savvy."

Being a woman in science

Thete says the only obstacle she has had to face, thus far, was when her doctorate took longer than expected, "I had it all planned to a tee, until I found out that I was expecting precious cargo to safely bring into the world," she quips. "But, I persevered and obtained my doctorate in the end."

Current position: CSIR senior researcher

Career type: Cell biologist

Current research interest: Development and screening of drug-like candidates against various ailments using high-throughput screening platforms

Education: Doctorate in Technology (Pharmaceutical Science), Tshwane University of Technology, 2015



Above: A 3D illustration of a human immunodeficiency virus.

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A career highlight was when the chairperson of the PhD examining committee congratulated me! It was a very anxious period. I travelled to the Netherlands to defend my PhD and got there just as the international Covid-19 lockdown did. I had to wait a week to find out if I could defend my research. Finally, when I did, I felt so relieved and excited, realising that my career as a researcher had taken off.

- Dr Nobuhle Majozi, CSIR

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CSIR researcher Dr Nobuhle Majozi

X-ray vision to follow water clues

Helping farmers to compute how much water to apply variably within their fields, instead of the same level of irrigation throughout, enables precision agriculture. This is the field in which the CSIR's Dr Nobuhle Majozi is making a difference. Majozi knows just how important it has become that we use water sustainably, especially in agriculture.

In high school, young Nobuhle Majozi wanted to become a radiographer. Not being able to pursue that, she took what might seem like a strange segue to pursue water resources and irrigation engineering for her BSc.

“At this point, we only had a short introduction to remote sensing. I remember the practicals on photogrammetry really fascinated me; little did I know that that would be my chosen career path,” she says. It was only after her MSc that she “sort of stumbled” into a career as a researcher.

Now Dr Majozi, at the CSIR since 2011, says, “In hindsight, I look at the relationship between remote sensing and radiography; the principles are similar in how radiography uses the X-ray to image the human body, while remote sensing uses the electromagnetic spectrum (in which the X-ray falls) to capture natural phenomena on the earth's surface.”

Precision work

Majozi's work involves using remote sensing images from satellites in orbit to estimate how much water vegetation, including crops, use. “I use meteorological, soil and plant biophysical data, together with data derived from the satellite images to develop and validate algorithms to estimate soil moisture and evapotranspiration. I use geographic information systems (GIS) and remote sensing tools to process my data.”

She believes this work is important if one considers the increasing necessity of sustainable water resource use, especially in agriculture, while maintaining a healthy ecosystem.

“I am currently working on modelling soil moisture using remote sensing technology for precision crop production. Soil moisture availability has major influences on crop yield. A remote sensing image gives farmers a detailed aerial view of their farm, identifying areas that need immediate attention. The extracted soil

moisture information from the remote sensing images gives the farmer spatial changeability of soil moisture within the field, as well as time-based changes in soil moisture during the whole crop growth phase.”

Helping farmers to compute how much water to apply variably within their fields, instead of the same level of irrigation throughout, enables precision agriculture. “The information we provide, when used effectively, reduces input costs such as energy and water, fertilisers and pesticides,” she adds.

Changing the status quo

Majozi is very supportive of girls planning a career in the science, technology, engineering and mathematics field. “It is possible to do it. Remember you are challenging the status quo. Be willing to put in the time from the beginning,” she says.

About success

“I am quickly learning that success is not about how much money one has, but contributing positively to humanity. Success is many things: the sense of fulfilment for accomplishing what I set out to do each day; watching my daughter grow up into a healthy, happy human being; or just helping someone through a challenging time.”

Current position: CSIR researcher

Career type: Geospatial scientist

Current research interest: Water resources modelling using remote sensing technology, especially in precision agriculture

Education: PhD in remote sensing, specialising in water use, University of Twente, the Netherlands, 2020



Above: Measuring maize physical properties during fieldwork on a farm near Vereeniging, Gauteng.

A botanist finds passion in waste management

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If you immerse yourself in your subject matter and become an expert in your field, people will treat you with the respect that you deserve.”

- Prof. Suzan Oelofse, CSIR

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CSIR principal researcher Prof. Suzan Oelofse

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undreds of thousands of South Africans go hungry, while about 34 per cent of food produced in the country goes to waste. Prof. Suzan Oelofse's research focuses on reducing the impact of waste on society and the environment. Knowing that her work matters, makes a demanding career worthwhile.

CSIR principal researcher Prof. Suzan Oelofse is a waste management specialist who works on projects that seek to provide scientific evidence on the impact of waste management on society and the environment. She develops policies, strategies and guidelines on waste management for government and industry, and has authored national domestic waste collection standards that apply to all municipalities in South Africa.

Oelofse's love for science presented her with an opportunity to do a PhD in botany, the scientific study of plants. "I never really decided to become a researcher. I did an MSc in biotechnology and plant tissue culture, out of interest, but continuing with a PhD was not an easy decision. But I did enjoy doing research and I qualified for a bursary from the National Research Foundation, so I continued with a PhD in botany," she says.

Her first job was in the biotechnology laboratory of a private company, but then a job opportunity as a waste management officer in the public sector crossed her path. Being a nature lover and concerned about environmental pollution, she saw an opportunity to make a difference. "I thought that this would mean the end of my science career though," she says. Ten years later, a research position in pollution and waste management was advertised at the CSIR, and her experience in the pollution and waste field landed her the job as a waste management researcher.

Research in waste management has many facets and no two projects are the same. She has estimated food waste generation in South Africa, undertaken waste characterisation studies, and developed policies and guidelines. Her work typically involves literature searches, conducting surveys, running extensive stakeholder consultation processes, and even physically sorting and measuring waste in the field. She appreciates every opportunity to learn and has worked on subject matters that she initially knew very little about, such as food waste, absorbent hygiene products and waste tyres.

"The benefits of conducting research are that you learn a lot through reading, conducting site visits, and meeting knowledgeable people," she says. She is proud to have been involved in the development of policies and standards that have been approved for national implementation, and hopes to continue to make a difference.

"I am currently working on a United Nations Industrial Development Organization project to support South Africa's transition from conventional plastics to more sustainable alternatives. The project aims to reduce the leakage of plastic into the environment," she says. This work is about understanding the environmental effects of both the alternatives and plastic leakage, and developing an action plan for South Africa. This will guide decision-makers and enable them to make informed decisions about the replacement of conventional plastics. "We cannot afford to replace problematic plastic products with something that may be worse for the environment."

She says that her proudest moments are when her work is taken up and implemented. One of the highlights of her career was when she met an entrepreneur, a black woman, whose business idea was sparked by an example that she has included in the *Municipal waste management – Good practices* guideline that she had compiled. This business now operates internationally.

Current position: CSIR principal researcher

Career type: Environmental scientist

Current research interest: Reducing the impacts of food losses and waste on food security and the environment

Education: PhD Botany (University of Johannesburg), 1994



Above: All in a day's work: plastic, tyre and food waste.

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“Everything seems difficult from a distance, until you have tried it yourself. So, if anyone plans to pursue a career in information technology, just be persistent, goal-oriented, focused and never let an opportunity to learn from others, pass.”

- Dr Noluntu Mpekoa, CSIR

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CSIR research group leader Dr Noluntu Mpekoa

Guardian of the information security front

Dr Noluntu Mpekoa is a specialist in cybersecurity who uses her competencies in data security and analytics to develop enabling technologies for the state, industry partners and universities. Her passion for mentoring and empowering young people in the field of science and technology continues to be the ultimate drive in her career.

Dr Noluntu Mpekoa, research group leader at the CSIR Information and Cybersecurity Research Centre, specialises in mobile technologies and security, with an emphasis on designing and developing mobile solutions for governments to deliver electronic services and enhance access for their citizens. Mpekoa and her team are passionate about the development of mobile solutions that not only enhance the lives of citizens, but also support governments and enable them to overcome economic, social and environmental challenges.

“The question we seek to answer is, how do we strengthen the security of mobile applications and mobile devices such that users at all levels feel safe to use them. Technology is here to stay and, with it, the need for cybersecurity. There will always be a need for improved algorithms and techniques for detecting threats. The scope for innovations in information security – solutions that people can use to protect their data and information – is vast. Success for me and my team means developing and deploying home-grown cybersecurity tools and technologies to protect our information – that of government and that of private organisations,” says Mpekoa.

An academic start

Mpekoa's career in information and technology started in the academic space when she was a lecturer at Walter Sisulu University in 2004, after she completed her BTech in information technology. She later completed her Master's degree in information and communication technology with the Tshwane University of Technology. Her research interest in the development of electronic voting technologies necessitated her pursuit of a PhD with the Nelson Mandela University. In her thesis, she developed a framework that seeks to enable the implementation of electronic voting in South Africa, with the view of improving human voting experiences in the country.

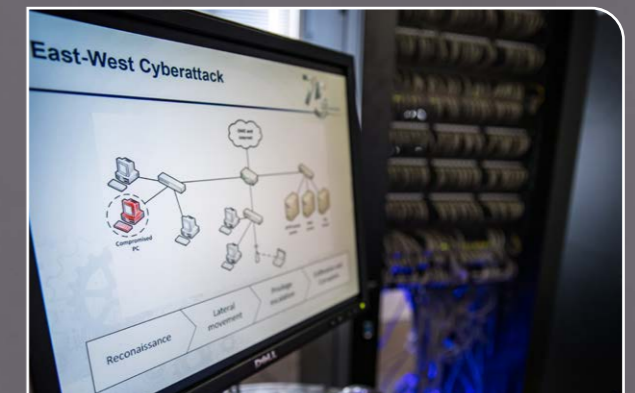
“In the academic space, one is always expected to improve one's skills and knowledge, so that's what I did, completing my PhD in just two years,” she says. Besides her PhD, she counts as her career highlights, developing the framework for electronic voting in South Africa and receiving a Y-rating from the National Research Foundation.

Mpekoa lectured at various universities for more than 16 years and, through her mentorship, she was able to pass down invaluable knowledge to many young people around the country. Witnessing her mentees graduating and succeeding in their careers has been one of the most awarding experiences on her journey.

Current position: CSIR research group leader
Career type: Data security and analytics researcher

Current research interest: Mobile technologies, mobile voting services and mobile security

Education: MTech (Information Technology), Tshwane University of Technology, 2014 and PhD (Information Technology), Nelson Mandela University, 2017



Above: The CSIR draws on its network and simulation capability to study the effects of network traffic in controlled environments.

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On a personal note, I would love to build a home for the elderly in my community where they can get the best care possible. I also have my heart set on an initiative to help boys do better. We tend to focus a lot on girls, but boys also need initiatives to help them reach their full potential.

- Mabatho Hashatsi, CSIR

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CSIR researcher Mabatho Hashatsi

Level-headed **problem solver** in the making

Mabatho Hashatsi, a CSIR bursary holder, joined the CSIR Graduate-in-Training Programme in 2020. Growing up, becoming a researcher did not even feature – all she knew for certain was that she wanted to solve societal problems. The die was cast when she heard about the CSIR and its work.

Mabatho Hashatsi always had an interest in engineering. As a child, she noticed that, while Soweto, where she grew up, went without electricity for long periods, the streetlights were often left on during the day. Not only did she notice this, but she also wanted to know why energy is not conserved so that when people really need it, it is available. She wanted to know how the electricity grid operates, and what other defects could be fixed with the right systems in place.

Learning

As a graduate in training, she spends a few months at a time in different research groups to learn about different areas of study. Hashatsi recently completed the first year of the three-year programme. During her first year, she was part of the CSIR's electronic warfare research group.

She relates her excitement at getting an opportunity to implement a project, “It started in the team, but was then handed over to me to see to completion. It is a tool introducing people to electronic warfare. It was my first time being exposed to something like this, and I really enjoyed it. At the moment, the e-learning tool is used for training purposes for the CSIR's clients in the defence sector. Being given the opportunity to present the electronic warfare 101 e-learning tool to the main stakeholder, was a highlight; as was experiencing how all the processes work, being part of the initial planning and seeing how things come together, and then how the client receives it.”

The Graduate-in-Training Programme offers excellent exposure to the nuances of the workplace. “With every project and every team, one's levels of responsibility change. One learns how to work in a team, but also how to take charge and communicate. One quickly learns how to contribute instead of just filling a space in the team. The only thing that remains consistent is one's mentor. This is a really good experience for me.”

She only just joined the Centre for High Performance Computing and would like to stay with this team for

some months because there is so much to learn. Eventually, she hopes to work in the CSIR Energy Research Centre, where her interest lies.

Good advice

Hashatsi shares advice that had been passed on to her, “This industry is still male dominated, and the only way it will change, is if women take the initiative and stand up to be heard. Never doubt your own value; we can contribute more than we think.”

She says, “I have not been treated any differently as a black woman. I think it depends on how you approach people. Once people see you play your part, they are receptive to new input.”

Success

Career-wise, success for Hashatsi will be solving a problem that affects people's lives. “For example, finding a way to address electricity theft. It is not just a simple matter of forcing people to pay. Some do not even realise that they are stealing – they come across an unoccupied dwelling and simply make a home with all the illegal connections already in place. Education is also necessary.

“I grew up in those communities, but went to a private school. I understand the different dynamics. I would like something to my name, some solution that bridges the gap between those two worlds.”

Current position: Graduate in training

Current research interest: Signal sorting, cloud computing, high performance computing, energy

Education: BSc (Electrical and Information Engineering) (with honours), University of the Witwatersrand, 2019



Above: The electronic warfare e-learning tool that Hashatsi has worked on.

Knowing the worth of water before the well is dry

Maronel Steyn is at the helm of a wastewater cleaning project spanning four countries in southern Africa. The team is using microalgae to clear pollutants like unwanted nutrients and pathogens from water in a process called phycoremediation.

CSIR senior researcher Maronel Steyn says clean water is ultimately about ensuring that people are healthy – something she’s been passionate about since her childhood, when she dreamt of becoming a medical doctor.

“It turned out somewhat differently, but my journey has surpassed my wildest dreams,” she says. Steyn received her Master’s in environmental health in 2003, and joined the CSIR in 2005. But she had already fallen in love with water research as an undergraduate at the former Technikon Free State (now Central University of Technology) in the mid-1990s.

“I love the everyday difference and variety that this work offers me, as my days are never the same!” One day she’s driving on rough roads to collect environmental water samples from a remote river in South Africa, and the next she’s dining with royalty at a World Water Day event in Sweden, dressed in a ball gown.

“My experience has shown me that water is intertwined in all of society, and you get to see the highs and the lows; the real issues in the country, which keeps you humble,” she says.

“You can find yourself sitting on warm sand under the shade of a Baobab tree interviewing household members about water security in Limpopo, then spend long grueling hours in the lab to finish an experiment.”

The phycoremediation project that she is currently leading is an African Development Bank initiative to improve the quality of wastewater downstream. Considered a green technology, the phycoremediation process is a naturally occurring phenomenon that is increasingly being used around the world to tackle water pollution and capture carbon dioxide from the air.

Steyn and her colleagues have been assessing the feasibility of the technology in Malawi, Mauritius, Mozambique and Namibia as a climate change mitigation measure in the SADC region.

She has also worked on hundreds of projects that include work for the European Union on managed

aquifer recharge in Atlantis in the Western Cape, an African Union project on integrated water resources management, and a recent assessment for the City of Cape Town on the water quality of the Steenbras Dam.

Steyn also sits on the management committee of the International Water Association’s specialist groups for health-related water microbiology, and metals and related substances in drinking water. “It is a great honour and a career highlight for me to serve on these, because it has opened amazing networking opportunities for me. I have been privy to international research associated with water and environmental health.”

Her advice for young women planning a career in science, technology, engineering and mathematics is to work hard and set clear goals. “It’s important to never give up, and to be willing to change some of your preconceived ideas about the field.

“I have never seen myself as any different to a man when it comes to hard, heavy-lifting jobs, but I believe female researchers are some of the hardest working individuals, also being mothers and wives. And we bring some heart, and a different level of excellence to our work.”

Steyn has published in many prestigious journals, including the *Agricultural and Forest Meteorology* journal, the *Journal of Environmental Management*, the *Environmental Science and Policy* journal, and the *Journal of Applied Phycology*.

She is working on completing her PhD, which looks at the potential human health impacts of acid mine drainage. She says that although she’s looking forward to finalising her degree, being called Dr Steyn has never been important. The most important things for her are to continue her work, and to pass on her knowledge and inspiration to students.

Current position: CSIR senior researcher

Career type: Environmental scientist

Current research interest: Emerging contaminants in the water environment

Education: Master’s in environmental health, Central University of Technology, 2003

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Water is intertwined in all of society.
– Maronel Steyn, CSIR
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Above and below: CSIR senior researcher Maronel Steyn and colleagues are studying the removal of nutrients from domestic wastewater by means of microalgae. In addition, they are investigating the beneficiation of the dried algae biomass. Below (right): Steyn demonstrates the spread of microorganisms and the importance of hand hygiene during the 2019 National Science week exhibition at the CSIR.



The stats show that Prof. Debba made the right prediction in high school



CSIR principal researcher Prof. Pravesh Debba

A love for mathematics in school, then grasping how statistics could help him shape his future at university and finally, being part of a community of researchers that solve real-world problems. This is how the roadmap to a fulfilling career unfolded for Prof. Pravesh Debba. As a CSIR principal researcher in statistics and impact area manager for the CSIR's inclusive smart settlements and regions group, Debba mines data to help his clients make informed decisions. His dedication to his craft has earned him the 2021 Thought Leader Award from the South African Statistical Association, with funding by Statistical Analytics Software.

Prof. Pravesh Debba has been at the forefront of professionalising the way statisticians are viewed in South Africa today. In 2011, as president of the South African Statistical Association, he introduced a peer-review conference to raise the bar on how researchers delivered their conference presentations and, at the same time, helped to assist researchers increase their profile as knowledge generators. He was also instrumental in establishing a professional body called the Institute of Certificated and Chartered Statisticians of South Africa, to accredit and promote the status of professional statisticians across the various disciplines.

An innate sense of curiosity

An innate sense of curiosity led Debba to leave lecturing after 17 years and see how he could apply his statistics skills in real-life settings.

"One of the biggest fears I had when joining the CSIR in 2008, was whether I would be able to succeed in the CSIR. I had come from a purely academic background and now had to learn how to write project-based reports and proposals to address a client's needs, attract funding and generate income. Creating a bespoke solution has been one of the best outcomes of joining the CSIR," Debba says.

Debba believes that his work is to show how data can be used to make decisions that contribute positively to society. Together with other researchers in the organisation, he has worked on an early warning detection system that uses remote sensing images to map out which vegetation is under stress. Urban simulations have helped his group to advise clients how to place key facilities that fulfill the present and future needs of a community. He has overseen the forecasting of the electricity demand for South Africa for Eskom,

which informs the electricity utility's Integrated Resource Plan; and his team uses statistical tools to predict the outcome of South Africa's elections with only 5% percent of the voting stations counted.

"Today, the most valuable thing is data. We can use a vast amount of information from various sources to generate more income, drive changed behaviour through a call to action and customise the services and offerings of service providers. However, suitable and quality data is paramount," he says.

The future of the statistician in the fourth industrial revolution

Conversations about the fourth industrial revolution usually bring on a debate about the future workforce and how machines will replace manual applications. This is no different to the evolution of the statistician who, in the past, collected data manually and now uses algorithms and automation for the same process. For Debba, this age is an exciting one because it creates new disciplines in the statistical fraternity and creates opportunities to develop new predictions by using tools such as satellite imaging, digital cameras and facial recognition. He notes that making the conversion can be difficult for some, "Researchers in this space must ask themselves if they want to make a difference. If the answer is yes, then one should be able to adapt to the changing world of statistics."

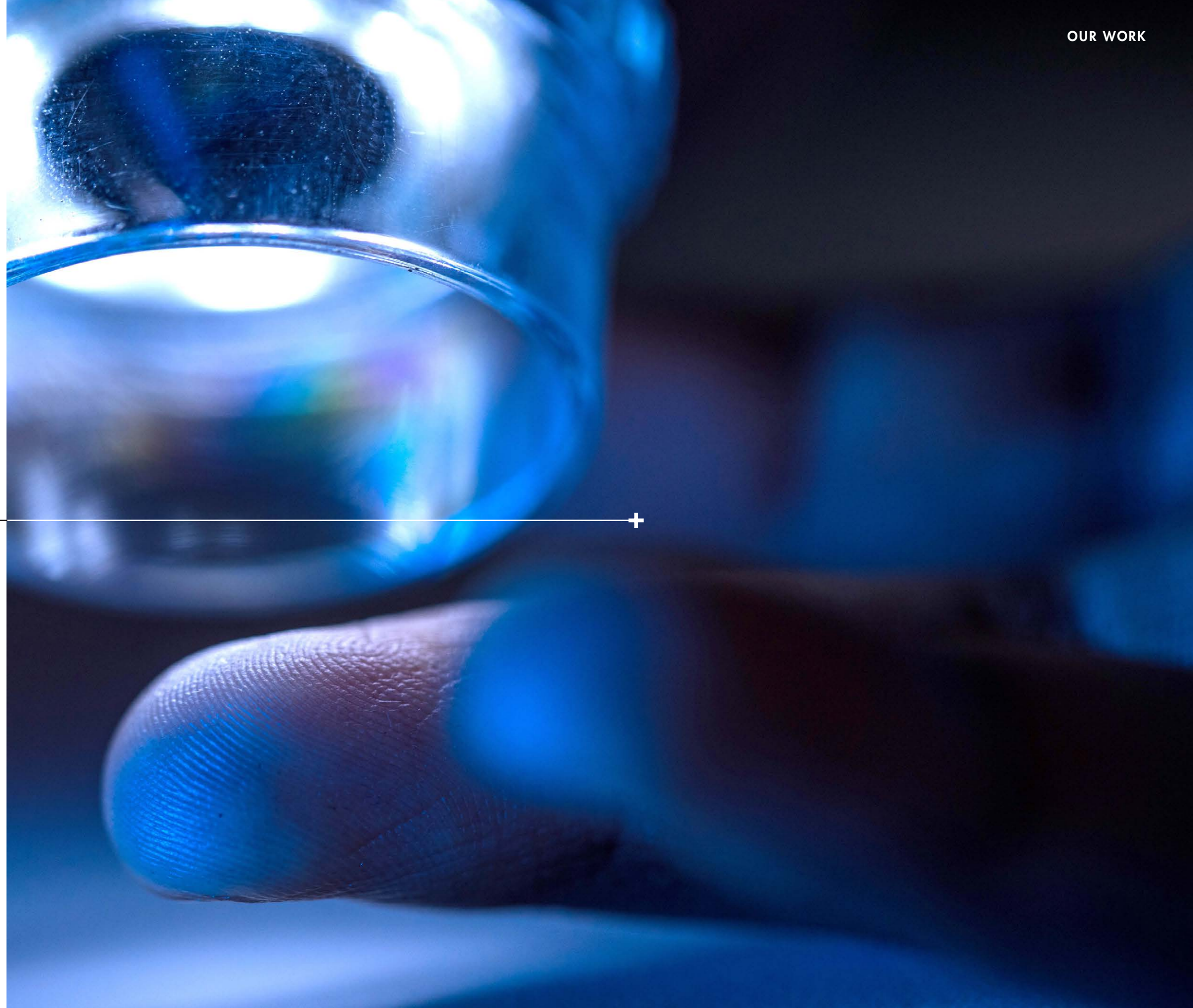
What gives Debba hope now is how the curriculum has changed by offering a wholesome approach that encompasses domain specialisation, computing skills and statistics to create what is now called data scientists. This has brought Debba full circle: from starting in the academic environment, conducting applied research and innovation, and now feeding back knowledge into the academic curriculum for future students.

Qualifications

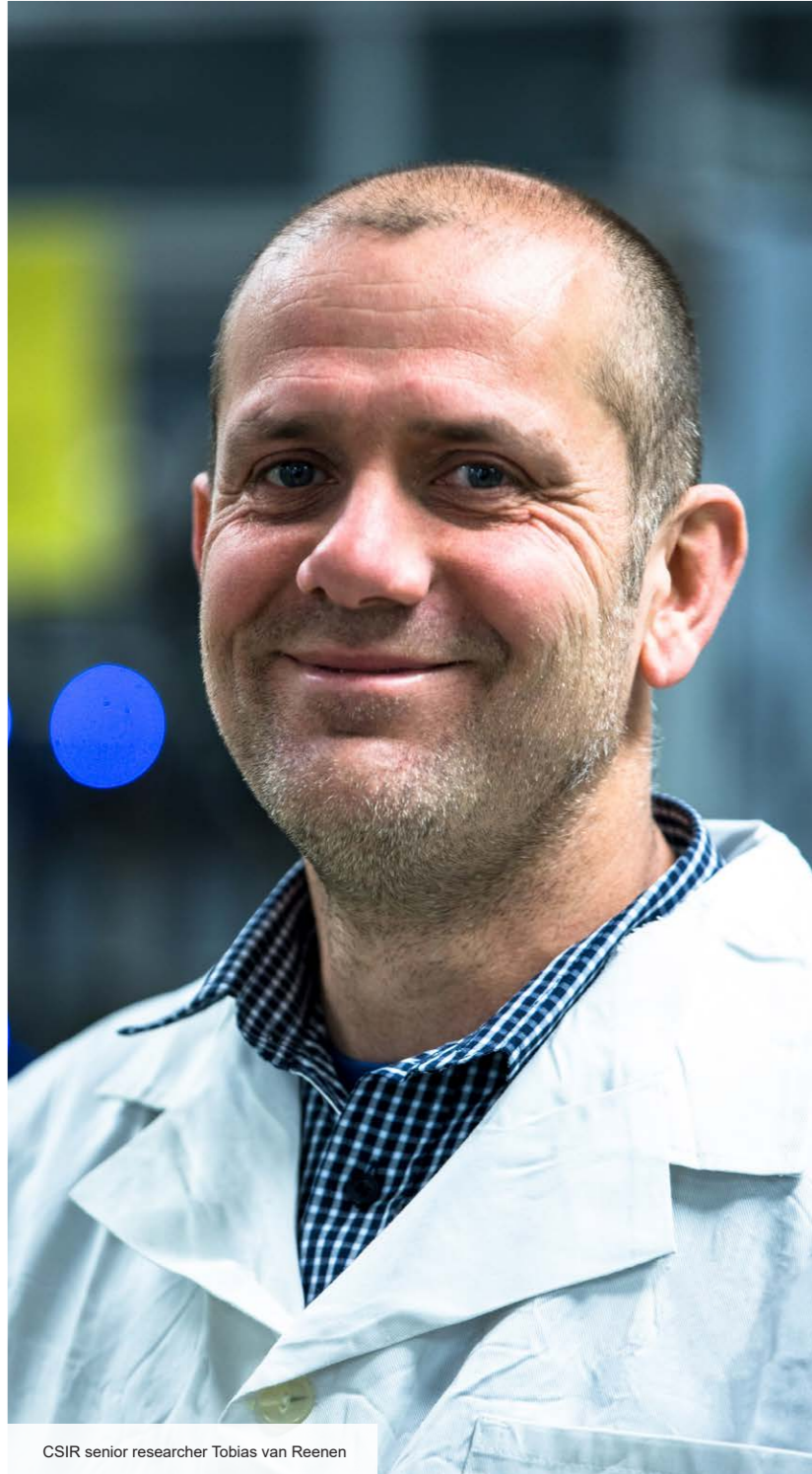
PhD (Statistics), International Institute for Geo-Information Science and Earth Observation ITC and Wageningen University, the Netherlands, 2006
MSc (Biostatistics), Universiteit Hasselt, Belgium, 1998
BSc Hons (Statistics), University of KwaZulu-Natal, 1992

OUR WORK

The CSIR's research into capturing useable, high-resolution biometric data of infants and children could realise government's ambition of using biometrics from cradle to grave.



Device that checks for airborne transmission risk installed in public health facilities



CSIR senior researcher Tobias van Reenen



Covid-19 is highlighting what we should have been doing for TB all along.

- Tobias van Reenen, CSIR



The CSIR has installed more than 40 monitors that check for airborne transmission risk in public health facilities across South Africa. The real-time airborne infection risk tool senses the level of carbon dioxide in the air inside a room and reports the real-time transmission risk.

Thanks to Covid-19 regulations, public health facilities are not as crowded as they used to be.

Many patients are seen by appointment only, or are requested to wait outside. Patients and staff wear masks and keep a distance of more than 1.5 metres. The windows and doors that are meant to be open to ventilate waiting areas are actually open.

And it's working. Not just to limit the spread of Covid-19 in these facilities, but also tuberculosis (TB).

"Covid-19 is highlighting what we should have been doing for TB all along," says Tobias van Reenen, a senior researcher at the CSIR. He specialises in engineering controls such as ventilation to prevent the spread of airborne contaminants, like viruses and bacteria, in indoor spaces.

Van Reenen's team has installed more than 40 monitors checking for airborne transmission risk in public health facilities across South Africa. "We call it the AIR Tool, short for Realtime Airborne Infection Risk Tool. It's a little box of electronics that senses the level of

carbon dioxide in the air inside a room and reports the real-time transmission risk."

He explains that since people breathe out carbon dioxide, which is then rebreathed by others, the level of carbon dioxide in the air can be used as a proxy for the risk of exposure to airborne pathogens that infect people. Like a traffic light, the device shows a green light if risk levels are low, an orange light when better ventilation is needed, and a red light when risk levels remain too high.

"The orange light is the first alert – the device sends an SMS to the person in charge, who then needs to check if the room might be overcrowded or if windows need to be opened," says van Reenen. "If nothing changes or the intervention is not effective, the red light indicates that the situation is now urgent – we know that the longer people are exposed to contaminated air, the more likely transmission will occur."

He says data from the sensors currently installed show that public health facilities are fairly empty and risk levels are thus low. "This means firstly that what we are doing for Covid-19 is working, and secondly, we should keep doing this for TB."

The 2020/2021 death toll in South Africa for TB is higher than for Covid-19, so it is actually still one of South Africa's biggest public health issues, he says. *Mycobacterium tuberculosis* is a very resilient bacteria that forms spores which, unlike the novel coronavirus, can theoretically survive indefinitely in the air within a room.

He says the AIR Tool is a useful operational tool in any building since it helps to prompt operational and maintenance checks. "If you get a red light, make sure the ventilation system is working. Check that the filters are clean and that equipment has been serviced.

"If you have been neglecting to do your maintenance, do it now. For Covid-19 and TB."

Van Reenen says all buildings, not just health facilities, should implement indoor air quality and safety standards and regulations that have always been there. "So it's business as usual, but not business as usual when it comes to ignoring regulations that are in place."

Now that van Reenen and his team have established the technical feasibility of the AIR Tool, they will fit 50 more units in healthcare facilities across the country thanks to a Global Fund grant and partnerships with non-governmental organisations and the Department of Health (DoH). "We have international attention on this

type of technology; in fact, the European Federation of heating, ventilation and air conditioning associations (REHVA) now recommends this kind of monitoring in high risk and public health facilities," he says.

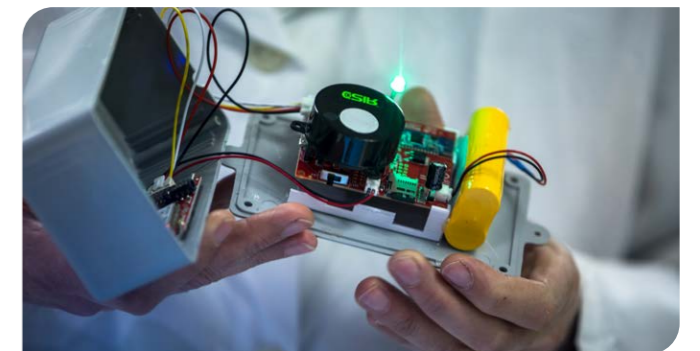
The CSIR will use this project to study how users adopt and respond to the new technology, and is working on automated reports that will give quality assurance officers, infection control managers and various departments of health real time data and trends to inform better operational and infrastructural interventions.

"We want to help the DoH identify facilities that need investment in ventilation infrastructure, and we want to help the owners of buildings better channel resources and develop better policies, like appointment systems to prevent overcrowding."

Van Reenen's team is also working on the national standards for ventilation, which will make compliance by building owners, as well as monitoring by the DoH, much easier. *Also read article on pages 46 and 47.*

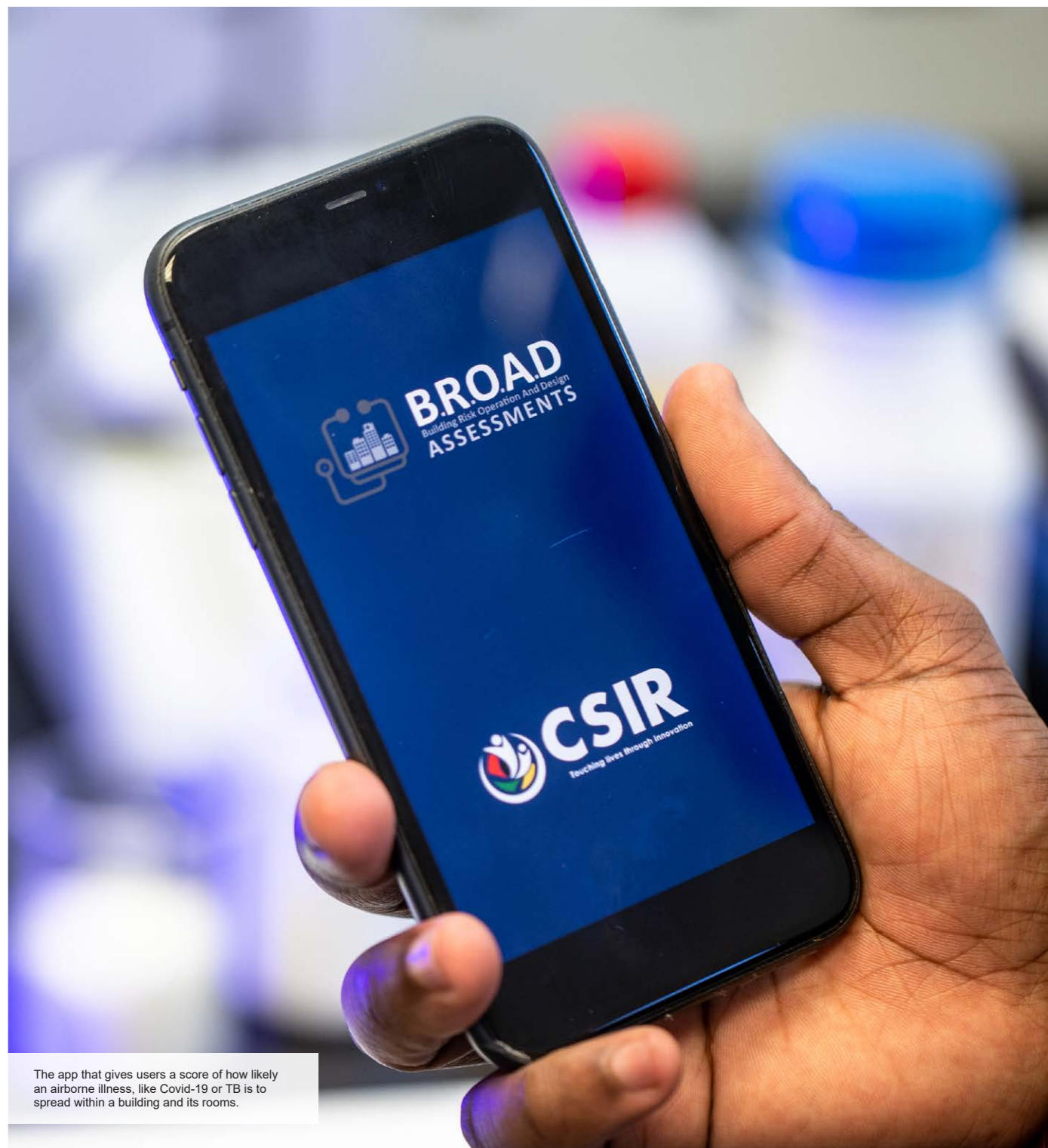
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Above: Components of the CSIR-developed device that monitors indoor carbon dioxide levels and generates an alarm when corrective action is needed.

Mobile app helps clinics and hospitals manage Covid-19 risk



The app that gives users a score of how likely an airborne illness, like Covid-19 or TB is to spread within a building and its rooms.

Patients can only be cared for if there are healthcare workers. And the same goes for learners and their teachers, or incarcerated people and prison staff. All of South Africa's public institutions, and the public they serve, depend on the health and safety of the people who work there. This fact is front of mind for Dr Jako Nice every time he visits a healthcare facility with a carbon dioxide sensor and his smartphone in hand.

On Dr Jako Nice's phone is an app that gives users a score of how likely an airborne illness, like Covid-19 or tuberculosis (TB), is to spread within a building and its rooms. It asks questions about things like room dimensions, windows, handwashing stations and personal protective equipment, and it uses information from the carbon dioxide (CO₂) sensor.

"We use CO₂ as a proxy for rebreathed air," explains Nice, a senior researcher and architect at the CSIR. "The higher the level of CO₂ in the room, the more likely that air is being rebreathed in that space."

The app, officially called the Building Risk, Operation and Design (BROAD) assessment platform, uses algorithms to calculate the risk of transmission, and can even recommend the optimum number of people to occupy a room at any given time.

"The BROAD app is almost like a real-time, live risk assessment. There is no other tool in the world that we know of that integrates risk assessment with a CO₂ sensor, runs on an online mobile platform, and is supported by a data centre," says Nice.

This pioneering design by fellow CSIR researchers, Tobias van Reenen and Sheldon Bole, means the app benefits the public sector in two ways.

First, the individual facility using the app instantly gets a report via email, which health and safety officers, infection and prevention control and quality control staff can use to change safety measures, identify gaps and request infrastructure.

Second, the data centre collects these reports on a secure server so that the data from all facilities using the app can be analysed to find common challenges.

The goal is to address these challenges on district, provisional and national levels through a mainstream, standardised process. "It has always been a problem that organisations like the World Health Organization, the CSIR, the National Institute for Communicable

Diseases and other non-governmental organisations do their own assessments, so we can't compare the scores. We don't always know if a particular assessment is best suited and up to standard," says Van Reenen.

The BROAD app was originally funded by the United States Centers for Disease Control and Prevention to help prevent the spread of TB, but Nice and his team rapidly tailored it for Covid-19 assessments.

In fact, they can customise the app questionnaires for any type of facility, including schools, correctional facilities, care homes and mines. "It is not hardcoded," says Van Reenen. "It is updated every time we learn about new risks and measures, and it can be adapted to anything, even food safety assessments in supermarkets."

Currently, at least 50 of South Africa's roughly more than 5 000 public healthcare facilities are using the BROAD app, and Nice hopes that it will eventually serve them all.

"In a week we would go to eight to ten facilities. We do training, provide support hold hands and get people on board so that they can do it themselves without needing specialists," says Nice.

"And what we are actually seeing in a lot of clinics and hospitals is that people are waiting outdoors. The staff are enforcing social distancing very well and are clearly separating people showing signs of Covid-19. They are following guidelines according to our assessments, and this is a very good thing because it means less facilities will have to close because of outbreaks.

"But we are also seeing where there are glaring challenges with infection prevention and control (IPC)." He says these include a lack of standard practices, IPC training and infrastructure, and at times poor managerial support.

"Our facilities are overburdened and they are adapting as much as they can, but we believe we can help using the IPC data from the BROAD platform."

Nice says in future they hope to support other African countries that have similar infectious disease burdens. "We are next door, and we think this tool can be useful on the continent and further abroad."

Also read article on pages 44 and 45.

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Supporting the country's need for locally produced **SARS-COV2** diagnostic kits



Above: Dispensing of kit reagents for extraction of nucleic acids from naso-opharyngeal (throat) swab samples.

A CSIR-developed diagnostic kit to test for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is undergoing validation tests using clinical samples.

Since the beginning of the Covid-19 pandemic, South Africa has been one of many countries that were heavily reliant on imported diagnostic kits and instruments. In an effort to meet the country's growing demands for more accessible diagnostic kits and related reagents, CSIR researchers developed a prototype nucleic acid extraction kit.

The nucleic acid-based diagnostic kit was developed to generate pure samples from nasal and throat swabs, which could then be tested for SARS-CoV-2.

The locally developed extraction prototype kit compares well against the gold standard extraction kits using laboratory standards.

The CSIR was assisted by one of its spin-off companies, ReSyn Biosciences, which optimised the magnetic bead technology of the diagnostic kit – which is a key component.

The CSIR's diagnostic facility, which continues to play a pivotal role in supporting the country's diagnostic testing efforts, is assisting with the validation of the diagnostic kit.

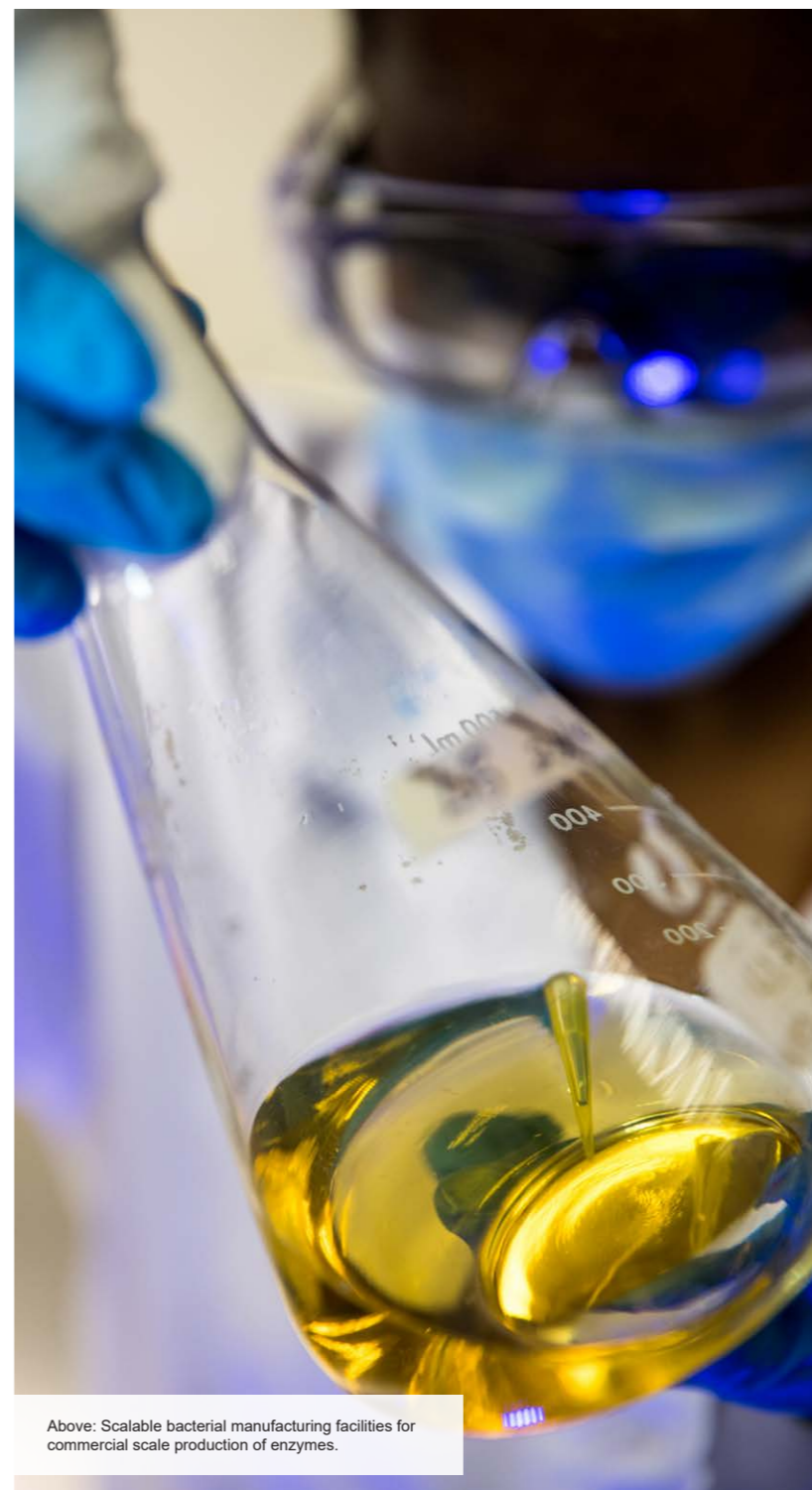
If the developed kit performs sufficiently well during validation tests, it will be licensed to local biotech partners who will register the kit with the South African Health Products Regulatory Authority and manufacture it.

This project is funded by the Department of Science and Innovation, the South African Medical Research Council and the Technology Innovation Agency.

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CSIR and CapeBio develop **Covid-19** diagnostic assay



Above: Scalable bacterial manufacturing facilities for commercial scale production of enzymes.

The CSIR, in collaboration with CapeBio, has demonstrated the efficiency of the bio-manufacturing process for two enzymes which have been combined to develop a locally produced one-step Covid-19 diagnostic assay. In July 2021, the South African Health Products Regulatory Authority gave the greenlight for the local manufacturing of the test kits.

The diagnostic assay, which was initially shown to detect severe acute respiratory syndrome coronavirus 2 (SARS CoV-2)-specific genetic biomarkers in the lab, has now been validated externally and has proven to have the capability to detect these biomarkers in more complex samples. Furthermore, the single-step diagnostic assay has the potential to reduce the turn-around time of tests and assist in managing and monitoring the spread of SARS CoV-2.

This research and development, funded by the South African Medical Research Council and the Technology Innovation Agency, will not only contribute to a reduced turnaround time for diagnosing active infections, but will also enable a faster response in terms of active case finding, quarantine and contact tracing. Additionally, the localisation of the production of these reagents will increase the accessibility to locally produced diagnostic kits – a very significant milestone that will reduce the country's reliance on international supplies.

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Contactless fingerprint technology for mobile device use



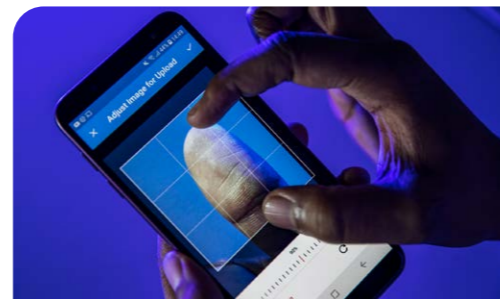
Covid-19 drives demand for **contactless systems**

Wongeta, a small, medium and micro enterprise specialising in finance technology, became the first user of a novel CSIR visitor identification system under the terms of a pilot license. The company used the system to authenticate recipients of funds using biometrics.

Drawing on its competences in biometrics, image processing and microscopy, the CSIR developed the visitor identification system to provide a contactless fingerprint solution that could be integrated with existing biometric systems. The contactless fingerprint technology enables imaging devices such as smartphones, webcams and digital cameras to be used as fingerprint scanners. Contactless systems have become particularly in demand due to the Covid-19 pandemic.

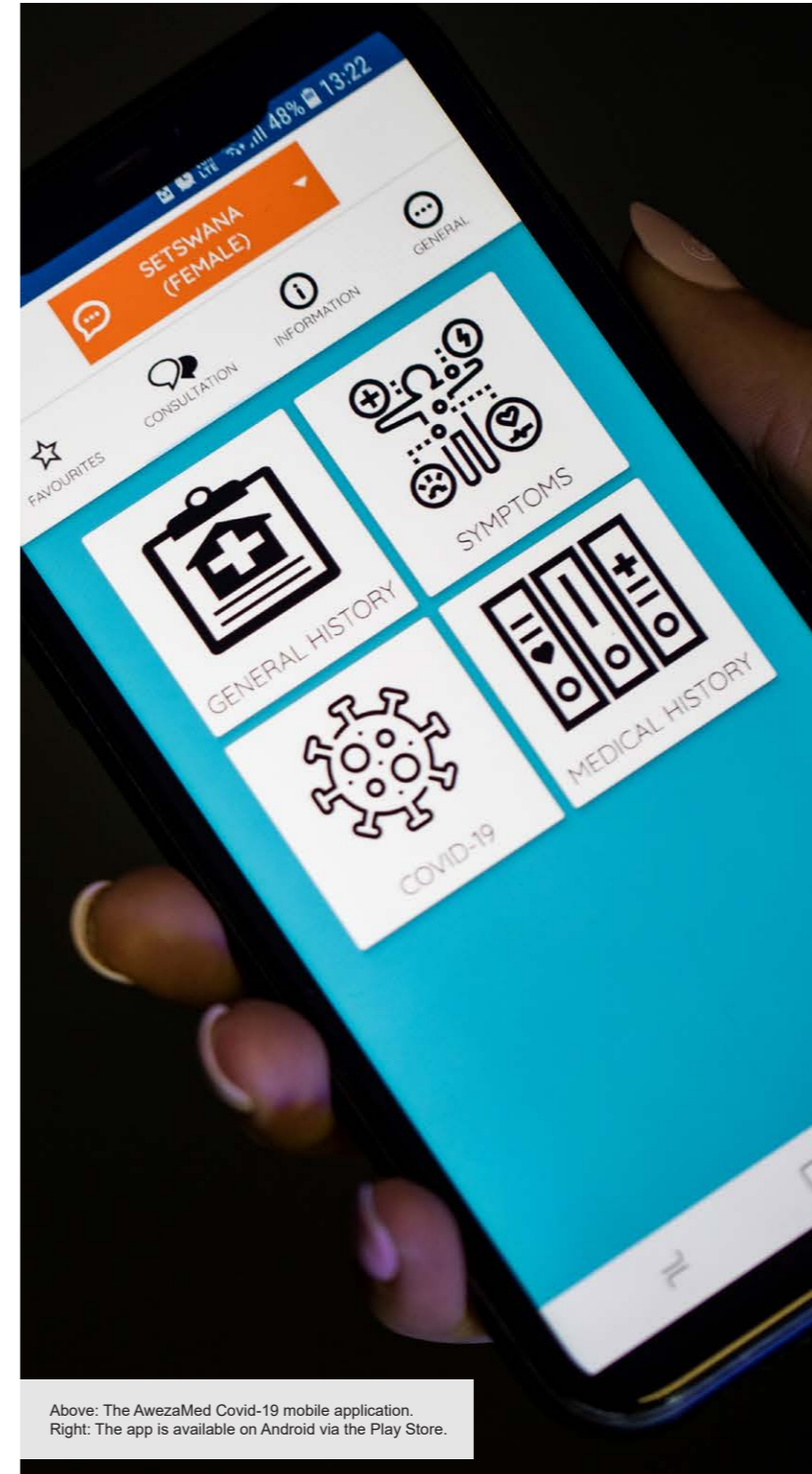
Pivotal to the completion of the technology was the development of a software-based system, including back-end, web-app and mobile-app designs. The CSIR is doing a pilot study on the use of the technology for its own visitor authentication purposes.

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Above and right: CSIR-developed biometric technology uses digital imaging devices to create fingerprint scanners. This provides institutions with affordable, locally developed and contactless fingerprint solutions that can be integrated with existing biometric systems.

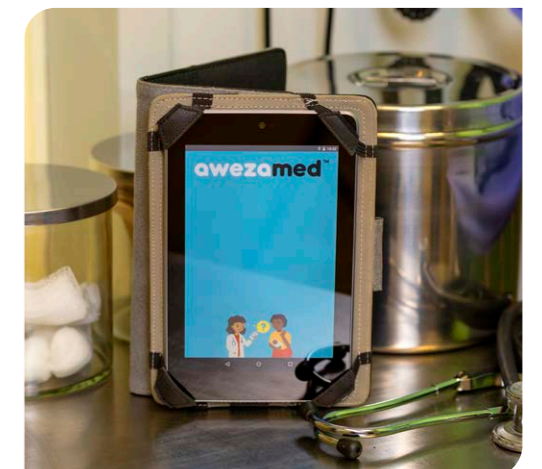
Bridging **communication** barriers between healthcare workers and patients



A mobile app originally developed with content pertaining to maternal healthcare and obstetrics was enhanced with Covid-19-related content to bridge the communication gap between healthcare workers and patients amidst the Covid-19 pandemic.

AwezaMed Covid-19 features localised speech technology, such as speech recognition, machine translation and text-to-speech, developed by the CSIR, and works on any Android smartphone. It enables healthcare providers to access a phrase in English, translate it into any South African official language, and play the phrase in the selected language. The app is available for download from the Play Store at no cost to the user. The content of the app was developed in collaboration with health experts.

AwezaMed emanated from a project funded by the Department of Sport, Arts and Culture that strives to bridge language barriers between healthcare practitioners and patients in clinics.



Above: The AwezaMed Covid-19 mobile application. Right: The app is available on Android via the Play Store.

CSIR co-develops **composite material** for one of Africa's largest steel pipe companies

The CSIR was the research and development institution of choice for one of Africa's largest steel pipe manufacturers, Hall Longmore, to develop an alternative polymer composite solution based on locally manufactured polymers.

Hall Longmore, a South African-based steel pipe manufacturer, imports a special polymer to coat pipes through a fluidised bed technology. However, fluctuations in the USD/ZAR exchange rate made it increasingly challenging to budget for projects. In response to this, Hall Longmore approached and contracted the CSIR to develop a composite material from locally produced polymers.

"We have expertise in formulation design, polymer modification, processing and characterisation, and an array of other capabilities that we leverage to provide our clients with a holistic solution," says CSIR research group leader for advanced polymer composites, Dr Vincent Ojijo.

"This created a conducive environment for us to co-design and construct a test rig with Hall Longmore. The project procured services from a local third-party polymer compounder for successful industrial optimisation and production of test materials at scale. The ultimate success of this project is credited to a strong collaborative and consultative effort from the parties," says Ojijo.

The CSIR undertook preliminary research that outlined the desired developmental approach to be taken. This was followed by lab-scale material development and the technical validation of its performance. Concurrently, a lab-scale fluidised bed for rapid coating trials was co-designed by the CSIR and Hall Longmore. The company co-constructed, installed and commissioned it for use in testing the developed material. After successful lab-scale validations, the pilot-scale optimisation process for the developed material was completed.

"The successful industrial trial takes us one step closer to offering the South African water industry a localised push-fit application for pressurised steel pipelines," says Managing Director of Hall Longmore, KC Van Rooyen.

Approximately nine tons of the CSIR-developed material for coating trials at Hall Longmore's industrial-scale

fluidised bed were successfully applied, which marked the conclusion of the development phase. The project is now in production phase at the third-party compounder, with the steel-pipe supplier having ordered 150 tons of the CSIR co-developed material.

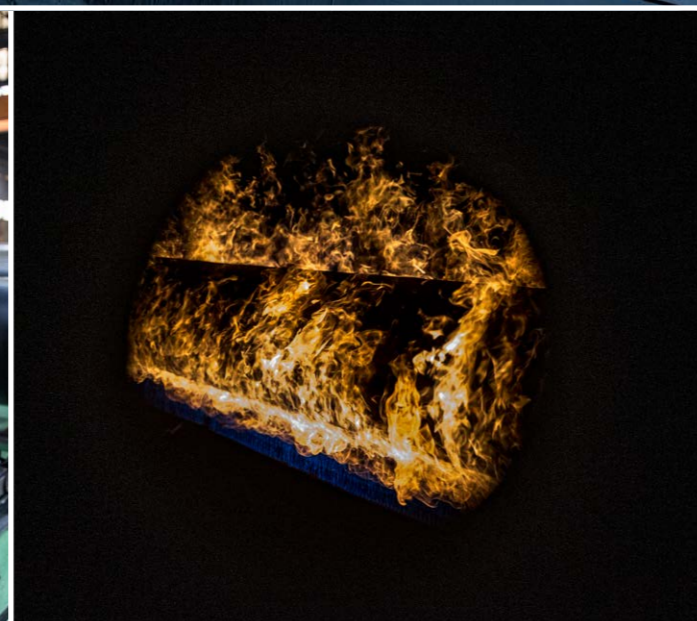
"One of the CSIR's strategic objectives is to collaboratively improve the competitiveness of high-impact industries to support South Africa's re-industrialisation; therefore, the successful collaboration between the CSIR and Hall Longmore shows our commitment to supporting South Africa's industry and growing our impact on the continent and around the world," says Dr Jan van De Loosdrecht, Cluster Executive Manager, CSIR Future Production: Chemicals.

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The CSIR-developed coating material (above) used by Hall Longmore to coat its steel pipes (below).



Top: A steel pipe that has been grit-blasted and flame-treated is ready for coating in a fluidised bed. Middle: Coating the pipe by dipping it in a fluidised bed with the locally manufactured material. Above (left): Coated air pipes are being air-cooled. Right: Flame treatment of the pipes before coating in a fluidised bed.

Plant-based 'sponges' better than chemicals at removing heavy metals, sewage from water

Nanocellulosics are nature's smart sponges. For example, they can suck up paints and pigments from the wastewater of textile factories, only to release them, as if new, to colour more fabrics. Prof. Suprakas Sinha Ray, an expert in nanomaterials at the CSIR, shares how CSIR research and development in this specialised field is set to give more people access to clean water.

and the public need to know about the huge potential of nanocellulosics to replace chemicals and move us towards a green economy because of the biomass it recycles," says Ray.

For South Africa, in particular, he sees the biggest potential for nanocellulose in giving more people access to clean water – and the technology is almost there.

"In simple terms, what we have right now can be used like a sponge to remove heavy metals, like chrome, from water – this cleans the water, but also recovers the chrome for other uses. It can also modify chemical pollutants, like sulphates, to make them harmless, and it can be used to kill bacteria."

He says they are now scaling up nanocellulose production at the CSIR's Durban-based biorefinery group so that they can begin treating wastewater, and for other applications.

Ray's team is also working on a nanocellulose membrane, or filter, that can be fitted to an ordinary tap. While this product may not immediately meet drinking water standards, he says it will allow households to clean sewer water so that it can be reused in the garden or in the toilet cistern.

"This nanocellulosic membrane can collect fatty acids, surfactants and soaps, and we hope to put it on the market within a few years.

"And in another few years after that, we should have a membrane that can produce water that is safe to drink," says Ray.

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"The beauty of nanocellulose is that, by just changing the pH or the acidity around it, you can make it adsorb or desorb," says CSIR chief researcher Prof. Suprakas Sinha Ray. In other words, like flipping a switch, the surface chemistry of this wonderfully versatile and eco-friendly material can be changed to either mop up harsh chemicals, microplastics and sewage, or let those same pollutants go again for recycling or safe disposal.

And then, of course, the nanocellulose itself can be used again and again, or it can be discarded to biodegrade without harming the environment.

This is because nanocellulose comes from cellulose, which is essentially fibrous plant material.

Trees are a good source of cellulose, and South Africa's wood processing and paper industry produces huge quantities.

"SAPPI produces a lot in their effluent. This used to be waste material, but you can digest the effluent at high pressures and temperatures to separate the cellulose from the harder lignin, and then you can convert the extracted cellulose into nanocellulose," explains Ray.

At the CSIR's biorefinery group in Durban, KwaZulu-Natal, sawdust is processed into nanocellulose in the same way. "They have a huge facility. It smells like wood when you first walk in, and when you get to the digester, it is more acidic; you can almost feel it if you move around in there," he says.

But the nanocellulose product at the end has no smell at all, because it contains no harsh chemicals. And yet, Ray believes, it is destined to replace chemical cleaning agents because it is so much more effective.

He makes this case in a recent open access publication, which has already been downloaded thousands of times. "We believe researchers, industry, policy-makers



A nanocellulose-based sponge.



Nanocellulose-based emulsion.



Nanocellulose powder.

Figuring out the science of growing mushrooms in a liquid, and on a mega-scale

In a first for Africa, the CSIR and biotechnology company Sawubona Mycelium produced 800 litres of product by cultivating Enokitake – popularly known as needle mushroom – using a liquid cultivation process.

This compound may be used in cosmetic products as an effective moisturiser and is beneficial for skin microbiome in cosmeceutical formulations. Additionally, as part of the production process, the researchers produced enough biomass to convert it into a dried mushroom powder, useful in food products such as thickeners or in supplements in the form of immuno-boosters.

With the SMME now taking on liquid cultivation to scale as part of its production process, it will continue to explore new product offerings for a variety of applications.

“We are now working on a purification method that will be suitable for the cosmeceutical industry. The incorporation of the mushroom-derived active ingredients into skincare products to produce clean, more effective and safe-to-use beauty products has become a global phenomenon. Therefore, as Sawubona Mycelium, we aim to continue to harness natural flora and botanical extracts, which also includes the use of mushrooms indigenous to southern Africa to produce fermented bio-based cosmetic products for the South African market,” says Busi Moloi.

The company currently has two technology products that have been developed and the process has been assigned a technology readiness level of eight, which is an indication of technology maturity. The B IDC has developed market samples for these products and has licensed the production technology to the SMME.

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Principal investigator of the project, Dr Ghaneshree Moonsamy, says the conventional method of growing mushrooms is in a bed of soil or other material such as agricultural residues or similar. The decision to grow this particular organism in liquid form was not only a technology shift for South Africa, but it also allowed the SMME to derive more valuable and super ingredients from Enokitake, which gives it an advantage to explore two or more products for market from one mushroom-cultivation process.

From the liquid-based production process designed by CSIR researchers, two fractions from the process were derived; the liquid fraction contained a high-value compound, which is referred to as beta-glucan.



Above: Enokitake, also called needle mushrooms, grown in a liquid medium. Below (left): Sawubona Mycelium's Busi Moloi and Neo Moloi at the CSIR Biomanufacturing Industrial Development Centre. Below (right): CSIR technician Tsepo Ramohomane during development of a separation process technology.



Tshwane wastes over 5 000 tons of fresh food every year, study finds

“

People don't want to buy anything that doesn't look perfect.

- Prof. Suzan Oelofse, CSIR

”

South Africa needs to minimise food waste and ensure that more South Africans have access to food and opportunities in the food supply chain. CSIR researchers have undertaken a study to quantify the food waste at the Tshwane Fresh Produce Market, part of a bigger national effort to quantify food waste.

In December, watermelons flock to Gauteng supermarket shelves like Gauteng citizens flock to the coast. With fewer people inland to eat them, it's just a quick stop at the shop for the giant pink and green berries before they arrive at the landfill.

“The peak of the food waste period at the Tshwane market is in summer, when many of us are on holiday at the beach,” says Dr Suzan Oelofse, an expert in waste management at the CSIR. Her team recently investigated food losses at the Tshwane Fresh Produce Market (TFPM), and on the small-scale farms that supply it.

“The most wasted items are leafy vegetables like lettuce and spinach, which wilt quickly and soft fruit, like tomatoes, that bruise easily. People don't want to buy anything that doesn't look perfect,” says Oelofse.

Just at TFPM, more than 5 000 tons of fresh produce goes to waste every year. That weighs about the same as 10 Boeing 747 aeroplanes.

The TFPM study forms part of a bigger national effort to define how much food is wasted along the entire value chain from farm to table, across South Africa. Oelofse says, so far, the picture looks very similar for other major fresh produce markets throughout the country. The ultimate aim of these studies is to minimise food waste and ensure that more South Africans have access to food and opportunities in the food supply chain. “We don't have to produce more food to feed hungry people, we just have to distribute available food, more effectively.”

The turnaround time of fresh food at the market is relatively short, to create space for new fresh deliveries. During harvesting season, crops are harvested daily and sent to the markets. The result is that food that is often still perfectly fine to eat but wasn't sold within the allowed timeframe, is either sent back to the farm or condemned to landfill. The food that is sent back to the farm is repurposed as animal feed or compost.

Since the market is just a middleman, the farmer only receives money for produce that is sold. In addition, oversupply of a specific commodity lowers the price per item, which in turn lowers the income potential of the farmer.

As part of the study, Oelofse's team analysed available data from the TFPM, and interviewed its manager. “What really struck me,” she says, “was a conversation with the manager about a meeting he'd had with 250 of their small farmer suppliers. When he'd asked them, ‘who produces tomatoes?’, nearly every farmer put their hand up. “He then asked them ‘why?’, and they said it's because everyone else does and there's always a market.” Yet, we know from the data that tomatoes are one of the most wasted items. So, Oelofse says better coordination between farmers and consumer demand would reduce waste and boost income for small farmers.

That is one of the recommendations she thinks will assist decision-makers in government. Specifically, the Departments of Forestry, Fisheries and the Environment, Agriculture, Land Reform and Rural Development, and Social Development. She says there may even be room for a central body to assist with coordination of production to better match demand of various food items, and that there are ways to balance small- and large-scale farming in a manner that is financially viable for the entire industry.

“One farmer we interviewed for the study said patty pans harvested on Mondays are too big to meet supermarket standards.

They harvest six days a week, from Monday to Saturday. Not harvesting on Sunday results in larger items being harvested on Mondays due to fast growth rates. These oversized veggies are often simply donated to charities,” says Oelofse.

While this situation may leave the average consumer feeling powerless, Oelofse says we can all do something to waste less food. For example ‘best before’ does not mean ‘bad after’, she says.

“Consumers need to know that those kinds of labels have nothing to do with food safety. ‘Sell by’ dates contain information for retailers, not consumers; they are all about ensuring that today's harvest will have space on the shelves tomorrow. All food is still good after the ‘sell by’ date. Expiry dates indicated as ‘use-by’ is the only date label that is aimed at the consumer.”

Oelofse says she also makes an effort in her own household to use produce that is bruised but otherwise safe to eat, rather than throwing it away. Her reluctance to waste good food is partly informed by her own research, but also spurred by the memory of a terrible stench in her childhood neighbourhood one summer. Local newspapers eventually reported the source – it turns out nothing quite stinks up a dump like a limp watermelon.

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Above: Fresh produce arrive and are sold at the Tshwane Fresh Produce Market. Prof. Suzan Oelofse says the country does not have to produce more food to feed hungry people, have to do better at distributing available food.

Modernisation in mining – A people-centric approach



Above: The Isidingo Drill was demonstrated to organised labour in a session in which feedback on the design was solicited.

The end goal of the Mandela Mining Precinct's journey to mine modernisation is sustainable relationships and shared value for all people in the minerals sector. To this end, the Precinct has developed a research programme that focuses solely on the role of people in a modernised mine in South Africa.

"As mining modernises, how are mining stakeholders affected and impacted by mining modernisation systems, processes and technologies? This is the key question framing our research agenda," says Dr Sherin Ramparsad, programme manager responsible for the Successful Application of Technologies Centred Around People (SATCAP) research programme at the Precinct.

To date, SATCAP has completed several literature reviews, which have delved into case studies and validated frameworks to understand how modernisation in mining can be effectively implemented, while taking into account all affected stakeholders.

Ramparsad believes that people are at the centre of all mining activities, with drillers, winch operators and shaft timbermen being the heartbeat of mines. "Through our research, we need to look at what skills these mine employees will require in a modernised mine. This will allow us to make recommendations to the Mine Qualifications Authority on what those key skills are," she says.

The SATCAP research programme comprises several research themes aimed at, among others, understanding job losses through impact assessments; developing a community inclusivity model; and developing a process for the inclusion of mine employees in the design and development of equipment. The latter theme has already gained importance with the alignment of SATCAP to the Isidingo Drill Design Challenge. This is further being addressed through a research theme led by the CSIR on people-centric modernisation. "We found that the best-practice approach to equipment design and development is one that is people-centric," says CSIR researcher Dr Jodi Pelders. She says the design should be suited to the individual using the equipment, rather than people being put under strain to use a particular piece of equipment.

The research team is expanding on the research undertaken to date to ascertain, among others, the perceptions held by various stakeholders in the industry

– mining houses, organised labour and original equipment manufacturers – about the need for employee engagement during equipment development, as well as the level at which this engagement should occur.

Nancy Coulson, senior lecturer at the Wits Mining Institute supports the view that the modernisation process has to be a bottom-up approach. "The issues are too complex and it is important to understand experiences at the site level, which will inform what is happening at national level, rather than the other way around," she says. Coulson leads the research theme on stakeholder engagement and emphasises that there will be many stakeholders to engage in a mine modernisation context.

From the perspective of stakeholder engagement, Coulson discourages the adoption of digital technologies, unless it comprises elements of two-way communication. The Precinct has commissioned the University of Pretoria (UP) Enterprises to develop a change management guideline for the mining industry. This research theme is led by Wessel Botha, senior consultant at UP Enterprises, who argues that the adoption of digital technologies in the change management process could be a viable option if the human element is strong. "The element of trust required to reduce employee resistance and obtain employee buy-in necessitates the presence of a human element when digitising," he says.

SATCAP research cuts across the other research programmes at the Mandela Mining Precinct and answers the difficult questions involving people-facing change in the industry, while providing a platform for organised labour to gain an understanding of the change processes required for modernisation. To this end, research has centered around reviewing current change guidelines and developing a new change management guideline; understanding the role of mine employees in equipment design; and designing frameworks to engage stakeholders.

The Mandela Mining Precinct is a public-private partnership between the Department of Science and Innovation and the Minerals Council South Africa. The Precinct is managed and co-hosted by the CSIR and the Minerals Council South Africa.

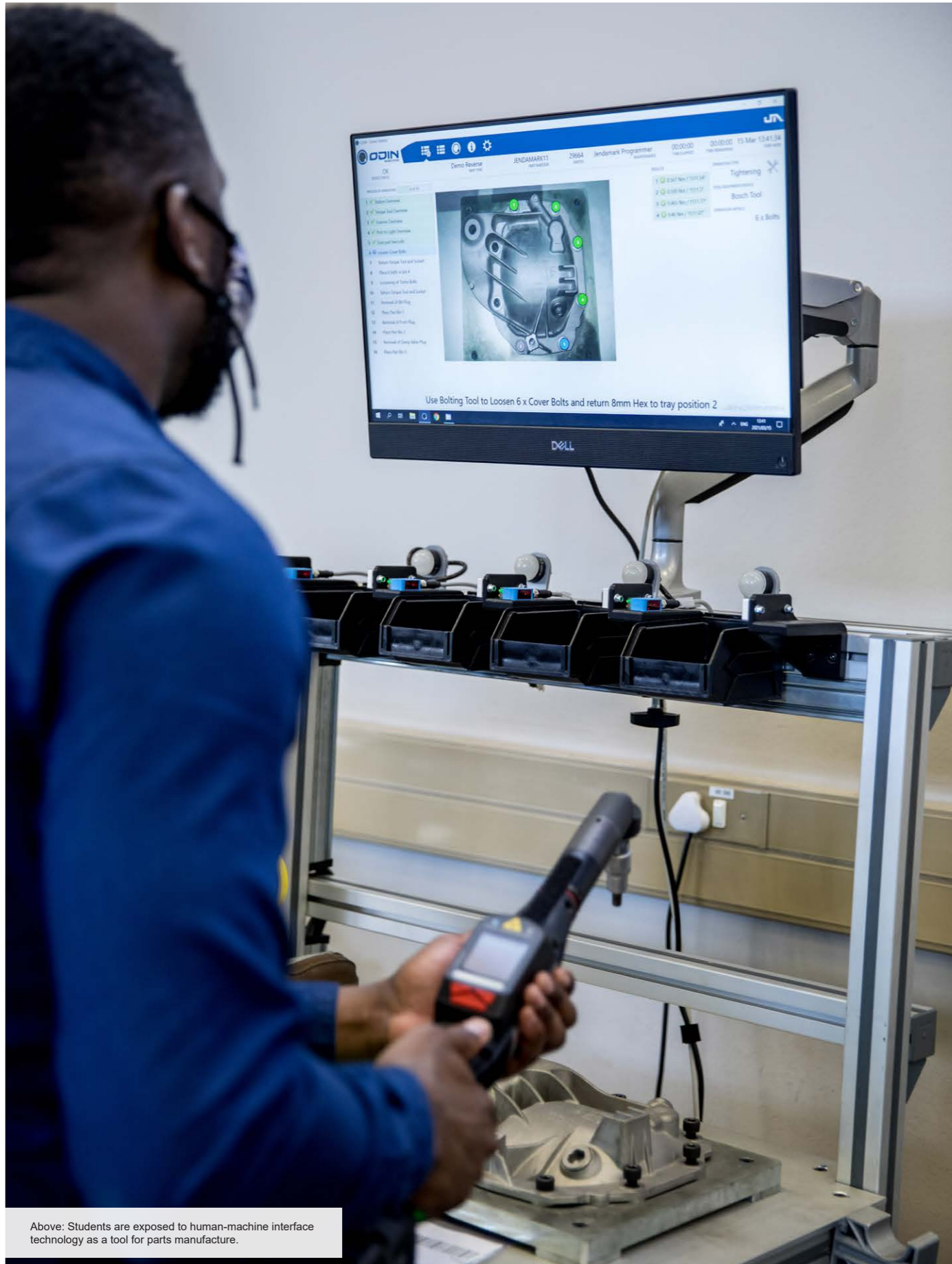
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OUR INFRASTRUCTURE

Learning factories have shown to be effective for developing theoretical and practical knowledge in a real production and non-production environment. Read more about a new demonstration platform of a learning factory developed by the CSIR and the Manufacturing, Engineering and Related Services Sector Education Training Authority on page 65.



A learning factory for fourth industrial revolution skills development



Above: Students are exposed to human-machine interface technology as a tool for parts manufacture.

The CSIR and the Manufacturing, Engineering and Related Services Sector Education Training Authority (merSETA) have developed a demonstration platform of a learning factory to promote skills development and innovation in support of digital technologies underpinning the fourth industrial revolution (4IR). Learning factories have shown to be effective for developing theoretical and practical knowledge in a real production and non-production environment.

The demonstration platform is the first step towards establishing a fully operation learning factory. The learning factory will focus on developing the skills required to conceptualise and develop disruptive technologies and processes and demonstrating advances in 4IR innovation.

The learning factory will offer a state-of-the-art industrial infrastructure to create a holistic setup for participants. It will provide access to an up-to-date curriculum that is on par with industry skill requirements. Through a practical training programme, participants are provided with opportunities to learn and apply information in an industrial setting.

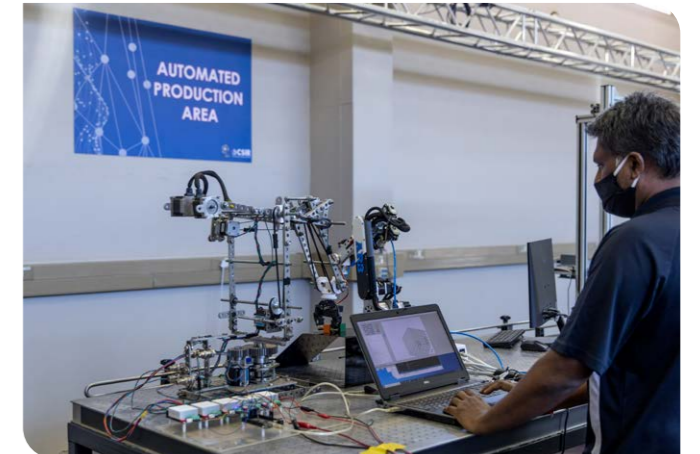
In addition to the master learning factory at the CSIR, the intention is for merSETA to establish learning factories at 18 public technical and vocational education and training colleges around the country, developing and honing the skills of learners and the national workforce to support the adoption of 4IR technologies in different industry sectors of South Africa.

The master learning factory features:

- Learning labs that facilitate skills development from a theoretical and practical perspective;
- Research labs that support research and innovation activities in the 4IR space with respect to design, incubation and prototyping; and
- Centres that support experiential learning by exposing learners to working environments in which 4IR technologies are being employed.

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The learning factory demonstration platform provides hands-on experience in working with technologies such as human-computer-based learning and programming robotic systems to perform tasks such as pick and place of small items.

A commitment to live learning continues at the **Cofimvaba Science Centre**

Generations of learners in the Eastern Cape will benefit from one of the most innovative science centres in the country. The CSIR-developed Cofimvaba Science Centre not only demonstrates technology, but also incorporates the latest sustainable technologies throughout the design process. The CSIR developed and constructed the centre and continues its involvement through a multiyear post-construction building performance assessment, as well as a further ecology education teaching infrastructure project.

The centre showcases innovative construction methods and how to achieve near net zero energy (producing more energy on site annually than it consumes) and near net water.

To create this live learning exhibition, the CSIR drew on its multidisciplinary skills base. Energy experts developed a microgrid in which solar panels, small-scale wind turbines and hydrogen fuel cells supplied by the North-West University (NWU) are used, along with a backup to the Eskom grid. Computational fluid dynamics experts helped model the air flow and pressure so that architects could design an optimal natural ventilation building. The centre is built with a light steel frame and insulated polystyrene infill panels covered with spray-on concrete plaster walls. The building is in part exposed so that students can see the technology and understand and learn from the structure. Other innovations relate to vertical airflow chimneys and grey water recycling, while the centre also features a planetarium with a telescope dome supplied by NWU, and an onsite South Africa Weather Bureau weather station.

The Cofimvaba Science Centre is funded by the Department of Science and Innovation and the Eastern Cape Department of Education, and supported by the Development Bank of Southern Africa.

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Above: The Cofimvaba Science Centre in the Eastern Cape.



Above: Solar chimneys, a natural ventilation strategy.



Above: The Interactive Visible Energy Centre.



Above: Water harvesting, with the main entrance in the background.



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