

ANNUAL REPORT
2020/2021



science & innovation

Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

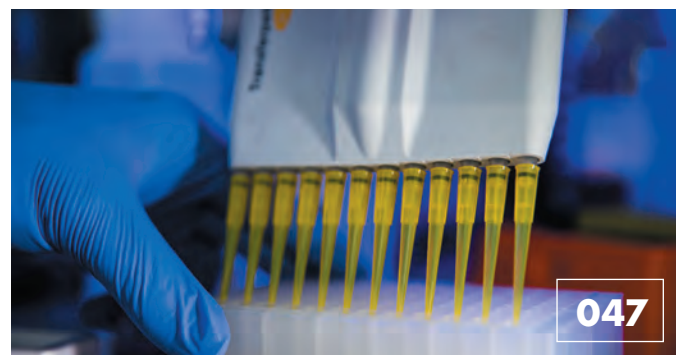


CSIR
Touching lives through innovation

“The objects of the CSIR are, through directed and particularly multidisciplinary research and technological innovation, to foster, in the national interest and in fields which, in its opinion, should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby contribute to the improvement of the quality of life of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act.”

(Scientific Research Council Act 46 of 1988, as amended by Act 27 of 2014)

CONTENTS



PART A	General information	003
PART B	Organisational highlights	023
PART C	Performance information	071
PART D	Governance	087
PART E	Human resource management	105
PART F	Consolidated financial statements	131
PART G	CSIR publications	175



PART A GENERAL INFORMATION

The Council for Scientific and Industrial Research (CSIR) is a leading **scientific and technology research organisation** that researches, develops, localises and diffuses technologies to accelerate socioeconomic prosperity in South Africa. The organisation's work **contributes to industrial development and supports a capable state**. The organisation plays a key role in supporting government's programmes through directed **research that is aligned with the country's priorities**, the organisation's mandate and its science, engineering and technology competences.

CSIR general information	004
List of abbreviations/acronyms	005
Chairperson's overview	006
Message from the Chief Executive Officer	012
Statement of responsibility and confirmation of accuracy for the annual report	018
Strategic overview	019
CSIR strategic intent	019
CSIR values	020
Organisational structure	021

CSIR GENERAL INFORMATION

REGISTERED NAME:	Council for Scientific and Industrial Research
PHYSICAL ADDRESS:	Meiring Naude Road Brummeria Pretoria
POSTAL ADDRESS:	PO Box 395 Pretoria 0001 South Africa
TELEPHONE NUMBERS:	012 841 2911
EMAIL ADDRESS:	enquiries@csir.co.za
WEBSITE ADDRESS:	www.csir.co.za
EXTERNAL AUDITORS:	Auditor-General South Africa
BANKERS:	ABSA

LIST OF ABBREVIATIONS/ACRONYMS

ADMIC	Advanced Design and Manufacturing Innovation Centre	merSETA	Manufacturing, Engineering and Related Services Sector Education Training Authority
AFIS	Advanced Fire Information System	MoU	Memorandum of Understanding
AGSA	Auditor-General of South Africa	MTEF	Medium-Term Expenditure Framework
AISI	Aerospace Industry Support Initiative	MTSF	Medium-Term Strategic Framework
APSO	African Professional Staffing Organisation	NASA	National Aeronautics and Space Administration
ARDP	Accelerated Researcher Development Programme	NCPC-SA	National Cleaner Production Centre South Africa
AUDA	African Union Development Agency	NDP	National Development Plan
B-BBEE	Broad-Based Black Economic Empowerment	NEPAD	New Partnership for Africa's Development
BD&C	Business Development and Commercialisation	NICD	National Institute for Communicable Diseases
BIDC	Biomanufacturing Industry Development Centre	NICIS	National Integrated Cyber Infrastructure System
BIDF	Biorefinery Industry Development Centre	NRF	National Research Foundation
BMGF	Bill & Melinda Gates Foundation	NVP	National Ventilator Project
BSL3	Biosafety Level 3	NWU	North-West University
C4IR SA	Centre for the Fourth Industrial Revolution South Africa	PACE	Plankton, Aerosol, Cloud, Ocean Ecosystem
CALC	Computer Automated Land Cover	PED	Pressure Equipment Directive
CEO	Chief Executive Officer	PFMA	Public Finance Management Act
CFO	Chief Financial Officer	PG	Parliamentary Grant
CiLLA	CSIR Innovation Leadership and Learning Academy	PPE	Property, Plant and Equipment
CMP	Campus Master Plan	PPF	Photonics Prototyping Facility
CoESTI	Centre of Excellence in Science, Technology and Innovation	PRMG	Provincial Roads Maintenance Grant
CSI	Corporate Social Investment	PSC	Project Steering Committee
CSIR	Council for Scientific and Industrial Research	PV	Photovoltaic
DEFF	Department of Environment Forestry and Fisheries	RAMS	Road Asset Management Systems
DOD	Department of Defence	RD&I	Research, Development and Innovation
DSI	Department of Science and Innovation	RIR	Recordable Incident Rate
dtic	Department of Trade, Industry and Competition	SAASTEC	South African Association of Science & Technology Centres
ELIDZ	East London Industrial Development Zone	SANEDI	South African National Energy Development Institute
EU	European Union	SANReN	South African National Research Network
EVP	Employee Value Proposition	SAR	Synthetic Aperture Radar
FY	Financial Year	SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
GDRT	Gauteng Department of Roads and Transport	SET	Science, Engineering and Technology
GIT	Graduate-in-Training	SHEQ	Safety, Health, the Environment and Quality
GPR	Ground-Penetrating Radar	SMME	Small, Medium and Micro Enterprises
GTCF	Greater Tzaneen Community Foundation	SO	Strategic Objective
IBS	Inter-Bursary Support	SOCCO	Southern Ocean Carbon and Climate Observatory
ICT	Information and Communications Technology	TR	Treasury Regulations
IEE	Industrial Energy Efficiency	TVWS	Television Whitespaces
KPI	Key Performance Indicator	UNDP	United Nations Development Programme

CHAIRPERSON'S OVERVIEW

Professor Thokozani Majozi

CSIR Board Chairperson

It is the Chairperson's role to represent the CSIR Board in, firstly, carrying out the terms of the agreement of work between the CSIR and its Executive Authority, the Minister of Higher Education, Science and Innovation; and, secondly, in transferring the spirit of that agreement through the ranks of the CSIR.

It is my pleasure to be able to report that the CSIR has performed well on both counts, making every effort to deliver on its agreement as well as rising to meet the challenges brought on by the Covid-19 pandemic, playing its role as scientific advisor and implementer of relevant solutions. This, while not being unscathed by the pandemic's repercussions – the loss of employees to Covid-19 and commensurate trauma experienced by colleagues, as well as dwindling economic resources in what the Organization for Economic Cooperation and Development refers to as the deepest recession since the Great Depression of 1930 for emerging economies. CSIR, I salute you.

Over the past decade, the CSIR has worked tirelessly to adapt to a fast-changing world – in terms of both socioeconomic stresses and rapid technological advances. It has reinvented its strategy to be global, regional and national priority-driven; transformed its structure to leverage its multidisciplinary nature and increase agility; and repositioned its focus on the industrial sector not only as an invaluable partner in addressing South Africa's triple challenges of inequality, poverty and unemployment, but also as a key beneficiary of the organisation's research, development and innovation (RD&I).

It was during the first year of delivering on its new strategy and coming to grips with far-reaching organisational changes that it also had to contend with the shock of the global Covid-19 pandemic.

I dare say there would be very few organisations who would not be reporting on the continuing disruptive effects of the pandemic on their businesses, not to mention the heartache suffered by many families. Certainly, it highlighted the importance of global connectedness, and has exposed socioeconomic challenges across the world.

On a positive note, the current crisis stimulated interest in innovative solutions in areas such as remote working methods, distance education, e-commerce and digital communication, and health solutions. It has also catapulted the CSIR into a space



One of the many high-level inputs into the CSIR Strategy is the **international Sustainable Development Goals (SDGs)**. These capture the essence of **sustainable development in support of a better world**.

where immediate, innovative action was required, harnessing all the lessons the organisation has learnt over the past decade concerning internal and external collaboration; dexterity; and world-class, relevant capabilities.

One of the many high-level inputs into the CSIR Strategy is the international Sustainable Development Goals (SDGs). These capture the essence of sustainable development in support of a better world.

Of the 17 SDGs, the CSIR's work dovetails with 12: A world with no poverty; Zero hunger; Good health and wellbeing; Clean water and sanitation; Affordable and clean energy; Decent work and economic growth; Sustainable industrialisation; Reduced inequality; Sustainable cities and communities; Climate action; Conservation and sustainable use of the oceans, seas and marine resources; and Protect, restore and promote sustainable use of terrestrial ecosystems.

Regionally, the South African Government gives high priority to African relations and Africa's development agenda. This is also reinforced in the 2019–2024 Medium-Term Strategic Framework (MTSF). The CSIR continued its endeavours to contribute to the realisation of the Science, Technology and Innovation Strategy for Africa, the SADC Industrialisation Strategy and the African Union Development Agency New Partnership for Africa's Development (AUDA-NEPAD). The proposed medium-term responses on supporting Africa's recovery as captured in the AUDA NEPAD White Paper, 'Harnessing Innovation and Emerging Technologies to Address the Impact of Covid-19 in Africa', focus on bracing the continent's small, medium and micro enterprises (SMMEs) and achieving food security – areas embedded in the CSIR Strategy.

The most important policy document guiding the CSIR Strategy is the National Development Plan (NDP). The NDP sets out the long-term developmental framework for the nation, which is supported by the MTSF; the recent White Paper on Science, Technology and Innovation; and the Industrial Policy Action Plan.

The CSIR's RD&I programmes respond to seven of the focus areas in the NDP:

- Economy and employment. New strategic RD&I clusters for the chemicals, mining, agriculture and manufacturing sectors focus specifically on this goal.
- Building a capable state. Here CSIR interventions focus on service delivery and its associated issues.
- Economic and social infrastructure. The CSIR employs its RD&I in

the areas of information and communications technology (ICT), water, transport, coastal infrastructure, as well as improved building design and improved building materials.

- Transition to a low-carbon economy. The CSIR is working on improving the measurement and management of natural resources, and understanding the long-term effects of climate change to assist government with mitigation and adaptation strategies.
- Transforming human settlements. Support to metropolitan areas and municipalities include spatial planning, the management of infrastructure and the transition to greener and smarter economies.
- Improving health. Health support ranges from technical support to the National Health Insurance initiative; the development of interconnected and inter-operable point-of-care devices; and the development of new methods to understand, manage and diagnose disease at the cellular and molecular level.
- Building safer communities. CSIR interventions in this area focus on supporting the acquisition and integration of technology by the country's security forces and national police.

Returning to the one issue that will remain high on the national as well as the CSIR's agenda: the South African Economic Reconstruction and Recovery Plan, post-Covid-19. The Reconstruction and Recovery Plan comprises four priority interventions, 1) a massive rollout of infrastructure throughout the country; 2) the rapid expansion of energy generation capacity; 3) an employment stimulus to create jobs and support livelihoods; and 4) a drive for industrial growth (including localisation in manufacturing).

The CSIR has demonstrated that it is well placed to meaningfully contribute to all of these areas. I thank the CSIR Board, the CSIR Executive Committee and every employee for their hard work, perseverance and commitment to unite their personal, professional and intellectual resources in helping South Africa and the region find its way through this time. I also extend my gratitude to the Minister of Higher Education, Science and Innovation, Dr Bonginkosi "Blade" Nzimande, and his department for their support and guidance.



Professor Thokozani Majozo
CSIR BOARD CHAIRPERSON

ELIJKAYO LIKASIHLALO

USolwazi Thokozani Majozi

USihlalo WeBhodi le-CSIR

NjengoSihlalo, kuyindima yami ukumela iBhodi lakwa-CSIR, okokuqala, ekufezeni imigomo yesivumelwano somsebenzi phakathi kwe-CSIR nobuHoli bayo Obuphezulu, uNgqongqoshe Wezemfundo Ephakeme, iSayensi kanye Nezokusungula; kanye, okwesibili, ukudlulisa umoya waleso sivumelwano ezigabeni ezahlukeni zakwa-CSIR.

Kuyintokozo enkulu kimi ukubika ukuthi i-CSIR isebenze kahle kakhulu kuzo zombili lezi zihloko, yenze yonke imizamo yokufeza isivumelwano sayo, kanye nokubhekana ngqo nezinsalele ezilethwe ubhubhane lwegciwane le-Covid-19, yadlala indima yayo njengomeluleki kwezisayensi nomqalisi wezixazululo ezifanele. Lokhu ikwenza, naphezu kokuphazanyiswa yimiphumela yalolu bhuhane – ukudlula emhlabeni kwabasebenzi bebulawa yigciwane le-Covid-19 nokuhlukumezeka emoyeni kozakwabo, kanye nokwehla kwezinsizakusebenza zomnotho kulokho i-Organisation for Economic Cooperation and Development ekubiza ngenzikanomtho ejule kunayo yonke kusukela kwaba khona i-Great Depression yonyaka we-1930 kwezeminotho esafufusa. CSIR, ngikwethulela isigqoko.

Eminyakeni eyishumi edlule, i-CSIR isebenze ingaphumuli ukuze ikwazi ukuhambisana nomhlaba olokhu uguquguquka ngokushesha – ngokwezingcindezi zomnotho emphakathini kanye nentuthuko esheshayo yezobuchwepheshe. Iphinde yavuselela isu layo lokusebenza emazingeni omhlaba-jikelele, esizindeneni, kanye nakuzwelonke; iguqule isakhiwo sayo ukuze kusetshenziswe ngokuphelele ubuningi bemikhakha yayo futhi kunwetshwe ibanga layo; futhi yakama kabusha egxile kukho emkhakheni wezimboni hhayi nje kuphela njengomlingani obaluleke kakhulu ekubhekane nezinsalele ezintathu zaseNingizimu Afrika okuwukungalingani, ubuphofu kanye nokuntuleka kwemisebenzi, kodwa futhi njengomhlomuli osemqoka ocwaningweni lwenhlangano, intuthuko kanye nokusungulwa kwezinto ezintsha (i-RDI).

Kwakuphakathi nonyaka wokuqala wokuletha isu lawo elisha kanye nokubhekana nezinguquko ezinkulu enhlanganweni lapho kwadingeka khona ukuthi ibhekane nokushaqeka komhlaba wonke okwadlwa ubhubhane lwegciwane le-Covid-19.

Ngineqiniso lokuthi zimbaleka kakhulu izinhlangano ezingeke zibike ngemiphumela eqhubekayo yokuphazanyiswa yilolu bhuhane emabhizinisini azo, ingasaphathwa eyobuhlungu imindeneni eminingi ebhekane nayo. Impela, iveze ukubaluleka kokuxhumana emhlabeni wonke, futhi iveze izinsalele zomnotho wemiphakathi emhlabeni wonke

Uma ngibheka kokuhle, inkinga yamanje ivuse intshisekelo kuzixazululo ezintsha ezindaweni ezinjengezindlela zokusebenza usekhaya, ukufunda ukude, ezokuhweba nge-inthanethi ukuxhumana okudijithali, kanye nezixazululo zezempilo. Iphinde yafukula i-CSIR yayikhuphulela endaweni lapho kudingeka khona ukunyakaza okusheshayo, kwenziwe amasu amasha, kusetshenziswa zonke izifundo inhlangano ezifunde kuleli shuminyaka eledlule mayelana nokusebenzisana kwangaphakathi nangaphandle; ikhono lokusebenza ngezandla zombili; kanye nezinga lomhlaba, amakhono afanele.

Amanye amagalelo amaningi ezinga eliphezulu kuleli Cebo lakwa-CSIR yiziNhloso eziZinzile zeNtuthuko zomhlaba wonke (ama-SDG). Lokhu kuveza ingqikithi yentuthuko esimeme ekwesekeni umhlaba oncono.

Kuma-SDG ayi-17, umsebenzi we-CSIR uhlangana khaxa nayi-12: Umhlaba ongenabo ubuphofu; Ukuphela Kwendlala; Impilo enhle nenhlalakahle; Amanzi ahlanzekile kanye nokuthuthwa kwendle; Amandla kagesi angabizi futhi ahlanzekile; Umsebenzi ohloniphekile nokukhula komnotho; Ukusimama kwezimboni; Ukuncipha kokungalingani; Amadolobha nemiphakathi esimeme; Umnyakazo Kwezesimo Sezulu; Ukongiwa kanye nokusetshenziswa okuzinzile kwezilwandle, izilwandle kanye nemithombo yolwandle; futhi Kuvikelwe, kubuyiselwe kuphindwe kukhuthazwe ukusetshenziswa okusimeme kwemvelo yasemhlabeni.

Ngokwesizinda, uHulumeni waseNingizimu Afrika ubeka eqhulwini ubudlelwano namanye amazwe ase-Afrika kanye nezinhlelo zentuthuko yase-Afrika. Lokhu kuphinde kwaqiniswa kuHlaka Lwamasu Esikhathi Esimaphakathi (i-MTSF) lwangowezi-2019-2024. I-CSIR iqhubekile nemizamo yayo yokufaka isandla ekugcwalisekeni kweQhinga lezeSayensi, Ubuchwepheshe kanye nokuSungula e-Afrika, Isu le-SADC Lokusungula Izimboni kanye ne-African Union Development Agency New Partnership for Africa's Development (AUDA NEPAD). Izimpendulo ezihlongozwayo zesikhathi esimaphakathi ekwesekeni ukululama kwe-Afrika njengoba kubekiwe ePhepheni eliMhlophe le-AUDA NEPAD, eliqanjwe ngokuthi 'Ukuhlanganiswa Kwamacebo Okusungula Nobuchwepheshe Ukubhekana Nomthelela Wegciwane le-Covid-19 e-Afrika', phecelezi 'Harnessing Innovation and Emerging Technologies to Address the Impact of Covid-19 in Africa', eligxile ekuqiniseni amabhizinisi ezwekazi amancane, aphakathi namancane (ama-SMME) kanye nokuqinisekisa ukutholalaka nokuvikeleka kokudla – izindawo ezifakwe kwiQhinga le-CSIR.

Umbhalo wenqubomgomo obaluleke kunayo yonke oqondisa Isu le-CSIR uHlelo LukaZwelonke Lwentuthuko (NDP). I-NDP ibeka ngokusobala uhlaka lwezwe lwentuthuko yesikhathi eside, olwesekwa yi-MTSF; iPhepha Elimhlophe lakamuva eliphathelene

Amanye amagalelo amaningi ezinga eliphezulu kuleli **Cebo lakwa-CSIR yiziNhloso eziZinzile zeNtuthuko zomhlaba wonke (ama-SDG)**. Lokhu kuveza ingqikithi yentuthuko esimeme ekwesekeni umhlaba ongcono.

nezeSayensi, ubuchwepheshe kanye nokuSungula izinto ezintsha; kanye noHlelo Lokusebenza Lwenqubomgomo Yezimboni. Izinhlelo zakwa-CSIR ze-RDI ziphendula ezihlokwani eziyisikhombisa okugxilwe kuzo ku-NDP:

- Umnotho nokuqashwa. Amaqoqo amasha amacebo e-RDI emikhakha yezamakhemikhali, ezezimayini, ezolimo kanye nezokukhiqiza agxile ngqo kule njongo.
- Ukwakha izwe elinamandla okuqhuba umsebenzi. Lapha ukungenelela kwe-CSIR kugxile ekulethweni kwezidingongqangi kanye nezinkinga ezihambisana nakho.
- Ingqalasizinda yezomnotho nezenhlalo. Abakwa-CSIR basebenzisa i-RDI yayo ezindaweni zobuchwepheshe bezokuxhumana (i-ICT), ezamanzi, ezokuthutha, ingqalasizinda yasogwini, kanye nokuthuthukiswa nokuklanywa kwamabhilidi nokuthuthukiswa kwezinto zokwakha.
- Ukushintshela emnothweni wekhabhoni ephansi. Abakwa-CSIR baphezu kwezinhlelo zokuphucula ukulinganiswa nokunganyelwa kwemithombo yemvelo, nokuqonda imiphumela yesikhathi eside yokuguquka kwesimo sezulu ukusiza uhulumeni ngamasu okunciphisa nokuzivumelanisa nezimo.
- Ukuguqula izindawo zokuhlala abantu. Ukwesekwa ezindaweni ezisemadolobheni amakhulu kanye nomasipala kubandakanya ukuhlelwa kwendawo, ukunganyelwa kwengqalasizinda kanye nokushintshela emnothweni ohlaza kanye nohlakaniphile.
- Ukuthuthukisa ezempilo. Ukwesekwa kwezempilo kusuka ekusekelweni kwezobuchwepheshe kuya kuhlelo lwe-National Health Insurance; ukwakhiwa kwamadivayisi okunakekela axhumene futhi asebenzisanayo; kanye nokwakhiwa kwezindlela ezintsha zokuqonda, ukuphatha kanye nokuhlonza izifo ezingeni lamangqamuzana kanye namamolekhuli.
- Ukwakha imiphakathi ephephile. Ukungenelela kwabakwa-CSIR kule ngxenye kugxile ekusekeleni ukutholwa nokudidiyelwa

kobuchwepheshe ngamabutho ezokuphepha aleli zwe namaphoyisa ezwe.

Ukubuyela kulolu daba oluzolokhu luphambili ezinhlelweni zikazwelonke, kanjalo nasezinhlelweni zakwa-CSIR: uHlelo Lokwakhiwa kabusha Nokuvuselelwa Kwezomnotho waseNingizimu Afrika, ngemva kokudlula kwegciwane le-Covid-19. Uhlelo Lokwakhiwa kabusha Nokuvuselelwa luqukethe izindlela ezine zokungenelela eziseqhulwini, 1) ukhukhulelangoqo wokusatshalaliswa kwengqalasizinda ezweni lonke; 2) ukunwetshwa okusheshayo kokukhiqizwa kwamandla kagesi; 3) umfutho wokuqashwa wokwakhiwa kwamathuba emisebenzi nokuxhasa izindlela zokuziphilisa; kanye neye-4) umkhankaso wokukhuliswa kwezimboni (kubandakanya izinhlelo zokukhiqiza endaweni).

I-CSIR isizibonakalisile ukuthi isesimweni esihle kakhulu sokuba negalelo elicacile kuzo zonke lezi zihloko.

Ngibonga iBhodi lakwa-CSIR, iKomidi eliPhezulu lakwa-CSIR kanye nabo bonke abasebenzi ngokusebenza kwabo kanzima, ukubekezela nokuzibophezela ekuhlenganiseni izinsizakusebenza zabo uqobo, ubungcweti nobuhlakani ukuze kusizakale iNingizimu Afrika kanye nesizinda sonkana ukuze sikwazi ukuthola indlela kulesi sikhathi.

Ngedlulisa futhi ukubonga kwami kuNgqongqoshe wezeMfundo ePhakeme, ezeSayensi Nezokusungula, uDkt Bonginkosi "Blade" Nzimande, nomnyango wakhe ngokuseseka nokusihola.



USolwazi Thokozani Majozi
USIHLALO WEBHODI LE-CSIR

KAKARETŠO YA MODULASETULO

Prof. Thokozani Majazi

Modulasetulo wa Boto ya CSIR

Bjalo ka Modulasetulo, ke mošomo wa ka go emela CSIR ka, sa mathomo, go phethagatša mabaka a tumelano ya mošomo gare ga CSIR le Taolophethiši, Tona ya Thuto ya Godimo, Saense le Mpshafatšo; le, sa bobedi, go fetišetša moya wa tumelano yeo ka maemo a CSIR.

Ke thabela go bega gore CSIR e šomile gabotse go dipalomoka ka moka, go šoma ka maatla go tšweletša tumelano ya yona, gammogo le go gola go fihlelela dihlhohlo tšeo di tlišitšwego ke leuba la Covid-19, go kgatha tema ya yona bjalo ka moeletši wa saense le mophethagatši wa diitharollo tša maleba. Se, le ge se se a angwa ke ditlamorago tša leuba – go lahlegelwa ke bašomi ka lebaka la Covid-19 le kgatelelo ya monagano ye e amanago le seo yeo e itemogetšwego ke badirišani, gammogo le go fokotšega ga methopo ya ekonomi ka seo Mokgatlo wa Tirišano ya Ekonomi le Tlhabollo o rego ke go fokotšega ga go tseenelela go tloga nakong ya Kgatelelo ya Monagano ye Kgolo ka 1930 go diekonomi tšeo di golago. Ke a go reta CSIR.

Mo pakeng ya go feta, CSIR e šomile ka maatla go itlwaetša lefase leo le fetogago ka lebelo – go ya ka dikgatelelo tša ekonomi ya leago le dikaonafatšo tša theknološi ya lebelo. E fetošitše mokgwa wa yona go ba wo o hlohleletšago ke tše bohlokwa tša lefase, selete le bosetšhaba; o fetošitše sebopego sa wona go huetša mokgwa wa dikarolo tše dintši le go oketša karabelo; le go fetoša nepo ya yona mo lekaleng la intasteri e sego fela bjalo ka modirišani yo bohlokwa mo go šoganeng le dihlhohlo tše tharo tša Afrika Borwa tša go hloka tekatekano, bohloki le tlhokego ya mošomo, eupša bjale gape ka moholegi wo mogolo wa dinyakišišo, kaonafatšo le mpshafatšo (RDI) tša mokgatlo.

Ke ka ngwaga wa mathomo wa kabo ya mokgwa wa yona wo mofsa le go kgona go laola diphetogo tšeo di tseeneletšego tša mokgatlo tšeo di swanetšego go lwantšhana le kgatelelo ya leuba la Covid-19 lefaseng.

Ke bolela gore go tla ba le mekgatlo ye mennyane yeo e ka se begogo ka ditlamorago tša tšhitišo tšeo di tšwelago pele tša leuba mo dikgobeng, re sa lebelele manyami ao malapa a itemogetšego wona. Ka nnete, e gateletše bohlokwa bja kgokagano, gomme e tšweleditše dihlhohlo tša diekonomi tša leago go phatlalala le lefase.

Go lebeletšwe tše dibotse, mathata a gonabjale a hlohleleditše dikgahelgo go diitharollo tša mpshafatšo go dikarolo tša go swana le mekgwa ya go šoma gae, thuto ya kgole, kgwebo ya inthanete le kgokagano ya tišitale, le diitharollo tša maphelo. E išitše gape CSIR sekgobeng seo kgato ya ka pela, ya mpshafatšo e nyakegago, ya

kgokaganya dithuto ka moka tšeo mokgatlo o ithutilego tšona mo pakeng ya go feta malebana le tirišano ya ka ntle goba ya ka gare; bokgoni, le bokgoni bja godimo, le mabokgoni a maleba.

Ye nngwe ya dikgopolo tša maemo a godimo mo Mokgweng wa CSIR ke Dinepo tša Kaonafatšo tša Lefase (SDGs). Se se tšweletša moya wa mpshafatšo ya tshwarelelo go thekga lefase le le kaone. Se se akaretša moya wa kaonafatšo ya go swarelela go thekga lefase le lekaone.

Go diSDG tše 17, mošomo wa CSIR o kopana le tše 12: lefase leo le se nago le bohloki; Go se be le tšala; Maphelo a mabotse le go phela gabotse; Meetse a go hlweka le tlhwekišo; Enetši ya go rekega gape ya go hlweka; Mošomo wa seriti le kgolo ya ekonomi; Intasteri ya Go swarelela; Go fokotšega ga go se lekalekane; Ditoropokgolo le diekonomi tša go swarelela; Kgato ya Klaemete; Go šomiša ga pabalelo le go swarelela ga mawatle, mawatle le methopo ya mawatle; le go šireletša, go aga lefesa le go godiša go šomiša ga go swarelela ga diphedi le diitokologo tšeo di phelago go tšona lefaseng.

Mo seleteng, Mmušo wa Afrika Borwa o etiša pele dikamano tša Afrika le lenaneo la kaonafatšo ya Afrika. Se se thekgilwe ke Tlhako ya Peakanyo ya Kotara ya Gare (MTFS) ya 2019-2024. CSIR e tšwetša pele mešongwana ya yona ya go kgatha tema mo temogong ya Mekgwa ya Saense, Theknološi le Mpshafatšo ya Afrika, Mokgwa wa Intasteri wa SADC le Tirišano ye Mpsha ya Mokgatlo wa Kaonafatšo wa Kopano ya Afrika wa Kaonafatšo ya Afrika (AUDA NEPAD). Dikarabo tšeo di šišintšwego tša kotara ya gare tša go thekga go tsošološwa ga Afrika bjale ka ge go ngwadilwe ka Kuranteng ya Mmušo ya AUDA NEPAD, 'Go kopanya Mpshafatšo le Diitokologo tšeo di Hlabologago go Šogana le Khuetšo ya Covid-19 ka Afrika' e nepiša mo go matlafatšeng dikgwebopatlana tša kontinente tše dinnyane le tša gare diSMME) le go fihlelela tšhireletšo ya dijo – dikarolo tšeo di tsentšwego ka Mokgweng wa CSIR.

Tokumente ya pholisi yeo e hlalago Mokgwa wa CSIR ke Leano la Mpshafatšo la Bosetšhaba (NDP). NDP e bea tlhako ya kaonafatšo ya naga, yeo e thekgwago ke MTFS; Kuranta ya Mmušo ya gonabjale ya Saense, Theknološi le Mpshafatšo; le Leano la Kgato la Pholisi ya Intasteri.

Mananeo a RDI ya CSIR a arabela go dikarolo tša nepišo tše šupa mo go NDP:

- Ekonomi le mešomo. Dihlopha tša RDI tša mokgwa wo mofsa tša makala a dikhemikhale, meepo, temo le tšweletšo di nepiša kudu go nepo ye.

Ye nngwe ya dikgopolo tša maemo a godimo mo Mokgweng wa CSIR ke Dinepo tša Kaonafatšo tša Lefase (SDGs). **Se se tšweletša moya wa mpshafatšo ya tshwarelelo go thekga lefase le le kaone.** Se se akaretša moya wa kaonafatšo ya go swarelela go thekga lefase le lekaone.

- Go aga mmušo wa bokgoni. Mo ditsenogare tša CSIR di nepiša kabo ya ditirelo le ditaba tše di amanago le yona.
- Ekonomi le infrastraktiša ya leago. CSIR e thwala RDI ya yona mo dikarolong tša ditheknolotši tša tshedimošo le kgokagano (ICT), meetse, dinamelwa, infrastraktiša ya mabopo, gammogo le moakanyetšo wa kago wo o kaonafadišwego le dimateriale tša kago tšeo di kaonafadišwego.
- Go fetogela go ekonomi ya khapone ye ya fase. CSIR e šoma go kaonafatša tekanyetšo le taolo ya methopo ya tlhago, le go kwešiša ditlamorago tša nako ye telele tša phetogo ya leratadima go thuša mmušo ka mekgwa ya kaonafatšo le phetogo.
- Go fetoša madulo a batho. Thekgo go mafelo a ditoropokgolo le mebasepala e akaretša peakanyo ya dikarolo tše tharo, taolo ya infrastraktiša le go fetogela go ekonomi ya tše ditala kudu gape tše dikaone kudu.
- Go kaonafatša maphelo. Thekgo ya maphelo e tloga go thekgo ya sethekniki go ya go lenaneo la Inšorense ya Maphelo ya Bosetšhaba; kaonafatšo ya sedirišwa sa lefelo la tlhokomelo la kgokaganyo le tšhomišo; le kaonafatšo ya mekgwa ye mefsa go kwešiša, go laola le go phekola malwetši mo legatong la selula le molekhula.
- Go aga ditšhaba tšeo di bolokegilego. Ditsenogare tša CSIR mo karolong ye di nepiša go thekga phihlelelo le kopanyo ya theknolotši ka mašole le maphodisa a naga.

Go boela go taba ye nngwe yeo e tla dulago e le godimo, gammogo le lenaneo la CSIR: Leano la Tsošološo le Kagolefsa ya Ekonomi ya Afrika Borwa, ka morago ga Covid-19. Leano la Tsošološo le Kagolefsa le na le ditsenogare tše nne, 1) go thongwa ga infrastraktiša ye kgolo nageng ka moka; 2) katološo ya lebelo ya bokgoni bja go hlola enetši; 3) tlhohloetšo ya mošomo go hlola mešomo le go thekga maphelo; le 4) tlhohloetšo ya kgolo ya intasteri (go akaretša go dira tšweletšo ya mo gae).

CSIR e bontšhitše gore e loketše go kgatha tema go dikarolo tše ka moka.

Ke leboga Boto ya CSIR, Komitiphethiši ya CSIR le mošomi yo mongwe le yo mongwe ka go šoma ka maatla ga bona, maitapišo le boikgafo bja bona go kopanya methopo ya bona ya motho, profešene le bohlale go thuša Afrika Borwa le selete go šoma ka maatla ka nako ye.

Ke rata go leboga gape Tona ya Thuto ya Godimo, Saense le Mpshafatšo, Ngaka Bonginkosi "Blade" Nzimande, le kgoro ya gagwe ka thekgo le tlhahlo ya bona.



Prof. Thokozani Majozi
MODULASETULO WA BOTO YA CSIR

MESSAGE FROM THE CEO

Dr Thulani Dlamini

CSIR CEO

If there is one thing our organisation has learnt in the past year, it is how to adapt and innovate within our own circumstances – working from home, navigating home schooling, reaching out to those with Covid-19 – while forging ahead to meet as many of our performance targets as possible.

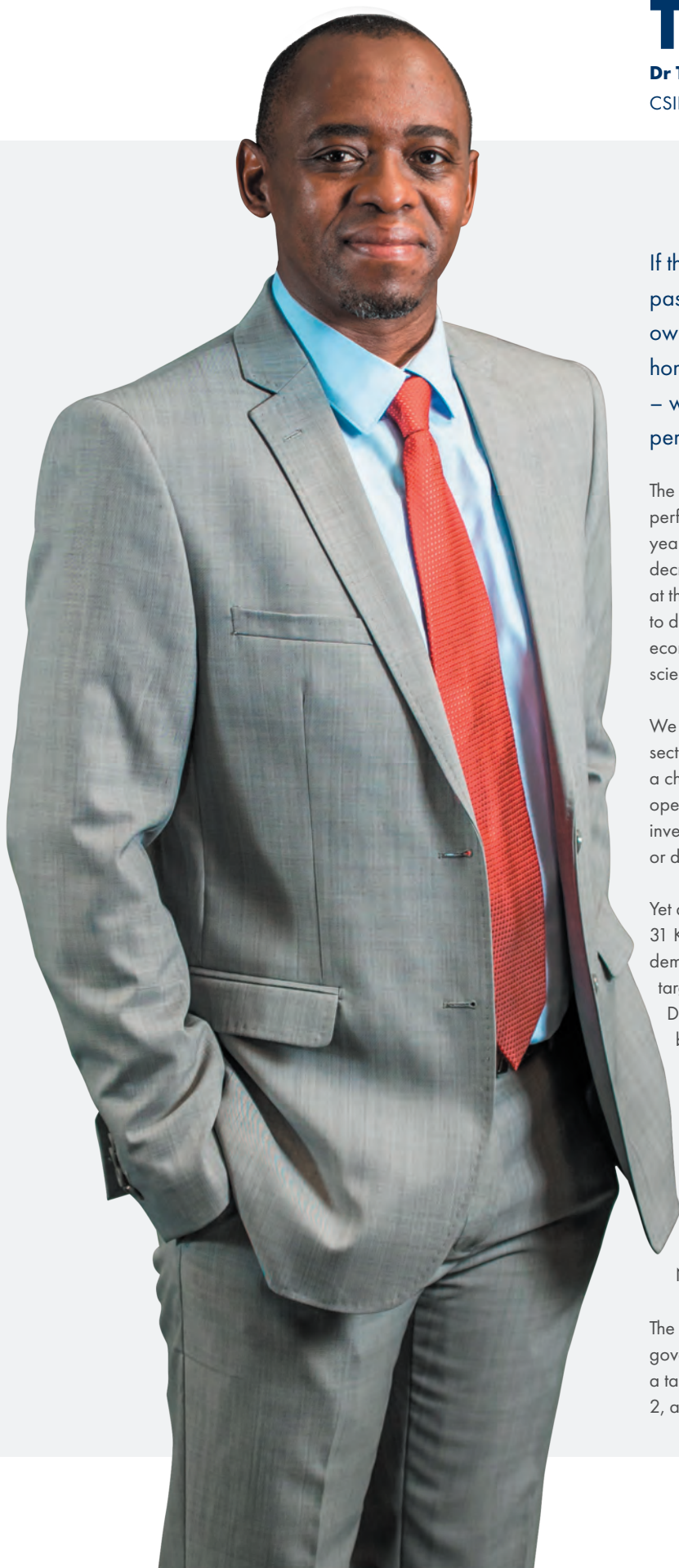
The Covid-19 pandemic occasioned a reassessment of our key performance indicator (KPI) targets for the 2020/21 financial year. Some challenges were experienced, although these have decreased as our employees and stakeholders became more adept at the new 'normal'. Initially reduced laboratory and field work led to decreased productivity. This improved with the opening of most economic sectors after June 2020 and the return to work of critical science, engineering and technology (SET) staff.

We experienced delays in contracting with the private and public sectors due to the national lockdown; however, contracting remains a challenge, particularly as budgets are re-directed to critical operational issues within our clients' organisations, rather than to investments in new RD&I programmes. Recruitment was also delayed or deferred due to uncertainty about contract income.

Yet despite these challenges, the CSIR met or exceeded 25 of the 31 KPIs. Targets for publication equivalents, patents and technology demonstrators and localised technologies have been met, whereas targets for licensed technologies are lagging. The Business Development and Commercialisation functions of the CSIR have been pursuing a strong pipeline of licensable technologies.

Our work with industry and in support of SMMEs has progressed well despite the challenges, and we have exceeded our performance thresholds in this regard by supporting 96 SMMEs against a target of 68. Research in support of a capable state started strong in the early part of the financial year due to the CSIR's contribution to national Covid-19 efforts, which, among others, included establishing the National Response Centre.

The CSIR has performed exceptionally with regards to good governance during 2020/21, reaching a B-BBEE level of 2 against a target of 3, a Recordable Incident Rate of 0.53 against a target of 2, and an unqualified audit opinion from the Auditor-General.



The CSIR has performed **exceptionally with regards to good governance during 2020/21**, reaching a B-BBEE level of 2 against a target of 3, a Recordable Incident Rate of 0.53 against a target of 2, **and an unqualified audit opinion from the Auditor-General.**

Looking at our people, the trend for SET staff showed growth in the 2020/21 financial year, from 1 367 at the end of 2019/20 to 1 474 at the end of 2020/21. This exceeded the target by 64, a positive development compared to the decline observed over the past four years. The decline was due largely to the change in strategy and associated re-organisation. The CSIR remains committed to maintaining transformation in the SET base. The percentage of Black SET staff increased from 63.4% to 66.5%, exceeding the target by 3.6%. The achievement of the target is due to directed recruitment and our retention interventions. The percentage of female SET staff grew slightly from 35% in the previous financial year to 36.4%.

Whatever the external and internal pressures, our strategic intent has not changed. Our intent is still to grow the CSIR business and use our capabilities to support inclusive growth of the South African economy. This entails developing and growing new capabilities and competencies, especially those relevant to the Fourth Industrial Revolution and to use this to grow the income and impact of the CSIR. We continually expand our ability to use CSIR-developed technologies to contribute to the advancement and sustainability of South African enterprises, and simultaneously benefit the financial sustainability of the organisation.

Impact remains our North Star, the focus of all our endeavours, such as the commercialisation of our technologies and innovations for industrial development, and technology and knowledge transfer to enable a capable state. Our work and its impact will demonstrate the relevance of innovation in achieving economic development; remaining relevant is critical to deliver on our mandate.

As such, we continue to pursue strategic programmes such as the development of our Gateway to Science and Innovation Centre. This forms part of our infrastructure development focus but will also, once complete, add immense value to RD&I engagements with stakeholders as well as youth – the problem solvers of tomorrow. The feasibility study and business case for the centre are near completion and we will be looking at marketing and fundraising next. Also part of our Campus Master Plan is a residential accommodation project, and a Shared Laboratory, Pilot and Pre-manufacturing Precinct. A needs analysis for the latter is underway. These interventions will

not only benefit our students and international stakeholders, but also SMMEs and industry who would be able to make use of these facilities. We also launched our Photonics Prototyping Facility, the fifth Department of Science and Innovation (DSI)-funded facility at the CSIR. The facility provides our industrial partners with access to first-rate expertise and infrastructure to test and upscale their developed technologies.

Referring to our commitment to Africa, our Board Chairperson in his overview referred to AUDA NEPAD. The CSIR has undertaken a major process of establishing a mutually beneficial relationship with this entity. As a result, the CSIR and AUDA NEPAD have partnered with Stellenbosch University to establish a Centre of Excellence in Science, Technology and Innovation (CoESTI), hosted by the CSIR at its Stellenbosch Campus. Developments are at an advanced stage, with AUDA NEPAD already occupying offices on the campus. The CoESTI will act as conduit for CSIR and Stellenbosch University-developed and proven innovations/technologies to be rolled out across Africa. This will form a major pillar of CSIR engagement in the African continent while the CSIR Africa Strategy is being developed.

The pages that follow narrate how the CSIR rallied behind South Africa's leadership to address Covid-19. It also features some of our RD&I highlights achieved during this year in accordance with our Shareholder's Compact.

I extend my gratitude to the DSI and the CSIR Board for their oversight, and to the leadership of the organisation and our employees who, during a year where throwing in the towel would have been easy, made our EPIC values come to life in delivering excellence, remaining people-centred, working with integrity, and embracing collaboration.



Dr Thulani Dlamini
CSIR CEO

UMYALEZO WESIKHULU ESIPHEZULU

uDkt Thulani Dlamini

Uma kunento eyodwa inhlangothi yethu eyifundile kulo nyaka odlule, sifunde ukuphila ngaphansi kwalezi zimo zethu ezintsha nokusungula izindlela ezintsha zokubhekana nezimo zethu – ukusebenzela emakhaya, ukubhekana nokufundela kwezingane zesikole emakhaya, ukwelula isandla kulabo abanegciwane le-Covid-19 – ngenkathi siphokophelele phambili ukuze sihlalangebezane nezimpokophelo zomsebenzi eziningi ngokusemandleni.

Ubhubhane lwe-Covid-19 lwenze ukuthi kuhlolwe kabusha izimpokophelo zezinkomba zokusebenza zethu ezisemqoka (KPI) kunyakamali wezi-2020/21. Zibe khonyana izinselele, yize lezi sezinciphile njengoba abasebenzi bethu kanye nababambiqhaza sebejwayelene ngokuthe xaxa 'nesimo sethu' esisha. Ukuncipha komsebenzi waselabhorethri kanye noqhutshwa emphakathini nakho kuholele ekwehleni kokukhiqiza. Lokhu kuye kwaba ngcono lapho kuvulwa imikhakha eminingi yezomnotho ngemuva kwenyanga kaNhlanguvana 2020 futhi nalapho kubuyela emsebenzini abasebenzi besayensi, ezobunjiniyela kanye nobuchwepheshe (SET).

Siye sabhekana nokubambezileka malungana nokuhlelwa kwezinkontileka emikhakheni ezimele kanye nekahulumeni ngenxa yokuvulwa kwezwe; kodwa-ke, ukuhlelwa kwezinkontileka kuhlezi kunezinselele, ikakhulukazi njengoba izabelomali seziquondiswa emisebenzini esemqoka ezinhlanganweni zamakhasimende ethu, kunokuba ziquondiswe kutshalomali lwezinhlelo ezintsha ze-RDI. Ukuqashwa kwabantu nakho kuye kwamiswa noma kwahlehliswa ngenxa yokungaqiniseki ngemali yezinkontileka ezongena.

Nakuba kube nalezi zinselele, i-CSIR iye yahlalangebezane noma yeqa ama-KPI angama-25 kwangama-31. Izimpokophelo ezifana nezishicilelo, amalungelo obunikazi kanye nezinkomba zezobuchwepheshe kanjalo nobuchwepheshe basendaweni kuhlangatshewene nazo, kanti izimpokophelo zobuchwepheshe obunamalayisense zisaselele. Imisebenzi yokuThuthukiswa kwezeBhizinisi nezoHwebo zakwa-CSIR ibilokhu iqhubeka nokuphokophela ngamandla ezobuchwepheshe ezinemvume.

Umsebenzi wethu nezimboni kanye nokweseka ama-SMME uqhubeke kahle ngaphandle kwezinsalele, futhi sisebenze saze seqa imigomo yokusebenza ebeyibekiwe maqondana nalokhu ngokuba seseke ama-SMME angama-96 lapho kuqhathaniswa nomgomo obubekiwe wangama-68. Ucwangingo lokweseka lokho izwe elinamandla okukwenza luqale ngamandla ekuqaleni konyakamali

ngenxa yeqhaza elibanjwe abakwa-CSIR emizamweni kazwelonke egciwaneni le-Covid-19, okubandakanya, phakathi kokunye, ukusungulwa kweSikhungo Sikazwelonke Sokubhekana Nesimo.

I-CSIR isebenze ngokuncomeka kakhulu maqondana nokubusa okuhle ngowezi-2020/21, yafinyelela ezingeni lesi-2 le-B-BEE uma kuqhathaniswa nalokho obekuhlosiwe okuyizinga lesi-3, Isilinganiso Sezehlakalo Esiyinqanaba esingu-0,53 uma kuqhathaniswa nempokophelo engu-2, kanye nombiko woMkwaningimabhuku-Jikelele ongenagcobho.

Uma sibheka abantu bethu, umkhuba ovamile kubasebenzi bakwa-SET ubonakalise ukukhula ngonyakamali wezi-2020/21, kusuka ezi-1 367 ekupheleni kowezi-2019/20 kuya ezi-1 474 ekupheleni kowezi-2020/21. Lokhu kweve kobekuhlosiwe ngenani elingama-64, nokuyintuthuko enhle kakhulu uma kuqhathaniswa nokwehla okubonakale eminyakeni emine edlule. Ukwehla lokhu kudalwe kakhulu ushintsho lwamasu kanye nokuhlelwa kabusha okuhambisanayo nalo lolu shintsho. I-CSIR isalokhu izibophezele ekugcineni ushintsho kusisekelo se-SET. Amaphesenti abasebenzi abaMnyama emkhakheni we-SET enyuke esuka kuma-63.4% aya kuma-66.5%, adlula inani ebelihlosiwe ngama-3.6%. Ukufinyelelwa kwezimpokophelo kungenxa kokuqashwa kwabasebenzi ngendlela ehleliwe kanjalo nezindlela zokungenelela ukubagcina. Amaphesenti abasebenzi besifazane ku-SET anyuke kancane esuka kuma-35% ngonyakamali odlule afinyelela kuma-36.4%.

Noma ngabe iyiphi ingcindezi yangaphandle neyangaphakathi, inhloso yamasu ethu ayikashintshi. Inhloso yethu kuseyikho ukukhulisa ibhizinisi le-CSIR nokusebenzisa amakhono ethu ukweseka ukukhula okubandakanya wonke umuntu emnothweni waseNingizimu Afrika. Lokhu kubandakanya ukuthuthukisa nokukhulisa amakhono amasha, ikakhulukazi lawo ahambisana neNguquko Yesine Yezimboni nokusebenzisa lokhu ukukhulisa imali engenayo kanye nomthelela we-CSIR. Silokhu siqhubeka nokukhulisa ikhono lethu lokusebenzisa ubuchwepheshe obuthuthukiswe yi-CSIR ukuze siphonse esivivaneni ekuthuthukisweni nasekusimamisweni kwamabhizinisi aseNingizimu Afrika, futhi ngesikhathi esifanayo sihlomule ekuzinzeni kwenhlangano ngakwezizimali.

Umthelela ulokhu uyinjongo yethu eseqhulwini, yiwo esigxilise kuwo yonke imizamo yethu, njengokuhweba ngezobuchwepheshe bethu kanye nokusungulwa kwezinto ezintsha zokuthuthukiswa kwezimboni, ubuchwepheshe kanjalo nokudluliswa kolwazi ukuze sibe nezwe elisemandleni. Umsebenzi wethu kanye nomthelela wawo yikho okuzokhombisa ukubaluleka kokuqanjwa kwezinto

ezintsha ukuze kufinyelelwe ekuthuthukisweni komnotho; ukuhlala siphambili kusemqoka kakhulu ukuze sikwazi ukufeza injongo yethu.

Ngenxa yalokho, siyaqhubeka nokuphokophela izinhlelo ezinamasu amahle njengokuthuthukiswa kwesikhungo sethu esibizwa nge-Gateway to Science and Innovation Centre. Lokhu kuyingxenywe yokugxila kwethu ekuthuthukisweni kwengqalasizinda kodwa futhi, uma sekuphuthuliwe, kuzokwengeza isisindo esikhulu emisebenzini ye-RDI nababambiqhaza kanjalo nentsha – okungabasombululizinkinga bakusasa. Ucwangingo lokuhlola ukuthi singaba yimpumelelo na isikhungo sekuseduze luphuthulwe bese silandelisa ngokugxila kwezokukhangisa nokuqokelelwa kwezimali. Okunye futhi okuyingxenywe yoHlelo Lwethu OluyiNhlolo Lwamakhempasi uhlelo lokuhlalisa abantu, kanye neLabhorethri ehlanganyelwe, isiKhungo Sokulinga Nesangaphambi Kokukhiqiza, phecelezi i-Shared Laboratory, Pilot and Pre-manufacturing Precinct. Uhlelo lokuhlaziya kwezidingo oluqondene nalokhu luyaqhubeka. Lezi zinyathelo zokungenelela ngeke nje zigcine ngokuhlomulisa abafundi bethu nababambiqhaza bamazwe omhlaba kuphela, kepha zizosiza nama-SMME nezimboni ezizokwazi ukusebenzisa lezi zikhungo. Siphinde sethula isikhungo sethu esibizwa nge-Photonics Prototyping Facility, isikhungo sesihlanu esixhaswe nguMnyango Wezesayensi kanye Nokusungula (i-DSI) e-CSIR. Lesi sikhungo sihlizeka ophathina bethu kwezizimboni ngokuba bafinyelele ezingeni lobuchwepheshe eliphambili kanye nengqalasizinda yokuhlola nokukhulisa ubuchwepheshe babo obuthuthukisiwe.

Ekhuluma ngokuzibophezela kwethu e-Afrika, uSihlalo wethu weBhodi embikweni wakhe uye wabhekisa ku-AUDA NEPAD. I-CSIR yenze inqubo enkulukazi yokusungula ubudlelwano obuhlomulisa izingxenywe zombili ngaleli bhizinisi. Ngenxa

yalokhu, i-CSIR ne-AUDA NEPAD babambisene neNyuvesi yase-Stellenbosch ukusungula isiKhungo sobuChule kwezeSayensi, Ubuchwepheshe Nokusungulwa Kwezinto Ezintsha, phecelezi i-Centre of Excellence in Science, Technology and Innovation (CoESTI), esingethwe yi-CSIR eKhempasini yayo yase-Stellenbosch. Umsebenzi ususesigabeni esiphambili kakhulu, njengoba i-AUDA NEPAD isivele inamahhovisi ekhempasini. I-CoESTI izosebenza njengomgudu we-CSIR kanye nobuchwepheshe obuthuthukisiwe obufakazelwe beNyuvesi yase-Stellenbosch ukuze busatshalaliswe e-Afrika yonkana. Lokhu kuzokwakha insika eyinhloko yokuzibandakanya kwe-CSIR ezwenikazi lase-Afrika ngenkathi kuthuthukiswa Isu le-CSIR Africa.

Amakhasi alandelayo alandisa ngokuthi i-CSIR yeseke kanjani ubuholi beNingizimu Afrika ukuze bubhekane negciwane le-Covid-19. Aphinde athinte ezinye zezinto ezivelele ze-RDI yethu ezikwazi ukuqezwa kulo nyaka ngokuhambisana nesivumelwano sabaBambiqhaza bethu esifushane.

Ngidlulisa ukubonga kwami okukhulu kwabe-DSI neBhodi le-CSIR ngokwengamela kwabo, nasebuholini benhlango kanjalo nabasebenzi bethu abathe, phakathi nonyaka lapho ukuphonsa ithawula bekuzoba lula kakhulu, kodwa benza izindinganiso zethu ze-EPIC zaba yimpumelelo ngokusebenza ngendlela encomekayo, ukuqhubeka nokugxila kubantu, ukusebenza ngobuqotho, nokwamukela ukusebenza ngokubambisana.



uDkt Thulani Dlamini
ISIKHULU ESIPHEZULU SE-CSIR

I-CSIR isebenze ngokuncomeka kakhulu **maqondana nokubusa okuhle ngowezi-2020/21**, yafinyelela ezingeni lesi-2 le-B-BBEE uma kuqhathaniswa nalokho obekuhlosiwe okuyizinga lesi-3, Isilinganiso Sezehlakalo Esingaqoshwa esingu-0,53 uma kuqhathaniswa nempokophelo engu-2, **kanye nombiko woMcwangingimabhuku-Jikelele ongenagcobho.**

MOLAETŠA WA MOHLANKEDIMOGOLOPHETHIŠI WA CSIR

Ngaka Thulani Dlamini

Ge go na le seo mokgatlo wa rena o ithutilego mo ngwageng wa go feta, ke ka go itlwaetša le go mpshafatša maemo a rena – go šomela gae, go hwetša tsela ya go tsena sekolo ka gae, go fihlelela bao ba nago le Covid-19 – mola re šomela pele go fihlelela dilebanywa tša phethagatšo tše dintši ka moo go kgonegago.

Leuba la Covid-19 le hlotše tshekatsheko ya dilebanywa tša taetšo ya phethagatšo ya rena ya motheo (KPA) tša ngwaga wa dišhelete wa 2020/21. Go itemogetšwe ditlhohlo tše di itšego, le ge di fokotšegile ka gore bašomi le bakgathatema ba tlwaetše kudu “setlwaedi” se sefsa. Mathomong go fokotšega ga mošomo wa laporotori le wa go šomela ka ntle o dirile gore go be le phokotšego ya tšweletšo. Se se kaonafetše ka go bulwa ga makala a ekonomi a mantši ka morago ga Phupu 2020 le go boela mošomong ga bašomi ba bohlokwa ba saense, boentšenero le theknolotši (SET).

Re itemogetše dititelego mo go feng dikotraka le makala a praebete le a setšhaba ka lebaka la go dula ka gae ga bosetšhaba; le ge go le bjalo, go fa dikotraka e sa le tlhohlo, kudu ka ge ditekanetšo di lebišitšwe go ditaba tša tirišo tše bohlokwa ka mekgatlong ya badirelwa ba rena, go na le go dipeeletšo mo mananeong a RDI. Kalatšo le yona e ditetšwe goba go šutišwa ka lebaka la dikgonono ka letseno la kontraka.

Le ge go na le ditlhohlo tše, CSIR e fihleletše goba go feta diKPI 25 tša tše 31. Dilebanywa tša badirišani ba phatlalatšo, tokelo ya ngwalollo le babontšhi ba ditheknolotši di a nanya. Mešomo ya Kaonafatšo ya Kgwebo le Papatšo ya CSIR e dutše e latela tsela ya ditheknolotši tša laesense.

Mošomo wa rena le intasteri le thekgo ya diSMME o tšwetše pele gabotse le ge go na le ditlhohlo, gape re fetile magomo a phethagatšo ya rena ka tsela ye ka go thekga diSMME tše 96 kgahlanong le selebanywa sa 68. Banyakišiši ba go thekga mmušo wa bokgoni ba thomile ka maatla mo karolong ya pele ya ngwaga wa dišhelete ka lebaka la go kgatha tema ga CSIR go maitapišo a Covid-19 a bosetšhaba, ao, gare ga a mangwe, a akaretšago Senthara ya Karabelo ya Bosetšhaba.

CSIR e šomile gabotse kudu malebana le taolo ye botse nakong ya 2020/21, go fihlelela legato la 2 la B-BBEE kgahlanong le selebanywa sa 3, Tekanyo ya Tiragalo ya Go rekotega ya 0,53

kgahlanong le selebanywa sa 2, le kgopolo ya tlhakišo ye botse go tšwa go Mohlakisipharephare.

Ge re lebelela batho ba rena, mokgwa wa bašomi ba SET o bontšhitše kgolo mo ngwageng wa dišhelete wa 2020/21. Se se fetile selebanywa ka 64, kaonafalo ye botse ge go bapetšwa le go se šome gabotse moo go itemogetšwego mo mengwageng ye mene ya go feta. Go se šome gabotse e be e le ka lebaka la go fetošwa ga mokgwa le peakanyo ye e amanago. CSIR e dula e ikgafile go thekga phetogo mo lekaleng la SET. Phesente ya bašomi ba SET e oketšegile go tloga go 63.4% go ya go 66.5%, go feta selebanywa sa 3.6%. Phihlelelo ya selebanywa ke ka lebaka la kalatšo ye e laolwago le diisenogare tša go swara bašomi. Phesente ya bašomi ba basadi ba SET e gotše go tloga go 35% mo ngwageng wa dišhelete wa go feta go ya go 36.4%.

Le ge go ka ba le dikgatelelo tša ka ntle le tša ka gare, nepo ya mokgwa wa rena ga se ya fetoga, Nepo ya rena e sa le go godiša kgwebo ya CSIR le go šomiša mabokgoni a rena go thekga kgolo ya kakaretšo ya ekonomi ya Afrika Borwa. Se se akaretša go kaonafatša le go godiša mabokgoni a mafa le bokgoni, kudu ao a lego maleba go Phetogo ya Intasteri ya Bone le go šomiša se go godiša letseno le khuetšo ya CSIR. Re tšwela pele go katološa bokgoni bja rena bja go šomiša ditheknolotši tše o di kaonafadišwego tša CSIR go kgatha tema go tšweletšopele le tshwarelelo ya dikgwebo tša Afrika Borwa, gomme ba hologa ka nako ye tee ka tshwarelelo ya dišhelete tša mokgatlo.

Khuetšo e dula e le Selo sa Godimo, nepo ya mešongwana ya rena ka moka, go swana le go bapatša ditheknolotši le dimphafatšo tša rena tša kaonafatšo ya intasteri, le phetišetšo ya theknolotši le tsebo go kgontšha mmušo wa bokgoni. Mošomo wa rena le khuetšo ya wona o tla bontšha go ba maleba ga mpshafatšo go fihlelela kaonafatšo ya ekonomi, go dula go le maleba go bohlokwa go fihlelela taolelo ya rena.

Ka gona, re tšwela pele go latela mananeo ao a beakantšwego a go swana le kaonafatšo ya Go bula Senthara ya Saense le Mpshafatšo. Se se dira karolo ya nepo ya kaonafatšo ya infrastraktiša eupša gape e tla, ka morago ga go phethwa, ya oketša go ba mohola go RDI mo go akaretšeng bakgathatema gammogo le bafsa – bararolli ba mathata ba ka moso. Tiragalo ya dinyakišišo tša kgonagalo le kgwebo tša senthara di kgauswi le go phethwa gomme tša go latela re tla ba re lebelela papatšo le kgoboketšo ya dišhelete. Gape karolo ya Leano le Legolo la Khamphase ke protšeke ya madulo a bodulo, le Laporotori ya Go

CSIR e šomile gabotse kudu malebana **le taolo ye botse nakong ya 2020/21**, go fihlelela legato la 2 la B-BBEE kgahlanong le selebanywa sa 3, Tekanyo ya Tiragalo ya Go rekotega ya 0,53 kgahlanong le selebanywa sa 2, **le kgopolo ya tlhakišo ye botse go tšwa go Mohlakišipharephare.**

abelanwa, Lefelo la Teko le Tšweletšo ya pele. Tshekatsheko ya dinyakwa ya phetho e tšwela pele. Ditsenogare tše di ka se hole fele baithuti ba rena le bakgathatema ba lefase ka moka, eupša le diSMME le intasteri tšeo di tla kgonago go šomiša dinolofatši tše. Re thakgotše gape Senolofatši sa rena sa Mmotlolo wa pele wa Fotoniki, senolofatši sa Kgoro ya Saense le Mpshafatšo (DSI) ya bohloko mo CSIR. Senolofatši se fa badirišani ba rena ba intasteri phihlelelo ya bokgoni bja maemo a godimo le infrastraktšha go dira diteko le go kaonafatša ditheknolotši tša bona tšeo di hlabologilego.

Ge re lebelela boikgafo bja rena go Afrika, Modulasetulo wa Boto ya rena mo kakaretšong ya gagwe o boletše ka AUDA NEPAD. CSIR e thomile tshepetšo ye kgolo ya go hlola kamano ya mohola le lakala le. Ka lebaka la seo, CSIR le AUDA NEPAD di šoma mmogo le Yunibesithi ya Stellenbosch go thoma Senthara ya Bokgoni ya Saense, Theknolotši le Mpshafatšo (CoESTI), yeo e swarwago ke CSIR Khamphaseng ya yona ya Stellenbosch. Ditšwelotšopele di legatong la godimo, ge AUDA NEPAD e šetše e tsene ka diofising tša ka khamphaseng. CoESTI e tla šoma bjalo ka mokgokaganyi wa dikaonafatšo tša CSIR le Yunibesithi ya Stellenbosch le dimphafatšo/ditheknolotši tšeo di thekgwago gore di thome ka Afrika ka moka.

Se se tla dira thekgo ye kgolo ya go kgatha tema ga CSIR mo kontinenteng ya Afrika mola Mokgwa wa Afrika wa CSIR o sa kaonafatšwa.

Matlakala a a latelago a hlaloša ka moo CSIR e thekgago boetapele bja Afrika Borwa go šogana le Covid-19. E akaretša gape dilo tše bohlokwa tša RDI tšeo re di fihleletšego nakong ya ngwaga wo ka tumelelano ye e Kopantšwego le Bengdišere.

Ke rata go leboga DSI le Boto ya CSIR ka taolo ya bona, go boetapele bja mokgatlo le bašomi ba rena bao, mo gare ga ngwaga go be go ka ba bonolo go ineela, ba dirilego meholo ya rena ya EPIC gore e šome ka go aba bokgoni, ba dula ba lebeletše batho, ba šoma ka botshepegi, le go amogela tirišano.



Ngaka Thulani Dlamini
MOHLANKEDIMOGOLOPHETHIŠI WA CSIR

STATEMENT OF RESPONSIBILITY AND CONFIRMATION OF ACCURACY FOR THE ANNUAL REPORT

To the best of my knowledge and belief, I confirm the following:

All information and amounts disclosed in the annual report is consistent with the annual financial statements audited by the Auditor-General.

The annual report is complete, accurate and is free from any omissions.

The annual report has been prepared in accordance with the guidelines on the annual report as issued by National Treasury.

The Annual Financial Statements (Part E) have been prepared in accordance with the International Financial Reporting Standards applicable to the CSIR.

The accounting authority is responsible for the preparation of the annual financial statements and for the judgements made in this information.

The accounting authority is responsible for establishing and implementing a system of internal control that has been designed to provide reasonable assurance as to the integrity and reliability of the performance information, the human resources information and the annual financial statements.

The external auditors are engaged to express an independent opinion on the annual financial statements.

In our opinion, the annual report fairly reflects the operations, the performance information, the human resources information and the financial affairs of the CSIR for the financial year ended 31 March 2021.

Yours faithfully



Chief Executive Officer

Dr Thulani Dlamini

13 August 2021



Chairperson of the Board

Prof. Thokozani Majozi

13 August 2021

STRATEGIC OVERVIEW



MANDATE

"The objects of the CSIR are, through directed and particularly multi-disciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act."

(Scientific Research Council Act 46 of 1988, as amended by Act 27 of 2014)



CSIR VISION

We are accelerators of socioeconomic prosperity in South Africa through leading innovation



CSIR MISSION

Collaboratively innovating and localising technologies while providing knowledge solutions for the inclusive and sustainable advancement of industry and society



CSIR OBJECTIVES

- Conduct research, development and innovation of transformative technologies and accelerate their diffusion;
- Improve the competitiveness of high-impact industries to support South Africa's re-industrialisation by collaboratively developing, localising and implementing technology;
- Drive socioeconomic transformation through RD&I that supports the development of a capable state;
- Build and transform human capital and infrastructure; and
- Diversify income, and maintain financial sustainability and good governance.

CSIR STRATEGIC INTENT

GROWTH

Refers to inclusive and dual growth for the country and the CSIR. The CSIR will use its capabilities in e.g. skilled human capital and infrastructure to assist in growing the economy; but will also grow to become a world-class organisation.

SUSTAINABILITY

Focuses on CSIR-developed technologies that lead to the advancement and sustainability of SA enterprises and the financial sustainability of the organisation in a resource-constrained environment.

IMPACT

Focuses on the commercialisation of our technologies and innovations for industrial development, as well as technology and knowledge transfer that enable a capable state.

RELEVANCE

Addresses the CSIR's role in driving the relevance of innovation in inclusive sustainable industrial development and the creation of a capable state.

CSIR VALUES

Our beliefs, principles and the impact we wish to make to improve the quality of life of South Africans are EPIC. Team CSIR pursues Excellence, celebrates People, personifies Integrity, and welcomes Collaboration.



EXCELLENCE

We excel at R&D and industrial **innovation** solutions that address South Africa's challenges. We are unashamedly **passionate** about the **impact** we make and pursue **excellence** in every facet of CSIR life.



PEOPLE-CENTRED

We **care** about people – our impact through innovation aims to **improve lives**. We respect each other's **diversity**, and uphold the **dignity** of every person, regardless of **culture or belief system**. We treat our **stakeholders** the way we like to be treated.



INTEGRITY

We value integrity – in ourselves and in others. We are **honest** and **fair** in how we work and how we engage the world around us. We respect the trust that our colleagues and our stakeholders place in us and commit to ethical decision-making, delivery and governance.



COLLABORATION

We are keen to learn from one another and **collaborate** across the organisation and with external partners, to ensure our work has the best chance to **innovate** a better future for South Africans.

ORGANISATIONAL STRUCTURE



science & innovation

Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA



Prof. Thokozani Majozi
CSIR Chairperson of the Board



Dr Thulani Dlamini
CSIR CEO



Khungeka Njobe
Group Executive:
Business Excellence
and Integration



Andile Mabindisa
Group Executive:
Human Capital and
Communications



**** Ashraf Dindar**
Chief Financial
Officer



**Dr Motodi
Maserumule**
Group Executive:
Mining,
Manufacturing,
Defence & Security



**Dr Rachel
Chikwamba**
Group Executive:
Chemicals,
Agriculture, Food and
Health



**Adv Esmé
Kennedy**
Group Executive:
Legal, Compliance
and Business
Enablement

*Nomcebo Monama was acting CFO until 30 June 2020

** Ashraf was appointed CFO effective 1 July 2020



PART B

ORGANISATIONAL HIGHLIGHTS

The CSIR's strategic objectives are well defined and **guide the organisation's research**, development and innovation investments and activities. This section highlights a small **sample of our work** against these objectives.

In a year dominated by the Covid-19 pandemic and its devastating impact, we are particularly proud to showcase how we were able to respond to the pandemic by assisting government through research, development and innovation that supports the development of a capable state. However, the challenge is two-fold, as science and technology also has to prove its capability to act as a force multiplier that contributes to the recovery of the South African economy. Amidst the pandemic, continuing with cutting-edge research and development in areas that will bring socioeconomic change therefore remained crucial.

Our highlights also show how we remained committed to building and transforming human capital and infrastructure, despite unprecedented challenges.

Chapter 1:	Conduct research, development and innovation, localise transformative technologies and accelerate their diffusion.....	024
Chapter 2:	Improve the competitiveness of high-impact industries to support South Africa's re-industrialisation by collaboratively developing, localising and implementing technology ...	032
Chapter 3:	Drive socioeconomic transformation through research, development and innovation that supports the development of a capable state	042
Chapter 4:	Build and transform human capital and infrastructure	058
Chapter 5:	Research, development and innovation for and with the rest of Africa	068

01

CONDUCT RESEARCH, DEVELOPMENT AND INNOVATION,
LOCALISE TRANSFORMATIVE TECHNOLOGIES AND ACCELERATE THEIR DIFFUSION

NOVEL CSIR FINGERPRINT SYSTEM TESTED IN FORENSIC MORTUARY

A CSIR-developed fingerprint system is being tested at the Bronkhorstspuit Forensic Mortuary, in Gauteng, as a means of acquiring fingerprints of corpses.

The system uses optical coherence tomography, a non-invasive imaging system that uses light waves to capture micrometre-resolution images. The technology enables the acquisition of both internal and surface fingerprints simultaneously to get an accurate print to match against a database. If the surface fingerprint is of low quality, for instance in the case of corpses, the internal fingerprint gets used instead.

The technology is of particular benefit to the South African Police Services' forensic mortuaries to conduct queries against the local criminal record centre database for identification of unidentified victims or perpetrators of crime. The system captures the fingerprint in 3D format and represents it in 2D and can therefore be used in databases together with prints acquired from conventional scanners.

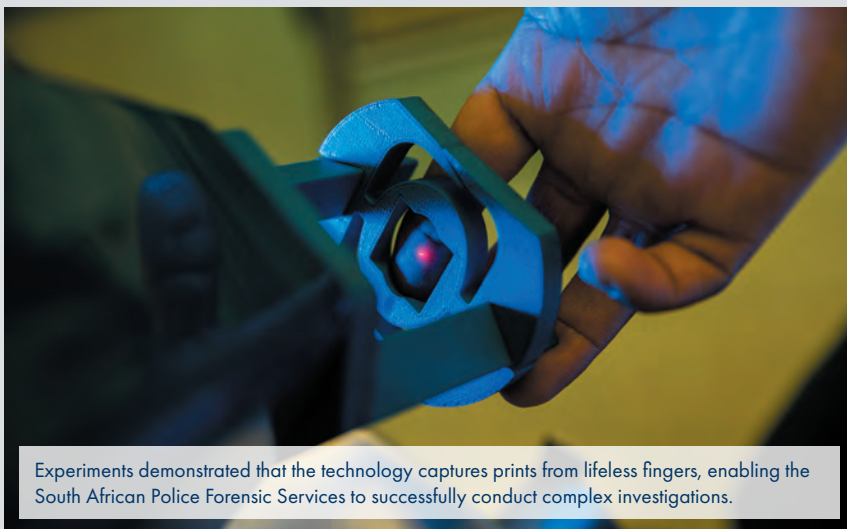
Aside from succeeding in capturing the print from a lifeless finger – which not all biometric systems can achieve – the technology can also be used in cases where the surface print of a person's finger is worn from manual labour. It also detects fake prints to prevent false identification attempts or spoofing. The system is contactless, making it more hygienic.

The CSIR conducted the work in collaboration with SolarBiotech, a local small, medium and micro enterprise that was key in the development of the technology and exploitation of the market.

Some of the updates made because of the pilot include the improvement of the image capturing protocols and the recalibration of the optical coherence tomography computer at the CSIR's Photonics Prototyping Facility. Mortuary personnel were also trained to use the technology.



CSIR-developed optical coherence tomography software enables security-based institutions to address identity theft and false identification, as well as to identify unidentified individuals through the capturing of accurate fingerprints.



Experiments demonstrated that the technology captures prints from lifeless fingers, enabling the South African Police Forensic Services to successfully conduct complex investigations.



The laser used in the system was calibrated by the CSIR's Photonics Prototyping Facility to ensure accuracy.

CONTACTLESS FINGERPRINT TECHNOLOGY FOR MOBILE DEVICE USE

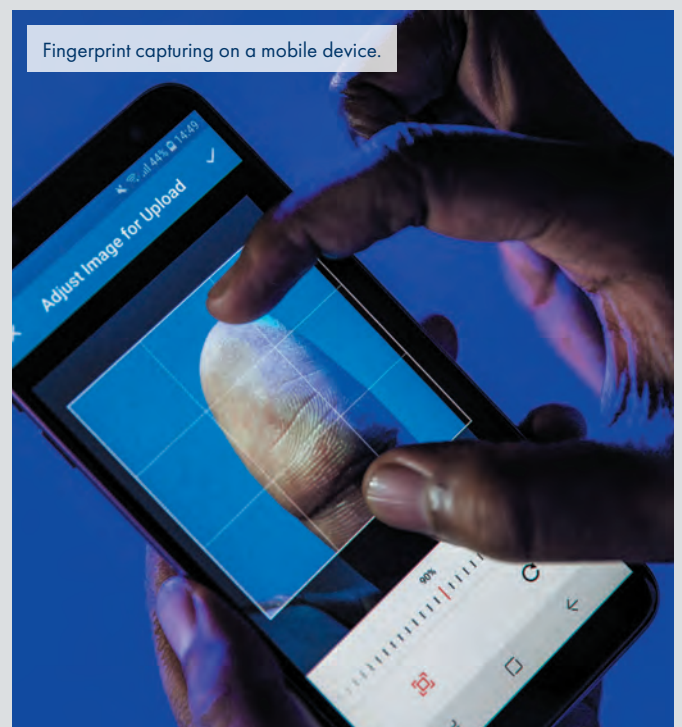


CSIR-developed biometric technology uses digital imaging devices to create fingerprint scanners.

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 licence. 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.



Fingerprint capturing on a mobile device.

01

CONDUCT RESEARCH, DEVELOPMENT AND INNOVATION,
LOCALISE TRANSFORMATIVE TECHNOLOGIES AND ACCELERATE THEIR DIFFUSION

FACE, BODY AND NUMBER PLATE RECOGNITION SYSTEM TESTED BY THE SA ARMY



The CSIR has developed face, body and number plate recognition technology for the biometric verification of individuals, recording of activities and reporting of incidences.

Overall access control and surveillance to secure facilities has become a necessity for most private companies and state-owned organisations. Furthermore, the Covid-19 pandemic has emphasised the need for contactless identity authentication.

The CSIR-developed system comprises independent recognition systems that can be integrated to collaboratively solve physical security and surveillance problems. It uses camera imaging technology, integrated with CSIR-developed modules for face

and human body recognition, according to uniform, to address the challenges of access control to secure facilities or any other entrance or exit points where security measures are needed.

In essence, the system fuses technologies that would otherwise be used independently, making it easy to view and track events.

The South African Army headquarters became the first point of deployment of the system in October 2020, where the system is being used to monitor the movement of vehicles and people at one of its access points. The CSIR provided hands-on training to personnel operating the system.

A biometric identification method will be added to offer bi-factor authentication of individuals to fulfil the security needs of the South African Army.

UPGRADED SURVEILLANCE RADAR TO COUNTER RHINO POACHING



CSIR researchers performed experiments with simulated poacher activities to test the effectiveness of the ground-based surveillance and classification system in the Kruger National Park. Aside from its use in counter-poaching, the technology could also benefit border safeguarding and farm protection.

The CSIR has deployed ground-based surveillance and classification radar, a proposed technological upgrade to a forerunner with well-documented successes, in curbing rhino poaching through wide-area surveillance in the Kruger National Park.

Despite unforgiving weather conditions at the deployment site, the system successfully detected and characterised (identified as humans or animals) targets at ranges of up to 10 km.

The CSIR ground-based surveillance and classification radar was developed primarily through funding from the Department of Science and Innovation over the last three years, but benefitted from several leading-edge technologies that have evolved from multiple CSIR radar research and development projects.

The system has the same benefits traditionally associated with utilising radar for detection, namely coverage over very long ranges and for all-weather, day/night operation.

As an added benefit, the CSIR-designed and built electronically steered antenna technology reduces the minimum detectable velocity of targets. This means that it is especially effective in exposing slow-moving poachers trying to evade the traditional methods of detection employed by both their prey and park ranger guardians.

The use of innovative machine-learning-based target classification enables automatic and real-time designation of observed objects as either human, animal or vehicle.

This brings the system closer to the development team's ultimate goal: a fully autonomous surveillance system to help protect wide swathes of the country's valuable natural resources.

01

CONDUCT RESEARCH, DEVELOPMENT AND INNOVATION,
LOCALISE TRANSFORMATIVE TECHNOLOGIES AND ACCELERATE THEIR DIFFUSION

NEW VERSION OF FIRE-DETECTING MOBILE APP SPARKS INTEREST

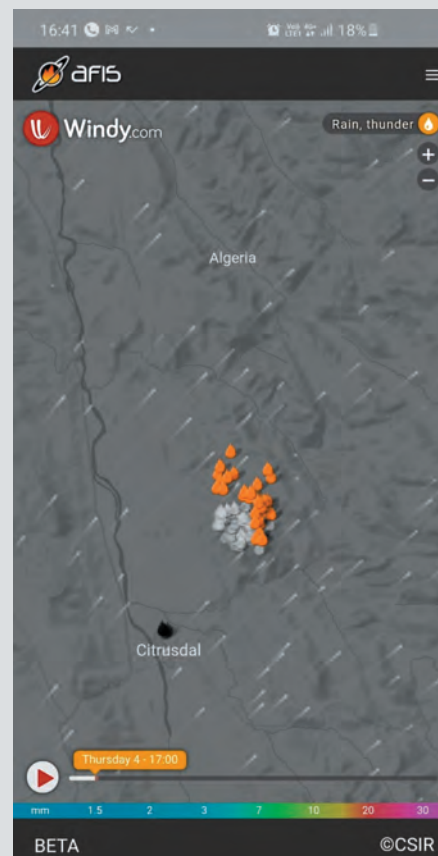
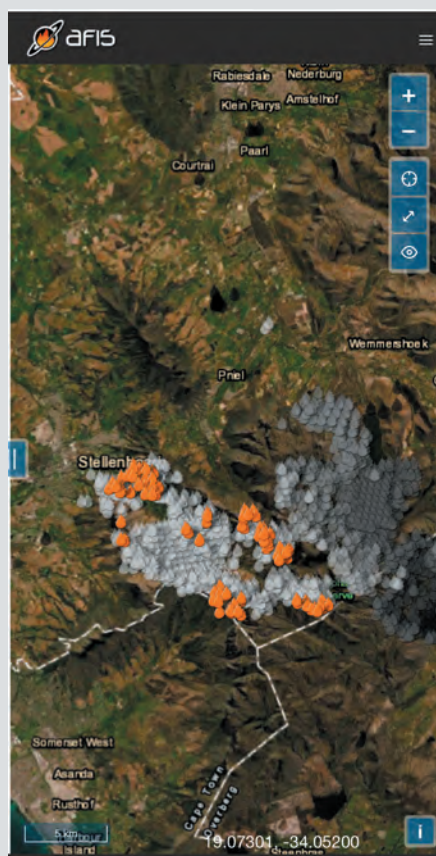
The CSIR has published a new version of its Advanced Fire Information System (AFIS) mobile app on the Google Play Store and the Apple App Store. The *AFIS Wildfire Map* provides native mobile access to the new web-based AFIS Viewer.

The new app and the web viewer enable the CSIR to continue the practice of providing a free wildfire information service to users around the globe, but also provide value-added content for CSIR customers.

The AFIS mobile app and web viewer form part of the larger system that supports fire managers with both historical and near real-time fire information. The system utilises information from various sources, including earth observation satellites and numerical weather prediction models, to assist in fire management. It provides access to the latest wildfire locations, fire danger forecasts, historical fire reports and more.

The CSIR often sees spikes of activity during large fires, when public interest and demand for up-to-date information peaks. The Nuweberg fire on the border of the Overberg and Winelands districts in the Western Cape, during 2021, was one such example. The fire started at the back of the Theewaterskloof Dam on 21 February 2021 and was reported to be 99% contained on 2 March after burning approximately 16 000 ha of fynbos and pine plantations, including the entire Jonkershoek valley near Stellenbosch. Fynbos is a fire-adapted species and will recover over the next few years, but species are lost when an area burns too often.

Visit www.afis.co.za for more information about AFIS.



Screenshots from the AFIS mobile app with (left) a map of a fire near Stellenbosch in the Western Cape and (right) a wind visualisation.



A landscape of burnt fynbos stretches as far as the eye can see after a fire swept through the valley near Stellenbosch in the Western Cape between 25 February and 2 March 2021. A previous fire in the valley occurred in March 2015 under very similar conditions.

CSIR QUANTIFIES THE OPPORTUNITIES OF THE HYDROGEN ECONOMY FOR SOUTH AFRICA

The CSIR played a leading role in studies to determine the viability of producing carbon-free hydrogen for the export market, using South African wind and sunshine. The organisation generated data on the cost of hydrogen generation, storage and conversion, as well as shipping from South Africa, from 2020 to 2050.

Hydrogen fuel can be produced using a variety of energy sources, including wind and solar. Countries like Japan plan to import hydrogen in bulk from 2030 – and carbon-free hydrogen by 2040 – in efforts to meet their decarbonisation obligations.

The first study, conducted to determine the production costs of hydrogen generation in South Africa from 2020 to 2050 using electricity from photovoltaic and wind, relied on published data and suitable assumptions.

The data generated was provided to the Department of Science and Innovation to serve as a baseline against which proposed concentrating solar-assisted hydrogen production could be compared. The costs at which South Africa could deliver hydrogen to Japan were compared with those of Argentina, Brazil, Egypt, Morocco and Somalia. South Africa appeared to be able to meet the Japanese cost and time constraints.

In a follow-up study, this analysis was further refined, replacing assumptions and published data with the outputs of calibrated



The CSIR has studied the production cost of hydrogen using South African wind and sunshine.

models, confirming the viability of exporting hydrogen to meet the requirements of Japan.

At the end of 2019, the German Development Agency selected the CSIR as the South African partner in a multiyear project, funded by the German Ministry for Environment, to support the development of renewable hydrogen markets in Argentina, Morocco and South Africa.

In 2020, the European Union (EU) delegation to South Africa commissioned the CSIR to develop a research paper on the opportunities for the country of powerfuels – fuels that are based on synthetic gaseous or liquid fuels based on renewable hydrogen. The work was presented at a webinar in February 2021, co-hosted by EE Business Intelligence and the EU delegation to South Africa, and attended by more than 1 000 delegates.

A ROADMAP TO IMPROVE SA'S HUMAN SETTLEMENTS

The CSIR has co-developed a roadmap aimed at deploying appropriate South African technologies and innovations to achieve green, smart and sustainable human settlements.

The Science Innovation and Transformative Technologies Roadmap for Sustainable Human Settlements aims to realise a better future through upscaling transformative innovations in houses and neighbourhoods. It was crafted with input from multiple stakeholders, in response to a number of persistent challenges, and funded by the Department of Science and Innovation.

South Africa faces growing challenges in achieving the constitutional imperative of access to adequate housing for all. Despite a sophisticated regulatory environment, sustained investment in social housing and established human settlement delivery programmes, the country's housing backlog is estimated at 2.3 million units. Other problems include the persisting apartheid spatial legacy, poor settlement quality and rising utility costs. Innovation in the human settlements sector is sporadic, uncoordinated, and enjoys poor uptake and mainstreaming.

The roadmap takes the position that these challenges can only be addressed through experimentation, to be achieved through a variety of pathways. These include promoting an innovation culture without compromising the need for sound governance and responsibility; introducing policy instruments that temporarily exempt technology demonstration projects from regulation that would otherwise hamper innovation and experimentation; and investing in infrastructure that harnesses the power of networked technology to improve efficiency and provide data for continuous improvement.

The roadmap anticipates accommodating the risks associated with innovation – which would otherwise act as disincentives – by making special arrangements and supporting the creation of experimental spaces and environments, such as demonstration platforms, to introduce new technologies.

At the 2020 Human Settlement Indaba, participants made a declaration to transform human settlements for spatial justice and social cohesion. It included a commitment to the systematic and progressive adoption of the roadmap.

01

CONDUCT RESEARCH, DEVELOPMENT AND INNOVATION,
LOCALISE TRANSFORMATIVE TECHNOLOGIES AND ACCELERATE THEIR DIFFUSION

HIGH-QUALITY RESEARCH DURING A TIME OF ISOLATION

CSIR researchers published 259 papers in accredited research journals in 2020/21. One of the most noteworthy papers was titled, 'Evaluating scenarios towards zero plastic solution', published in the respected journal, *Science*, with an impact factor of 41.845, featuring CSIR principal researcher Dr Linda Godfrey as co-author. The paper was published in support of a full technical report.

'BREAKING THE PLASTIC WAVE' STUDY

Between 2018 and 2020, Godfrey was part of an international group of experts who modelled global plastic flows and stocks, with the objective of providing an evidence-based strategy to achieve near-zero leakage of plastic into global oceans. The study was undertaken by US- and UK-based The Pew Charitable Trusts and SYSTEMIQ, in partnership with the University of Oxford, University

of Leeds, Ellen MacArthur Foundation and Common Seas. South Africa's participation helped ensure that Africa was adequately represented in the model, and in the data and assumptions that went into the model. Africa is facing a growing waste – and plastic waste – problem. Studies such as these are crucial to informing Africa's response to plastic use and plastic waste management.

The report provided the evidence countries urgently need to develop intervention strategies. Strategies that the model shows, can be more cost-effective and provide greater social, environmental and economic benefit than a business-as-usual approach. Some of the key findings of the study point to how important the informal sector is to the global plastics value chain, and to reducing the leakage of plastic into the environment.

The CSIR has since partnered with The Pew Charitable Trusts, Oxford University and SA Plastics Industry to pilot the application of the global model at the local level, in this case, to South Africa. This will provide an evidence-based strategy for addressing the leakage of plastic waste into the South African environment.



A paper co-authored by the CSIR's Prof. Linda Godfrey featured in *Science*, Vol 369, Issue 6510, 18 September 2020.

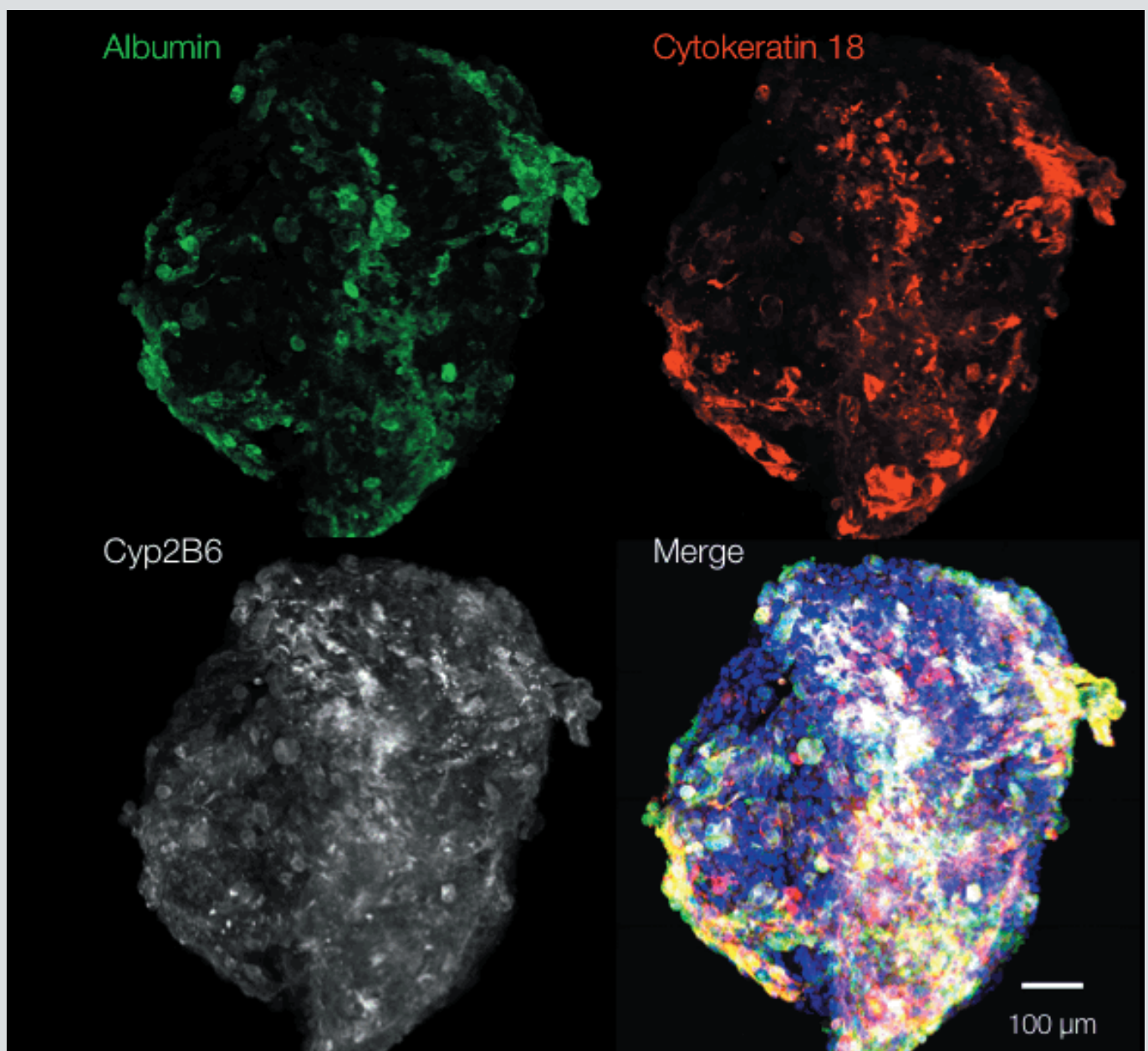
GREAT STRIDES IN RESEARCH AIMED AT BETTER TB, HIV/AIDS AND CANCER TREATMENT

The CSIR has generated microlivers from induced pluripotent stem cell-derived cells from individuals of African descent.

The researchers are growing these tiny artificial livers in petri dishes to replace human and animal subjects for drug-safety testing. They grow them from induced pluripotent stem cells, which are a cutting-edge, ethically acceptable type of stem cell that is not extracted from human embryos.

The milestone is regarded as a significant breakthrough in the research on providing information for the best treatment outcomes for high-impact diseases, such as tuberculosis, HIV/Aids and cancer in South Africa.

Using CRISPR genome engineering – a technique in which a specific sequence of DNA can be precisely modified inside a cell – the team is adding important African mutations, which uniquely and significantly contribute to adverse drug reactions in South Africa.



Cells in red are cytokeratin 19-positive cells, while albumin is shown in green – a classic liver cell marker. Cyp2B6 is a Phase I metabolising enzyme, which shows that the team is making highly functional liver-like cells – in a dish. In 2020, the team managed to increase this marker by over 100-fold – thus getting close to ‘real’ human liver cells. This is particularly significant given the vast genetic diversity in South Africa and how this affects the efficacy of the drugs that South Africans take for these high-impact diseases.

02

IMPROVE THE COMPETITIVENESS OF HIGH-IMPACT INDUSTRIES TO SUPPORT SOUTH AFRICA'S RE-INDUSTRIALISATION BY COLLABORATIVELY DEVELOPING, LOCALISING AND IMPLEMENTING TECHNOLOGY

CSIR CO-DEVELOPS COMPOSITE MATERIAL FOR STEEL PIPE MANUFACTURER



Air-cooling of coated pipes.

The CSIR has assisted one of Africa's largest steel pipe manufacturers, Hall Longmore, to develop an alternative product based on locally manufactured polymers.

The steel pipe supplier imports a special polymer to coat the pipes using fluidised bed technology. However, fluctuations in the exchange rate have made it difficult to budget for projects. Hall Longmore contracted the CSIR to develop a material that could be locally produced and replace the imported material.

First, 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. They 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 next milestone was the industrial process optimisation and the production of nine tons of the CSIR-developed material for coating trials in the subsequent phase. The successful coating trials at Hall Longmore's industrial scale fluidised bed marked the conclusion of the development phase. The client has started production at a third party's premises.



Coating material used for Hall Longmore's steel pipes.

CSIR AND ASPHALT INDUSTRY COLLABORATE TO CONSTRUCT A SUSTAINABLE ROAD SECTION

The CSIR and Much Asphalt Pty Ltd used locally available micro-fillers and recycled tyres to pave a 200-m long section of road as part of a controlled trial in Roodepoort, Gauteng. This followed ongoing research to provide alternative sustainable solutions for the asphalt pavement industry and a year of combined laboratory development and evaluation.

The CSIR has been investigating locally available alternative additives that would be cheaper than conventionally imported additives, as well as creating sustainable use of recycled materials that have an economical benefit for the industry, while resolving an environmental challenge for the country.

The trial section included a 60 mm modified high modulus asphalt base layer, known as enrobés à module élevé, and 40 mm modified

bitumen rubber surfacing layer that was constructed over a cleaned gravel base layer treated with a bituminous emulsion prior to paving.

The findings of the trial were that no edge-breaking was present where heavy vehicles were moving onto and off of the surfacing; no permanent deformation was present on the surfacing, with particular focus at stopping locations or where vehicle turning took place; and, to date, there had been no signs of any deflection or temperature-induced crack formation.

For bitumen users, asphalt manufacturers or any other intermediary bitumen suppliers, this outcome could indicate an easier means of correcting poor bitumen to comply with performance specifications or improving the performance of standard bitumen from one grade to another, in the event of national bitumen shortages. Benefits of this invention for the country would be an increase in the recycling of waste tyres in the road industry, as well as better-performing roads.



A road section constructed in Roodepoort, Gauteng, as part of an industry collaboration on the use of recycled materials in road construction.

02

IMPROVE THE COMPETITIVENESS OF HIGH-IMPACT INDUSTRIES TO SUPPORT SOUTH AFRICA'S RE-INDUSTRIALISATION BY COLLABORATIVELY DEVELOPING, LOCALISING AND IMPLEMENTING TECHNOLOGY

CSIR AND HENSOLDT JOINTLY DEVELOP NEW RADAR TECHNOLOGIES



CSIR Divisional Group Executive: Mining, Manufacturing, Defence and Security, Dr Motodi Maserumule (left) and HENSOLDT South Africa Managing Director, Rynier van der Watt at the signing of an agreement to jointly develop radar technologies. The partners will use such technologies in cutting-edge radar products that are software-configurable, and offer increased resistance against countermeasures, at a competitive price.

The CSIR and Hensoldt South Africa have entered into an agreement on the development and commercialisation of a new-generation tactical surveillance radar. The two organisations have embarked on the development of the radar, which will modernise one of Hensoldt's key radar product lines.

Hensoldt is a key player in the South African defence industry, with specialised product development experience, radar portfolio management skills and insights into global market requirements. The

CSIR has vast experience in radar research and development. The new radar products, utilising modern technology, are set to be software-configurable and boast increased resistance against countermeasures at a very competitive price.

In the past year, the CSIR and Hensoldt technical teams have executed the preliminary design phase, culminating in a preliminary design review of the new surveillance radar. The first products are expected to be ready for the commercial market by the end of 2023.

The development of modern radar technologies contributes to the growth of the defence industry in South Africa.

LOCAL SYSTEM DEVELOPED TO TRACK DRONES AND OTHER OBJECTS ON LAND, AIR AND SEA

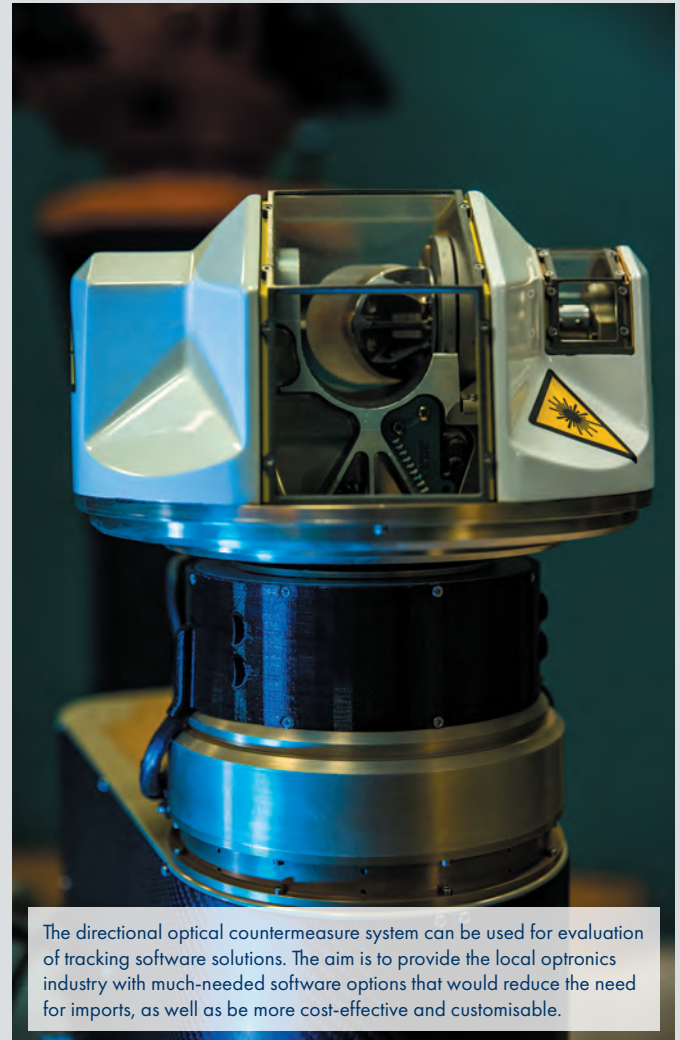
The CSIR developed a system that serves as a platform for the integration and testing of tracking algorithms for slow- to fast-moving small targets at long ranges. The targets of interest include drones and missile systems.

The directional optical countermeasure system has been tested and evaluated against a drone target – a current threat to infrastructure such as airports or operational bases. The favourable outcome of the tests has also led to discussion with Air Traffic Navigation Services on a variant that could potentially be used for the control of air traffic.

The newly developed system has the potential to play a role in the testing and evaluation of effective and affordable tracking software solutions, which are in high demand in the South African optronics industry. At present, the local industry integrates imported software tracking solutions in its product offerings, which is expensive and not customisable for optimal performance in its products. The platform can be used to test and evaluate such tracking software solutions and provides insights into improvements and adaptations to support localisation of the technology.

The development is viewed as an intermediate step in the quest to develop an indigenous directed infrared countermeasures capability for the protection of aircraft against infrared-guided missile systems.

The system is innovative in that it decouples the opto-mechanical moving parts from the bulky camera, allowing for the use of large aperture and long focal length imaging systems, for imaging and tracking targets at long range, but still providing the agility for fast-moving targets such as drones.



The directional optical countermeasure system can be used for evaluation of tracking software solutions. The aim is to provide the local optronics industry with much-needed software options that would reduce the need for imports, as well as be more cost-effective and customisable.



```

DIVCM
s - Emergency Stop
e - Initialise
c - Position Control
  w,x,a,d
t - Toggle Tracking
y - Pause Tracking
1,2 - Zoom
3,4 - White Balance
5,6 - Tracking Box
8,9,0 - Record Single, Data, Vid
STATUS
Integration Time 313
Zoom 37
Joystick Logitech Logitech Extrem
DIVCM EL 261591 AZ 34179
DIVCM EL 261591 AZ 34160
DIVCM EL 89.2 AZ 271.9
DIVCM AN -271.2
Tracking Size 64
Tracking Tracking
          Tt (us) 1763
          Dt (us) 2821
Recording None
  
```

Experiments with the countermeasure system demonstrated the ability of the imaging system to track targets at long range but with the required agility to capture fast-moving targets such as drones.



02

IMPROVE THE COMPETITIVENESS OF HIGH-IMPACT INDUSTRIES TO SUPPORT SOUTH AFRICA'S RE-INDUSTRIALISATION BY COLLABORATIVELY DEVELOPING, LOCALISING AND IMPLEMENTING TECHNOLOGY

DEVICE THAT DETECTS IMMINENT MINE ROOF COLLAPSES GOES ON TRIAL

The CSIR has supplied 10 prototypes of a device that detects and provides early warnings of goafs – a dangerous event that sees the underground roof in coal mines collapse – to a mining house in the South African coal mining industry.

The CSIR has worked on various technology platforms for geotechnical investigations and to monitor microseismic events and detect the failure of the rock mass. Large rock mass failure is responsible for roof collapses in underground mines. Such fall-of-ground events are a leading cause of fatalities in underground mining, and also have an economic impact.

During the first phase of the trials at the mine, improved false alarm suppression was demonstrated, while miners' manual observations also correlated with GoafWarn data.

The device was integrated into the mine's network for real-time observations in the mine as a first step to Internet of Things enablement.



The CSIR-developed device that detects and provides early warnings of collapsing underground mine roofs.

EXPERIMENTAL SURVEYS SHOW VALUE OF ELECTRICAL RESISTANCE TOMOGRAPHY IN MINING

The CSIR has demonstrated, through a number of research studies and surveys, that electrical resistance tomography is a useful reconnaissance mapping tool for delineating geological structures that compromise the continuity and normal flat-lying nature of planar orebodies.

The Advanced Orebody Knowledge Programme was established by the CSIR, in collaboration with the Mandela Mining Precinct, to investigate how in-mine electrical resistance tomography could be optimised.

Experimental surveys demonstrated that recent advances in technologies associated with in-mine electrical resistance tomography have contributed to its feasibility for routine in-mine application. A number of identified technology and electrical resistance tomography process enhancements were tested during an in-mine survey in November 2020. The survey proved that targets other than potholes/geological slump structures could be imaged with electrical resistance tomography.

The research outcome means that the mining sector can now obtain useful geological information ahead of the mining face. This will contribute to the business value drivers of safety and optimal extraction.

CSIR HOSTS CENTRE THAT ENABLES THE ADOPTION OF FOURTH INDUSTRIAL REVOLUTION TECHNOLOGIES



The CSIR has assumed its role as host of South Africa's Centre for the Fourth Industrial Revolution (C4IR South Africa). The centre is a platform for public and private stakeholders to collaborate on developing frameworks and guidelines to enable the adoption of fourth industrial revolution (4IR) technologies.

The South African government, through the Department of Science and Innovation, established the centre to lead the process of developing quality governance protocols that maximise the benefits of the South African economy.

The vision of the C4IR SA is to help shape the development and application of emerging technologies for the benefit of the country. Its mission is to co-design, test and refine enablers for the adoption of 4IR technologies. It looks at governance protocols and policy frameworks to maximise the benefits and minimise the risks of advanced science and technology.

C4IR SA is affiliated to the World Economic Forum's Fourth Industrial Revolution Network to tap into the expertise available within the C4IR global network.

To drive change, the C4IR South Africa brings together government departments, state entities, big business, dynamic start-ups, civil society, academia and expertise in the C4IR global network, to work together. The centre's focus areas are data policy; Internet of Things (IoT), robotics and smart cities; blockchain and distributed ledger technology, as well as artificial intelligence and machine learning.

Through a series of engagements, the centre is working with government departments and leading multinationals to pilot new governance frameworks that will speed up South Africa's adoption of new technology applications. It has conducted a workshop to identify key data policy issues within the South African context and is building a pilot project to assist small, medium and micro enterprises in adopting industrial IoT technologies that will ease the way they do business.

02

IMPROVE THE COMPETITIVENESS OF HIGH-IMPACT INDUSTRIES TO SUPPORT SOUTH AFRICA'S RE-INDUSTRIALISATION BY COLLABORATIVELY DEVELOPING, LOCALISING AND IMPLEMENTING TECHNOLOGY

NOVEL PROCUREMENT METHODOLOGY TO PROCURE RENEWABLE ENERGY

The CSIR has developed a tender package and evaluation criteria to assist the East London Industrial Development Zone (ELIDZ) with procuring electricity generated from renewable sources, specifically electricity that is generated by solar photovoltaic plants.

ELIDZ is part of a sub-regional economic growth and employment creation initiative driven by the government's micro-economic reform strategy, as implemented by the Department of Trade, Industry and Competition.

The CSIR supported the ELIDZ energy transition programme by deploying its researchers to develop a Request for Proposal document based on the *Build, Own, Operate and Transfer* model. The model does not require ELIDZ to fund initial capital investments,

but it requires it to purchase electricity at competitive tariffs from the preferred developer on the Power Purchase Agreement, with the intent to take over the plant at the end of the 10-year agreement. Technically, the buyer pays higher electricity costs during the initial agreement period with a forecast of making profits during the remaining period of the plant's lifetime.

A well-built, high-quality solar photovoltaic plant with proper periodic maintenance is set to produce at least 80% of its rated capacity well after 20 years. To protect buyer interest, the CSIR researchers emphasise the quality and reliability of the system, while introducing a performance evaluation metric, with guaranteed annual values. The preferred developer will invoice for the electricity supplied monthly, while evaluating the plant performance annually and submitting a compliance report to be assessed and reviewed by ELIDZ.

SUPPORTING MUNICIPALITIES IN PROCUREMENT OF PHOTOVOLTAIC SYSTEMS

CSIR energy experts developed an online training course and guidelines to assist municipalities with cost-efficient procurement of photovoltaic (PV) assets.

The training course is available online at www.training.sseg.org.za with four additional courses aimed at developing the small-scale embedded generation at municipalities. The first training session held in November 2020 reached 18 participants from municipalities across South Africa.

The training course supplements a guideline on the same topic developed under contract with German development agency, GIZ. The guideline is based on the methods developed at the CSIR and the lessons learnt during the procurement of four PV systems for self-consumption at the organisation's Pretoria campus.

The guideline supports municipalities in South Africa with cost-efficient procurement of solar PV electricity generators for installation at municipal facilities. The guide focuses on self-funded PV systems for self-consumption of the electricity produced.



The CSIR has developed a course and guidelines that focus on procurement of PV systems, such as this one, that are self-funded for electricity self-consumption.

SUPPORTING LOCAL INDUSTRY WITH EFFICIENT AND CLEAN-PROCESS HEATING SOLUTIONS

The CSIR and the South African National Energy Development Institute (SANEDI) have established a thermal systems programme to support industry in the transition to efficient and clean-process heating solutions.

The South African industry is facing the dual challenge of rising energy costs and the high-carbon intensity of production. As thermal energy accounts for an estimated 70% of the energy end-use by industry, it is critical to develop highly efficient and low-carbon solutions for process heating.

Waste heat recovery, and combined heat and power technologies have the potential to significantly improve the efficiency of process heating systems, thus simultaneously reducing costs and emissions. Once processes have been fully optimised, further decarbonisation requires the transition to cleaner heat generation technologies, either through the electrification of heat using clean electricity or through biomass and solar thermal systems.

Researchers assist large industrial clients to audit their thermal energy systems to identify opportunities for heat recovery and other efficiency improvements. They also develop thermal software models of furnaces, boilers and other heat transfer equipment.

The team has developed and tested a combined heat recovery, thermal energy storage and drying system for a ceramic small, medium and micro enterprise. The technology will allow the company to recover waste heat from a series of high-temperature ceramic kilns to provide drying capacity for casting moulds, thus eliminating the use of current electric driers. This solution will be piloted at the site of the industrial partner in the next year.

Having invested in capabilities in thermo-fluid process optimisation and digital twinning, the CSIR is establishing a thermal laboratory for targeted technology development in waste heat recovery, thermal energy storage, advanced heat pumps and solar thermal systems.

LOCAL FOUNDRIES SUPPORTED TO ACCESS EXPORT MARKET

Three South African foundries can now include the European Union (EU) stamp of accreditation on components manufactured for the pump and valves market. The foundries have obtained the Pressure Equipment Directive (PED) certification, thanks, in part, to an industry support programme managed by the CSIR.

The Kimberly Engineering Works, Rely-Intracast and Vestcast foundries can now manufacture castings that comply with PED 2014/68/EU requirements. The support was provided by the National Foundry Technology Network, an initiative hosted by the CSIR on behalf of the Department of Trade, Industry and Competition.

The pumps and valves market has been designated for local production with a minimum of 70% local content. A key requirement to participate in the pumps and valve market is the PED 2014/68/EU. The standard applies to the design, manufacture, and conformity assessment of stationary pressure equipment with a maximum allowable pressure greater than 0.5 bar.

The only foundry in South Africa with PED accreditation was liquidated in 1996, creating a vacuum in the sector and leading to imports of the same standard components. Following the intervention,



The National Foundry Technology Network has supported three local foundries with accreditation on components manufactured for the pump and valves market.

and the subsequent compliance with international required standards for PED testing, the castings can now be exported to Europe, and new orders were received from original equipment manufacturers.

02

IMPROVE THE COMPETITIVENESS OF HIGH-IMPACT INDUSTRIES TO SUPPORT SOUTH AFRICA'S RE-INDUSTRIALISATION BY COLLABORATIVELY DEVELOPING, LOCALISING AND IMPLEMENTING TECHNOLOGY

FIRST SMALL ENTERPRISES RECEIVE SUPPORT IN DRIVE TO INCREASE LOCAL CONTENT IN THE MARINE SECTOR



Western Cape-based Marine Solutions specialises in technical, sales and manufacturing support for remotely operated underwater vehicles. The company was supported to obtain the relevant ISO accreditation that will allow access to market opportunities in diamond mining, oil and gas industries and other underwater surveillance projects.

Six companies in the marine sector received support as the first beneficiaries of a programme to assist small enterprises to achieve accreditation and compliance with marine standards for their products and services.

The Department of Trade, Industry and Competition tasked the Aerospace Industry Support Initiative (AISI) with the implementation of the Marine Manufacturing and Repairs Supplier Development Programme in 2019. As part of the drive to increase local content in the marine sector, specific components were designated for local procurement and public working vessel procurement to have at least 60% local content to support component manufacturers. However, very few local suppliers have the required accreditation, and components are still being sourced from abroad, which prevents the local industry from developing and benefitting. This, despite the fact that ship and vessel manufacturing and repair have significant scope to achieve growth and job creation in the local economy.

AISI is a programme of the Department of Trade, Industry and Competition, implemented and managed by the CSIR.



A custom payload frame design for LED lighting on an autonomous underwater vehicle, produced by Marine Solutions.

NATIONAL CLEANER PRODUCTION CENTRE WINS INTERNATIONAL ENERGY PROJECT OF THE YEAR 2020



Significant energy users such as furnaces, fans and compressed air systems are the first to be targeted in an industrial energy management system. This Consol Glass site in Gauteng was among those supported by the IEE Project of the NCPC-SA to save on its energy consumption.

CSIR-hosted programme, the National Cleaner Production Centre (NCPC-SA), has received international recognition for implementation of the South African Industrial Energy Efficiency (IEE) Project. The IEE Project was named International Energy Project of the Year by the global Association of Energy Engineers in October 2020.

The NCPC-SA received the award in recognition of its efforts to transform energy use patterns in South African industry and mainstream energy management across economic sectors.

Since 2011, the IEE Project team has assisted hundreds of companies to implement energy management systems and energy systems optimisation in industrial and commercial companies. As a result,

measured and verified energy savings of 6 194 GWh have been recorded in 138 large and medium industrial plants – equivalent to five years of load shedding at the 2019 level of 1.352 TWh. This translates into cumulative cost avoidance of R5.3 billion in these companies, with a carbon mitigation of 6.1 million tonnes of CO₂e.

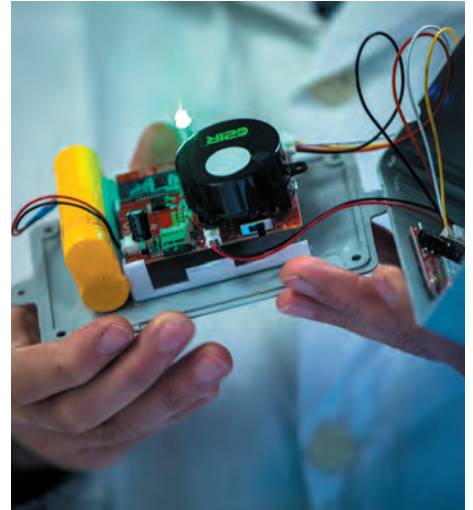
In addition, the NCPC-SA has trained over 6 000 end-users and 220 experts in industrial energy efficiency, developing and delivering 12 different courses in partnership with international IEE Project partner, the United Nations Industrial Development Organization.

Through participation in the project, companies can enjoy actual savings through the practical component of the expert level training. The NCPC-SA also supports companies wishing to implement an energy management system for ISO 50001 – the international energy management standard – certification.

03

DRIVE SOCIOECONOMIC TRANSFORMATION THROUGH RESEARCH, DEVELOPMENT AND INNOVATION THAT SUPPORTS THE DEVELOPMENT OF A CAPABLE STATE

THE CSIR RESPONSE TO COVID-19



CSIR-DEVELOPED VENTILATOR INSTRUMENTAL IN SAVING LIVES DURING COVID-19 PANDEMIC



Between May and November 2020, the CSIR developed and distributed 10 000 CSIR Lung Inspiratory Flow Enabler ventilators on behalf of the Solidarity Fund, for use by Covid-19 patients throughout the country. The ventilators were approved by the South African Medical Health Regulatory Authority. Distribution of ventilators continued in response to the third Covid-19 wave in South Africa.

The CSIR helped alleviate the impact of the Covid-19 pandemic by developing a novel, easy-to-use ventilator system.

The ventilator, the CSIR Lung Inspiratory Flow Enabler, uses standard, hospital-grade oxygen supply, and features easy-to-use, on-device flow gauges to adjust the fraction of inspired oxygen (oxygen-enriched air) in steps of 10% oxygenation.

The project was undertaken for the National Ventilator Programme, conducted under the auspices of the Department of Trade, Industry and Competition, and with support from the Solidarity Fund. Several collaborators were involved in the design, manufacturing and distribution process.

Work commenced towards the end of May 2020 and – utilising a digital product development process – the team could start distributing ventilators to hospitals around the country by September. The product development and manufacturing time frame included the formal process of testing and evaluation by the South African Health Products Regulatory Authority.

By November, 10 000 units were distributed to between 60 and 70 hospitals in South Africa, and further orders were received as the second wave of infections hit the country.

The ventilators are based on the continuous positive airway pressure (known as CPAP) design that provides a mild level of oxygenated

air pressure to keep the airways open and, thus, assist with those in respiratory distress. The units are non-invasive (applied to the face and not inserted in the airway), easy to attach to oxygen sources and easy to apply to patients.

The device can be used in both high-tech clinical environments and temporary settings, such as field hospitals and quarantine facilities such as those that were established around the country to handle rising Covid-19 cases.

Lockdown restrictions and the urgency caused by the spreading pandemic brought particular challenges – design, testing and manufacturing processes which would normally run sequentially, had to run in parallel, and flight restrictions impacted the global supply chain. The circumstances created the opportunity for local design and manufacture to fill the gap.

All planning, mapping, and simulation and testing were done digitally using product lifecycle software, before developing the physical product. Cost savings were possible because the digital methodology obviated the need to set up a plant first, and all production optimisation could be done virtually.

The CSIR is working on a bi-level positive airway pressure ventilator for patients with more severe symptoms. These units assist with both inhalation and exhalation, either in fixed-pressure modes or by sensing the oxygen supply required by a patient and adjusting the pressure accordingly.

03

DRIVE SOCIOECONOMIC TRANSFORMATION THROUGH RESEARCH, DEVELOPMENT AND INNOVATION THAT SUPPORTS THE DEVELOPMENT OF A CAPABLE STATE

CSIR ADDITIVE MANUFACTURING SKILLS HELP MITIGATE COVID-19 CHALLENGES

Additive manufacturing became a much-relied on manufacturing process in efforts to mitigate challenges brought about by the Covid-19 pandemic. The CSIR created additive manufacturing components and products for diverse fields. These included moulds, face shield parts and field hospital infrastructure.

Hospital infrastructure is a major challenge for South Africa. The CSIR developed a prototype hospital bed suitable for intensive care unit (ICU) use, with some components manufactured using additive manufacturing processes. Currently, all beds of this type are imported.

The prototype ICU bed was developed in accordance with South African Health Products Regulatory Authority requirements. A call for industry participation via an expression of interest has brought the local manufacturing of these beds a step closer. The Department of Science and Innovation co-invested in the project.



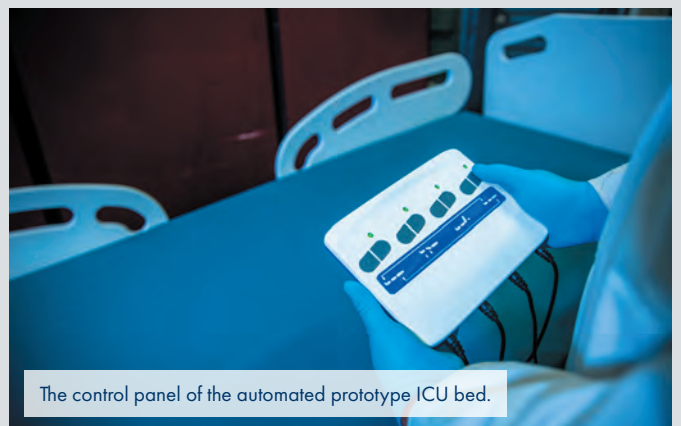
A face shield produced through additive manufacturing.



A prototype ICU bed designed and manufactured by the CSIR.



The prototype ICU bed being tested.



The control panel of the automated prototype ICU bed.

BRIDGING COMMUNICATION BARRIERS BETWEEN HEALTHCARE WORKERS AND PATIENTS

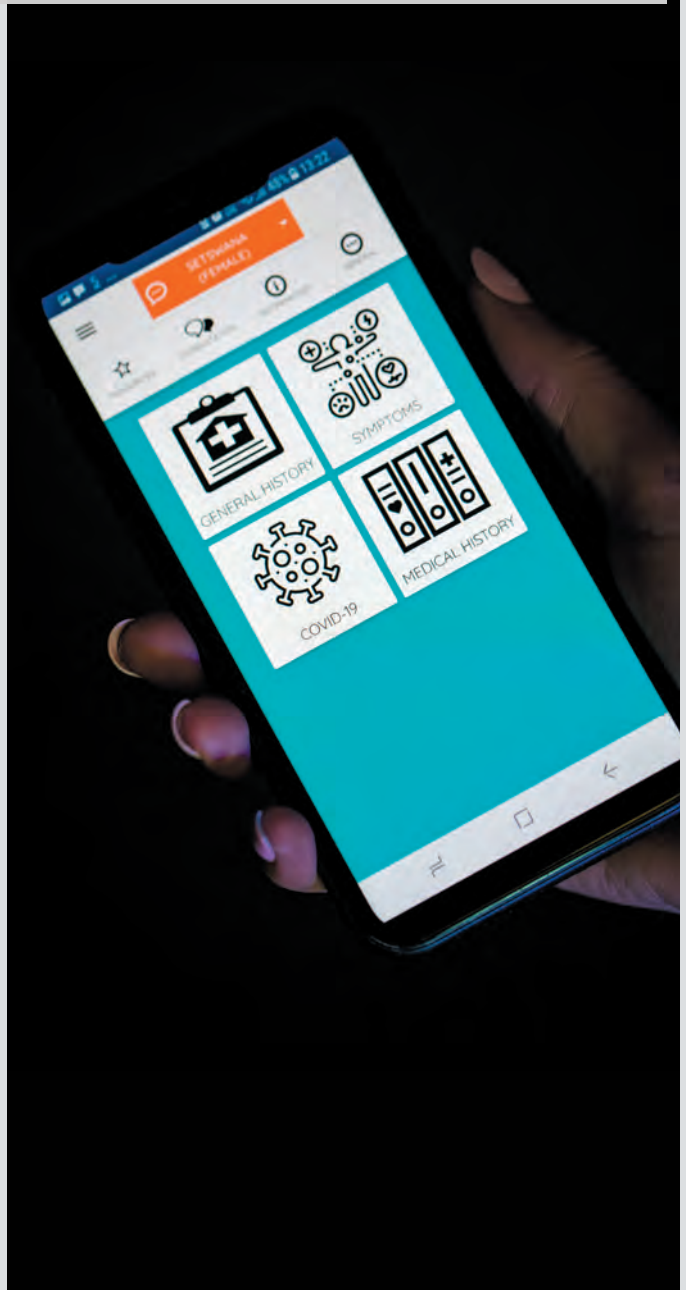
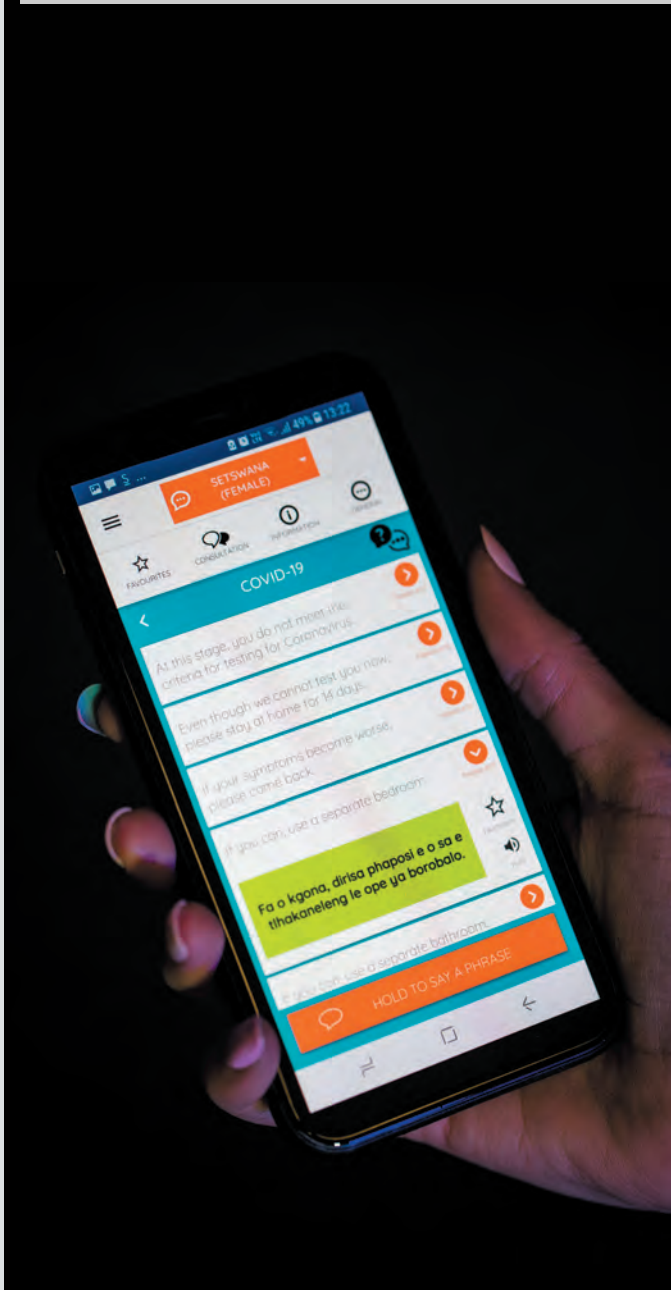
A mobile app originally developed with content pertaining to maternal healthcare and obstetrics was enhanced with Covid-19-related content to bridge the communication gap between healthcare workers and patients amidst the Covid-19 pandemic.

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.

A healthcare provider uses the AwezaMed Covid-19 mobile application to access a phrase in English and play it to the patient in a selected South African language, in this case, Setswana.



03

DRIVE SOCIOECONOMIC TRANSFORMATION THROUGH RESEARCH, DEVELOPMENT AND INNOVATION THAT SUPPORTS THE DEVELOPMENT OF A CAPABLE STATE

CONTRIBUTING TO AN INCREASED NATIONAL COVID-19 TESTING CAPACITY

At the height of Covid-19 infections in 2020, the CSIR repurposed its existing state-of-the-art Biosafety Level 3 (BSL3) laboratory to help ramp up government's Covid-19 testing. Reliable testing was a key requirement to manage the spread of the disease in many industries, as well as in the public sector.

The facility is certified as a BSL3 diagnostic laboratory, in line with approved international standards for Covid-19 testing. The World Health Organization approved the use of real-time reverse transcription polymerase chain reaction tests for the qualitative detection of nucleic acid from severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in upper and lower respiratory specimens.

Following the successful validation of samples provided by the National Health Laboratory Services, the CSIR laboratory counted among the most sophisticated in the country, with the necessary equipment and infrastructure to test for SARS-CoV-2.

The laboratory was first launched by the then Department of Science and Technology in 2010, and was dedicated to tuberculosis and HIV research and development work at the time.

The laboratory continued to provide Covid-19 testing for the mining sector throughout the second and the third waves of the pandemic in South Africa.



The CSIR repurposed an existing laboratory to help ramp up government's Covid-19 testing.

COLLABORATION TOOL FACILITATES RAPID SET-UP OF COVID-19 NERVE CENTRE

The CSIR established and hosted the National Department of Health Covid-19 Information Centre in April 2020 to assist government with data support and an integrated view of Covid-19 spread and containment across South Africa, right at the onset of the national state of disaster.

The CSIR-developed Cmore collaboration tool formed the backbone of the system, which was used to collect data from around the country and present it in an integrated manner. Screening teams used the mobile application version of the Cmore platform to share data from various locations and was able to provide data on spread patterns and vulnerable areas.

The department was able to monitor the spread of the Coronavirus against the backdrop of population density maps of all provinces; available private and public health facilities, both in terms of location and capability; as well as location of possible quarantine services. As the pandemic spread and data grew, the CSIR-hosted Centre for High-Performance Computing joined the team to assist with computing and data capacity handling. A South African cellular company donated 20 000 smart phones to the department for use during household screenings, undertaken by the department. All the donated smart phones were installed with the Cmore app and successfully synchronised with the Cmore server.

The CSIR's assistance enabled the Department of Health and other stakeholders to allocate resources and take preventative actions based on the data.

SUPPORTING THE COUNTRY'S NEED FOR LOCALLY PRODUCED SARS-COV-2 DIAGNOSTIC KITS

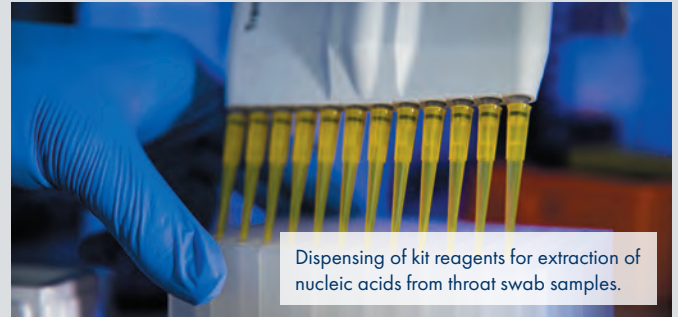
A CSIR-developed diagnostic kit to test for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has progressed to validation tests, using clinical samples.

Since the beginning of the Covid-19 pandemic, South Africa has proven to be 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 – a key component.



Dispensing of kit reagents for extraction of nucleic acids from throat swab samples.

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 Product 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.

CSIR AND CAPEBIO COLLABORATE FOR A ONE-STEP COVID-19 DIAGNOSTIC ASSAY

The CSIR, in collaboration with CapeBio, has demonstrated the efficiency of the biomanufacturing process for two enzymes which have been combined to develop a locally produced one-step Covid-19 diagnostic assay.

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 significant milestone that would reduce the country's reliance on international supplies. The technology is undergoing final validation with a regulatory authority.



Large-scale downstream capabilities coupled with chromatography enables purification of recombinant enzymes.

03

DRIVE SOCIOECONOMIC TRANSFORMATION THROUGH RESEARCH, DEVELOPMENT AND INNOVATION THAT SUPPORTS THE DEVELOPMENT OF A CAPABLE STATE

PROVIDING EXPERT INSIGHT FOR MODELLING COVID-19

The CSIR was part of a leading group of digital modellers and collaborators who were called on by the National Institute for Communicable Diseases (NICD) to assist government as it responded to the challenges brought about by the Covid-19 pandemic.

The team used an evidence-based scientific process to assist decision-and policymakers to allocate resources more effectively, conduct scenario analysis and help inform the different levels of lockdown. Data science, as well as statistical and mathematical modelling, were at the forefront of understanding the spread of the outbreak and being able to forecast the number of deaths, test different strategies and interventions, determine the number of those who are critically ill at a specific point in time at localised geographical locations, as well as determine if there are adequate intensive care unit beds, ventilators and other critical resources within the healthcare system.

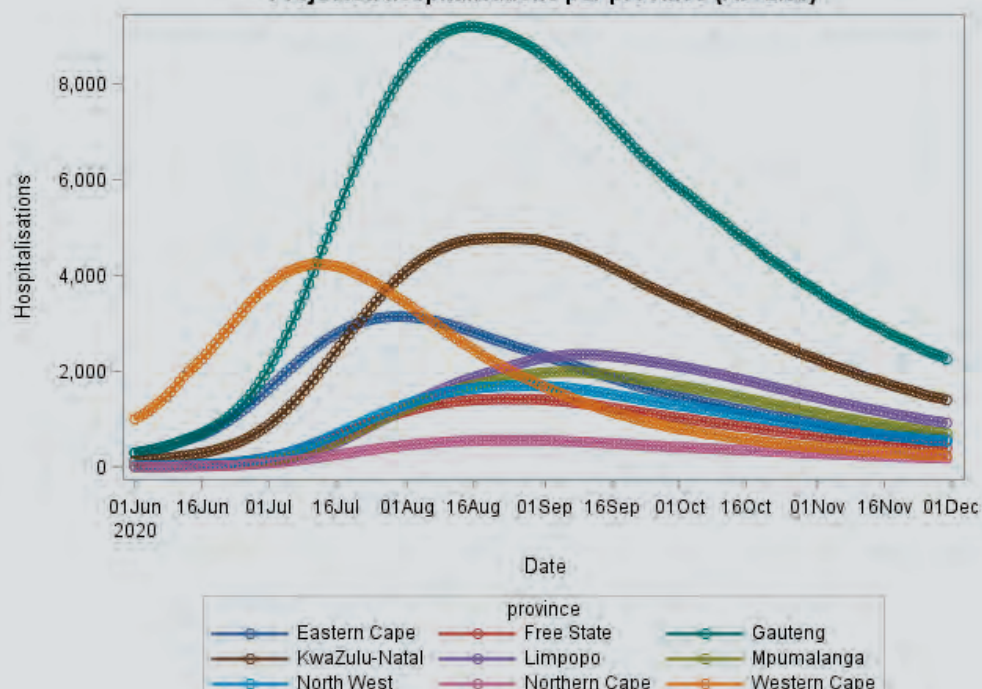
Collecting quality, timely and disaggregated spatial data was challenging as the ownership of the information and data ranges across various government, academic, public and private sectors, as well as science councils.

Through collaboration with the South African Medical Research Council, the Human Science Research Council, and the universities

of KwaZulu-Natal, Pretoria, Witwatersrand and Hasselt in Belgium, as well as the NICD, the modelling group focused on different spatial and non-spatial modelling approaches. The team used a data-driven modelling approach to determine reliable forecasting of the number of cases, recoveries and deaths at national and provincial levels; ward-level case data to support and improve the understanding of area-level variation of the pandemic and its drivers for targeted interventions and to determine local clusters of infection and hotspot detection; as well as a spatial model to respond to different lockdown scenarios in different municipalities, based on the forecast of the pandemic at a local level, while taking into account differences in transmission rates, population density, demographics and other factors at a localised level.

The team also joined an international consortium on the use of data science to respond to Covid-19 challenges and was awarded a project led by York University in Canada. The project is funded through the International Development Research Centre on predictive modelling and forecasting of the transmission of Covid-19 in Africa using artificial intelligence. The group focuses on determining initial disease spread characteristics within South African communities prior to the introduction of non-pharmaceutical interventions by building spatial disease spread models for the outbreak of Covid-19 at a localised level. The intention is to extend this work to other countries in Africa.

Projected hospitalisations per province (R0=2.86)



DATA PLATFORM TO HELP GOVERNMENT RESPOND TO COVID-19

The CSIR developed a data platform to help government respond to the Covid-19 pandemic. The platform was used throughout the pandemic to collect and analyse Covid-19 data for weekly reports to the National Coronavirus Command Council.

The National Policy Data Observatory Platform provides an environment for collecting, storing, processing, analysing and visualising social, health, and economic data to aid decision-making and planning in government.

This platform has the ability to collect and deal with Covid-19 data, social dynamics data for the District Development Model, mobility patterns, education, financial data, as well as research and monitoring of vaccination roll-out.

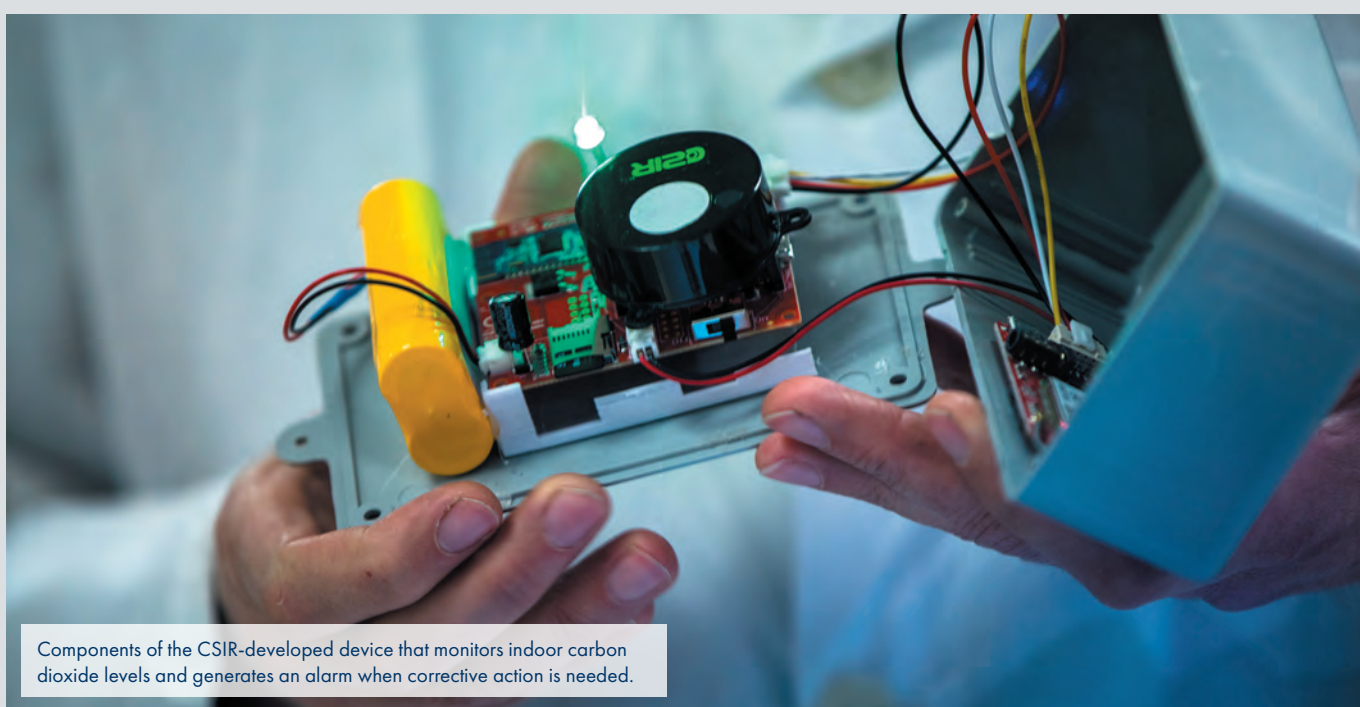
The platform is continuously being improved to cater for various data sources, analysis and modelling for weekly reports of the National Joint Operational and Intelligence Structure to the National Coronavirus Command Council. It is also relied upon by state institutions such as the Department of Planning, Monitoring and Evaluation, the State Security Agency and Statistics South Africa for their data requirements and analysis.



03

DRIVE SOCIOECONOMIC TRANSFORMATION THROUGH RESEARCH, DEVELOPMENT AND INNOVATION THAT SUPPORTS THE DEVELOPMENT OF A CAPABLE STATE

INNOVATIONS TO MANAGE THE RISK OF AIRBORNE TRANSMISSIONS OF DISEASES



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

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.

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.

With the technical feasibility of the tool established, the CSIR is proceeding to fit 50 more units in healthcare facilities across the country, following a Global Fund grant and partnerships with non-governmental organisations and the Department of Health.

The research team has also developed an app that uses algorithms to calculate the risk of transmission, and recommends the optimum number of people to occupy a room at any given time. The 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. A 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.



A monitor that checks for airborne transmission risk in a public health facility.

HEALTH AND SAFETY SUPPORT TO THE MINING INDUSTRY AMIDST THE COVID-19 PANDEMIC

The CSIR offered health and safety support to the mining industry amidst the Covid-19 pandemic. The CSIR rendered essential, specialised testing services, including testing for legislative compliance in the mining industry, at a time when the majority of the country was under lockdown.

The South African mining industry faced enormous operational challenges under level 4 and 5 Covid-19 restrictions in early 2020. Under these restrictions, some mines were allowed to resume full production and operation, while others were only allowed to operate partially under strict safety regulations.

The CSIR compiled Covid-19 risk assessment and mitigation plans to ensure compliance with relevant regulations issued by the Department of Employment and Labour. This necessitated workshops with relevant stakeholders wherein various health and safety experts shared their inputs. Compliance officers who were authorised to ensure adherence to Covid-19 risk controls were appointed at all mining testing and training sites.

As part of this mobilisation, the CSIR tested 1 074 samples from 75 mines in the CSIR self-contained self-rescuer laboratory; the mechanical testing laboratory tested 161 samples from 15 companies that support the mining industry; and 579 ropes from 18 mines and 4 rope manufacturers were tested by the rope testing laboratory in April 2020.



The CSIR provided training, expertise and support to the mining industry amidst the 2020 Covid-19 restrictions, ensuring compliance to safety regulations.

IN SHORT ACCELERATING MEDICAL TECHNOLOGY LOCALISATION IN RESPONSE TO COVID-19

SHARING KNOWLEDGE ON REGULATION TO ACCELERATE MEDICAL DEVICE PRODUCT DEVELOPMENT

In partnership with a consortium of companies, the CSIR helped set up the Covid-19 Agile Solutions Team. The team set out to offer financial and regulatory support and access to expertise to innovators to accelerate product development. The CSIR headed up the medical devices regulatory working group. The team created a manual on research, development and funding of medical devices for manufacturers and suppliers.

PARTNERING TO SUPPORT BUSINESS

The CSIR joined the Business South Africa Covid-19 Expert Innovation Group to offer South African innovators support to accelerate medical technology localisation during Covid-19. The group consists of corporates such as Anglo Platinum, Deloitte, Accenture, PwC, and the Industrial Development Corporation of SA, and works closely with other groups to bring improved working mechanisms and industrialisation of local manufacturing.

IMPACT ASSESSMENT OF COVID-19 ON THE NORTH WEST

The CSIR assessed the impact of Covid-19 on the economy of the North West for its Department of Economic Development, Environment, Conservation and Tourism. Researchers assessed the current and long-term impact on different sectors, including the small, medium and micro enterprise sector. The team developed recovery plans for various parts of the province's economy.

03

DRIVE SOCIOECONOMIC TRANSFORMATION THROUGH RESEARCH, DEVELOPMENT AND INNOVATION THAT SUPPORTS THE DEVELOPMENT OF A CAPABLE STATE

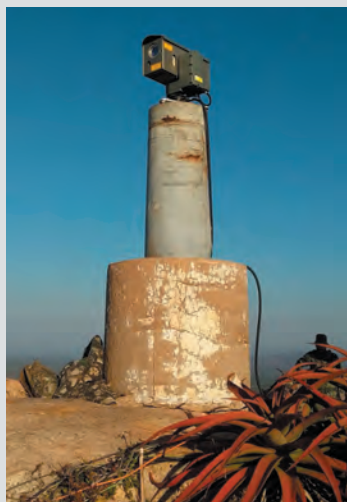
OTHER WORK IN SUPPORT OF A CAPABLE STATE DEVELOPING A PORTFOLIO OF LIGHT-WEIGHT BORDER SAFEGUARDING CAMERAS

The CSIR has developed a portfolio of border safeguarding cameras and made significant progress on the manufacturing of two cameras.

The cameras predominantly operate in combination with a radar system due to the long-range surveillance requirements during border safeguarding missions. While radar technology takes care of the initial detection, the role of the cameras is mainly to confirm object identity, which necessitates very narrow fields of view for imaging objects such as humans, animals and vehicles at ranges in the order of 5 to 10 km under realistic atmospheric conditions.

New developments have been largely driven by experiences in the operational environment and have led to the development of a novel near-infrared illumination solution for zero light night-time conditions.

The first camera is a stand-alone multichannel, multispectral camera system that can either be operated independently or integrated with a designation source, such as a radar. It boasts a cooled sensor and a thermal channel, and has an operational recognition range of 5 km for human targets. It is also suitable for covert intelligence operations, either manned or remotely. The second camera is a large aperture, cooled, single-channel camera system that has an operational recognition range of 10 km for human subjects. The cooled system has excellent dusk/dawn performance and can be used in light levels approaching half-moon conditions. It is ideal for integration with a radar, provided that the two systems are compatible and suitable for the mission and logistics profile.



The CSIR has developed a portfolio of border safeguarding cameras to confirm object identity. These cameras have been deployed at different locations in South Africa.

CSIR DEVELOPS LONG-TERM INFORMATION TECHNOLOGY AND SECURITY PLAN FOR CORRECTIONAL SERVICES

The CSIR developed an information systems and security technology plan for the Department of Correctional Services (DCS) to guide its capability development and business model going forward.

CSIR systems engineers led a participative process at different levels within the department. It included several strategic planning sessions with senior officials, as well as with both the Minister and Deputy

Minister of Justice and Correctional Services. The team developed a capability roadmap, as well as an interactive web portal through which architectural elements could be reviewed to arrive at a well-considered master plan.

The plan has been signed off, with recommendations for the CSIR to continue its involvement through implementation of the plan and conducting future studies. Implementation of physical security solutions for five priority DCS sites has commenced.

SMART SURVEILLANCE FOR SAFER CORRECTIONAL FACILITIES

The CSIR has piloted a new camera-based imaging and alerting system for wide-area surveillance and intrusion detection at a Department of Correctional Services facility in the Eastern Cape.

The CSIR was called upon by the Department of Correctional Services to assist with a security solution for a chicken farming operation at one of its facilities, which was losing significant quantities of stock worth thousands of rand per month.

The CSIR, together with a private company specialising in perimeter intrusion technologies, developed a system featuring movement detection, using radar and video images from day-and-night cameras. A first attempted intrusion was detected and the reaction teams thwarted the trespassing. No further theft incidents occurred during the period that the system was deployed.

The core of the system is a CSIR-developed smart physical security platform that can be rapidly deployed to evaluate situational awareness capability at a client site and, from there, develop a custom system through experimentation. The software performs automatic detection, recognition and classification of small targets in high-resolution images without any human intervention. The targets can be humans, animals, vehicles, or any other object of interest within the monitored environment up to a distance of 350 metres. Alerts are generated by the application when threats are detected. The software provides for an option of sending such alerts to mobile devices, computers in the local control room and remote command and control services.

The system has clear benefits in large-area security solutions for industrial or power plants and farms.



Long or medium-range cameras can be deployed to detect small targets.



A surveillance system deployed at a correctional services facility.

03

DRIVE SOCIOECONOMIC TRANSFORMATION THROUGH RESEARCH, DEVELOPMENT AND INNOVATION THAT SUPPORTS THE DEVELOPMENT OF A CAPABLE STATE

PROVIDING AFFORDABLE BROADBAND FOR SOUTH AFRICAN TOWNSHIPS AND RURAL AREAS



From left: CSIR principal researcher and project lead, Dr Luzango Mfupe; the chief executive officer of SMME beneficiary Mdantsane Mobile, Songezo Mhambi; UNDP head of experimentation, Klariska Moodley; and CSIR chief researcher and project lead, Dr Fisseha Mekuria at the handover of the network to the SMME.

The CSIR is helping bridge the digital divide through a collaborative project with the United Nations Development Programme (UNDP) that assists digital entrepreneurs with support to roll out affordable broadband networks in South African townships and rural areas using the CSIR's Television Whitespaces (TVWS) technology.

The CSIR is implementing wireless network infrastructure for affordable broadband Internet connectivity in the neediest communities around the country through small, medium and micro enterprises (SMMEs) owned by women, youth and the disabled. TVWS technology uses the gaps, known as white spaces, between terrestrial television broadcasts to deliver affordable broadband networks.

The CSIR assists the selected SMMEs with on-demand technical support, capacity-building webinars and technical training on the use of the CSIR spectrum innovation toolboxes as well as TVWS network planning and deployment. Phase 1 was rolled out in the Eastern Cape, KwaZulu-Natal, Free State and the Western Cape. Phase 2 of the project will see 10 more SMMEs being funded to install low-cost Internet in their respective communities.

The project is implemented by the CSIR and funded by the UNDP, through the Government of Japan. The Foreign, Commonwealth and Development Office of the United Kingdom government has also come on board to support the initiative through a partnership project with the CSIR that will focus on the long-term sustainability of the beneficiary SMMEs. It will do this by providing them with business and technical capacity building, ongoing technical support, as well as monitoring and evaluation support.

A NEW COMPUTER-AUTOMATED LAND COVER SYSTEM SPEEDS UP LAND COVER MAPPING

The CSIR, in partnership with industry, has developed a computer-automated land cover system that significantly reduces the time to produce land cover maps, easing strategic decision-making for government, as well as the private sector. The system utilises medium-resolution satellite data, runs in the cloud, requires minimal user input, and is accessed using a web browser.

In line with their responsibilities delineated in the Spatial Data Infrastructure Act, 2003 (Act 53 of 2003), the Departments of Forestry, Fisheries and the Environment and Agriculture, Land Reform and Rural Development produce land cover maps as crucial reference datasets for spatial planning and resource management purposes.

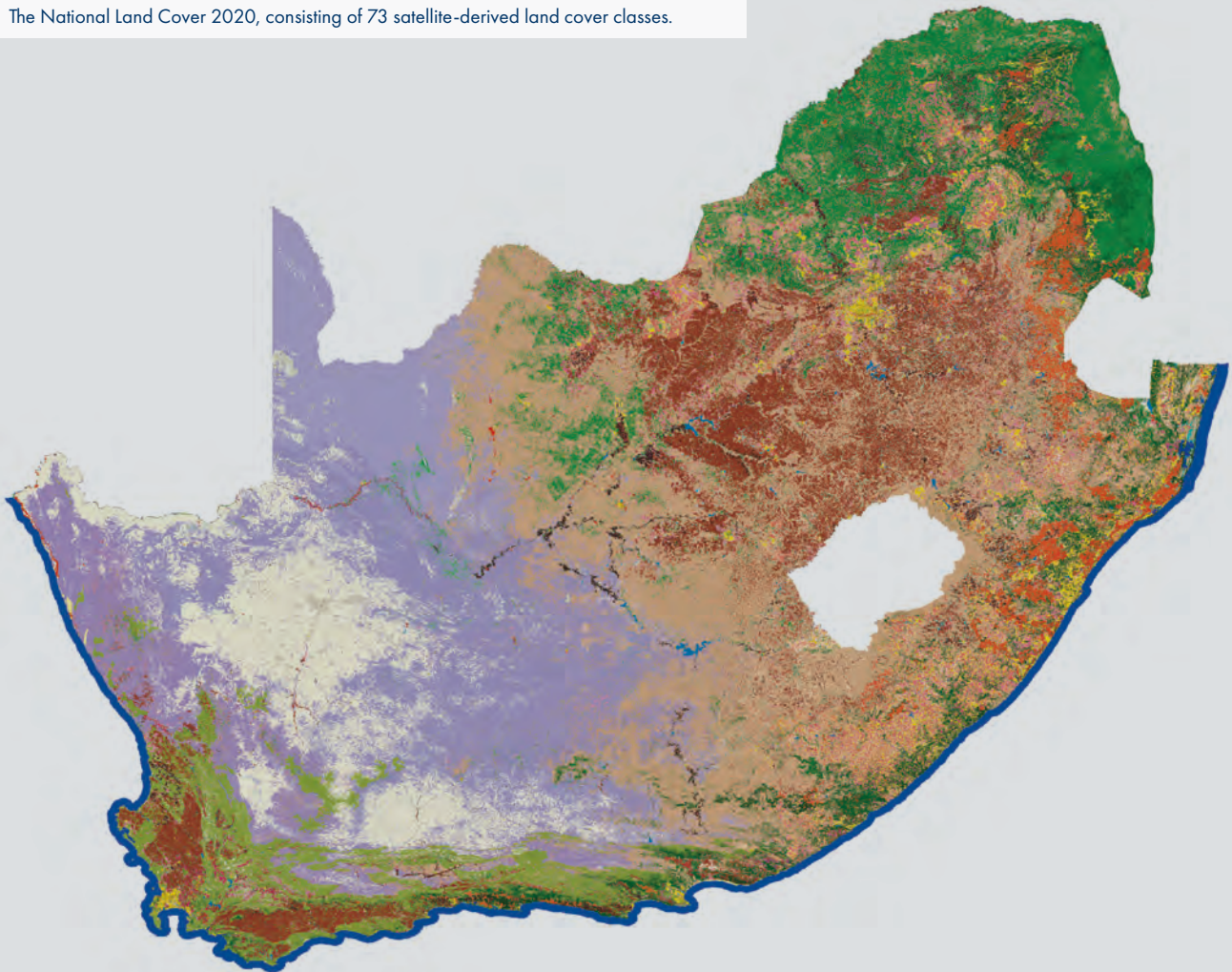
Collaboration between the CSIR and GEOTERRAIMAGE SA, which formulated the land cover classification models, resulted in

an operational system that offers automated and rapid land cover generation capabilities to the departments.

Nearly 7.5TB of Sentinel-2 satellite data are needed to produce one land cover map. Downloading and manual processing of such are, thus, impractical. The CSIR's research improved cost and time efficiency of land cover mapping by developing a local, highly automated production system, capitalising on advances in earth observation and increased computational resources offered by cloud platforms.

The new system accesses and processes Sentinel-2 data, and performs automated mapping of 73 land cover classes, which is annually repeatable. The system can also automatically perform and report on accuracy assessments of land cover classes and change detection. The result is that, while historical land cover mapping campaigns took a minimum of 18 months to complete, the new system produces all three land cover products within two weeks.

The National Land Cover 2020, consisting of 73 satellite-derived land cover classes.



03

DRIVE SOCIOECONOMIC TRANSFORMATION THROUGH RESEARCH, DEVELOPMENT AND INNOVATION THAT SUPPORTS THE DEVELOPMENT OF A CAPABLE STATE

SUPPORTING THE DEPARTMENT OF HOME AFFAIRS WITH IDENTITY MANAGEMENT

The CSIR has supported the Department of Home Affairs on aspects of identity management. The organisation designed and developed the systems requirements and technical specifications for the new National Identity System, an integrated information repository of data from the national population register, and contributed to the draft Official Identity Management Policy, which was published for comment in late 2020.

The CSIR also assisted the department with the proposed policy for identity

management through several research-based inputs on, for example, the collection, storage and verification of identification credentials, including biometric data for adults and children, as well as specifications for the population register. The policy governs access and use of the National Identity System, in line with other legislation.

Key in the process is the development of single digital identities (or e-identities) that will allow government and private identity management systems to interface using biometric data. In particular, 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.



The CSIR-developed biometric recognition system uses algorithms to verify the identities of individuals from infancy to adulthood.

A FRAMEWORK TO GUIDE INVESTMENTS IN THE WESTERN CAPE'S ECOLOGICAL INFRASTRUCTURE

The CSIR has developed an investment framework that will inform decisions on where and how to invest in the Western Cape's ecological infrastructure.

Ecological infrastructure refers to naturally functioning ecosystems that deliver valuable services to society; such as water, climate regulation, soil formation and disaster risk reduction. It is the nature-based equivalent of built or hard infrastructure, and can be just as important for providing services and underpinning socioeconomic development.

The Ecological Infrastructure Investment Framework is informed by the benefits that society derives from ecological infrastructure and the potential loss of some (or all) of these benefits in cases where such ecological infrastructure is not restored or protected. The focus is on specific risks, such as risks to water security (primarily due to alien plant invasions and rangeland degradation), the risks to human life, property and livelihoods posed by uncontrolled fires and floods (coastal and inland), and the risks to food supply and livelihoods due to rangeland degradation, particularly from overgrazing.

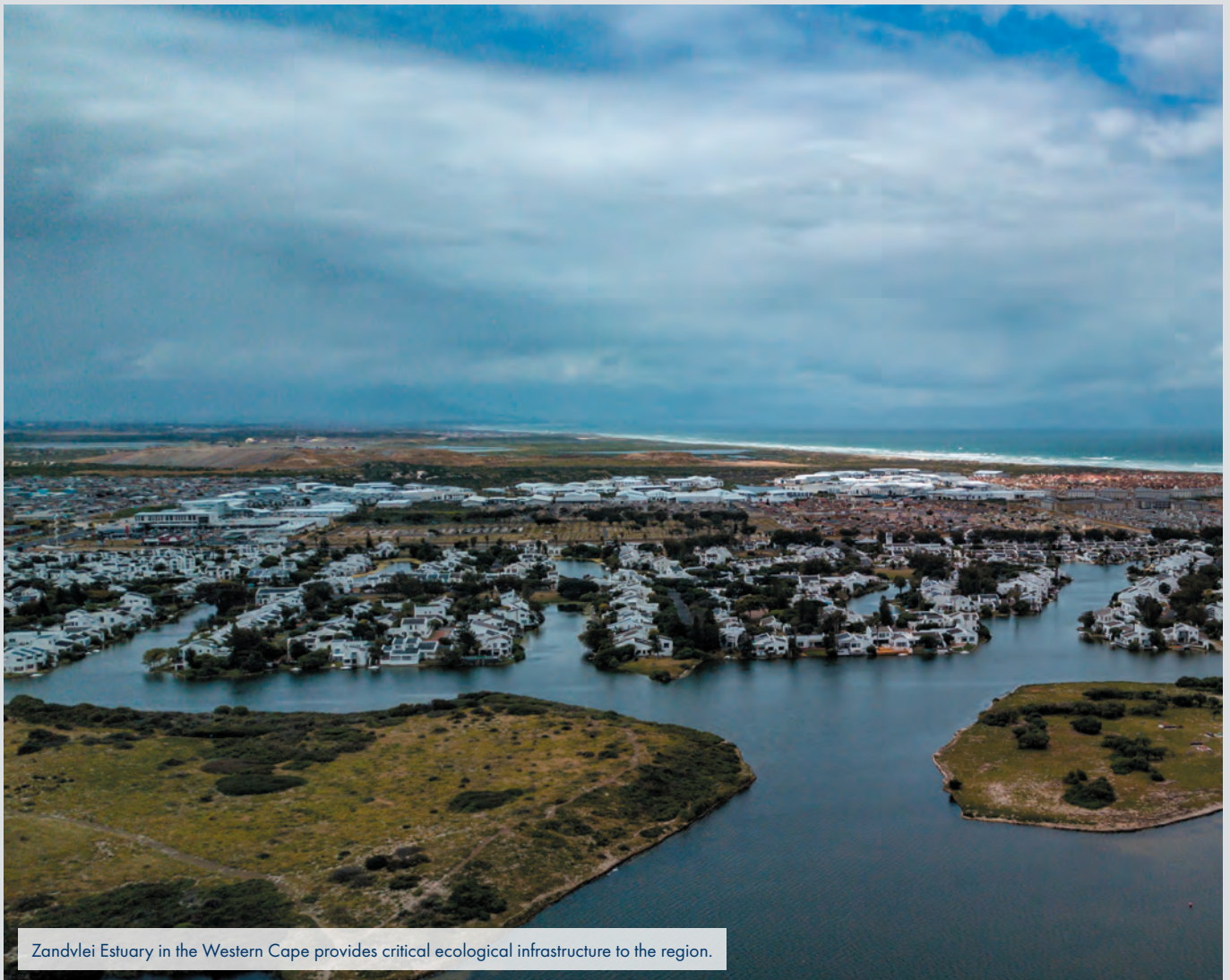
The framework focuses on where and how maximum benefits can be derived from the restoration of ecological infrastructure to alleviate these risks.



Ecological infrastructure, such as estuaries, generates valuable services to people.

The framework provides the Western Cape Provincial Department of Environmental Affairs and Development Planning with a tool to guide decision-makers from both the private and public sectors in making choices on where and how to invest in ecological infrastructure to promote resilience and maximise benefits.

FIRST EXPERIMENTAL ECOSYSTEM ACCOUNTING METHODOLOGY FOR SA'S ESTUARIES



Zandvlei Estuary in the Western Cape provides critical ecological infrastructure to the region.

The CSIR, in collaboration with the Department of Forestry Fisheries, and Environment and the Nelson Mandela University, has developed an ecosystem accounting methodology for South Africa's estuaries.

Ecosystem accounting is an integrated approach to the assessment of the environment through the measurement of ecosystems, and measurement of the flows of services from ecosystems into economic and other human activity.

Researchers have prepared the first extent and condition accounts, as well as pressure and ecosystem services accounts for the estuary realm. The study largely made use of available country-level information generated as part of the estuaries section of the National Biodiversity Assessment 2018, which was led by the same research team.

Estuaries constitute highly productive habitats in the coastal space, providing disproportionately high socioeconomic benefits to society per unit area compared to other natural systems. Estuaries form part of the set of small high-value ecosystem types (making up less than 5% South Africa's territory) that function as critical ecological infrastructure that should be prioritised for planning, management and protection. It necessitates an ecosystem account separate from larger freshwater or marine ecosystem accounts.

South Africa's estuarine estate covers 200 730 hectares. The national estuarine ecosystem condition index is estimated at 63.7 (out of 100). The estuaries' condition accounts show a significant decline with only 21% of the country's systems still in a natural state and 40% in a near-natural state. However, by extent, only 23% of the estuarine estate remains in a natural/near-natural state, with 63% in a heavily modified state or worse.

The work was undertaken in consultation with the South African National Biodiversity Institute and Statistics South Africa.

04

BUILD AND TRANSFORM HUMAN CAPITAL AND INFRASTRUCTURE

CSIR AWARDS BURSARIES TO TOP-PERFORMING MATRICULANTS

After a 2020 academic year riddled with challenges for South Africa's matric class, the CSIR gave hope to 14 top-performing 2020 matriculants from schools in Gauteng and the Western Cape. The CSIR is funding their pursuit for higher learning. The move was spurred by the newly established CSIR Corporate Social Investment Programme, which focuses on education and skills, socioeconomic development, as well as employee volunteerism.

Three learners are funded for studies at the University of Cape Town. They are Kamogelo Baloyi (BSc Computer Science), Karabo Ntje (BSc Mechanical Engineering), both from the Sikhululekile High School, and Lebogang Sithebe (BEng Mechanical) from Ekinisweni Secondary.

The University of the Witwatersrand is the new home to three learners from Ekinisweni Secondary, Lithabo Molefe, Nancy Lishivha and Tukiso Rahlagane, who are all pursuing a BSc (Civil Engineering). The University of Pretoria welcomed Koketso Moeaha (BSc Chemical Engineering), Kgolagano Kgoebane (BSc Industrial Engineering) and Nompumelelo Tshabalala (BEng Computer Engineering) as first years.

Two students are pursuing studies at Stellenbosch University – Lebogang Bapela from Sikhululekile High School is pursuing a BSc (Molecular Biology and Biotechnology) and Palesa Gama a BSc (Chemistry).

Busisiwe Makhubela is pursuing a BSc (Life and Environmental Sciences) and Letlotlo Maje is pursuing a BEng (Electrical Engineering) at the University of Johannesburg.

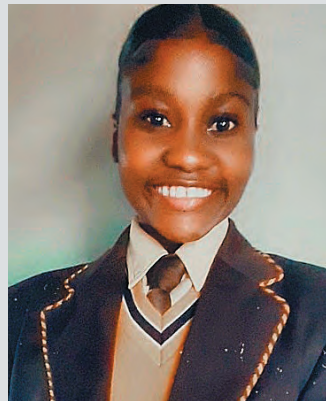
Kwanele Ndolosh was accepted at the University of KwaZulu-Natal to study a BEng (Chemical) degree.



Botho Maje



Busisiwe Makhubela



Koketso Moeaha



Kwanele Ayanda



Lithabo Dimolish



Nancy Lishivha



Nompumelelo Tshabalala



Kwanele Ayanda

DEVELOPING AGILE GRADUATES WHO ARE ADAPTABLE TO CHANGE

Resilience, independence and focus are some of the words that students use to describe what was demanded from them on their journey in the CSIR's Graduate-in-Training programme during 2020. The pilot project, which exposes trainees to as many CSIR functions as possible – through induction and rotation – took a virtual turn for the cohort of 14 former CSIR bursary holders. Many CSIR employees moved their workspaces to their homes during the Covid-19 lockdown periods – presenting difficulties for training programmes, but also preparing them for the unpredictable nature of a career in research.



ATLEGANG NYAKALE

Qualification: BEng (Hons) Chemical Engineering, University of Pretoria, 2020

Nyakale joined the design, analysis and testing group of CSIR Future Production: Manufacturing. She conducted literature studies for a metal-fuels project and assisted in a lithium dissolution test research and process design. Part of her duties included assisting the group with defining and compiling a hazard and operability study for a graphite oxidation process. The group has a diverse range of engineering capabilities in functional prototypes and manufacturing process development as well as materials testing.



LESEGO NTSEANE

Qualification: BSc (Hons) Computer Science, North-West University, 2019

Ntseane joined the optronics sensor systems team at CSIR Defence and Security. She worked as a software engineer in the initial stages of a camera streaming test. Projects include developing new and novel electro-optic sensors/imagers and image processing techniques. The group conducts modelling, simulation, engineering, testing and evaluation of advanced electro-optical sensor systems and develops day-, night- and multispectral surveillance systems.



THABISA MAWENI

Qualification: BEng Electrical and Electronic Engineering, University of Johannesburg, 2020

Maweni joined the digital electronic warfare group of CSIR Defence and Security. She worked on a risk study with an international partner. The group is developing an advanced surface-based radar jammer, based on active electronically scanned array and the latest processing technologies, including digital radio frequency memory and heterogeneous computing for multi-threat engagement. The system is envisioned to operate in different conflict scenarios, which could vary from surveillance of insurgents in a civilian-commercial setting to high-intensity state-on-state conflict.

CELEBRATING THE CLASS OF 2020

The CSIR has supported the academic development and transformation of its staff, both in the science, engineering and technology and support bases. In 2020, 47 staff members obtained their Master's or Doctorates in line with the organisation's value of excellence.

Class of 2020

00:20:20

				
Dr Karen Nortje CSIR senior researcher PhD (Anthropology), University of Johannesburg	Dr Thanyani Pandelani CSIR senior researcher PhD (Bio-engineering), Imperial College London	Dr Tovhowani Ramulongo CSIR senior researcher PhD (Microbiology), University of Pretoria	Dr Jodi Pelders CSIR researcher PhD (Public Health), University of the Witwatersrand	Amy Pieterse CSIR senior researcher M (Town and Regional Planning), University of Pretoria
				
Dr Katekani Shingange CSIR postdoctoral researcher PhD (Physics), University of Free State	Lionel Jean Michél CSIR divisional communications manager International Master of Business Administration, University of Reading, UK	Dr Nenekazi Mkuangwe CSIR researcher DPhil (Electrical and Electronic Engineering), University of Johannesburg	Dr Coralie van Reenen CSIR principal researcher PhD (Architecture), University of Pretoria	Dr Xoliswa Dyosiba CSIR postdoctoral researcher PhD (Chemical Engineering), Tshwane University of Technology
				
Athi Gxumisa CSIR researcher MPhil (Urban and Regional Science), Stellenbosch University	Lucia Sethunya CSIR technologist MTech (Chemical Engineering), University of South Africa	Kyla Purdon CSIR researcher MEng (Mechatronics), Nelson Mandela University	Dr Valerie Maswanganyi CSIR postdoctoral researcher PhD (Organic Chemistry), University of Pretoria	Carl-Peter Wehlitz CSIR researcher MEng (Port and Coastal Engineering), Stellenbosch University
				
Nikiwe Mashaba CSIR engineer MSc (Physics), University of Witwatersrand	Mpho Motloutung CSIR researcher MSc (Chemistry), University of Johannesburg	Chantel Ludick CSIR candidate researcher MSc (Geographical Information Science), University of Pretoria	Eric Mkhondo CSIR senior technical engineer MTech (Mechanical Engineering), University of Johannesburg	Dr Nicolene Roux CSIR technical leader PhD (Technology Management), University of Pretoria
				
Sipho Chauke CSIR technologist MSc (Medicinal Plant Science), University of Pretoria	Dr Precious M. Radingoana CSIR postdoctoral researcher PhD (Material Science and Engineering), Université Paul Sabatier III- Toulouse	Dhiveshni Moodley CSIR assessment practitioner MSc (Environmental Science) (cum laude), University of KwaZulu Natal	Dr Johan Van der Westhuizen CSIR postdoctoral researcher PhD (Chemistry), University of Pretoria	Innocent Monareng CSIR technologist MTech (Engineering Metallurgy), University of Johannesburg

04

BUILD AND TRANSFORM HUMAN CAPITAL AND INFRASTRUCTURE



Leave

Dr Greg Schreiner CSIR researcher DPhil (Science-Policy Interface), University of the Witwatersrand	Dr Jan van de Loosdrecht CSIR cluster executive manager: Chemicals MBA (Renewables), Beuth University of Applied Sciences, Germany	Pfarelo Daswa CSIR engineer MEng (Metallurgy), University of Pretoria	Dr Lesego Tshweu CSIR researcher PhD (Chemistry), University of Pretoria	Katlego Mosito CSIR researcher MEng (Radar and Electron Defence), University of Cape Town
Prof. Ronald Machaka CSIR principal researcher Master of Management (Innovation Studies) (with distinction), Wits Business School	Bongzi Ntsoelengoe CSIR cluster executive manager: Mining Master of Business Administration, Gordon Institute of Business Science	Nkosinathi Ndlovu CSIR senior engineer MSc (Computer Science) (cum laude), University of Witwatersrand	Themba Shoji CSIR research engineer MSc (Computer Science), University of Zululand	Mogau Sebopa CSIR candidate researcher MEng (Civil Engineering)
Dr Advaita Singh CSIR postdoctoral researcher PhD (Biotechnology), University of Pretoria	Tlou Boloka CSIR researcher MSc (Computer Science), University of Witwatersrand	Dr Masixole Lugongolo CSIR postdoctoral researcher PhD (Science), University of South Africa	Mxolisi Mtshali CSIR research engineer MSc (Computer Science), University of Zululand	Mmatabane Hlapisi CSIR procurement specialist MBA, Regent Business School
Mpho Moeketsi CSIR Facilities services manager MPhil, University of Pretoria	Dumisani Kunene CSIR researcher MSc (Computer Science and Applied Maths), University of the Witwatersrand	Mfanufikile Shange CSIR researcher MEng (Mechanical Engineering), Central University of Technology	Dr Glenda Motsi CSIR postdoctoral researcher PhD (Materials Science), University of Limpopo	Tsholofelo Malatji CSIR engineer MEng (Electronic Engineering), University of Pretoria
Laubscher Van der Merwe CSIR researcher MEng (Industrial Engineering), Stellenbosch University				

04

BUILD AND TRANSFORM HUMAN CAPITAL AND INFRASTRUCTURE

A COMMITMENT TO REDRESS WHO HAS ACCESS TO MARINE SCIENCES

The CSIR-led Southern Ocean Carbon and Climate Observatory (SOCCO) has become renowned for its commitment to human capital development in oceanography and climate science. SOCCO is a South African science programme in support of the Department of Science and Innovation's Global Grand Challenge and Marine and Antarctic Research Strategy, with a clear commitment to ocean and climate science stewardship.

SOCCO prioritises human capital development through extensive student training in interdisciplinary numerical modelling and analysis skills and is committed to transformation to help ensure that South Africa meets its goal of a diverse, representative and dynamic workforce.

In the 2021 academic year, SOCCO hosted 15 students – 3 MSc students, 9 students studying towards their PhDs and 3 postdoc students. Of the 14 students that are SOCCO funded, 46% are female and 86% are from historically disadvantaged groups.

SOCCO attracts students with a nationwide recruitment programme that actively seeks students of different disciplines who are not ordinarily exposed to, nor inclined towards marine science. By highlighting the applicability of their research to globally important problems, such as climate change, SOCCO manages to attract students from diverse scientific backgrounds.

SOCCO research addresses issues relating to the role of the Southern Ocean in driving 21st century regional and global climate through advanced interdisciplinary research at the intersection of oceanography, physics, biogeochemistry, marine technology, ocean colour remote sensing and numerical modelling. The technological and science platforms that the students are exposed to are helping address transformation needs in scientific and technological research and innovation. Many of the techniques used in the research are new to South Africa and, as such, knowledge transfer and training from local and international collaborators adds knowledge and expertise to the South African scientific community.

SOCCO uses a variety of models to train postgraduate students. These include the traditional apprenticeship model (a one-on-one mentoring relationship between student and supervisor with co-supervisory arrangements and scholarly exchanges); the course-based model (using a structured curriculum); and degree by publication (examined on the basis of a series of peer-reviewed academic papers). In addition, it employs the more recent cohort-based model, which represents a shift from a solitary experience defined by an individual student-supervisor relationship to a shared (group) experience. Advantages of a cohort model in the South African context are that it provides a critical mass of students and supervisors and offers economies of scale.



Dr Sarah Nicholson, a researcher at the Southern Ocean Carbon and Climate Observatory oversees the dismantling of a profiling seaglider by Pholani Magam, left, of the Cape Peninsula University of Technology.

NEW CENTRE FOR ADVANCED DESIGN AND MANUFACTURING SUPPORTS INDUSTRY

The CSIR has established an advanced manufacturing facility that offers capabilities such as additive manufacturing – using polymers and powders – 3D scanning and product lifecycle management, in a bid to help improve the competitiveness of industry.

The Advanced Design and Manufacturing Innovation Centre (ADMIC) also provides ongoing research into new manufacturing techniques, technologies and materials, as well as specialised design and manufacturing training for local and international industries.

The centre is dedicated to the complete process, from conceptualising or designing a solution through to material selection, prototyping, testing, manufacturing and delivery. Firm security measures are in place at the centre, making it ideal to serve defence clients, as well

as companies performing pre-competitive prototyping, conceptual design and low-volume manufacturing of new products for testing. This ensures the security of clients' intellectual property and confidentiality.

With the new equipment barely in place, ADMIC found itself at the heart of the fight against Covid-19 in South Africa. The centre was used for the rapid design and production of face shields for use by soldiers deployed to infection hot spots at the start of the pandemic. A number of other projects have since been initiated for the defence industry.

Clients in the aerospace, automotive, agricultural, maritime and medical sectors are set to benefit from the technologies at the centre as part of the CSIR's commitment to supporting industry competitiveness and accelerating industrialisation.



The MetraScan 750 Optical elite scanner is used to scan a Toyota Land Cruiser. This scanner performs highly accurate and repeatable metrology-grade measurements and 3D geometrical surface inspections to create 3D models of objects. Top (right): A bird's eye view of the Advanced Design and Manufacturing Innovation Centre.



04

BUILD AND TRANSFORM HUMAN CAPITAL AND INFRASTRUCTURE

A LEARNING FACTORY FOR FOURTH INDUSTRIAL REVOLUTION SKILLS DEVELOPMENT

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 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.

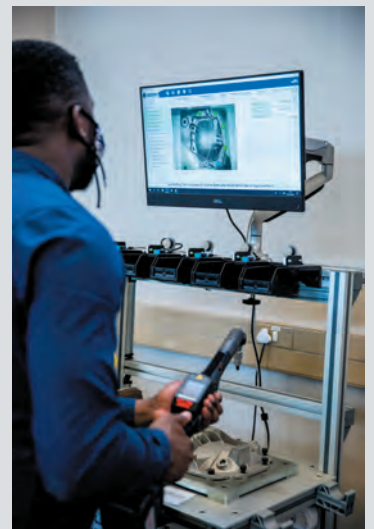
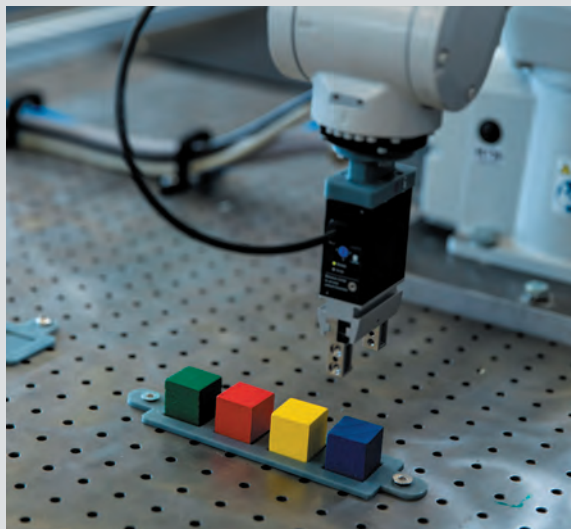
In addition to the master learning factory at the CSIR, the intention is for merSETA to establish learning factories at 18 public technical and vocational education and training colleges around the country, developing and honing the skills of learners and the national workforce to support the adoption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



The 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.

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.



WORLD-CLASS PHOTONICS PROTOTYPING INFRASTRUCTURE LAUNCHED

The CSIR is contributing to the growth of South Africa's photonics industry through a photonics prototype facility launched at its Pretoria campus.

The investment by the CSIR and the Department of Science and Innovation will help speed up product development of photonics technology and devices.

The CSIR aims to address the present shortage of marketed photonic products in South Africa by providing access to experts, as well as state-of-the-art infrastructure and networks necessary to accelerate the development of photonics-based innovations.

The facility is available to all photonics role-players that have a proven innovation concept but do not have the resources to take the inventions to the next phase. Such innovators may be from established industries, existing small, medium and micro enterprises, and start-ups or institutions and research councils.

Photonics technologies do not only have the potential to address societal challenges, such as energy generation, healthcare provision, and security, but also to become a driving force in accelerating economic growth.

The Director-General of the DSI, Dr Phil Mjwara, and CSIR CEO, Dr Thulani Dlamini, officially launched the facility on 5 March 2021. A large audience from diverse sectors and media houses witnessed the proceedings via streaming.



Compact development of a 3D fingerprint optical coherence tomography device.



Thermal imaging of an additive manufacturing test bed.



A splicing process to join two optical fibres for fibre laser development.

04

BUILD AND TRANSFORM HUMAN CAPITAL AND INFRASTRUCTURE

BUILDING A CONTINUOUS PHARMACEUTICAL MANUFACTURING INDUSTRY IN AFRICA

The CSIR is growing its capabilities in pharmaceuticals process innovation to stimulate the country's active pharmaceutical ingredient manufacturing industry.

To help foster an environment that will enable Africa to become a viable and sustainable manufacturer of pharmaceutical ingredients and drugs, the CSIR has received a substantial investment from National Treasury and the Department of Science and Innovation to establish an open innovation facility.

Fourth industrial revolution technologies are affording Africa the opportunity to leapfrog existing batch manufacturing technologies and move directly into modern continuous flow manufacturing approaches. As part of the process of creating a continuous pharmaceutical manufacturing technology in South Africa, the CSIR, in collaboration with the University of Pretoria (UP) and Imperial College London, has made significant progress on demonstrator projects. One of these focuses on developing an optimised integrated multistep process for the production of an oncology drug used in the treatment of breast cancer. The scaling up of this process to kilogram scale is ongoing and, if successful, will demonstrate the techno-economic viability of the drug for future local production.

Another area of focus for the team in the past year has involved the validation of a UP-developed flow process for the production of an anti-inflammatory drug, which is being optimised at the CSIR to make the process more amenable to scale-up. Over the next year, CSIR researchers will be facilitating the inclusion of engineering solutions that will allow the process to be completely automated and performed in a continuous manner, with integrated in-line analytics.

As part of acquiring the right expertise in this area, the CSIR is investing in six MSc and PhD and four postdoctoral students.



CSIR postdoctoral researcher Dr Valerie Maswanganyi sets up a reactor used in research aimed at driving technology development for active pharmaceutical ingredient manufacturing in South Africa.



The mixing chip and coil reactor of a UniQsis FlowSyn Maxi system.



The computational interface for reactor automation, showing physical control systems and collection of data from in-line analytics.

A COMMITMENT TO LIVE LEARNING 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 African Weather Services 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.



The Cofimvaba Science Centre in the Eastern Cape.



Solar chimneys, a natural ventilation strategy.



Water harvesting, with the main entrance in the background.



The Interactive Visible Energy Centre.

05

RESEARCH, DEVELOPMENT AND INNOVATION FOR AND WITH THE REST OF AFRICA

AFRICAN PARTNERSHIP TO SUPPORT DEVELOPMENTAL PRIORITIES

The CSIR, the African Union Development Agency-NEPAD and Stellenbosch University have joined forces to host the AUDA-NEPAD Centre of Excellence in Science, Technology and Innovation.

The centre is one of five centres of excellence that have been approved by the African Union and that are being implemented by AUDA-NEPAD. The other four are in the fields of rural resources and food systems (Senegal), human capital and institutional development (Kenya), climate resilience (Egypt) and supply chain and logistics (host country yet to be named).

The partnership has been forged to accelerate the effective implementation of the African Union's Agenda 2063.

The AUDA-NEPAD Centre of Excellence in Science, Technology and Innovation will provide a platform for supporting and sourcing funding and other resources for the upscaling, dissemination and localisation of proven innovations to African Union member states and governments in support of their developmental priorities and the implementation of Agenda 2063. The centre acts as a channel for innovators to access alternative solution rollout options for reaching their clients and end-users.

Over 40 home-grown innovations have already been identified. These are innovations coming out of long-running programmes at Stellenbosch University and the CSIR, and represent widely tested and proven technologies or practices ready for upscaling and commercialisation across the continent. The innovations cover a wide spectrum of solutions in areas such as health, renewable energy, agriculture, water and sanitation to support countries in the aftermath of the Covid-19 pandemic.

HELPING UGANDA DEVELOP ITS ESSENTIAL OILS SECTOR

The CSIR produced a guideline for the development of the essential oils sector in Uganda and presented recommendations at a knowledge-sharing workshop with a broad range of stakeholders from Uganda and South Africa.

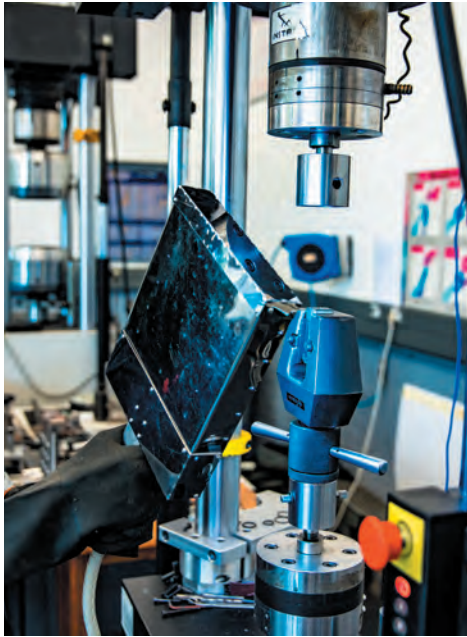
Essential oils are aromatic compounds distilled from plants that find application in industries that manufacture fragrances, flavours, cosmetics, household products and related high-value commodities. Uganda is well-positioned to contribute to this sector as the country has an abundance of fertile land, a tropical climate, basic infrastructure and a strong tradition in agriculture.

The CSIR-led essential oils pilot project provided information on crop yields, as well as the quality and marketability of the essential oils that are steam-distilled from the harvested plants. This information is required for future decisions on the economic viability of cultivating and processing essential oil plant species in Uganda for commercial purposes. The successful development of this sector will provide a diverse agricultural opportunity to numerous small-scale farmers in Uganda by benefiting economically from markets in first-world countries.

The project, undertaken with the Uganda Industrial Research Institute, was funded by the Department of Science and Innovation through the National Research Foundation, as part of a bilateral agreement between South Africa and Uganda. The CSIR has been involved in developing the essential oils sector in South Africa for more than 15 years.



Essential oils are extracted from aromatic plants.







PART C

PERFORMANCE INFORMATION

This section provides an overview of the **organisation's performance against the set objectives and targets for the 2020/21 financial year**. The overview provides a description of any significant developments that may have **impacted on the organisation's ability to deliver on its Strategic Plan and Annual Performance Plan**.

Auditor's report: Predetermined objectives.....	072
Situational analysis	072
Performance information by strategic objective.....	075
Revenue collection.....	084

AUDITOR'S REPORT: PREDETERMINED OBJECTIVES

The Auditor-General of South Africa (the external auditor) currently performs the necessary audit procedures on the performance information to provide reasonable assurance in the form of an audit conclusion. The audit conclusion on the performance against predetermined objectives is included in the report to management, with material findings being reported under the *Predetermined Objectives* heading in the **Report on other legal and regulatory requirements** section of the Auditor's Report.

For the Auditor's Report, refer to page 132 in PART F.

SITUATIONAL ANALYSIS

SERVICE DELIVERY ENVIRONMENT

A number of external and internal environmental factors influence the strategic direction of the Council for Scientific and Industrial Research (CSIR). Our research programmes address national priorities and, as such, our research, development and innovation (RD&I) activities are developed in response to national strategies such as the National Development Plan (NDP) and its derivative strategies and policies through various government departments, especially the Department of Science and Innovation (DSI). Equally, we develop capabilities to respond to national and international private sector requirements. We are cognisant of the changing environmental factors, both internally and externally, that may influence our strategic direction.

The 2020/21 financial year has been a very challenging one, as a result of the Covid-19 pandemic, which impacted economic activity, social life, and work environments globally and locally. Uncertainty due to an invisible, unforeseen challenge in the form of a virus has never in the past brought the world to a standstill so quickly. The outbreak and rapid spread of the Covid-19 virus and the threat to human life on the planet required rapid action on a global scale, necessitating innovative and swift changes to be implemented to safeguard people, our biggest asset, against the unknown.

The announcement of the South African national lockdown prior to the start of the financial year changed the world of work dramatically overnight. The business-as-usual environment became business unusual, requiring employees to stay at home to curb the spread of Covid-19. The pandemic brought the economy to a standstill and necessitated the implementation of government and CSIR protocols to ensure the health, safety and security of all staff of the CSIR. The use of the Internet, social media platforms and deployment of virtual communication tools enabled staff to continue with work remotely and conduct business as unusual. Initial challenges included communication, change management, and deployment of technology, hard- and software to enable employees to work remotely. Covid-19 had an adverse impact on business and operational planning across all entities in the CSIR during the 2020/21 financial year.

As a result of the Covid-19 pandemic and the national lockdown, the government had to raise funds for Covid-19 health and relief initiatives. The special 2020 Adjustments Budget brought an Adjustments Appropriation Bill and a Division of Revenue Amendment Bill to Parliament. It also formalised tax relief Bills aimed at giving effect to the government's Covid-19 response package and required Parliament's approval of these Bills. The CSIR was not spared from the parliamentary grant (PG) cut, which amounted to R99.7 million (10% of the initial Medium-Term Expenditure Framework allocation).

All the implementation pillars of the new CSIR Strategy, namely strategic clusters, capability development, human capital development and strategic infrastructure were affected by the PG cut. Innovation, commercialisation, technology transfer and diffusion activities were also affected and so was the funding to ring-fenced projects of the DSI that are hosted at the CSIR.

The Covid-19 lockdown had direct impacts on the achievement of organisational objectives and key performance indicators (KPIs) as per the agreed contract in the 2020/21 Shareholder's Compact. Delays in contracting, fieldwork and general productivity delayed outputs for the 2020/21 financial year. Proper governance channels were followed to revise the KPIs to take the lockdown effect into account. The CSIR Board Chairperson and the Minister of Higher Education, Science and Innovation agreed on the addendum to the 2020/21 Shareholder's Compact on 30 July 2020.

RD&I is critical to the future of South Africa. The government recognises that generating knowledge and improving the understanding of science enable society to find solutions to today's economic, social and environmental challenges, as well as achieve sustainable development. Historically, scientific and technological developments have underpinned industrial and economic advances, improvements in health systems, education and infrastructure, and have, thus, contributed to the quality of life of the people.

The state and nature of funding for RD&I remain a concern for the National System of Innovation, and particularly for the CSIR. The

Gross Expenditure on Research and Development remains well below the target of 1.5%, set by the then Department of Science and Technology. In addition, the PG allocation of the CSIR has experienced cuts for several years.

Our response in addressing funding constraints and achieving growth through our new strategy is to increase private sector and international income by aligning our offerings to market needs. Still, public sector income remains a key component of our income as offerings and services to public institutions enable the fulfilment of our mandate and strategic objectives (SOs). However, the National Treasury Regulations make it increasingly difficult for public entities to contract directly with government and state-owned enterprises. Public institutions require the CSIR to compete for research and development activities in open tenders, which, as a public entity mandated to perform this type of work, should not be the case. Annually, this practice led to the loss of revenue opportunities to the tune of over R450 million.

KEY POLICY DEVELOPMENTS AND LEGISLATIVE CHANGES

Our research programmes address national priorities as articulated by the President of South Africa in the State of the Nation Addresses, and are aligned with various national strategies and frameworks, such as the NDP, the Medium-Term Strategic Framework 2019–2024, and the departmental policies, particularly those of the DSI. The CSIR Strategy also seeks to give meaning to the DSI's White Paper on Science, Technology and Innovation, 2019, in particular. In addition to existing strategies, plans, policies and frameworks, the CSIR also intends to respond and contribute to the implementation of national priorities of the sixth democratic government that are under development. These include the NDP Five-year Implementation Plan, the Department of Trade, Industry and Competition's 'Re-imagining Industrialisation Strategy for South Africa' and its sector master plans, the DSI's Decadal Plan and the District Model.

What is encouraging is that industrial policies continue to place science, technology and innovation at the centre of industrial development, with a clear statement that certain sectors, such as mining, can only be transformed through technological innovations and strong partnership between government and the private sector.

ORGANISATIONAL PERFORMANCE ENVIRONMENT

The CSIR is a complex organisation that supports many industrial sectors. Its functional business and RD&I units, known as clusters, support the mining, healthcare, chemicals, agriculture and food, defence and security, manufacturing, smart places, and smart mobility sectors, together with the digitisation of government, public and private institutions.

As the result of the PG cuts, the organisation took initiatives to ensure financial sustainability through various directed cost-saving interventions. Safety and governance remained priorities for the

CSIR. In the safety area, we have maintained a good safety record for the year. Despite the budget cuts, the CSIR maintained the staff complement and increased its SET base by 4.8%. Salary increases were also put on hold for the 2020/21 financial year as a risk mitigation measure against reducing income streams.

The Covid-19 pandemic and associated national lockdowns resulted in decreased levels of productivity, as some staff could not work during level 4 and level 5 restrictions. The CSIR was unable to earn income on contracts due to delays in the procurement of goods required to support projects; as well as a reduction in income as a result of adverse economic conditions and inability to deliver on commitments to international clients due to limited mobility.

On the positive side, the situation led to reductions in operating costs (utilities, etc.) and the rethinking of ways of working that have an impact on the cost of doing business (limited travel, webinars, etc.). Moreover, the new opportunities that presented themselves in the health and manufacturing space were not in the business plans.

Despite the PG cuts, the CSIR delivered on various initiatives that contributed towards the national effort to manage and control the Covid-19 pandemic. The role of the CSIR in supporting the state was again highlighted during the onset of the Covid-19 pandemic, as the CSIR was requested to assist in a number of areas, including through establishing the National Response Centre, leading the ventilator production initiative, providing a testing service, and undertaking vaccine development and production of personal protective equipment. This is a testament to both the expertise and the multidisciplinary nature of the CSIR.

Performance in respect of scientific targets, such as publication equivalents and patents granted, exceeded targets. Translation of knowledge into technology demonstrators also exceeded targets, which means that the CSIR is doing more work in developing products that are at high technology readiness levels. Technology licences and joint technology development with industry did not meet targets. The main reason for underperformance in this regard was as a result of the strained economic conditions following the Covid-19 pandemic-induced recession due to the economic lockdowns across the world.

The number of small, medium and micro enterprises (SMMEs) supported during the reporting year exceeded the annual target set. Many projects supporting national policy and capability development for the state were completed in the fourth quarter, with both these performance areas exceeding targets.

Overall, the CSIR met or exceeded 25 of the 31 KPIs achieved and 19 of the 25 are over achieved. Of concern is the nature of the KPIs that were not met – 6 of 31 – as these relate to human resources and those associated with industrial development support, e.g. technology licence agreements and joint technology development with industry. As we move into the new financial year and implement the CSIR Strategy further, meeting these KPIs is an area of focus.

STRATEGIC OUTCOME-ORIENTED GOALS

The strategic intent of the new CSIR Strategy can be summarised as growth, sustainability, impact and relevance. These four pillars bring alignment between responding to our mandate and addressing internal organisational imperatives.

The CSIR's intention is to use its capabilities, such as skilled human resources, infrastructure and intellectual property, to support the growth of the South African enterprises and assist in growing the South African economy, contributing to the alleviation of poverty, and addressing unemployment and inequality. The CSIR also intends to grow as an organisation, strengthening its human capital base and other competencies required to remain a world-class organisation, while strengthening its financial position. Our intentions on sustainability refer to the CSIR developing technologies and innovations by diffusing/commercialising these to improve the competitive

advantage of South African enterprises and ensuring that they are financially and environmentally sustainable. New viable industries are also being created as part of the new strategy. This intent also speaks to the financial sustainability and good governance of the CSIR in a resource-constrained environment.

The CSIR will strive to make a greater impact on the economy and society through the commercialisation of technologies and innovations for industrial and socioeconomic development, as well as technology and knowledge transfer that enable a capable state.

The fourth pillar – relevance – relates to the appreciation of the relevance of innovation in industrialisation by private sector decision-makers and public sector policymakers. The intention is also to ensure that the organisation is relevant by addressing market needs and socioeconomic challenges, as well as being able to deliver on its mandate of improving the quality of life of the people of South Africa.

The strategy of the organisation hangs on its clearly defined SOs, which are derived from the prevailing strategic drivers in our operating environment:

S01

CONDUCT RD&I OF TRANSFORMATIVE TECHNOLOGIES AND ACCELERATE THEIR DIFFUSION.

This strategic objective seeks to ensure that the CSIR undertakes cutting-edge research and development in areas that will bring transformative change in the South African economy and society.

S02

IMPROVE THE COMPETITIVENESS OF HIGH-IMPACT INDUSTRIES TO SUPPORT SOUTH AFRICA'S RE-INDUSTRIALISATION BY COLLABORATIVELY DEVELOPING, LOCALISING AND IMPLEMENTING TECHNOLOGY.

This strategic objective seeks to improve the competitiveness of South Africa's high-impact industries through research, development, technology localisation and industrialisation in a collaborative manner with partners, thereby contributing to the re-industrialisation of the country.

S03

DRIVE SOCIOECONOMIC TRANSFORMATION THROUGH RD&I THAT SUPPORTS THE DEVELOPMENT OF A CAPABLE STATE.

This strategic objective emphasises the CSIR's role in supporting the development of a capable state and enabling the government to drive the socioeconomic transformation of South Africa through research, development and innovation.

S04

BUILD AND TRANSFORM HUMAN CAPITAL AND INFRASTRUCTURE.

This strategic objective seeks to build and transform the required human capital and invest in infrastructure to drive industrialisation and the advancement of society.

S05

DIVERSIFY INCOME, AND MAINTAIN FINANCIAL SUSTAINABILITY AND GOOD GOVERNANCE.

This strategic objective seeks to improve the CSIR's financial sustainability by diversifying revenue sources and optimising the business model to achieve competitiveness supported by good (efficient and sound) governance.

PERFORMANCE INFORMATION BY STRATEGIC OBJECTIVE



CONDUCT RD&I OF TRANSFORMATIVE TECHNOLOGIES AND ACCELERATE THEIR DIFFUSION

Some programmes implemented to contribute towards SO1 included:

During 2020/21, the CSIR compiled and edited a draft version of a book titled: **The application of geophysics to deep-level gold and platinum mining in South Africa**. The compilation of the book was an output of a PG-funded project aimed at developing an in-house, in-mine geophysics capacity of the CSIR through training. The book publication will raise the CSIR's profile and enhance the marketing effort of our geophysics offering to the local mining industry. The book provides decision-makers at the mines, who may have limited geophysical experience or knowledge, with a better understanding of the various geophysical methods that may apply to standard deep-level gold and platinum mining problems. The book will serve as a much-needed source of training material for mining professionals and students at tertiary education institutions. In February 2021, a book proposal was sent to the Springer publishing company in the Netherlands and, after the initial review, the proposal was accepted in principle. Springer subsequently made an offer to publish the book when it presented the CSIR with a draft contract. This publishing option is currently being pursued, and the book is expected to be published in mid-2021. Once the book is published, it will contribute towards the 2021/22 SO1 Publication Equivalents KPI.

The CSIR's Information and Cybersecurity Centre has completed the development of the **VeristicPrint Visitor Identification System**, which combines in-house veristic biometric algorithm, web camera, and contactless fingerprint scanners. The core components of the software base system, including back-end, web-app and mobile-app designs, have been completed. The new base system configuration has also been completed, tested and deployed into the ICT servers. This base system has been integrated with mobile and web apps. End-to-end testing has been completed, and a pilot study within the CSIR visitors' environment is planned for 2021/22.

Project Inhlava entails the definition, specification and implementation of beyond visual range (BVR) and stand-off weapons (SOW) mission simulations. This was done as a subcontracted collaboration with Midnite Aerospace Solutions. BVR and SOW mission simulation aims to provide simulation-based acquisition and operational support for the air weapons and aircraft groups, allowing a deeper understanding of the complex interactions between various aircraft systems, weapons and their effective use in a threat/operational environment. The initial phase of the project is complete. Integrating and testing the minimum viable product is planned before evaluating it during the next phase.

The CSIR's Advanced Delivery Systems Platform has secured funding worth R2.7 million from 3Sixty/Tautomer Biopharmaceuticals Consortium. Researchers are developing a product of an **antimalarial nanoformulation** for bioequivalence testing in human clinical trials. This project first started in 2017, after CSIR researchers secured funding worth US\$1 million from the World Health Organization for the reformulation of antimalarial drugs towards an artemisinin-combination therapy. In a collaborative partnership with the University of Cape Town's Drug Discovery and Development Centre, a team of CSIR researchers successfully reformulated lumefantrine, which displayed increased water solubility and resulted in ~7-fold increase in lumefantrine absorption in mice – thus improving the therapeutic outcomes.

The formulation was based on a lipid matrix and showed that an additional fatty food intake was not required for improved exposure. Therefore, this halved the efficacy dose parameter when tested on infected mice with a high curing rate. Furthermore, the research project's success demonstrated the potential of the nano-encapsulation platform to reduce the dose frequency of antimalarial drugs.

As a result of the success achieved over the years through the team's scientific research and development efforts, the team will now partner with the Institute of Primate Research in Kenya to test the developed antimalarial nanoformulations on a baboon malaria model to demonstrate bioequivalence.

Using data obtained from preclinical testing, the most promising candidate(s) will be scaled up and taken forward for Good Manufacturing Practices-certified manufacturing. After this process has been established, the clinical dossier will be ready, and phase one human clinical trials will commence.

Umbiflow – The CSIR was contacted by the Bill & Melinda Gates Foundation (BMGF) to discuss how Umbiflow could benefit other investment projects by BMGF in the field of ultrasound and maternal and child health. The BMGF projects are targeting higher-end imaging applications that would not compete with the anticipated market sector for Umbiflow. One idea that is being followed up on concerns a licence for the algorithm within Umbiflow that processes the Doppler data with a view to develop the high-end machines, also producing the Umbiflow index value that is used to guide referrals.

The CSIR and mining companies' collaborative initiative – the Impact Catalyst – has shown interest to fund an intervention of Umbiflow's system into one district to explore the impact, ahead of rolling out

the system in all districts of interest around South Africa in due course (~212 clinics).

Umbiflow's clinical trial results were presented at the Global Health Science & Practice Technical Exchange Conference in April 2021. A dedicated session was set up solely to inform the global community of the South African clinical trial results. The results show a positive impact in reducing stillbirths and on the development of the baby

in the first few years, particularly in respect of muscle mass and neurological development.

In the past two years, Anglo American contracted the CSIR to evaluate and undertake local municipal capacity building in all municipalities where Anglo American mines are based. Anglo American is delighted with the CSIR's approach in executing this contract. The contract has been extended, increasing the total service level agreement value.

SO1 KPIs: Planned targets and actual achievements

SO1: Conduct research and development of transformative technologies and accelerate their diffusion.

Performance Indicator	Actual Achievement 2019/20	Planned Target 2020/21	Actual Achievement 2020/21	Deviation from Planned Target to Actual Achievement for 2020/21	Comment on Deviations	Threshold/ Number
KPI 01: Publication equivalents	437.5	278	406.5	46%	Target exceeded	>95%/>264
KPI 02: New priority patent applications filed	4	3	5	67%	Target exceeded	>75%/>2.3
KPI 03: New patents granted	21	10	26	160%	Target exceeded	>80%/>8
KPI 04: New technology demonstrators	37	38	48	26%	Target exceeded	>85%/>32
KPI 05: Number of technology licence agreements signed	8	17	3	-82%	Underperformance was due to subdued private sector activity and unconducive economic environment for the uptake of early-stage technologies	>75%/>12.8

The CSIR performed very well in knowledge generation during the 2020/21 financial year. The organisation produced 406.5 publication equivalents against an adjusted target of 278, thus exceeding (by 46%) the targeted performance level set. Five new priority patents, against an adjusted target of three, were filed, and there was a further 26 new patents granted against an adjusted target of ten. The adjusted target of 38 for technology demonstrators, was overachieved by 26%, with 48 submissions approved. The CSIR signed only three licence agreements for the financial year against a target of 17.

The CSIR acknowledges the support from the National Intellectual Property Management Office's Intellectual Property Support Fund towards maintaining the CSIR patent portfolio.

List of new priority patents filed

No	Patent title	Filing date	Application number	Country
1	Microemulsion drug delivery system for treatment of acute respiratory distress syndrome	7/08/2020	2020/04916	South Africa (SA)
2	Microemulsion drug delivery system for treatment of acute respiratory distress syndrome	7/08/2020	2020/04917	SA
3	Microemulsion drug delivery system for treatment of acute respiratory distress syndrome	7/08/2020	2020/04918	SA
4	Anti-viral biodegradable modified polysaccharides	11/08/2020	2020/04927	SA
5	Chemical-based self-contained self-rescuer	21/10/2020	2020/06525	SA

* 1-3 are all applications of a CSIR delivery system used in conjunction with antiviral lectins, immunomodulatory compounds and existing antiviral drugs.

New patents granted

No	Patent Title	Patent Number	Issue Date	Country
1	Membrane and method for preservation of produce	3346843	19/02/2020	European Patent Office (EPO)
2	Production of a spinel material	10-2085903	2/03/2020	South Korea
3	Electronically deriving a conclusion of the condition of slurry flow in a non-vertical conduit	AP 5088	8/04/2020	African Regional Intellectual Property Office (ARIPO)
4	Spinel material	3394919	29/04/2020	EPO
5	Immunomodulation by controlling ELR+ proinflammatory chemokine levels with the long non-coding RNA UMLILO	3234135	29/04/2020	EPO
6	Electronically deriving a conclusion of the condition of slurry flow in a non-vertical conduit	10,655,995	19 05 2020	United States of America (USA)
7	Site-specific nuclease single-cell assay targeting gene regulatory elements to silence gene expression	3041931	10/06/2020	EPO
8	Apparatus, methods and systems for measuring and detecting electrical discharge	10-2133619	7/07/2020	South Korea
9	Threat detection method and system	3449204	22/07/2020	EPO
10	Liquid flame retardant composition	10,731,290	4/08/2020	USA
11	Production of a layered lithium-manganese-nickel-cobalt oxide material	3164363	19/08/2020	EPO
12	Liquid flame retardant composition	3155068	26/08/2020	EPO
13	Isotactic polypropylene-based composite	10,767,018	8/09/2020	USA
14	Accelerated Pavement Testing (Divisional)	10,768,084	8/09/2020	USA
15	Accelerated Pavement Testing	3256837	23/09/2020	EPO
16	A method of switching from a first encoded video stream to a second encoded video stream	342096	21/07/2020	India
17	Production of a layered lithium-manganese-nickel-cobalt oxide material	AR 102033	29/04/2020	Argentina
18	A system for monitoring the condition of structural elements and a method of developing such a system	2845803	22/09/2020	Canada
19	Production of a spinel material	2,880,876	7/07/2020	Canada
20	A wing control system	BR 11 2013 003942-6	1/12/2020	Brazil
21	Production of a layered lithium-manganese-nickel-cobalt oxide material	6807307	9/12/2020	Japan
22	Method for encapsulating pharmaceutical actives	AP 5291	6/10/2020	ARIPO
23	Site-specific nuclease single-cell assay targeting gene regulatory elements to silence gene expression	2014316676	5/11/2020	Australia
24	Method for encapsulating pharmaceutical actives	359311	24/02/2021	India
25	A method and system for analysing a biological sample of label-free cells for presence of an infective agent	3574306	3/03/2021	EPO
26	Preventative treatment and remission of allergic diseases	PI 0708554-0	19/01/2021	Brazil

Technology licence agreements signed

No.	Licensee	Technology	Date signed
1	CapeBio	Hotstart Polymerase Chain Reaction (PCR) kit	30/09/2020
2	Sawubona Mycelium (Pty) Ltd	Flammulina velupites – various products	25/02/2021
3	Hensoldt Optronics (Pty) Ltd	Core Radar technology	10/02/2021



IMPROVE THE COMPETITIVENESS OF HIGH-IMPACT INDUSTRIES TO SUPPORT SOUTH AFRICA'S RE-INDUSTRIALISATION BY COLLABORATIVELY DEVELOPING, LOCALISING AND IMPLEMENTING TECHNOLOGY.

Some programmes implemented towards SO2 include:

Photonics Prototyping Facility (PPF) launch – The facility houses class 1 000 clean rooms, technical and optical equipment, ranging from electronic, mechanical and diagnostic equipment for a variety of wavelengths. To demonstrate the practical uptake of the services of the PPF and its importance to the industry, two current clients participated in the launch. Their projects were showcased as part of the facility tour. These were the technology development on a laser rangefinder project for Kutleng Engineering Technologies and the characterisation of a first optical system to the company Adiviv Solutions, which integrated it into South Africa's first commercial metal additive manufacturing machine.

The other two current projects include the **GasCam** project, a collaboration between the National Laser Centre, Industrial Sensors and the SMME, UVIRCO, and the **optical coherence tomography** project that focuses on developing a novel fingerprint acquisition device. The system extracts both the internal (sub-dermal) and external (surface) fingerprints, thus avoiding false identification or fraud. It is a non-contact device and has applications in banks, mortuaries and forensic service facilities. While the project is in a prototype testing phase, a commercial partner has been identified for possible licensing of the technology.

Hensoldt Development Agreement and Licensing Agreement

– The CSIR and Hensoldt South Africa have signed co-development and licence agreements for new-generation radar technology. A new generation of tactical 3D surveillance radar systems, which will modernise one of Hensoldt's key radar product lines and further enhance its extensive radar portfolio, is being developed for naval and land deployment. Hensoldt South Africa (SA) has entered into a research and development agreement with the CSIR and will be leveraging its radar heritage built up over the past 75 years.

Hensoldt AG in Germany (the parent company of Hensoldt SA) made a strategic decision to develop this in South Africa as part of a strategy to create a radar business in South Africa. They found that the CSIR has the appropriate technology and capability to develop this radar with Hensoldt SA as an industry partner.

The CSIR and Hensoldt technical teams have formed an effective joint project team to develop the radar. They completed the preliminary design phase in the past year, leading to the initial design review. Hensoldt highly commended the quality of the design phase output.

The Licensing Agreement will enable Hensoldt to manufacture and sell the South African radar worldwide and royalties will be paid to the CSIR.

The development of world-class, disruptive radar technologies at the CSIR has successfully attracted significant foreign direct investment to develop an advanced product in South Africa while enabling the establishment of industry in South Africa. This will result in the export of a high-value South African product, in partnership with one of the premier radar companies in the world, and will contribute passive

income to CSIR revenues, thus contributing to the objective of income diversification.

As a world-class facility, the **CSIR Biomanufacturing Industry Development Centre (BIDC)** has provided product scale-up support to a female, black-owned SMME called Sawubona Mycelium. Using the centre's world-class equipment and its research and development expertise, the team and the SMME were able to successfully produce about 800 litres of the product by cultivating Enokitake (a type of mushroom) in a liquid cultivation process, which is a first in South Africa.

According to Dr Ghaneshree Moonsamy, the principal investigator for this project, the conventional method used to grow mushrooms is usually in a bed of soil that may contain other additives. However, the decision to produce this particular organism in liquid form is not only a technology shift, but it allows the SMME to derive more value and super ingredients from the mushroom. This key advantage gives the SMME the option to explore two or more products for market from one mushroom cultivation process.

From the liquid-based production process designed by CSIR researchers, a high-value compound referred to as Beta-Glucan can also be extracted from the liquid fraction. This compound may be used in cosmetic products as an alternative, more cost-effective compound in product formulation. Additionally, as part of the production process, the team of researchers was also able to extract enough biomass, which was converted into a dried mushroom valuable powder in food products as additives or flavourants.

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 various applications. Currently, it has two technology products that have been developed, and the process has been assigned a technology readiness level of 8, which is an indication of technology maturity (9 being the most mature technology level). The BIDC has produced market samples for these products and licensed the production technology to the SMME.

The proposal of postdoctoral researchers affiliated with the Earth Observation Group, Drs Marie Smith and Lisl Robertson Lain – to become 'Early Adopters' (EA) of the **National Aeronautics and Space Administration (NASA) Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE) mission** – was successful. The specific EA project can be viewed on the PACE website. PACE is currently in the design phase of mission development. The satellite is scheduled to launch in 2022, extending and improving NASA's over 20-year record of satellite observations of global ocean biology, aerosols (tiny particles suspended in the atmosphere) and clouds. Dr Smith presented the proposed project during the PACE EA mission teleconference on 10 August 2020. Following the satellite launch, the proposed EA work of the CSIR Earth Observation Group will be one of the first to have access to the hyperspectral radiometry observations of the satellite, which will be used to enhance the fisheries and aquaculture decision-support tool for the South African coast.

SO2 KPIs: Planned targets and actual achievements

SO2: Improve the competitiveness of high-impact industries to support South Africa's re-industrialisation by collaboratively developing, localising and implementing technology.

Performance Indicator	Actual Achievement 2019/20	Planned Target 2020/21	Actual Achievement 2020/21	Deviation from Planned Target to Actual Achievement for 2020/21	Comment on Deviations	Threshold/ Number
KPI 06: Number of localised technologies	9	10	5	-50%	Effects of the Covid-19 pandemic. Explanation in the text following.	>75%/>7.5
KPI 07: Number of joint technology development agreements being implemented for industry	23	20	25	25%	Target exceeded	>75%/>15
KPI 08: Number of SMMEs supported	116	68	96	41%	Target exceeded	>75%/>51

At the end of the 2020/21 financial year, the CSIR did not achieve the targeted number of localised technologies. Only five technologies were localised against a revised target of ten. Work delays and restrictions due to the Covid-19 pandemic and the resultant lockdowns under the national state of disaster have hampered our efforts to meet with potential clients. The CSIR planned to localise CO₂ fermentation technologies from the United Kingdom (UK), but the visit to the UK in March 2020 was cancelled due to the Covid-19 pandemic. The CSIR also planned to localise insulin technology from the International Centre for Genetic Engineering and Biotechnology in Italy, but this was also delayed due to the pandemic.

Twenty-five joint technology agreements were implemented with the industry partners against a revised target of 20.

The CSIR exceeded the adjusted target set to support 68 SMMEs and supported 96 SMMEs by the end of the financial year. The importance of the SMME sector driving and taking up innovations is key to the CSIR achieving its strategic intent. This performance is also a testament to the CSIR's commitment to supporting emerging industries, small businesses, and the national objectives of economic development and job creation.



DRIVE SOCIOECONOMIC TRANSFORMATION THROUGH RD&I THAT SUPPORTS THE DEVELOPMENT OF A CAPABLE STATE.

Some programmes that contributed towards SO3 were:

The **Department of Defence (DOD)** has contracted the CSIR to provide synthetic aperture radar (SAR) and ground-penetrating radar (GPR) research support. These technologies play a crucial role in identifying hazardous areas that may have been compromised by subsurface cavities or developing sinkholes – particularly in dolomitic areas and where DOD infrastructure and facilities are at risk. The NextGen Enterprises and Institutions cluster is responsible for the SAR component, and the Defence and Security cluster has been tasked with handling the GPR component. Due to the promising performance of GPR in past joint projects, the Defence Works Formation of the DOD has subsequently identified the need to build an in-house GPR capability that would enable the ongoing and sustainable application of the technology at its facilities.

Consequently, the Defence and Security cluster is assisting the DOD with a phased technology transfer between the CSIR and the Defence Works Formation. As part of this technology transfer,

the CSIR was tasked to advise the DOD on acquiring suitable GPR equipment and to assist in procuring the selected hardware. The procured system arrived in South Africa from Canada in December 2020, following a lengthy tender-based procurement process. The system was subsequently assembled, deployed and tested in January 2021. The CSIR also provided training to selected DOD staff to establish an in-house capability for the DOD to perform GPR surveys across its various facilities in the country.

Dr Moshe Masonta, together with other staff from the Defence and Security cluster, participated in the development of the **Gauteng 4IR Strategy**. Dr Rachel Chikwamba, CSIR Group Executive: Chemicals, Agriculture, Food and Health, co-chaired the strategy development process. The strategy was presented to Gauteng Premier, Mr David Makhura, and was well received.

At the end of March 2021, the Computer Automated Land Cover mapping system (CALC) was implemented for the **Department of Environment Forestry and Fisheries (DEFF)** to increase the

department's capacity to fulfil its own spatial land cover data requirements. This system enables DEFF and the National Geo-spatial Information agency to produce a crucial land cover reference dataset for resource management and planning at all levels of government. The system utilises Sentinel-2 satellite imagery to map land cover at 20 m in 73 distinct classes. CALC, in its totality, resides on the Amazon Web Services cloud platform, where automated processing creates yearly products and change assessments between years. This system produces national land cover products within a week, whereas manual methods produce datasets in 6 to 18 months. CALC already produced land covers for 2018 and 2020. This system was developed in partnership with a private company, Geoterrimage, which developed the algorithms and models of vegetation's spectral characteristics.

The **Draft National Spatial Development Framework** has been approved by Cabinet and published for national comments to provide a spatial vision and guidelines to the national government (including sector departments), districts and municipalities to ensure that long-term plans, infrastructure investment and development management contribute to national resource sustainability and spatial transformation. Through the process, national risk regions have subsequently been identified to secure joint national action to mitigate national risks (climate change, water, economic transition, socioeconomic decline). Technical assistance was provided to three metropolitan municipalities through National Treasury's Cities Support Programme. Climate change risk and vulnerability data from the Green Book were shared, and planning support was provided

to interpret, analyse, and mainstream information into planning instruments and processes.

The Green Book team successfully updated the City of Tshwane's climate risk and vulnerability assessment, developed climate risk zones and adaptation actions for all the relevant city functions as part of the City's Climate Action Plan. The work will be published online in the Green Book and will serve as a 'template' for the other eight metropolitan profiles.

The CSIR entered into an agreement with the **Gauteng Department of Roads and Transport (GDRT)** to support road asset management for three years. The agreement is an extension of two similar contracts; the first one from 2014 to 2017 and the second one from 2018 to 2021.

The Provincial Roads Maintenance Grant (PRMG) is a conditional grant established by the government in 2013 to ensure proper road maintenance. The introduction of this grant made Provincial Road Asset Management Systems (RAMS) a priority. It is required for provincial road departments to have a functional RAMS with up-to-date condition data to qualify for funds from the PRMG.

Through this programme, the CSIR will assist the GDRT with various activities to maintain, support and update the province's current RAMS, and with the collection and analysis of condition data for the provincial road network and provincial bridges' major culverts to determine the maintenance needs for these assets. The CSIR will further assist with conducting annual road safety appraisals and presenting training courses to GDRT staff.

SO 3 KPI: Planned targets and actual achievements

SO3: Drive socioeconomic transformation through RD&I that supports the development of a capable state.						
Performance Indicator	Actual Achievement 2019/20	Planned Target 2020/21	Actual Achievement 2020/21	Deviation from Planned Target to Actual Achievement for 2020/21	Comment on Deviations	Threshold/ Number
KPI 09: Number of reports contributing to national policy development	24	17	21	19%	Target exceeded	>75%/>12.8
KPI 10: Number of standards delivered or contributed in support of the state	10	9	11	22%	Target exceeded	>75%/>6.8
KPI 11: Number of projects implemented to increase the capability of the state	67	36	44	22%	Target exceeded	>75%/>27

The CSIR exceeded all targets that contribute to the support of a capable state. Of note and related to SO3 is that, with the outbreak of the Covid-19 pandemic worldwide, as at mid-March 2020, the CSIR was called upon to deploy its scientific and technological expertise to support the national effort to combat the pandemic. Several Covid-19 projects were initiated during quarter 4 and will be ongoing during 2020/21. The CSIR was heavily involved in the National Ventilator Project (NVP). The NVP requirement of 10 000 ventilator systems was completed and delivered to clinics and hospitals across the country.

SO4

BUILD AND TRANSFORM HUMAN CAPITAL AND INFRASTRUCTURE.

Build and transform human capital: The CSIR Human Capital function has four strategic pillars that drive the human capital delivery and excellence. These are as follows:

Building a diverse talent ecosystem and a sustainable future supply, which recognises the critical role that human capital has in meeting the immediate talent demands of the business post-restructuring, and responding to new CSIR Strategy demands in addressing the longer-term talent requirements and sources of supply. This encompasses building and retaining our own talent, as well as implementing the CSIR Talent Sourcing Strategy through LinkedIn to source disciplines now and in the future, and better enable the movement of skilled resources across the three divisions.

Strengthening leadership and deepening professionalism, which reinforces the commitment to leadership development and deepening professional SET and non-SET competencies. Leadership competencies are being strengthened through the enhancement and rollout of core leadership programmes, a commitment to the development of leaders and high-potential staff, and succession planning. In addition, the drive to increase behavioural and technical competencies is delivered through leveraging the CSIR Innovation Leadership and Learning Academy, supplemented by business, commercial and function-specific skills development, and increasing the profile of technical professionals.

Improving individual and organisational performance, which emphasises simplifying the organisation to better integrate competencies on a CSIR-wide basis and focuses on making the new

structures work. This includes support to the business critical to the CSIR Strategy.

Increased efficiency and the effectiveness of human resource systems and processes is key to the standardisation and simplification of human resource processes supported as necessary by information technology solutions, in response to the 4IR and further implementation of the human capital operating model.

Strategic Infrastructure Programmes. During 2020/21, 23 infrastructure projects were funded as part of the Annual Capital Investment Plan. The projects fell under the categories of ICT and facilities, and general infrastructure.

The CSIR, with support from the DSI, also continues to operate five research and development facilities that provide the capability for industrial innovation initiatives, such as prototyping, upscaling, pilot manufacturing and testing and which allow research to be translated into market-ready products. These facilities include the Photonics Prototyping Facility, the BIDC, the Biorefinery Industry Development Facility, the Nanomaterials Industry Development Facility and the Nano-micro Device Manufacturing Facility.

Already in the reporting period, funding by National Treasury through the DSI, amounting to R185 million (including VAT) over three years, was invested in research infrastructure intended to impact the pharmaceutical, manufacturing, smart mobility and infrastructure industries.

SO4 KPIs: Planned targets and actual achievements

SO4: Build and transform human capital and infrastructure.

Performance Indicator	Actual Achievement 2019/20	Planned Target 2020/21	Actual Achievement 2020/21	Deviation from Planned Target to Actual Achievement for 2020/21	Comment on Deviations	Threshold/ Number
KPI 12: Total SET staff	1 367	1 410	1 474	4.5%	Target exceeded	>95%/>1 340
KPI 13: Percentage of SET staff who are black	63.35	63%	66.5%	4%	Target exceeded	Within 2%pts/ ≥61%
KPI 14: Percentage of SET staff who are female	35.04	37%	36.4%	-1%	Target met	Within 2%pts ≥35%
KPI 15: Percentage of SET staff with PhDs	21.87	22%	20.9%	-1%	Target met	Within 1%pt ≥21%
KPI 16: Total chief researchers	11	12	15	25%	Target exceeded	>90%/>13.5
KPI 17: Percentage of chief researchers who are black	18.18	25%	20%	-5%	Target met	Within 5%pts ≥20%

SO4: Build and transform human capital and infrastructure.

Performance Indicator	Actual Achievement 2019/20	Planned Target 2020/21	Actual Achievement 2020/21	Deviation from Planned Target to Actual Achievement for 2020/21	Comment on Deviations	Threshold/ Number
KPI 18: Percentage of chief researchers who are female	18.18	17%	20%	3%	Target exceeded	5%pts/ ≥12%
KPI 19: Total principal researchers	149	184	179	-3%	Target met	>95%/>175
KPI 20: Percentage of principal researchers who are black	28.19	37%	30.7%	-6%	Intense competition for SET skills in the market contributed to the CSIR not meeting the target.	Within 3%pts ≥34%
KPI 21: Percentage of principal researchers who are female	16.11	20%	19%	-1%	Target met	Within 3%pts ≥17%
KPI 22: Number of exchange programmes with industry	11	11	8	-28%	Secondments were affected by the Covid-19 pandemic and resultant lockdowns.	11
KPI 23: Property, plant and equipment(PPE) investment (Rm)*	85.51	55	89.4	87.6%	Target exceeded	>95%/>52%

The total CSIR staff headcount at the end of the 2020/21 financial year was 2 143, compared to 2 104 as at 31 March 2020, an increase of 39 (1.9%) for this financial year. The CSIR headcount at the end of quarter 4 included 1 474 (68.8%) SET staff and 669 (31.2%) support staff. Compared to the previous financial year when the headcount included 65% SET staff and 35% support staff. The proportion of SET staff has increased by 3.8%.

The CSIR also continued to invest in its human capital development programmes, such as the Graduate-in-Training programmes, with 14 new individual intakes in 2020/21 and the Accelerated Researcher

Development Programme with 10 candidates participating as part of its strategy to 'grow its timber'.

In 2020/21, the CSIR allocated a PPE budget of R55 million and formally approved a Capital Investment Plan that prioritised infrastructure and equipment procurement projects in the areas of RD&I, ICT and general infrastructure, including for facilities management. Expenditure against the PPE budget made available in 2020/21 was above target, at R89.4 million. The CSIR is putting stringent measures in place to improve the delivery of infrastructure and expenditure of budget allocated for the future year.



DIVERSIFY INCOME, MAINTAIN FINANCIAL SUSTAINABILITY AND GOOD GOVERNANCE.

Income diversification remains a key objective for the CSIR. The aim is to reduce the financial risk associated with a significant reliance on public sector income. Income diversification is also expected to improve the CSIR's profitability. As part of its reviewed business model, the CSIR aims to increase private sector R&D income as well as rigorously pursue international opportunities, especially on the African continent. Commercialisation and

technology transfer will be intensified as part of achieving impact, in line with our strategic intent, but also to grow our royalty and licensing income.

Good governance is the bedrock of the CSIR's performance goals and the organisation aims to maintain an unqualified audit outcome, keep a good safety record and improve its B-BBEE credentials.

SO5 KPIs: Planned targets and actual achievements

SO5: Diversify income, maintain financial sustainability and good governance.						
Performance Indicator	Actual Achievement 2019/20	Planned Target 2020/21	Actual Achievement 2020/21	Deviation from Planned Target to Actual Achievement for 2020/21	Comment on Deviations	Threshold/ Number
KPI 24: Total income (Rm)	2 747	2 709	2 569	-140	Effects of the Covid-19 pandemic. Explained in text following.	>95%/>2 574
KPI 25: Net profit (Rm)	55	-83,4	96	+R179.4m	Target exceeded	>95%/>-79.3
KPI 26: South African public sector income (% total income)	55	58,5%	56%	-2.5%	Target in line with CSIR Strategy in terms of income diversification. Read in relation to KPI 27 and KPI 28 – less reliance on public funding.	>95%/>55.6%
KPI 27: South African private sector income (% total income)	5	9,6%	13%	3.4%	Target exceeded	>95%/>9.1%
KPI 28: International contract income (% total income)	5	5,9%	5.0%	-0.9%	The gap can be mainly attributed to the inability to secure and finalise a number of planned contracts due to international travel restrictions.	>95%/>5.6%
KPI 29: B-BBEE rating*	4	3	2	Improved	Target exceeded	3
KPI 30: Recordable incident rate	1.82	2	0.53	Improved	Target exceeded	2
KPI 31: Audit opinion	Unqualified audit opinion	Unqualified audit opinion	Unqualified audit opinion	Target met		Unqualified audit opinion

For the reporting year, the CSIR's total income amounted to R2 569 million. This was less than the budget of R2 709 million, also lower than the 2019/20 performance of R2 759 million. The net profit at R96 million exceeded the budget by R179.4 million and the prior year's actuals by R41 million. Contract income amounted to R1.9 billion and this is R98.3 million or 4.9% below the budget. The gap can be mainly attributed to the inability to secure and finalise a number of planned contracts. Total expenditure amounted to R2 514 million and this was 11% below budget.

As a result of the Covid-19 pandemic and associated lockdowns, the following had an impact on operating revenue during the year:

- Sales secured but no capacity to earn revenue and still impacting on ability to earn revenue in some clusters;
- Travel restrictions on local work during earlier stages of lockdown and which continues to impact on international work;
- Laboratories and other technical facilities not operational for extended periods; and
- ICC events cancelled – restrictions on large gatherings.

The largest portion of the CSIR's income, 56%, is contract R&D from the public sector, and this is followed by the PG at 27%. Private

sector and international income were at 13% and 5.0%, respectively, during the reporting year. The gap can be mainly attributed to the inability to secure and finalise a number of planned contracts, technical facilities that were not operational for extended periods; and travel restrictions imposed during the various stages of the national lockdown impacted on delivery. The strengthening of the value of the South African rand against major currencies also impacted on international contract income.

During 2021/22, the CSIR will continue to increase its focus on the private sector by aligning its offerings to their needs, and will also enhance collaborations and co-investment opportunities with this sector of the economy.

The CSIR improved with regard to its B-BBEE rating level, moving from level 4 to level 2. Measures that were implemented to improve performance in this regard include the CSIR's participation in the Youth Employment Service programme.

During the reporting year, the recordable incidence rate, a performance measure for safety, was at 0.53, and this was below the set target of 2.

REVENUE COLLECTION

Sources of revenue	2020/2021			2019/2020		
	Estimate	Actual Amount Collected	(Over)/Under Collection	Estimate	Actual Amount Collected	(Over)/Under Collection
	R'000	R'000	R'000	R'000	R'000	R'000
Parliamentary grant	703 100	657 846	-45 254	758 068	731 202	26 866
Contract income	2 005 400	1 907 110	-98 290	2 098 168	2 006 942	91 226
Royalty income	-	3 691	3 691	3 090	3 616	-526
Total	2 708 500	2 568 647	-139 853	2 859 326	2 741 760	117 566

The CSIR has earned less than the estimated PG over the two financial years due to reduction of budget votes by the National Treasury. The gap in contract income can be mainly attributed to the inability to secure and finalise a number of planned contracts.

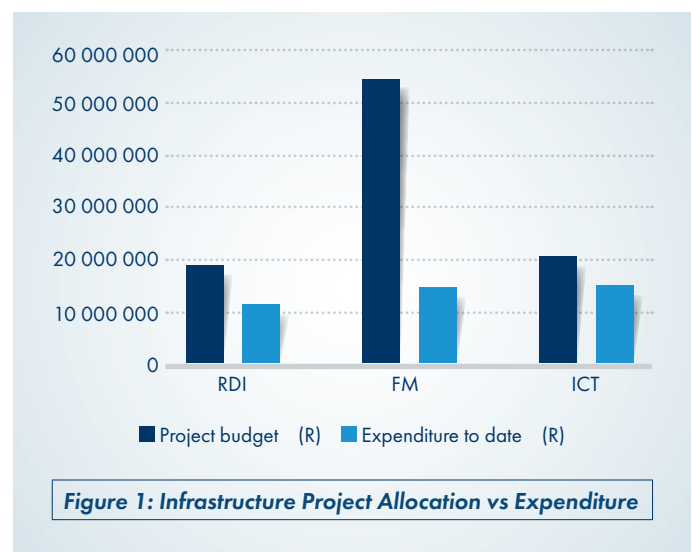
CAPITAL INVESTMENT

Investing in infrastructure is a key intervention to achieve the objectives of the CSIR strategy and in particular strategic objective 4. On 11 June 2020, the Capital Investment Plan (CIP) for the 2020/21 financial year was presented and approved by the CSIR EXCO. The CIP 2020/21 performance is reported on capital investment planning and the execution of capital projects, consolidated from reports provided by the different areas which have funding approved by EXCO.

Table 1: CIP 2020/21 Investment

Category	Value
Research and development infrastructure (External Funding)	R66 389 067
State	R5 489 067
Grant	R13 500 000
National Treasury	R47 400 000
Information and Communications Technology	R20 600 000
CSIR PPE Funding	R5 600 000
Department of Health	R15 000 000
Facilities and General infrastructure	R55 400 000
CSIR PPE Funding	R44 400 000
Department of Science and Innovation	R10 000 000

On average, 43% of the allocated infrastructure funds for the 2020/21 financial year has been spent. From the allocated infrastructure funds, ICT has spent 73% of funds, the RDI office 58% of the externally funded projects and facilities management spent only 26% of the allocated funds. The budget vs expenditure is as shown in Figure 1 and it is evident that better planning is required to fully utilise the funds requested by each area.



Research and development capital projects

The programme was initiated in February 2021, and remains in the early phases of implementation. As such, most of the work carried out to date is attributed toward the programme and project initiation phases.

Overall, the programme is on a track and it is envisaged to be completed within the agreed three-year period and budget. The programme will also continuously monitor of the progress and document key aspects to assess whether the programme is performing as envisioned/intended. Furthermore, considering the early phase of the programme, the format and content of this report remains of a basic nature and is expected to be more comprehensive in the next report.

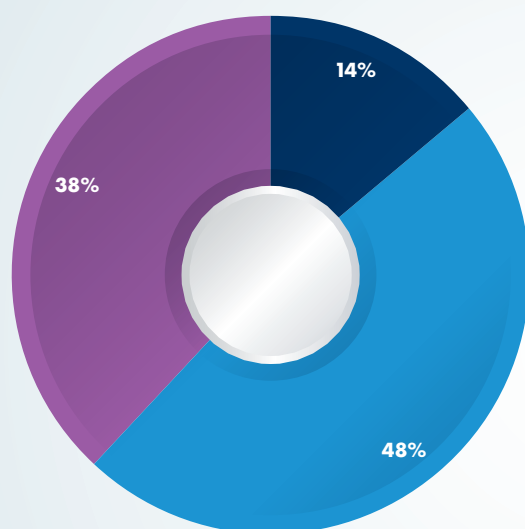
Expenditure for the FY 2020/21 amounted to 10% of the budget (as at 31 March 2021).

Facilities and general infrastructure

Due to the Covid-19 challenges in 2020/21, most of the projects in this space are carry-over projects and committed projects from the last financial year. There are also two key projects that are required for the continuation of the National Treasury projects. There is currently a mix of projects, with most projects in procurement

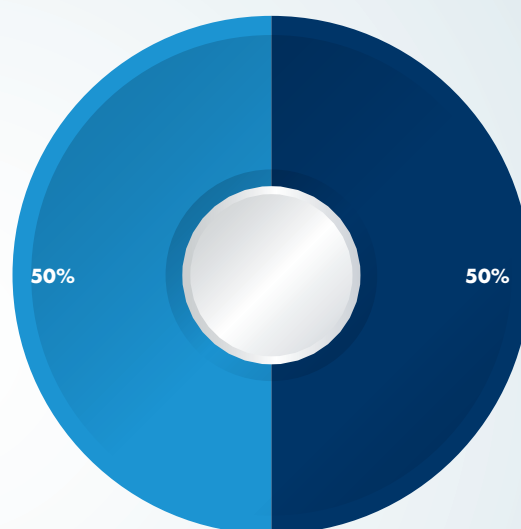
stages. Of the 21 planned projects for the financial year, eight are complete, 10 are at procurement and three are at the development and design stage. Only 26% of the allocated funds have been spent in this financial year and the remaining funds are committed for the following financial year as the projects have been initiated. There is one project (Disability Access Audit), that has overspent an amount of R307 000 from the initially allocated amount. However, this project is complete. The facilities projects focus largely on addressing

the deferred maintenance priorities related to building systems and infrastructure. Currently, 38% of the projects are complete. A further 48% of the projects are at procurement stage, and 14% are at the design and development phase as seen in Figure 2. Since most of the projects are already committed, these will require commitment in terms of funding in 2021/22. Such projects will be referred to as committed funds and will request funding in 2021/22 CIP.



■ Design and Development ■ Procurement ■ Completed

Figure 2: Facilities management projects at different phases



■ Design and Development ■ Procurement

Figure 3: ICT Projects at different phases

Information and Communications Technology projects

ICT has two current projects, with one project in the planning phase and one completed. The projects involved mainly the architecting of solutions, after which procurement of the equipment is done and thereafter the installation and commissioning thereof. The projects allocated to ICT included the externally funded National Department of Health Data Centre hosting, which is now complete, and the upgrade of the CSIR Data Centre project funded by the CSIR is currently in the planning phase. This area has good progress with about 73% of the funds allocated spent on the projects. Initially, the externally funded project was the priority focus. Of the internally funded CSIR project (data centre upgrade), the feasibility and planning phases have been completed. This project aims to initially upgrade the uninterrupted power supply to increase capacity and resilience and then upgrade the current ICT facility in building 16. ICT aims to request funding for this infrastructure project in 2021/22.

PRIORITY PROJECTS

Gateway to Science and Innovation Centre (Visitors/ Science Centre): Phase 1 – Strategy and planning

The Gateway project business case and feasibility study are complete. The studies form the basis of the next stage of the project which will identify partners and funding. A workshop was held with a fundraiser which further helped finalise the possible different options. A road map is finalised, and the development of the Digital Gateway has been identified to be the start of the broader Gateway

to Science and Innovation Centre project. This will be an initial step that will help focus on sourcing external funding for the further development of this project.

Residential accommodation

Delta Built Environmental Consultants and BDO, the Transactional Advisers, have delivered the first draft of the Strategic Road Map, including the proposed transaction model, risks, implications for the CSIR, market study, technical study, legal study, an implementation plan and the financial model. This project is on track considering the external environment and will soon be ready to go to market to attract investors.

Mega interdisciplinary Shared Laboratory Model

Request for Proposals (RFPs) for the development of these projects have been created. These are for studies to understand the external and internal needs for the Shared Labs and Pilot and Pre-manufacturing Precinct. Internal stakeholder engagement on the RFP development has been undertaken and RFPs for both projects developed. Only one response was received on the Shared Lab RFP, and the latter will be resubmitted to the market at a later stage.

Pilot and pre-manufacturing facility

The development of the RFP, in consultation with line management, to undertake a needs and gap analysis to inform concept development, is underway.



PART D

GOVERNANCE

The CSIR Board, along with its various committees, is responsible for the **oversight of the application of the CSIR mandate** through delivering on the annual plan and the performance of the organisation. **This section provides an overview of the governance systems**, processes and controls in place to hold the organisation to account.

Introduction	088
Portfolio committees.....	088
Executive authority.....	089
The CSIR Board.....	090
Risk management.....	097
Internal audit and audit committees	098
Compliance with laws and regulations.....	099
Fraud and corruption.....	099
Minimising conflict of interest.....	100
Code of conduct.....	101
Health, safety and environmental issues.....	101
Board secretary.....	101
Social responsibility.....	102
Audit and risk committee report.....	102
B-BBEE compliance performance information.....	103

INTRODUCTION

Corporate governance embodies processes and systems that direct, control and hold public entities to account. In addition to legislative requirements based on a public entity's enabling legislation and the Companies Act, 2008 (Act 71 of 2008), when it comes to public entities, corporate governance is applied through the precepts of the Public Finance Management Act (PFMA), 1999 (Act 1 of 1999) and associated regulations, and run in tandem with the principles contained in the King IV Report on Corporate Governance. While the King IV Report on Corporate Governance is not legally binding, it serves as a benchmark against which the conduct and performance of the CSIR's governance structures are measured, allowing the CSIR to act with independence and within the best interest of the organisation, and in support of its mandate to accelerate socioeconomic prosperity through leading innovation.

Parliament, the Accounting Authority (CSIR Board of Directors) and the Accounting Officer (CSIR Chief Executive Officer [CEO] and delegated executives) of the public entity are responsible for corporate governance.

PORTFOLIO COMMITTEES

The Chairperson of the Board and the Executive Management Committee (EXCO) hold bilateral meetings with the Executive Authority to ensure that performance is in line with the Shareholder's Compact.

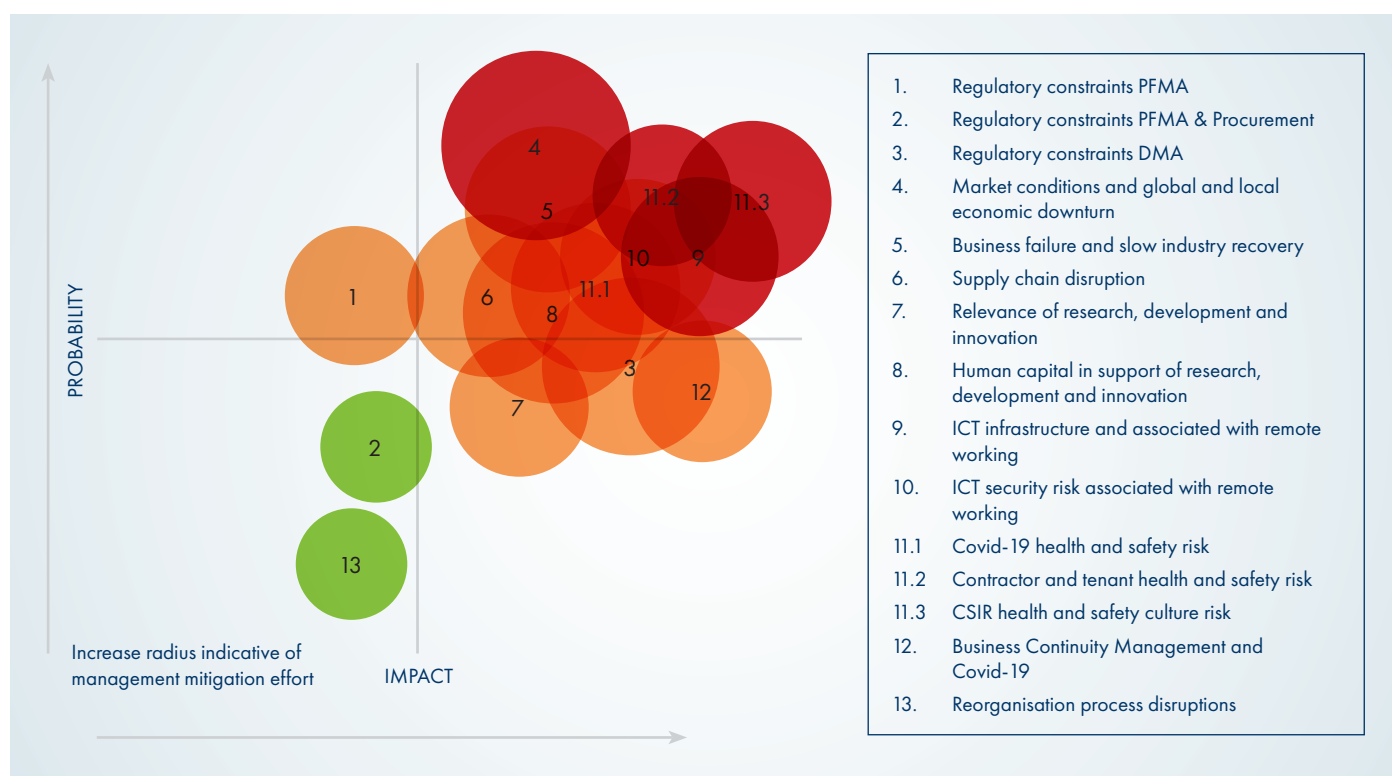
The table below details the engagement activities.

Date	Activity	Details	Type of Engagement	Responsible Person/Party
15 July 2020	Briefing by the CSIR on the impact of the Covid-19 pandemic on its operations	Presentation to Higher Education, Science and Technology	Accountability	CSIR Board/EXCO
20 October 2020	CSIR on impact of Covid-19 on its operations	Presentation to the Standing Committee on Appropriations	Profiling CSIR	CSIR Board/EXCO
13 November 2020	Annual Report briefing	Presentation to Higher Education, Science and Technology	Accountability	CSIR Board/EXCO
16 March 2021	Tabling of the CSIR Shareholder's Compact	Tabling of the Compact in ATC no. 38 of 19 March 2020	Accountability	CSIR Board/EXCO

AREAS OF RISK AND IMPLEMENTATION PLANS/ACTIONS

The following graph presents the top risks mapped for the organisation during last year and is reflective of the CSIR's year-end risk profile.

For each of these risks the organisation has a defined risk mitigation strategy and risk owner from the executive to monitor the mitigation progress and risk movement. It is presented to the Executive Committee monthly and to the Board Audit and Risk Committee quarterly.



EXECUTIVE AUTHORITY

The Executive Authority of the CSIR is the Minister of Higher Education, Science and Innovation. The Accounting Authority of the CSIR is the CSIR Board, duly appointed by the Minister. The Practice Note issued by National Treasury dealing with the Submission of Corporate Plans requires the inclusion of the following in the Corporate Plan:

- a. Five-year Strategic Plan
- b. Annual Performance Plan
- c. Governance Structures
- d. Risk Plan
- e. Fraud Plan
- f. Financial Plan
- g. Materiality/Significance Framework

The Executive Authority requires quarterly reporting from the CSIR on prescribed dates. For the 2020/21 financial year the following reports were submitted

- h. Quarter 1 Report – 20 July 2020
- i. Quarter 2 Report – 20 October 2020
- j. Quarter 3 Report – 20 January 2021
- k. Quarter 4 Report – 20 April 2021

No issues were raised by the executive authority on reports submitted.

THE CSIR BOARD

INTRODUCTION

The governance infrastructure of the CSIR is the collection of governance operating models – the people, processes and systems – that have been put in place to govern daily organisational activities.

This infrastructure also includes the processes used to gather and report information to the Board and external stakeholders, as well as management.

The Board is responsible for oversight across the organisation, in areas such as business and risk strategy, organisational structure, financial soundness, and regulatory compliance.

The CSIR governance operating model assists the Board to engage management in providing the information that the Board requires to exercise governance and risk oversight. It ensures the requisite oversight needed and gives input on policies that ultimately influence the manner in which governance is conducted, and actively engages management on understanding governance activities that occur at various levels within the organisation, as well supports management in its efforts to enhance programme efficiency and effectiveness.

The Board Committees are governed by committee charters that define the committees' responsibilities and address linkages between the committee, the broader executive team, and the Board of Directors.

The CSIR organisational design and reporting structure provides a clear, comprehensive organisational structure that defines reporting lines for decision-making, risk management, financial and regulatory reporting, public disclosures, and crisis preparedness and response.

The Board of Directors, which constitutes the Accounting Authority, is responsible for the preparation and fair presentation of the consolidated and separate financial statements in accordance with International Financial Reporting Standards and the requirements of the PFMA, and for such internal control as the Accounting Authority determines is necessary to enable the preparation of consolidated and separate financial statements that are free from material misstatement, whether due to fraud or error. In preparing the consolidated and separate financial statements, the Accounting Authority is responsible for assessing the group's ability to continue as a going concern, disclosing, as applicable, matters relating to going concern and using the going concern basis of accounting.

The role of the Board

The responsibilities of the Board are governed by the Scientific Research Council Act, 1988 (Act 46 of 1988) and the PFMA. The Board approves the strategy, goals, operating policies and

priorities for the organisation and monitors compliance with policies, applicable legislation and achievement against objectives. Except for the CEO of the CSIR, all members of the Board are non-executive. Board members are actively involved in and bring independent judgement to bear on the Board's deliberations and decisions. The Board, whose current number of members adheres to the statutory minimum requirements, meets quarterly.

For the year under review, the Board met four times. The meetings were held on 17 April 2020, 17 July 2020, 16 October 2020 and 19 February 2021. A Board strategic session was held on 20 August 2020. The annual financial statements for the 2020/21 financial year were approved on 29 July 2021.

The Board further engaged in various ad hoc meetings to be advised and provided specific input on matters of strategic importance.

The Board comprises three sub-committees, namely the Audit and Risk Committee; the Human Resources, Social and Ethics Committee; and the Research, Development and Innovation Committee (see page 96). These committees are selected according to the skills sets required for the committees to fulfil their functions. The Board has adopted formal Terms of Reference reflected in the Board Charter, whereas the Board committees are governed by their respective charters, which define the roles and responsibilities in their respective advisory capacities to the Board of Directors.

BOARD CHARTER

The CSIR Board Charter sets out the functions and responsibilities of the Board, along with certain matters relevant to the operations of the Board. These responsibilities are aligned and encompass the provisions of the Scientific Research Council Act, the PFMA, and the King IV Report on Corporate Governance.

The CSIR Board of Directors has decided to apply the corporate governance principles of the Protocol on Corporate Governance in the Public Sector, and the King IV Codes on Corporate Governance to their activities, in order to regularise and improve the corporate governance of the CSIR. This Board Charter sets out the corporate governance policies of the CSIR, as adopted by the Board and must be read with the Shareholder's Compact between the CSIR and the Minister of Higher Education, Science and Innovation.

While this Charter includes references to minimum acceptable standards of governance, in pursuit of its underlying ideals, it is critical that substance prevails over form. The Charter reaffirms the Board's intention to exceed these corporate governance standards wherever reasonable, having due consideration for:

- Recognised standards of governance;
- Best practice locally and internationally;
- The recommendations of the King IV Code on Governance;

- The Protocol on Governance of State-Owned Entities; and
- The objectives set out in Section 3 of the Scientific Research Council Act.

The Board Charter aims to regulate the parameters within which the Board will operate and ensure the application of the principles of good corporate governance in all dealings by, in respect and on behalf of the organisation.

The Board has made significant progress in compliance with the Charter in that the Board:

- Has guided the continued integration of the CSIR's values and standards of conduct and ensuring that these are adhered to through its input and oversight of the review and re-alignment of all CSIR policies.
- Provides leadership to the CSIR within a framework of prudent and effective controls that enable assessment and management of risk.
- Reviews the CSIR's directions, strategies and financial objectives, annually, and ensures that the necessary resources are in place for the CSIR to meet its objectives, while assessing the progress made, quarterly.
- Oversees and ensures that the performance of CSIR Executive Management and the Board itself (and Committees) is assessed and monitored regularly.
- Oversees information technology governance through quarterly engagements on business development, commercialisation and technology innovation through the Research, Development and Industrialisation Committee and annual interaction with and reporting by the Research Ethics Committee.

THE CSIR BOARD



Prof. Thokozani Majozi
Chairperson of the CSIR Board
NRF/DST Chair: Sustainable
Process Engineering, University of
the Witwatersrand



Dr Thulani Dlamini
Chief Executive Officer, CSIR



Ms Phindile Baleni
Director-General, Gauteng
Premier's Office



Ms Amber-Robyn Childs
Senior Lecturer at Rhodes
University



Dr Ramatsemela Masango
Executive Director, Mzansi Energy
Solutions and Innovations (Pty) Ltd



Mr Stafford Masie
Non-Executive Director and
Shareholder, Thumbzup
(South Africa, Australia/AsiaPac,
London and USA)



Ms Tiny Mokhabuki
Chief Financial Officer,
MICT SETA



Dr Vuyo Mthethwa
Senior Human Resources Director,
Durban University of Technology



Mr Joel Netshitenzhe
Executive Director, Mapungubwe
Institute for Strategic Reflection
Board Vice-Chairperson



Dr Christine Render
Independent Consultant



Mr Cassim Shariff
Executive Director at SDB GAS
and Lirazest

Table 1: Composition of the Board

Name	Date Appointed	Date Resigned	Qualifications	Board Directorships	Other Committees or Task Teams (e.g.: Audit and Risk committee/ Ministerial task team)	No. of Meetings attended
Prof. Thokozani Majozi Chairperson of the CSIR Board	2015	Active	University of Manchester Institute of Science and Technology PhD (Process Integration) University of Natal MSc (Engineering) BSc (Chemical Engineering)	<u>Director</u> – A1 Consulting Engineers CC Zyblue Pty Ltd	Presidential Visit 09 April 2020	8
Dr Amber Robyn Potts (Childs) CSIR Board Member	2019	Active	Rhodes University PhD (Ichthyology) MSc (Cum Laude) (Ichthyology)	None	RD&I Committee	8
Dr Ramatsemela Masango CSIR Board Member	2015	Active	Pennsylvania State University PhD (Nuclear Engineering) MSc (Nuclear Engineering) Lyceum College Diploma in Project Management Cape Peninsula University of Technology BTech Degree (Chemical Engineering)	<u>Executive Director</u> Mzansi Energy Solutions and Innovations (Pty) Ltd (Mzesi) Mzesi Energy Mzesi Academy Mzesi Holdings <u>Non-Executive Director</u> ArioGenix Face to Face Foundation Redhorn Holdings Mzesi Water & Construction Yonga Energy Tingo Technologies Amanzi Technologies Certo Project Integrators Africa Energy Wise Solutions Zondibex Miyenzi Investments Vito		7
Dr Thulani Dlamini	2017	Active	University of Witwatersrand BSc Chemistry BSc (Hons) Chemistry PhD Chemistry, Catalysis University of South Africa Master's in Business Leadership	<u>Council Member</u> National Advisory Council on Innovation <u>Director</u> Vumelana Trade 120 Kusile Invest 125 Mavela Consulting Services		7
Dr Christine Render	2019	Active	Leeds University PhD (Chemical Engineering) BSc Hons. (Chemical Engineering)	<u>Partner/Shareholder</u> Owner – Team Consultation Pty (Ltd)		8
Dr Vuyo Mthethwa	2019	Active	University of KwaZulu-Natal PhD Higher Education Governance	<u>Employee; Senior Director</u> Durban University of Technology		8

Name	Date Appointed	Date Resigned	Qualifications	Board Directorships	Other Committees or Task Teams (e.g.: Audit and Risk committee/ Ministerial task team)	No. of Meetings attended
Ms Phindile Baleni	2015	Active	University of the Witwatersrand BProc LLB	<u>Member</u> Wits University Council: (<u>non-remunerative</u>) <u>Board Member</u> IIASA NMO (RSA): (<u>non-remunerative</u>) <u>Employee: (Director General)</u> Gauteng Provincial Government <u>Shares</u> First Rand Black Directors BEE Scheme/ Trust New Shelf (Pty) Ltd First Shelf (Pty) Ltd <u>Trustee</u> Rev LW Mbethe Education Trust (<u>Non-remunerative</u>)		3
Mr Cassim Shariff	2019	Active	Leicester Business School, DeMontfort University Master's in Business Administration	<u>Executive Director</u> Aquaworx Remediator & Infrastructure Solutions Southern Cross Diamonds <u>Director</u> Lirazest – Greenstone Energy <u>Non-Executive Director</u> Silver Crown Trading		8
Mr Stafford Masie	2019	Active		<u>Non-Executive Director & Shareholder</u> Thumbzup South Africa Thumbzup Australia/AsiaPac Thumbzup International (London) Thumbzup USA GATTACA- SnapTutor- Razorlogix <u>Shareholder/Funder</u> Green Moon Transact LRXYM Fitness <u>Non-Executive Director & Board Member</u> Advtech – Sauronai Holdings LLC (USA) : (South Africa)		7

Name	Date Appointed	Date Resigned	Qualifications	Board Directorships	Other Committees or Task Teams (e.g.: Audit and Risk committee/ Ministerial task team)	No. of Meetings attended
Ms Tiny Mokhabuki	2019	Active	University of KwaZulu-Natal PGDA (with CTA) University of the Witwatersrand Bachelor of Commerce Global Institute of Business Sciences Aspen Management Programme CA(SA)	<u>Director</u> Business Entrepreneur Community - (<u>Dormant, deregistration process</u>) Equota Mokhabuki Building and Construction Sphimokha Digiten <u>Employee</u> MICT SETA		6
Mr Joel Netshtenzhe	2015	Active	University of London MSc (Financial Economics) Post-graduate Diploma (Economic Principles) Institute of Social Sciences, Moscow Diploma (Political Science)	<u>Executive Director</u> Mapungubwe Institute of Strategic Reflection <u>Director</u> Nedbank Group Nedbank Life Healthcare Group Lushote Trading (Fledgling) Topaz Sky Trading 316 (<u>Fledgling</u>) Betascap (<u>Dormant</u>) <u>Member</u> Camel Rock Trading 434 (<u>Dormant</u>) <u>NEC Member</u> African National Congress <u>Patron</u> Oliver & Adelaide Tambo Foundation <u>Visiting Professor</u> Wits School of Governance		8

COMMITTEES

Table 2: List of Board Committees

Committee	No. of meetings held	No. of members	Name of members
Audit and Risk Committee	Four meetings were held: 14 April 2020 07 July 2020 06 October 2020 08 February 2021	5	Ms Tiny Mokhabuki – Chairperson Mr Stafford Masie Dr Christine Render Ms Phindile Baleni Dr Vuyo Mthethwa
Human Resources, Social and Ethics Committee	Four meetings were held: 07 April 2020 07 July 2020 09 October 2020 10 February 2021	4	Dr Vuyo Mthethwa – Chairperson Ms Phindile Baleni Mr Cassim Shariff Dr Ramatsemela Masango
Research, Development and Industrialisation Committee	Four meetings were held: 09 April 2020 09 July 2020 08 October 2020 11 February 2021	5	Dr Christine Render Dr Ramatsemela Masango Dr Amber Robyn Potts (Childs) Mr Cassim Shariff Mr Joel Netshitenzhe

Remuneration of board members

Name	Remuneration	Other allowance	Other re-imbursements	Total
Prof. Thokozani Majozi	R15 696 per meeting	None	None	R549 360.00
Dr Amber-Robyn Potts (Childs)	R11 664 per meeting	None	None	R128 304.00
Dr Ramatsemela Masango	R11 664 per meeting	None	None	R163 296.00
Mr Stafford Masie	R11 664 per meeting	None	None	R163 296.00
Dr Vuyo Mthethwa	R11 664 per meeting	None	None	R174 960.00
Dr Christine Render	R11 664 per meeting	None	None	R174 960.00
Mr Cassim Ebrahim Shariff	R11 664 per meeting	None	None	R174 960.00
Ms Tiny Mokhabuki	R11 664 per meeting	None	None	R116 640.00
Ms Phindile Baleni	None – Public servant (Office of the Premier – Gauteng)			None
Mr Joel Netshitenzhe	R11 664 per meeting	None	None	R111 568.71



RISK MANAGEMENT

The Board is responsible for ensuring that there is a comprehensive and effective system risk management in place, including accountability for risk governance. Enterprise risk management in the CSIR is an ongoing process that focuses on identifying, assessing, managing, and monitoring all known forms of risks across all operations. A structured process of enterprise risk management ensures that the goals and objectives of the CSIR are attained. This takes cognisance of the fact that the risks identified are often inter-linked and cannot be managed in isolation. The management of risk is assigned at appropriate levels throughout responsibility areas of activity across the entire organisation to ensure adequate responses.

CSIR has a Board-approved Risk Management Policy and a supporting framework. The policy and framework is operationalised through the implementation of the supporting structures, standards, processes, technologies, and system/tool.

The CSIR has an annual risk management plan that is approved by the Board and published as part of the CSIR Shareholder's Compact. An annual Enterprise Risk Management Plan is also approved and monitored by the Executive Committee to ensure the adequacy and effectiveness of the risk management system.

The CSIR has repositioned the Enterprise Risk Management Services/portfolio to ensure that it is fit for purpose and aligned to the business needs and requirements. The new structure was implemented during the 2020/21 financial year in line with the re-organisation process.

Quarterly strategic and operational risk assessments are conducted to ensure an effective management of the existing business risks, as well as the identification and mitigation of emerging risks. The risk assessments are conducted by line management in the clusters,

portfolios, strategic projects and key collaboration partnerships/initiatives. The outcome of the various risk assessment is collated to formulate a CSIR risk register (commonly referred to as the CSIR top risks).

The risk assessment process is structured to analyse and evaluate three key categories, namely:

Systemic risks

These are risks that originate from macro-economic and national challenges affecting the National System of Innovation and the National Government Business Enterprise space in which the CSIR operates.

Strategic risks

These are risks that have a direct impact on the ability of the CSIR to deliver on its mandate.

Operational risks

These risks include financial, legal and compliance risks, and are those risks that affect the systems, people, and processes through which the CSIR operates.

As part of re-positioning its support services to align with the CSIR Strategy, the CSIR is establishing an operational Risk Management Committee that will be the key role-player in maturing the combined assurance model of the organisation.

Based on the internal audit reports, the organisational results achieved, the audit report on the annual financial statements and the management report of the Auditor-General, the Board is satisfied that the risk management system has been effective during the year under review.



INTERNAL AUDIT AND AUDIT COMMITTEES

The Group has an internal audit function that is responsible for reviewing the design and operating effectiveness of the organisation's governance, risk and internal control processes. The CSIR internal audit function reports to the Audit and Risk Committee, which is responsible for approving the Internal Audit Charter, the annual audit plan and budget to maintain its independence.

The annual audit plan is based on the key risks to the organisation, the outcome of the enterprise risk assessment conducted by management, as well as specific areas highlighted by internal audit and the Audit and Risk Committee. In addition, areas highlighted by the external auditors in the internal control reviews are incorporated into the internal audit plan for follow-up.

In line with the PFMA requirements, the internal audit activity assured the Audit and Risk Committee and management that the internal controls were appropriate and effective. This was achieved by means of objective appraisal and evaluation of the risk management processes, internal control and governance processes, as well as identifying corrective action and suggested enhancements to the controls and processes. A comprehensive report on the status of implementing the annual audit plan, the key findings identified and the status of resolving the previously reported internal and external audit findings is presented to the Audit and Risk Committee, quarterly.

The Internal Audit activity is fully supported by management, the Board and the Audit and Risk Committee, and has full, unrestricted access to all organisational activities, records, property and personnel.

For the period under review, Internal Audit performed an evaluation of the adequacy and effectiveness of controls in the following areas:

- Governance;
- Risk Management;
- Organisational Change Management;
- Performance Reporting;
- Human Capital Management and Development;
- Employee Wellness;
- Contract Income and Project management;
- Financial Management;
- Property Plant and Equipment;
- Supply Chain Management and Accounts Payable;

- Supplier Contract Management;
- Tenants & Lease Management;
- International Convention Centre; and
- Information, Communication and Technology.

KEY ACTIVITIES AND OBJECTIVES OF THE AUDIT AND RISK COMMITTEE

The Audit and Risk Committee enhances the independence of the Internal Audit activity and provides oversight over risk management, governance and control processes. The Audit and Risk Committee assists the Board in the effective execution of its responsibilities with the ultimate aim of achieving the CSIR's objectives. The CSIR Audit and Risk Committee continues to function and has met four times during the period under review. The Audit and Risk Committee is responsible for improving the operations of the organisation by overseeing the audit functions, internal controls and the financial reporting process.

The Audit and Risk Committee assists the CSIR to:

- Create and maintain an effective internal control environment, financial controls, accounting systems and reporting;
- Deal with all matters prescribed by the regulations issued regarding the PFMA and the Scientific Research Council Act;
- Identify material risks and management thereof;
- Agree on the scope and review the annual external audit plan and the work of the CSIR's internal auditors;
- Review and approve the Internal Audit Charter and the risk based on a three-year strategic internal audit plan and annual audit plan;
- Act in an unfettered way to understand the dynamics and performance of the organisation without restrictions;
- Ensure that the CSIR is able to prevent, detect and respond to fraud and allegations of fraud; and
- Discharge its responsibility relating to:
 - safeguarding of assets;
 - operation of adequate procedures and controls;
 - reviewing of the financial information and the preparation of the financial statements; and
 - attendance of Audit and Risk Committee meetings by Audit and Risk Committee members (tabular form).

The following table discloses relevant information on the Audit and Risk Committee members:

Table 3: Relevant information on the Audit and Risk Committee members

Name	Internal or external	If internal, position in the public entity	Date appointed	Date Resigned	No. of Meetings attended
Ms Tiny Mokhabuki	External		2019	Active	4
Dr Thulani Dlamini	Internal	CEO	2015	Active	4
Ms Phindile Baleni	External		2015	Active	3
Dr Christine Render	External		2019	Active	4
Mr Stafford Massie	External		2019	Active	4
Dr Vuyo Mthethwa	External		2019	Active	4

COMPLIANCE WITH LAWS AND REGULATIONS

Regulatory compliance requires the CSIR to continuously analyse its unique requirements and any mandates specific to the organisation and then develop processes to meet these requirements.

Typical steps to achieve regulatory compliance include the following:

- Identifying applicable regulations – determine which laws and compliance regulations apply to the CSIR's industries and operations.
- Determining requirements – identify the requirements in each regulation that are relevant to the organisation, and consider plans on how to implement these mandates.
- Documenting compliance processes – clearly document compliance processes, with specific instructions for each role involved in maintaining compliance.
- Monitoring changes and determining whether they apply – compliance requirements are updated constantly and changes

are continuously monitored to determine if they are relevant to the CSIR and how best they should be integrated.

- Conducting in-house compliance audits to review the CSIR's adherence to regulatory guidelines.
- Preparing in-house audits, which help to prepare for externally conducted, formal compliance audits carried out by independent third parties.

The repositioning of the CSIR's support resources during the year under review has allowed the development of a dedicated compliance functionality housed within the Legal and Compliance structure. The focus and mandate of the compliance functionality is targeted at developing a well-defined regulatory/compliance universe for the CSIR and ensuring that the policy and processes align to facilitate continued and effective compliance. Specific focus areas introduced also include privacy law compliance, trade compliance and corporate governance.

FRAUD AND CORRUPTION

The CSIR Fraud Prevention Plan (FPP) has been developed in compliance with section 3.2.1 of the Treasury Regulations of the PFMA. The CSIR subscribes to the principles of good corporate governance, which require business to be conducted in an honest, ethical and transparent manner. Consequently, the CSIR is committed to eradicating fraudulent behaviour at all levels within the organisation.

This FPP is premised on the CSIR's core ethical values driving its business, the development of its systems, policies and procedures,

interactions with upstream and downstream stakeholders in its value chain and overall value proposition, including public and private sector customers, members of the public at large, suppliers and service providers, employees and its shareholder.

In alignment with the CSIR's core organisational values of excellence, people-centred, integrity and collaboration (EPIC), this FPP is the cornerstone of promoting ethical conduct and determining how incidents or suspected incidents of fraud and corruption will be prevented, detected and investigated.

The FPP is a dynamic plan and it will continuously evolve as the CSIR strives to further promote ethics and prevent fraud.

The CSIR's FPP encompasses controls that have three strategic objectives:

- Prevent instances of fraud and corruption from occurring;
- Detect instances of fraud and corruption when they do occur; and
- Respond appropriately and take corrective action when fraud and corruption occur.

The policy of the CSIR is one of zero tolerance to fraud and corruption as captured in the CSIR Ethics Statement and Code of Conduct. All alleged cases of fraud and corruption will be investigated and followed up by the application of all remedies available, within the full extent of the law, and the implementation of appropriate prevention and detection measures. These measures include existing financial and related controls and verification mechanisms as prescribed in the systems, policies and procedures of the CSIR.

The CSIR wishes to facilitate a culture of disclosure of information relating to suspected fraud and related misconduct by employees in a responsible manner. Employees and stakeholders are encouraged to report suspicions of fraudulent activity without fear of reprisals or recriminations.

The efficient application of instructions contained in the regulations, policies and procedures of the CSIR is one of the most important duties of every employee in the execution of his/her daily tasks.

The CSIR's policy position is captured in its revised Ethics Statement and Code of Conduct that underwent significant review and restatement in the period under review and was approved by the Board on 16 October 2020. A supplementary Fraud Prevention and Management Policy is under development and will be tabled for the

Board's consideration in the next financial year.

The main principles upon which the FPP of the CSIR is based are as follows:

- Creating a corporate culture that is ethical, fair and intolerant to fraud and thereby aligned with the CSIR's core organisational EPIC values;
- Deterring fraud and corruption;
- Reporting suspicious fraudulent activity without fear of reprisals or recriminations;
- Detecting of fraud;
- Investigating any detected fraud;
- Taking appropriate action in the event of fraud, e.g. disciplinary action, recovery of losses and prosecution; and
- Applying sanctions, such as blacklisting of suppliers/service providers guilty of corrupt practices.

This plan applies to all allegations, attempts and incidents of fraud that have an impact or the potential to have an impact on the CSIR. All CSIR employees and management must comply with the spirit and content of the plan.

A person who holds a position of authority as stipulated in section 34 of the Prevention and Combating of Corrupt Activities Act, 2004 (Act 12 of 2004) should report any suspected corrupt activity and/or an offence of theft/fraud to the police.

The CSIR's Audit and Risk Committee significantly influences the fraud control environment, particularly by overseeing the tone at the top of the organisation. This is achieved in the discharge of its duties in terms of the PFMA and Treasury Regulations.

The Audit and Risk Committee systematically oversees, and periodically reviews the internal controls established by the management of CSIR.

MINIMISING CONFLICT OF INTEREST

Board members may not place themselves in a position in which their personal interests conflict, or may possibly conflict, with their duty to act in the best interests of the CSIR. This gives rise to the following duties:

- To act bona fide in the interests of the CSIR;
- Not to compete improperly with the CSIR; and
- To disclose direct or indirect personal or private interests, as envisaged in the provisions of section 50 (3) (a) of the PFMA, which shall be duly recorded in the minutes at a Board Meeting.

Board members are required to inform the Board, through the Board Secretary, in advance of any conflicts or potential conflicts of interest they may have in relation to particular items of business to be transacted at a meeting.

Board members may not vote and must not be counted in the quorum of a meeting to pass a resolution in respect of any business where they have a direct or indirect interest.

If any Board member wilfully or negligently fails to disclose an interest as required or, if he/she participates in the proceedings of the Board notwithstanding any conflict of interest, the relevant proceedings of the Board may, at the discretion of the other Board members, be declared null and void.

In exceptional circumstances, the Board may decide that, in the light of interests disclosed by a Board member, such Board member shall not be entitled to receive any further information on any particular matter before the Board and shall instruct the Board Secretary accordingly. A Board member who is aggrieved by the Board's decision in this regard shall be entitled to make representations to the Board, which will refer the matter to an independent governance expert whose decision shall be final and binding on the parties.

CODE OF CONDUCT

The Board and the CSIR Executive Committee have approved and adopted an Ethics Statement and Code of Conduct that reflects their commitment to a policy of fair dealing and integrity in conducting their operations. The Code has been significantly restated to ensure that it closely aligns to the CSIR set of values, compliance

to laws and regulations, and requires all employees to maintain the highest ethical standards, ensuring that business practices are conducted in a manner that is beyond reproach. An Ethics Hotline has been established to facilitate anonymous reporting of ethical transgressions.

HEALTH, SAFETY AND ENVIRONMENTAL ISSUES

The CSIR's commitment to sustainable development as a strategic priority encompasses the organisation's commitment towards safety, health, environment and quality (SHEQ). In delivering on its mandate, the CSIR ensures that its greatest consideration and priority is for the health and safety of colleagues, contractors, suppliers, customers and local communities, and the protection of the environment. The CSIR is committed to excellence in managing these areas through the SHEQ function.

The CSIR Audit and Risk Committee assists the Board to monitor the effectiveness of SHEQ management systems within the CSIR and to guide the Board in decision-making from a SHEQ perspective.

A dedicated SHEQ department works with the business to ensure that the company has deliverable policies, is proactive in its risk assessment and professional in its remediation. In line with CSIR's

re-positioning of its support services, the SHEQ structure is also now adapted to include a significant enhancement of operational oversight, advice and support.

In the year under review, the CSIR achieved its target to secure a recordable incident rate (RIR) of less than two, by achieving an RIR of 0.53. Despite this achievement, the CSIR is continuously monitoring its health and safety (H&S) risks and implementing appropriate response measures to address undesirable trends as and when identified. This includes numerous management safety walkabouts, H&S articles published on the Intranet and safety tips communicated with secretariats of SHE committees in the clusters, centres, portfolios and regional sites to raise awareness on the number of recordable incidents that occurred during the year, the lessons learned and near misses.

BOARD SECRETARY

The Board Secretary's responsibilities include:

- Providing the Board and individual Board members with guidance as to the nature and extent of their duties and responsibilities, and how such duties and responsibilities must be properly discharged in the best interests of the CSIR and the Shareholder.
- Ensuring the induction of new and inexperienced Board members and, together with the Chairperson of the Board, developing mechanisms for providing continuous education and training for all Board members, in order to improve and maintain the effectiveness of the Board.
- Assisting the Chairperson in determining the Annual Calendar and Annual Board Plan and other issues of an administrative nature.
- Providing a central source of guidance and advice to the Board on matters of business ethics and good governance – the Board Secretary's appointment is subject to the same 'fit and proper test' to which a new Board member's appointment is subject.

SOCIAL RESPONSIBILITY

In 2020, the world was hit by the Covid-19 pandemic, which led to the country to introduce lockdown and as a result, many events were cancelled. Therefore, most of the outreach activities planned for the year did not take place.

Only two initiatives took place.

The South African Association of Science & Technology Centres (SAASTEC) in partnership with the Greater Tzaneen Community Foundation (GTCF) hosted a series of colloquiums under the theme 'The impact of Covid-19 on Science and Technology centres'. The

CSIR participated in virtual discussions aimed at finding solutions by improving scientific knowledge and skills in society.

In line with the CSIR mandate of improving the quality of life of the people of South Africa, the CSIR contributed to Mandela Day 2020 by donating facial masks to old age homes, orphanages and previously disadvantaged schools in Hammanskraal. By donating the facial masks, the CSIR contributed to enabling learners to attend school in a safe environment during these difficult times. The old age homes and orphanages were also protected from contracting and spreading the virus.

AUDIT AND RISK COMMITTEE REPORT

We are pleased to present our report for the financial year ended 31 March 2021.

AUDIT AND RISK COMMITTEE RESPONSIBILITY

The Audit and Risk Committee has complied with its responsibilities arising from Section 77 of the Public Finance Management Act and Treasury Regulation 3.1.13. The committee has adopted formal Terms of Reference as its charter, approved by the Board. Accordingly, the committee has conducted its affairs in compliance with this charter and has discharged its responsibilities as contained therein.

COMMITTEE MEMBERS AND ATTENDANCE

The Audit and Risk Committee consists of members as stated on page 96 of this report. In terms of its terms of reference, the committee convened at least four meetings for the period under review. The meetings and schedule of attendance are shown on page 99 of this report.

The Chief Executive Officer, the Executive management, and representatives of internal and external auditors attended committee meetings by invitation. The committee also periodically meets separately with internal and external auditors. The internal and external auditors have unrestricted access to the committee.

THE EFFECTIVENESS OF INTERNAL CONTROL

The system of internal control that the CSIR applies over financial risk management is effective, efficient and transparent. In line with the PFMA and King IV, the internal audit provides the committee and management with assurance that the internal controls are appropriate and effective. This is achieved by means of the risk management process, as well as the identification of mitigating measures and an on-going assessment thereof.

From the quarterly reports of the internal audit, the audit report on the annual financial statements and the management report of the Auditor-General of South Africa, it was noted that no matters that

include any material deficiencies in the system of internal control or any deviations therefrom were reported. Accordingly, the committee can report that the system of risk management and internal control over financial reporting for the period under review was efficient and effective.

IN-YEAR MANAGEMENT AND QUARTERLY REPORTS

The committee has noted and is satisfied with the content and quality of the quarterly reports prepared and issued by the CSIR during the year under review.

EVALUATION OF FINANCIAL STATEMENTS

We have reviewed the annual financial statements prepared by the CSIR for the year ended 31 March 2021. Based on the information provided, the Committee considers that it complies, in all material respects with the requirements with the requirements of the various Acts governing disclosure and reporting on the annual financial statements.

AUDITOR'S REPORT

We have reviewed the public entity's implementation plan for audit issues raised in the prior year and we are satisfied that the matters have been adequately resolved.

The Audit and Risk Committee concurs and accepts the conclusions of the external auditor on the annual financial statements and is of the opinion that the audited annual financial statements be accepted and read together with the report of the auditor.



Ms Tiny Mokhabuki
Chairperson of the Audit and Risk Committee
CSIR
29 July 2021

B-BBEE COMPLIANCE PERFORMANCE INFORMATION

The following table has been completed in accordance with the compliance to the Broad-Based Black Economic Empowerment (B-BBEE) requirements of the B-BBEE Act, 2003 (Act 53 of 2013) and as determined by the Department of Trade and Industry.

Has the department/public entity applied any relevant Code of Good Practice (B-BBEE Certificate Levels 1 – 8) with regards to the following:		
Criteria	Response Yes/No	Discussion
Determining qualification criteria for the issuing of licences, concessions or other authorisations in respect of economic activity in terms of any law?	No	The CSIR does not issue any licences/concessions or authorisations to allow economic activity in terms of any law. This would likely only apply to entities responsible for issuing trade licences or mining/exploration licences and the like.
Developing and implementing a preferential procurement policy?	Yes	We developed and implemented a procurement policy that incorporates preferential procurement, together with various templates, evaluation criteria, frameworks, etc. to ensure same is achieved. This is monitored monthly.
Determining qualification criteria for the sale of state-owned enterprises?	No	We do not generally engage in such sales, but when we do, certain criteria would be developed on a case-by-case basis to align with the nature of the asset/technology on sale, the CSIR mandate, and to secure sustainable offerings in the interest of South Africa. Case in point is the sale of laboratories where we set criteria to secure a buyer that would allow for the service offering to remain sustainable and available in the South African context.
Developing criteria for entering into partnerships with the private sector?	No	Certain criteria would be developed on a case-by-case basis to align with the objective of the collaboration to align with the CSIR mandate and to secure sustainable offerings and commercialisation of technology in the interest of South Africa. In these instances, where the opportunity allows for feasible and sustainable commercialisation through SMMEs, criteria such as B-BBEE levels/status or black/female ownership could be included. There is no firm policy on this as the nature of the technology and available markets would determine the feasibility of such criteria.
Determining criteria for the awarding of incentives, grants and investment schemes in support of B-BBEE?	No	The award of grants, incentives and investments is not a core activity in the CSIR, and we do not make material investments in this context, save for the context of the YES Programme application, bursary awards and corporate social investment initiatives that would target previously disadvantaged categories of individuals or institutions (such as schools, higher education institutions etc.)



PART E

HUMAN RESOURCE MANAGEMENT

This section provides a detailed account of the **strategies, programmes and interventions implemented in the year under review** and the outcomes of these in the human capital portfolio.

Introduction	106
Human capital services	108
Staff and transformation profile	113
Staff movements	115
Learning capability development and CSI	117
Talent acquisition and management.....	120
Rewards and recognition	121
Employee relations and transformation	122
Employee wellness	124
Human capital business enablement and efficiencies	124
Human capital policies and procedures.....	124
Human capital system improvements	125
Human resource oversight statistics	126

INTRODUCTION

The CSIR plays an instrumental role in support of national strategic objectives through investment in and development of skilled human capital who are capable to contribute to achieving the national imperatives. They do this through world-class scientific research, innovation and technology development that is required to address the socioeconomic challenges of the country.

As discussed earlier in the Performance section (Part B), the Human Capital Portfolio derives its mandate from strategic objective four (SO4), which is to **Build and transform human capital and infrastructure**. This objective concerns the critical responsibility of providing a sustainable supply of human capital to meet internal capacity demands with relevant skills and capabilities so that the CSIR can live up to its mandate. A conducive workplace, cohesive organisational culture, embedded value system and engaged workforce are prerequisites for achieving organisational effectiveness, improved productivity, enhanced performance, and pursuance of excellence.

Developing and managing our human capital is an immutable pillar in effecting a transformed and suitably skilled workforce, as well as embedding the organisation's EPIC values: Excellence, People-centred, Integrity and Collaboration.

Limited capabilities exist to leverage the opportunity of new technologies impacting all industry sectors and society. Innovative and efficient human capital development and infrastructure is therefore paramount to drive industrialisation for the advancement of society. SO4 emphasises the need for targeted capability development to leverage emerging technologies and capabilities.

2020/21 has been a challenging year. The Covid-19 pandemic impacted economic activity, social life, and global and local work environments in every sphere of society. The virus's outbreak, rapid spread, and danger posed to human life required rapid action to safeguard our employees.

EXTERNAL CONTEXT

The South African economy and workplaces in general adapted several times during the first three quarters to doing business as unusual. Unemployment increased to record highs during this period. Despite the lockdown regulations changing several times with different implications, quarter 4 normally has a slow start following the festive season and December holidays. Many businesses, particularly in the private sector, closed, further exacerbating diminished economic activity.

Political – In the 2020 State of the Nation Address, the President of South Africa, Mr Ramaphosa, highlighted the crisis of more than half of the youth being unemployed and the urgency to create opportunities for employment. The establishment of the

Presidential Youth Employment Intervention include scaling up the YES Programme to create further employment opportunities for the youth. The Human Capital Portfolio, through the CSIR's YES Programme, will continue to remove barriers for employment with a focus on achieving the employment equity objectives and improving the B-BEEE scorecard. The areas highlighted in the 2020 State of the Nation Address where the CSIR has an opportunity to enable the state to respond to national priorities, such as driving economic development, development skills and creating jobs, will remain priorities during 2021/22.

Economical – The implementation of the South-African national state of disaster and lockdown regulations further impacted the way the CSIR conducted its business. Alternative ways had to be sought to ensure continuity of business activities. The resulting downturn of economic activity and economic growth forecasts increased pressure on the organisation's financial position.

Reduction of the PG and the tightening of the National Treasury procurement processes also impacted the CSIR's ability to attract contract income. As a result of financial constraints, investment in human capital initiatives have been affected. The CSIR's need to diversify its income and reduce its heavy reliance on fiscal budget is imperative in the short to medium term.

Social – Investment in SET as a driver for economic growth can also address our country's triple challenge of poverty, unemployment (especially of youth) and inequality. The CSIR implemented several initiatives during the 2020/21 year in response to these challenges. Initiatives implemented included development of the Corporate Social Investment (CSI) Policy, implementation of the YES Programme and the GIT Programme. The Human Capital Portfolio will continue to focus on programmes that create interest in learners to pursue science, technology, engineering, and mathematics subjects, deploy SET solutions to social challenges, and enable the organisation to partner with communities more meaningfully. Implementation of a new CSI programme will elevate the role and contribution of the CSIR to addressing social challenges in disadvantaged communities as a result of poverty, unemployment and inequality.

Technological – The Covid-19 pandemic and resultant lockdown shifted the work scene abruptly from being office-bound to adapting to working from home. This placed enormous pressure on the organisation to provide and implement suitable technological solutions to conduct work from home and ensure business continuity; it also emphasised the importance of technology as an enabler to conduct work remotely and employees' reliance on supporting systems.

Preceding the pandemic, but still ongoing, the CSIR revitalised its strategy and brand to increase its focus on industrial development. Key elements of the industrial development strategy include stimulation of economic growth, sustainable

technological development, creating an impact in society through commercialisation of technology and skills transfer, and ensuring relevance of the contribution towards industrial development. Investment in human capital towards achieving the organisation's industrial development strategy is an imperative.

Environmental – As government enforces environmental compliance on various institutions, including Carbon Tax, the CSIR is poised to offer innovative technology solutions to respond such that the cost of compliance does not cripple industry competitiveness. In addition, the CSIR continues to build unique capabilities and competence in climate change and environmental sustainability to inform policy and enable decision-making.

Legal and legislative – As an organ of state, the CSIR must continue to exercise good governance as required by the different legislations (such as PFMA, LRA, OSH Act, BBBEE Act, EE Act). Amendments to existing legislation (such as changes to the Conditions of Service) and new legislation, for example the Protection of Personal Information Act, need to be embedded within the organisation through training and awareness initiatives. The Human Capital Portfolio will focus on the development and implementation of training plans during the 2021/22 financial year with the intent, firstly, to increase compliance to legislation, policies and procedures, and secondly, to mitigate audit findings and minimise risks of non-compliance.

INTERNAL CONTEXT

The reduction in PG in the 2020/21 year and the tightening of the National Treasury procurement processes continued to impact several human capital projects and initiatives planned for the year in quarter 4. Attraction of highly skilled talent in a highly competitive market remained a challenge.

The CSIR was not in a position to reward staff with bonus payments and no increases were awarded due to financial constraints. This impacted negatively on retention, resulting in highly skilled permanent staff leaving the CSIR. During quarter 4, the Human Capital Portfolio focused on reviewing procedures in support of policies and the implementation of planned initiatives as outlined in the portfolio plan.

During the reporting year, the CSIR implemented a new strategy, operating model and programmes for enhancing its capabilities in scientific research, innovation and development of new technologies. This strategy is aimed at increasing the impact and role of the CSIR in response to the socioeconomic challenges of the country and drive initiatives in support of industrialisation, stimulating economic growth and creation of new job opportunities.

However, transformation of CSIR staff, particularly the SET base, remains a challenge, even though some progress has been made in the past few years in terms of demographic diversity and strengthening the SET base.

With regards to talent management, the organisation has experienced high turnover of key staff such as Chief, Principal and Senior Researchers (and especially Black and female SET staff), which has had a negative impact on the researcher profile, project delivery and mentorship of young and emerging researchers.

The turnover challenge has been compounded by the lack of an affirming career development and performance management culture, which is crucial in developing, rewarding and retaining different segments of talent.

The organisation has a high number of vacancies in critical positions, which is indicative of an uncoordinated and reactionary approach to workforce planning and recruitment. The Human Capital Portfolio must drive the organisation's workforce and recruitment planning process to ensure a clear and consistent approach to the current and future resourcing needs.

The new operating model provides the roadmap for future organisational growth aligned to the organisational and human capital strategy. It will ensure that the CSIR has a healthy and productive workforce to support its core business.

A number of pipeline development programmes aim to improve attraction and retention of critical skills. The pipeline programmes provide the organisation with access to PhD graduates to increase the percentage of staff qualified with doctoral qualifications. A need also exists for the organisation to focus attention on leadership and management development programmes to equip all levels of management (from supervisory to executive) with critical management competencies.

Providing the organisation with reliable people data to assist with decision-making as well as the protection of such data, is critical. The importance of human capital systems as enablers cannot be overemphasised.

Efficient systems make management responsibilities such as recruitment, performance reviews and similar administrative responsibilities easier, and afford managers more time for other equally important operational matters. These systems must also be efficient in tracking important organisational metrics and simplifying reliable reporting to support faster decision-making.

The CSIR recognises that, from a business and ethical perspective, it is important to entrench employment equity and diversity in the workplace, and to comply with legislative requirements. To further this end, the CSIR has established an Employment Equity and Skills Development Committee and Consultative Forums. These platforms represent CSIR employees with the view to effectively address strategic employment equity and skills development issues.

The CSIR seeks to address, through the committee and forums, the inequalities in racial, gender and skills development which, in the past, have created barriers to full and equal participation of the majority of the population in economic life.

HUMAN CAPITAL SERVICES

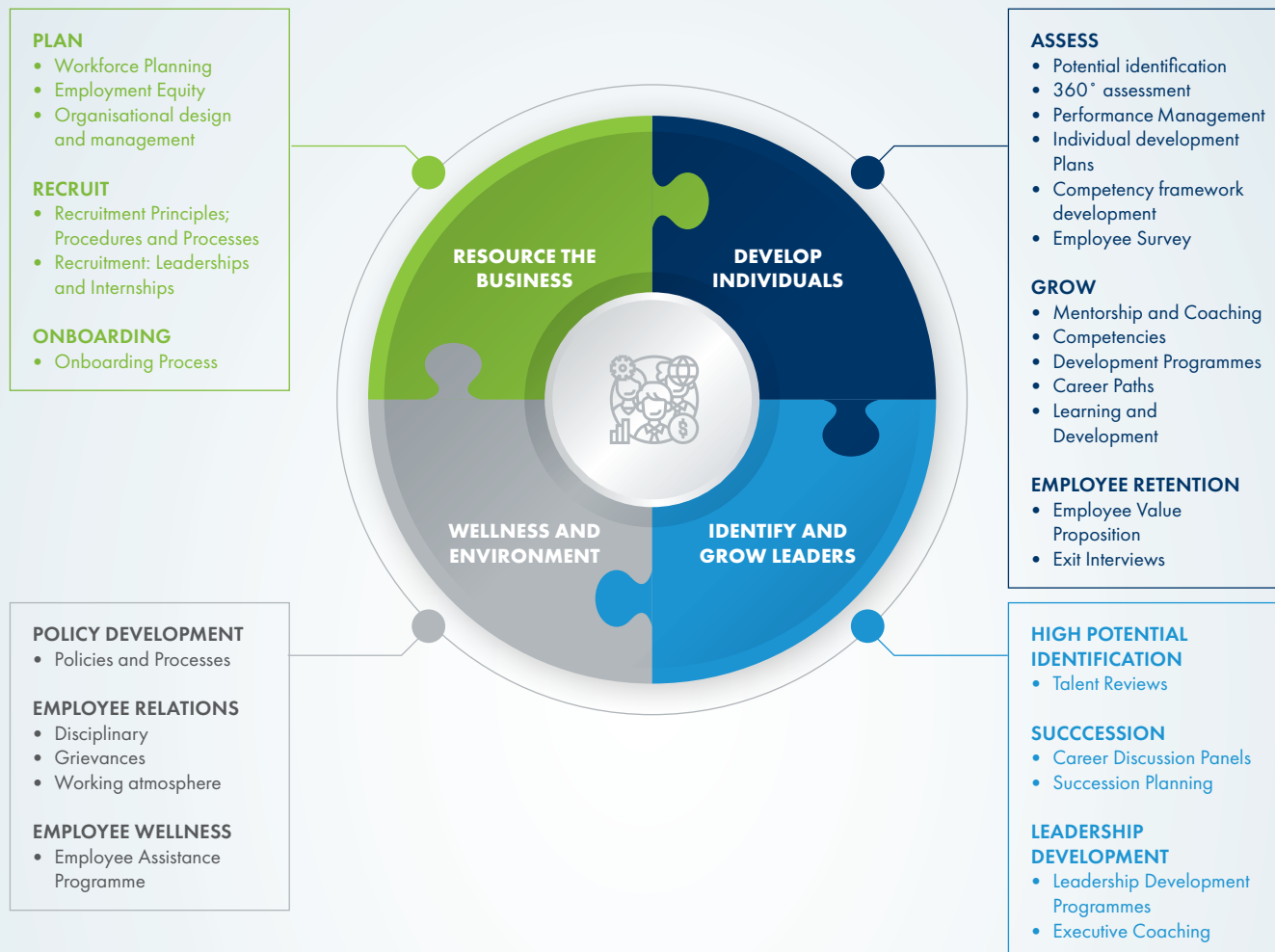


Figure 1: Human Capital services

SUMMARY OF HUMAN CAPITAL PORTFOLIO STRATEGIC OBJECTIVES FOR 2020/21

Table 1: Human Capital Portfolio Strategic Objectives with outputs

Build a diverse talent ecosystem and a sustainable future supply

- Develop and implement workforce planning and capability and recruitment planning.
- Develop and implement a talent sourcing strategy.
- Enhance the CSIR recruitment capability.
- Enhance pipeline development programmes.
- Develop a revised and improved Employment Equity Plan and implement supporting structures.
- Consolidate and strengthen key strategic partnerships with key institutions such as the DSI, NRF, universities, SETAs, etc.

Strengthening leadership and deepening professionalism

- Bolster and embed the Competency Development Framework (leadership; behavioural; environment, health and safety (EHS); and technical competencies).
- Develop and implement a targeted Leadership and Management Development Programme.
- Enhance and reinforce the CILLA Academy blended approach offering to business.
- Provide a targeted, accelerated development programme for critical staff.

Improving individual and organisational performance

- Implement the Employee Value Proposition (for attraction and retention) in alignment with the EPIC values as part of the new CSIR culture.
- Develop the performance management culture.
- Implement performance policy and procedure.
- Develop a Talent Management Framework to enhance the talent pipeline and succession plans.
- Introduce a 360° evaluation to encourage a culture of giving and receiving feedback.
- Reconfigure Career Ladder and Job Family (SET definition) to align with new operating model.
- Reposition reward programmes to include tangible and intangible benefits.
- Develop a Wellness policy and strategy.
- Integrate the Employee Wellness programme within other Human Capital portfolios and support services, such as health services.
- Provide managers with tools to effectively manage employee wellbeing and performance.
- Implement the Pipeline Development Policy.

Increased efficiency and effectiveness of HR systems and processes

- Implement the Workforce Planning System (PeopleSoft Position Management module).
- Enhance the CSIR Recruitment System.
- Implement the PeopleSoft Competency Management module.
- Implement the Organisational Design Analytic Tool (OrgVue).
- Implement the LinkedIn system.
- Implement the PeopleSoft e-Performance Management system.
- Implement the PeopleSoft Manager Dashboard module.
- Implement the PeopleSoft Employee Relations module.
- Upgrade PeopleSoft HRM from version 9.1 to 9.2.
- Upgrade the ImageNow system.
- Improve the utilisation of the Business Information System (BIS) for strategic engagements with business.
- Implement a succession planning system. Source succession planning system to integrate 360° evaluations, performance scores, assessment to apply and assessment matrix to support succession planning.
- Align human capital policies and processes to create an enabling environment.
- Automate key human capital processes and make mobility solutions available to users.

PROGRESS AGAINST PORTFOLIO STRATEGIC OBJECTIVES**Table 2: Summary of Progress against Portfolio Strategic Objectives**

Building a diverse talent ecosystem and a sustainable future supply	
Intervention	Impact and Progress
Develop and implement workforce planning and capability and recruitment planning.	The project for the implementation of the Peoplesoft Position Management System is severely delayed due to ICT resource constraints and other high priority ICT projects. Recruitment against targets has improved compared to previous years. The interventions put in place to improve attraction are starting to yield results.
Develop and implement a talent sourcing strategy.	Talent sourcing strategy implemented. LinkedIn used to source new talent. Talent Review Procedure completed. Human Capital staff trained on the methodology. Talent reviews scheduled for April 2021.
Enhance the CSIR recruitment capability.	The project to enhance the recruitment system is impacted due to ICT resource constraints and budget constraints.
Enhance pipeline development programmes.	• The pipeline programmes were expanded with the introduction of the YES Programme and the GIT Programme was expanded through the intake of the second cohort of graduates. • Bursary management system procured – to assist in tracking performance and wellbeing of students to better provide support. • 20 of the graduates appointed in the GIT programme, 2 on internships, 4 absorbed and appointed permanently. • YES Programme implemented successfully. Second cohort appointed by 1 March 2021.
Develop a revised and improved Employment Equity Plan and implement supporting structures.	Employment Equity and Skills Development Consultative Forums have been established. The CSIR is participating in a process to determine employment equity targets for the sector, and for Department of Employment and Labour approval.

Building a diverse talent ecosystem and a sustainable future supply

Intervention	Impact and Progress
Consolidate and strengthen key strategic partnerships with key institutions such as DSI, NRF, Universities, SETAs, etc.	DSI extended the Inter-Bursary Support (IBS) contract by another 3 years for R110 million. Relationships maintained with all key stakeholders such as DSI, merSETA, NRF, MICTSETA, ECSA, through continuous engagement and timeous reporting and attendance to queries.

Strengthening Leadership and Deepening Professionalism

Bolster and embed the Competency Development Framework (Leadership; Behavioural; EHS and Technical competencies). Implement the Competency Framework to inform job descriptions, competency assessments.	- Competency framework informs all job descriptions and performance contracts. - Implementation of the Competency Framework approved by business. - All existing and new job descriptions have required competencies. - Comprehensive job catalogue completed and available to Human Capital staff on Vibe. - Existing job descriptions are continuously updated and added to the catalogue.
Develop and implement a targeted Leadership and Management Development Programme.	To commence in 2021/22 with Senior Manager: Talent Acquisition and Management appointed.
Revitalise the CILLA Academy blended approach offering to the business; CSIR Learning and Development offerings through CILLA aligned to competencies and business requirements.	Development of the blended curricula. Complete offering of learning interventions that include e-learning, classroom and others implemented. Refinement of the comprehensive curricula. Appropriate learning interventions sourced and offered. Launch and implementation of the curricula. The programme is partially impacted as a result of budget constraints, to be initiated in 2021/22. e-Learning platform piloted; results of the pilot used to draft a request for proposals, which was issued in March 2021. Roll out expected in 2021/22.
- Provide a targeted development programme for critical staff. - Quality of candidates and increased participation in the Career Ladder process. - Expansion of the ARDP. - Increase the number of Black and female chief and principal researchers by 50%. - Training plans developed and implemented.	- Third cohort of Graduates-in-Training (GIT) appointed in March 2021. - Impacted – Moratorium on Career Ladder Assessments. - Programme extended by 2 candidates to 10. - Advisory panel consisting of chief researchers and senior management appointed to assist candidates with their development. Each candidate assigned a mentor from the panel. - The total investment in training of staff at the end of March amounted to R6 156 577. During this time, all the training was done virtually. A total of 911 employees trained. Appropriately trained employees in alignment with organisational strategy.
Develop exchange programmes with universities and industry.	Exchange programme strategy defined. Strengthened capacity through staff exchanges. Define and implement the exchange programme strategy. Five staff members involved in exchange/joint appointment programmes.
- Building employee relations/human resources capacity and transfer skills and knowledge. - Training of management on internal and external employee relations processes with strict adherence to the organisational policies, procedures and South African legislative procedure as required. - Managers trained on internal and external employee relations processes and procedures.	Human Capital staff has been trained on how to support the business to handle employee relations matters related to discipline, grievance, and incapacity. A plan is being finalised to capacitate line managers on issues relating to discipline and incapacity due to poor work performance and ill-health or injury.
- Understanding of transformation and employment equity, including the impact on CSIR's BBBEE score card. - Develop Employment Equity Plan with targets aligned to National EAP and Department of Labour's Occupational Levels.	- Employee Relations and Transformation strategy has been developed and approved. - Employment equity targets are being determined by the sector for the Department of Employment and Labour's approval. - CSIR's employment equity targets are aligned to sector's targets. - The terms and reference for the Employment Equity and Skills Development Committee has been finalised and the nomination process has been completed.

Building a diverse talent ecosystem and a sustainable future supply	
Intervention	Impact and Progress
Improving Individual and Organisational Performance	
Implement the Employee Value Proposition (EVP) (for attraction and retention) in alignment with the EPIC values as part of the new CSIR culture.	- A comprehensive, well-researched and developed EVP, used for engagement, attraction, and retention. - Communicate and implement the CSIR EVP in the organisation. - The CSIR Recognition Programme and the Total Rewards Statement, inputs to the EVP, have been approved by the Executive Committee (Exco). - The EVP is in the process of being finalised.
- Develop the Performance Management culture (reinforce a performance culture). - Performance policy and procedure implemented.	- E-Performance tool implemented successfully with an effective e-learning tool developed to guide staff and managers on completing the electronic process. - The overall status of performance management process (contracting and assessments) is regularly being monitored and communicated to the organisation. - Performance contracting above 99.04% realised and mid-year review completion rate at 95.2%.
- Develop a Talent Management Framework to enhance the talent pipeline and succession plans. - Succession planning policy and guidelines. - Implement a fit-for-purpose Talent Management System and train Human Capital professionals, line managers and employees on the system. - Implement Talent Reviews. - Succession Planning Reviews apply assessment matrix and identify succession pool.	- Functional Talent Management system and succession planning. - Succession planning policy and guidelines implemented. - Fit-for-purpose Talent Management System implemented and Human Capital professionals, line managers and employees trained on the system. - Talent Reviews implemented. - Succession Planning Reviews conducted, assessment matrix applied, and succession pool identified. - The programme for Talent Reviews has been compiled and has commenced in Q4.
Introduce a 360° evaluation to encourage a culture of giving and receiving feedback.	- Effective and efficient utilisation of the 360° evaluation system. Develop or source 360° evaluation aligned to EPIC values, behavioural and leadership competencies. 360° evaluation system was developed internally and improvements are being implemented to refine the system.
Career Ladder and Job Family (SET definition) reconfiguration to align with new operating model.	Career Ladder and Job family definitions reviewed and aligned to operating model. Implementation effective 1 April 2021.
Reposition reward programmes to include tangible and intangible benefits.	- An appropriate employment value proposition aligned with organisation culture and objectives and achieving a balance between the needs of the employer and employee. - Reward Policy and guidelines approved and implemented. - Design and implement an appropriate employment value proposition aligned with organisation culture and objectives and achieving a balance between the needs of the employer and employee. - Pay for performance implemented. - Exco approved proposals for a Recognition Programme and Total Reward Statements.
Develop a Wellness policy and strategy.	Employee Wellness Strategy has been approved and Employee Wellness Policy is being converted to a guideline.

Building a diverse talent ecosystem and a sustainable future supply

Intervention	Impact and Progress
- Integrate the Employee Wellness Programme within other Human Capital portfolios and support services, such as health services. - Provide training and support focusing on the areas of disease management, mental health management, injury on duty and incapacity due to ill-health, occupational health education and promotion for employees and line managers at different platforms. - Training sessions provided. - Collaborations with other support functions.	Employee Wellness has achieved its target to work very closely with other functions with the organisation, particularly the Medical Centre to provide employee assistance.
Provide managers with tools to effectively manage employee wellbeing and performance.	The Employee Wellness Guideline, which is being converted from policy, will upon approval be a tool for managers to manage employee behavior.
Implement the Pipeline Development Policy.	The Board advised that the policy should rather be implemented as procedures. The pipeline development procedure has been developed.

Increased Efficiency and Effectiveness of HR Systems and Processes

Implement the Workforce planning system (PeopleSoft Position Management module).	The implementation of the system is in progress – challenges are being experienced with availability of ICT developer resources to assist. Funding will be sourced to obtain assistance from contracted resources to complete the project. A project plan and templates for workforce planning are in the process of development.
- Enhance the CSIR Recruitment system to ensure full utilisation of system functionality. - Training of the recruitment and Human Capital professionals on the system and process.	The enhancements to the system were not affected due to financial constraints and other higher priority projects. Funding will be sourced to contract a resource to effect the changes. The CSIR signed an MoU with the African Professional Staffing Organisation (APSO) to upskill Human Capital professionals on recruitment.
Implement the PeopleSoft Competency management module.	The project has been put on hold due to budget cuts and resource constraints in ICT.
Implement the Organisational Design Analytic Tool (OrgVue).	The project has been put on hold due to budget cuts.
- Implement the LinkedIn system. - Fully utilised LinkedIn system for talent sourcing and branding purposes. - Ensure branding material is updated and published by Communications department on a regular basis. - Increase in the number of candidates sourced and appointed via the LinkedIn platform.	- LinkedIn fully implemented and Human Capital staff trained. A meeting is scheduled with service provider to finalise the annual plan. - Increased number of candidates sourced via LinkedIn. - Amplify the leadership profile on LinkedIn and enhance the CSIR branding.
Implement the PeopleSoft e-Performance Management system.	The e-Performance Management system was implemented, and mid-year and final year-end performance evaluations are being finalised through use of the system.
Implement the PeopleSoft Manager Dashboard module.	The project has been put on hold due to budget cuts and resource constraints in ICT.
Implement the PeopleSoft Employee Relations module.	The project has been put on hold due to budget cuts and resource constraints in ICT.
Upgrade PeopleSoft HRM from version 9.1 to 9.2.	The project has been put on hold due to budget cuts and resource constraints in ICT.
Upgrade the ImageNow system.	The project for upgrading the Imagenow system is in progress.
Improve the utilisation of the BIS for strategic engagements with business and providing reports on workforce and KPIs.	The BIS needs to be upgraded with the new KPI definitions. The system will be handed over to ICT for development and maintenance.

Building a diverse talent ecosystem and a sustainable future supply

Intervention	Impact and Progress
- Implement a succession planning system. - Source succession planning system to integrate 360° evaluations, performance scores, assessment to apply and assessment matrix to support succession planning.	A project for the implementation and utilisation of the Peoplesoft functionality for implementation of succession planning has been initiated. System configuration are in progress. Changes are required before it will be implemented as supporting tool for the talent review process.
Aligning human capital policies and processes to create an enabling environment.	All policies submitted to the Board have been approved.
Automate key human capital processes and make mobility solutions available to users.	Reviewed human capital processes and workflows to ensure alignment to RAPID/ best practice. A number of manual processes have been automated through the Apex portal. System approval templates were updated to reflect the new approval framework which includes routing to the Operational Managers. Examples include: - Termination process; - Manager and level changes –completed; and - Long service recognition – system specification compiled and signed-off.

STAFF AND TRANSFORMATION PROFILE

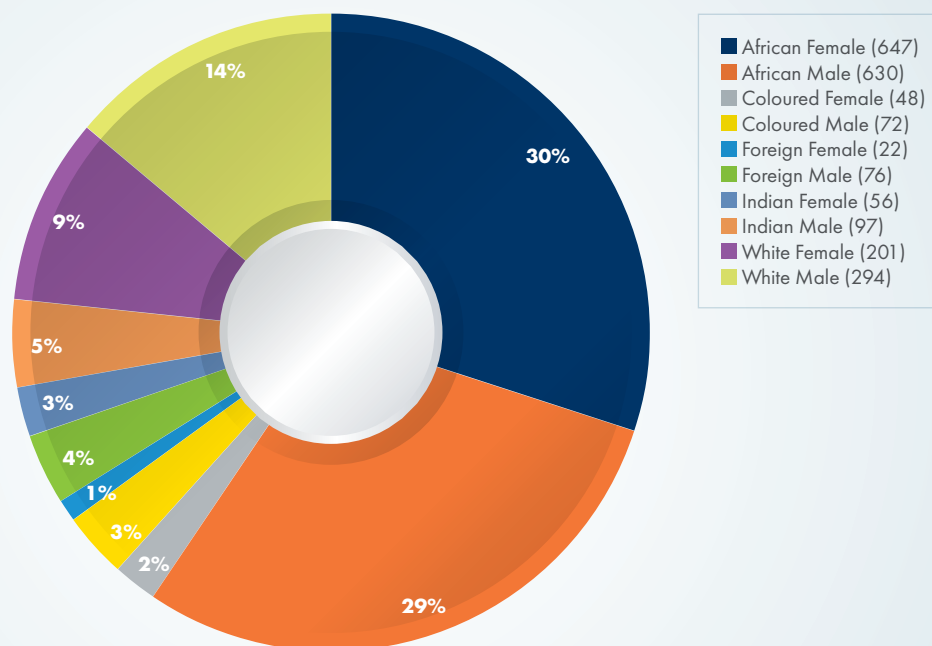


Figure 2: Staff profile

The CSIR total staff headcount at the end of 2020/21 was 2 143, compared to 2 104 as at 31 March 2020, an increase of 39 for this financial year. The CSIR headcount at the end of quarter 4 includes 1 474 (68.78%) SET staff and 669 (31.22 %) support staff. Despite the challenging conditions brought about by Covid-19 and national lockdown, the CSIR increased the total number of staff and number of SET staff.

Table 3: CSIR staff profile as at 31 March 2020/21

STAFF CATEGORY	SET Staff	%	Support Staff	%	Total	%
Permanent	1193	55.67%	640	29.86%	1833	85.53%
Temporary staff	80	3.78%	24	1.12%	104	4.90%
Studentships	35	1.63%	0	0.00%	35	1.63%
Graduates in training	43	1.96%	0	0.00%	43	1.96%
Interns	39	1.82%	5	0.23%	44	2.05%
In-service trainees	0	0.00%	0	0.00%	0	0.00%
YES Programme	84	3.92%	0	0.00%	84	3.92%
Total	1474	68.78%	669	31.22%	2143	100.00%

STAFF TRANSFORMATION PROFILE

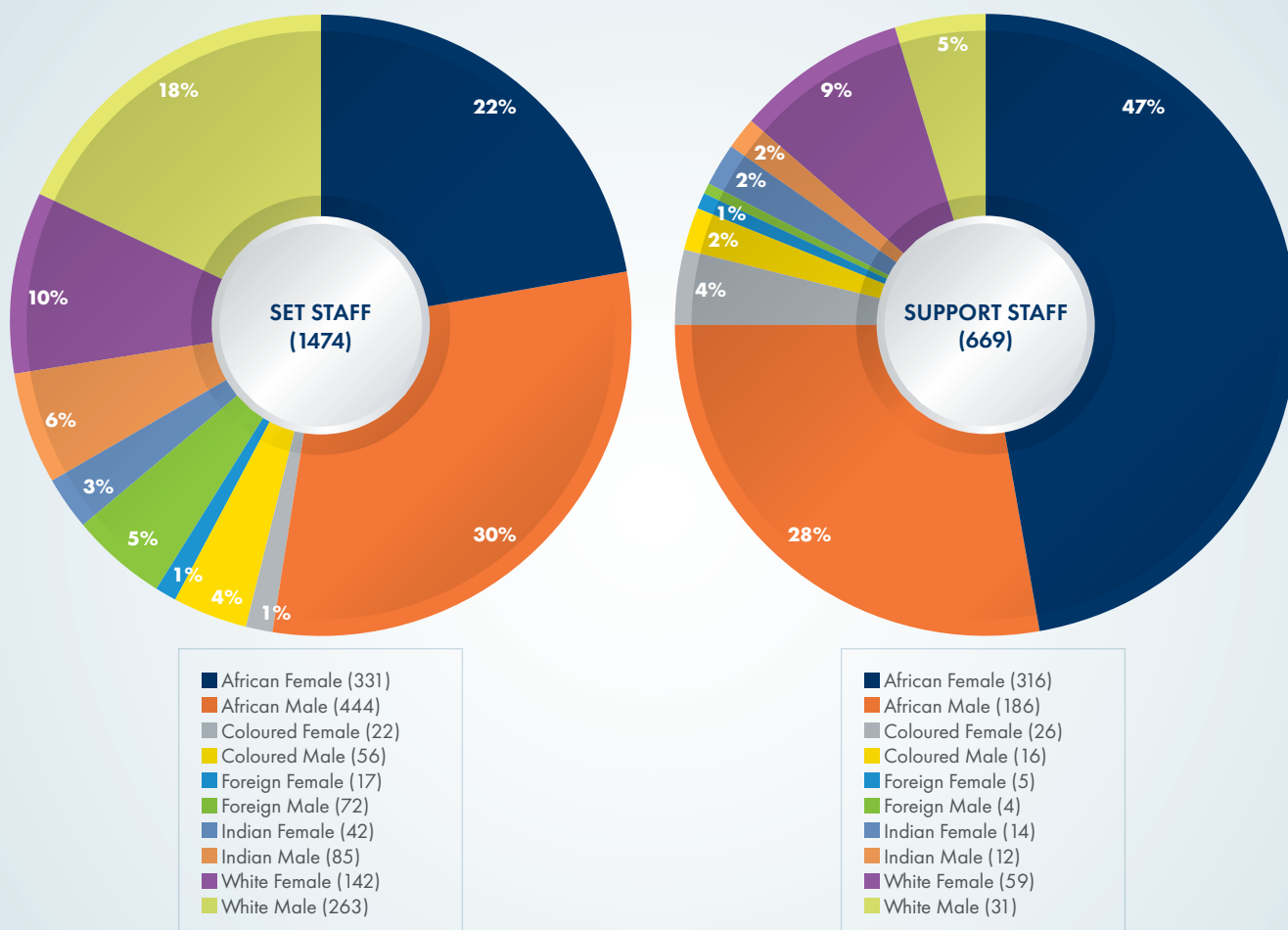


Figure 3: SET and support staff profile

CSIR EMPLOYMENT EQUITY PERFORMANCE AGAINST NEAP TARGETS

Table 4: Performance against NEAP Targets

PERFORMANCE	AM	AF	CM	CF	IM	IF	WM	WF	Total SA	FM	FF	Total Foreign	Grand Total
TARGET %	42.7	35.8	5.2	4.4	1.7	1.1	5.1	4	100	0	0	0	100
ACHIEVED %	29.4	30.2	3.4	2.2	4.5	2.6	13.7	9.3	95.3	3.6	1.1	4.7	100

The table reflects the transformation profile against National Economically Active Population targets as at 31 March 2021.

NUMBER OF STAFF WITH DISABILITIES

Table 5: People with disabilities across occupational levels

Occupational Category	AM	CM	IM	WM	AF	CF	IF	WF	Total	Total Staff	%
TOP MANAGEMENT	0	0	0	0	0	0	0	0	0	16	0
SENIOR MANAGEMENT	0	0	0	0	0	0	0	0	0	92	0
MIDDLE MANAGEMENT	2	0	0	6	0	0	0	2	10	795	0.5
SKILLED	3	1	0	4	1	0	1	1	11	910	0.5
SEMI-SKILLED	0	0	0	0	0	0	0	0	0	221	0
UNSKILLED	15	0	0	0	23	0	0	0	38	109	1.8
TOTAL	20	1	0	10	24	0	1	3	59	2143	2.80

STAFF MOVEMENTS

APPOINTMENTS BY OCCUPATIONAL LEVEL

A total of 265 employees, which include 233 (87.9 %) Black South Africans and 132 (49.8%) female South Africans, were appointed from 1 April to 31 March 2021.

Table 6: Appointments across occupational level

CATEGORY	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
TOP MANAGEMENT	0	1	0	0	1	0	0	0	2	0	0	0	2
SENIOR MANAGEMENT	3	1	0	0	1	0	0	0	5	1	0	1	6
MIDDLE MANAGEMENT	12	7	2	1	3	2	2	0	29	2	1	3	32
SKILLED	19	10	1	1	3	1	1	3	39	0	0	0	39
SEMI-SKILLED	0	2	1	0	0	0	0	0	3	0	0	0	3
TOTAL PERMANENT	34	21	4	2	8	3	3	3	78	3	1	4	82
TEMPORARY	8	18	0	0	3	2	7	7	45	2	1	3	48
PIPELINE	10	17	1	0	0	1	0	2	31	0	0	0	31
GRADUATES IN TRAINING	1	8	3	0	1	0	2	1	16	0	0	0	16
YES PROGRAMME	31	46	10	1	0	0	0	0	88	0	0	0	88
TOTAL	84	110	18	3	12	6	12	13	258	5	2	7	265

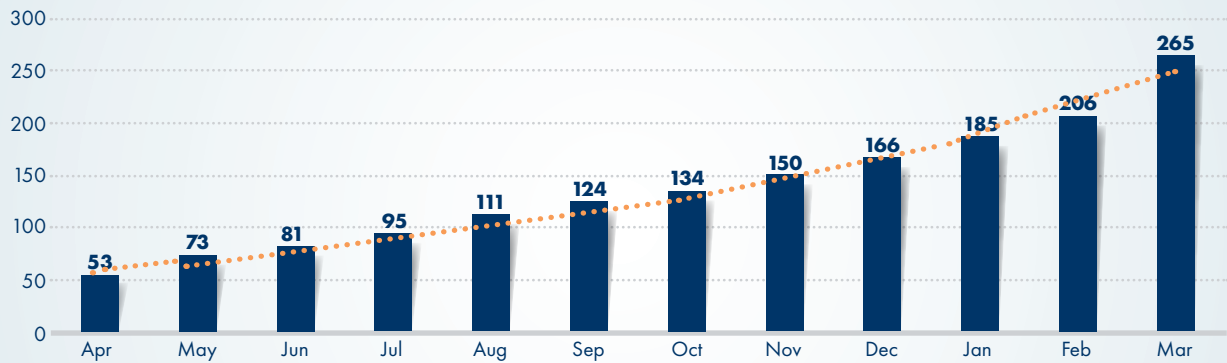


Figure 4: Cumulative appointments

The total number of staff exits of 226 employees during the period 1 April 2020 to 31 March 2021 included 141 permanent and 85 temporary staff members whose contracts came to an end.

Table 7: Total staff exits

OCCUPATIONAL CATEGORY	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
PERMANENT	43	30	5	5	7	8	16	18	132	7	2	9	141
TEMPORARY	23	36	2	0	2	2	9	7	3	1	81	4	85
TOTAL	66	66	7	5	9	10	25	25	135	8	83	13	226

Permanent staff exits of 141 included 98 (69.5%) Black (SA) and 61 (43.3%) females (SA).

Table 8: Permanent staff exits across occupational level

OCCUPATIONAL CATEGORY	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
TOP MANAGEMENT	3	1	1	0	0	0	0	1	6	0	0	0	6
SENIOR MANAGEMENT	1	0	0	0	0	0	0	0	1	0	0	0	1
MIDDLE MANAGEMENT	10	11	1	0	1	0	3	7	33	0	1	1	34
SKILLED	28	17	2	4	5	8	10	7	81	6	1	7	88
SEMI-SKILLED	1	1	1	1	1	0	3	3	11	1	0	1	12
TOTAL	43	30	5	5	7	8	16	18	132	7	2	9	141

Table 9: Permanent staff exits by category

PERMANENT STAFF EXITS	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
DECEASED	3	1	1	0	0	0	0	1	6	0	0	0	6
DISMISSAL	1	0	0	0	0	0	0	0	1	0	0	0	1
NO-FAULT DISMISSAL	10	11	1	0	1	0	3	7	33	0	1	1	34
RESIGNATION	28	17	2	4	5	8	10	7	81	6	1	7	88
RETIREMENT	1	1	1	1	1	0	3	3	11	1	0	1	12
TOTAL	43	30	5	5	7	8	16	18	132	7	2	9	141

Improved career development was the top reason provided by 36 of the 88 permanent staff members who resigned during the period 1 April 2020 to 31 March 2021.

Table 10: Temporary staff exits

TEMPORARY STAFF EXITS	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
END OF CONTRACT	23	36	2	0	2	2	9	7	3	1	81	4	85
TOTAL	23	36	2	0	2	2	9	7	3	1	81	4	85

LEARNING CAPABILITY DEVELOPMENT AND CSI

HUMAN CAPITAL DEVELOPMENT

PIPELINE DEVELOPMENT

The number of students in the human capital development pipeline programmes as at 31 March 2021 is illustrated in the following figure.

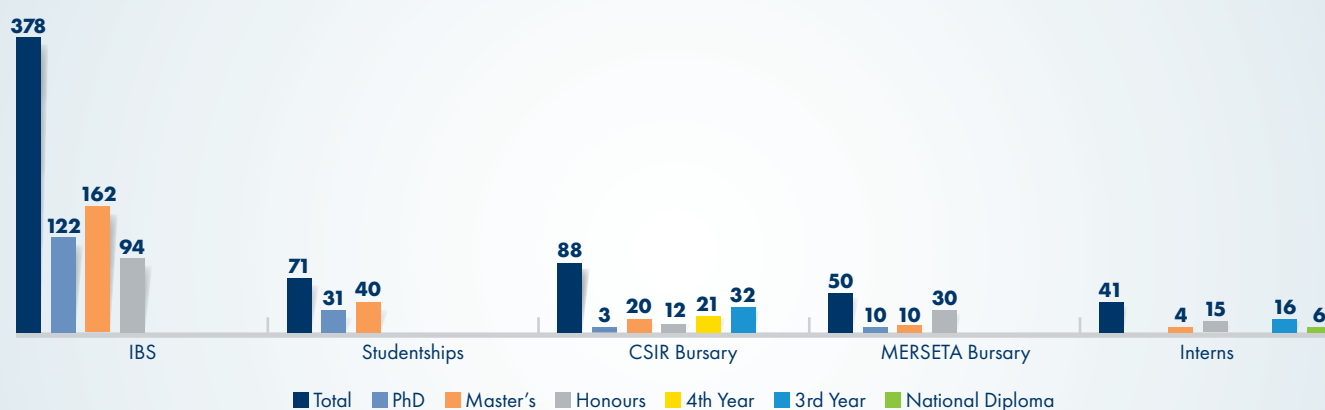


Figure 5: Number of students in the Human Capital Development Pipeline Programme

The demographics for the human capital development pipeline programmes follow.

Table 11: Human Capital Development Pipeline Programmes

PROGRAMME	AM	AF	CM	CF	IM	IF	WM	WF	Total SA	FM	FF	Total Foreign	Grand Total
BURSARY STUDENTS	31	33	5	1	3	2	5	8	88	0	0	0	88
IBS STUDENTS	95	200	2	2	6	8	28	24	365	9	4	13	378
STUDENTSHIPS	23	37	0	2	2	1	3	3	71	0	0	0	71
MERSETA BURSARIES	30	18	0	0	0	0	1	1	50	0	0	0	50
INTERNS	22	15	0	0	0	1	1	2	41	0	0	0	41
TOTAL	201	303	7	5	11	12	38	38	615	9	4	13	628
PERCENTAGE	32%	48%	1%	1%	2%	2%	6%	6%	98%	1%	1%	2%	100%

INTER-BURSARY SUPPORT (IBS) PROGRAMME

The programme has been successful in supporting postgraduate students in key areas of research as prioritised by the DSI. The IBS contract was renewed by the DSI this year in line with the MTEF period for the next three years. The contract for year one of funding was concluded and the funding of just over R42 million was received. The process to recruit students for the 2021 academic year was started in October 2020 and concluded in December 2020 with 302 students awarded bursaries, including 57 honours, 132 master's and 113 doctoral level students. The contracts for some master's and PhD students who were unable to complete their studies were extended for periods of 6 and 12 months, respectively. A process is underway to migrate all the students to a new Bursary Management Platform to allow for seamless management of the programme. The annual report for the DSI has been drafted and will be submitted once the finances have been reconciled.

STUDENTSHIPS

The number of studentships has been decreasing in line with the plan to initiate a postgraduate bursary programme at master's and PhD level. In quarter 4 of 2019/20 the total number of studentships was 76 with 34 doctoral students and 42 master's students. The number of studentships decreased to 35 as at 31 March 2021. In the 2020/21 financial year, a total of 41 students graduated and were appointed to permanent and temporary positions.

Table 12: Studentship absorption

LEVEL	NUMBER GRADUATED
Master's	24
PhD	17
Total	41

BURSARY PROGRAMME

A total of 88 students were funded under the bursary programme. Of these, 56 students were due to complete their studies in the 2020 academic year, and 50 completed (89% success rate). Of those who graduated, 20 joined the GIT Programme. The rest of the graduates are furthering their studies at local universities.

Vacation work was organised for students as part of fulfilling academic degree requirements in June/July 2020 as well as December/January 2021. The students were hosted by various CSIR clusters and strict Covid-19 protocols were followed to ensure safety of the students.

A process to recruit students at master's and doctoral level was initiated, this was finalised in February 2021.

The procurement of a Bursary Application and Management System was finalised. Excel@Uni was appointed as a preferred service provider for a period of three years. An initiation meeting took place, and a list of current students was provided to migrate into the Excel@Uni system. Regular engagements and approval of the CSIR Privacy and Information Security offices to introduce and implement the system have been concluded successfully.

YES PROGRAMME

The YES Programme was a success; it contributed to the CSIR obtaining B-BBEE level 2 this financial year. The second cohort of youth (54) was recruited and appointed on 1 March 2021. This includes 14 GIT candidates and 40 youths appointed through Youth@Work. The CSIR continues to partner with Youth@Work as an implementation agency. This year, 21 of the youths are hosted by the Chemicals Cluster in its laboratories, eight have been placed at the CSIR's industry facing centres – the BDC, BDF, NIDF and PPF and 13 have been placed with the SMEs that have been supported by the cluster. In future, the plan is to increase the number of youths hosted internally by the CSIR or with our stakeholders.

GIT PROGRAMME

The GIT continued with their training programme while working from home. They also attended various virtual training courses. Twenty graduates formed the third cohort of graduates in the programme – bringing the total to 65 candidates. This year, 11 GIT were absorbed permanently by the various clusters. Additional funding was received from merSETA for a candidacy programme, these funds are used towards the training and development of the candidates.

UNIVERSUM RESULTS

Universe commissions surveys with professionals and students alike to test their career aspirations and employers of choice. This year the CSIR was ranked second by science students as an employer of choice and fourth by engineering students pursuing a career in the public sector. In terms of professionals, the CSIR was ranked first by science professionals and fourth by engineering professionals pursuing a career the public sector. This indicates that the CSIR brand is recognised by students and professionals.

ALUMNI PROGRAMME

A concept paper for the Alumni Programme was presented to Exco in December 2020. The programme aims to 1) Provide a platform for former employees to be involved as part of the CSIR community; 2) Foster a spirit of loyalty with exiting employees subsequent to leaving the CSIR; and 3) Retain employees as brand ambassadors after their exit for recruitment and business development purposes.

An invite was sent to 2 134 former employees to join the programme. A positive response was received from 791 former employees. An alumni webpage is being created. It will provide a platform to engage with CSIR alumni and allow for registration of new members. The plan is to launch the Alumni Programme in the latter part of 2021 and implement the programme.

E-LEARNING PLATFORM

CSIR Learning and Development evaluated an online training platform that employees can use on demand, to meet both their work-related and personal learning goals. A pilot was done with Udemy who provided the CSIR with 120 licences over a period of four weeks. A total of 116 employees accepted and participated in the pilot. Employees enrolled for 268 courses, the spread and type of courses are as follows:

Courses enrolled for during the trial period:

- Content marketing
- Uncategorized
- Communication
- Spreadsheets
- Web Development
- Project management
- Graphics design
- Programming languages
- Analytics
- Personal growth
- Operating systems and servers
- Art and creativity
- Design tools
- Statistical analysis
- Machine learning
- Hardware
- Strategies
- Learning and development
- Mobile development
- Development tools

Feedback from employees who participated in the trial was very positive and was used to inform the procurement process to secure an appropriate service provider for an e-learning platform. A Request for Proposals for the CSIR e-Learning platform was prepared and advertised in March 2021.

STAFF TRAINING

The total investment in training of staff at the end of March amounted to R6 156 577. During this time, all the training was done virtually, except the course on Facilitation, which was provided at the ICC.



Figure 7: Summary of training costs by month

Table 13: Training Costs across occupational levels

CATEGORY	NUMBER OF STAFF	RAND	% OF TOTAL TRAINING COST
TOP MANAGEMENT	3	37 877	0.62%
SENIOR MANAGEMENT	38	232 841	3.78%
MIDDLE MANAGEMENT	392	3 215 416	52.23%
SKILLED	411	2 487 478	40.40%
SEMI-SKILLED	61	173 792	2.82%
UNSKILLED	6	9 174	0.15%
TOTAL	911	6 156 577	100.00%

Table 14: Training costs by event type

TRAINING EVENT	NO. OF STAFF	AMOUNT
Computer-based Training	312	2 562 241
Conferences	134	647 216
Seminars	465	2 947 120
TOTAL	911	6 156 577

Table 15: Training provided across occupational levels

OCCUPATIONAL CATEGORY	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
TOP MANAGEMENT	0	0	0	0	0	0	1	0	1	1	1	2	3
SENIOR MANAGEMENT	8	2	2	0	1	1	10	6	30	8	0	8	38
MIDDLE MANAGEMENT	91	58	12	4	43	12	47	90	357	22	13	35	392
SKILLED	152	165	8	7	12	15	31	15	405	3	3	6	411
SEMI-SKILLED	33	20	5	3	0	0	0	0	61	0	0	0	61
UNSKILLED	6	0	0	0	0	0	0	0	6	0	0	0	6
TOTAL	290	245	27	14	56	28	89	111	860	34	17	51	911

LEARNING FACTORIES

The main objective of this programme is to establish and operationalise learning platforms for skills development and innovation in support of 4IR. The Learning Factory is divided into two focus areas:

- 1. CSIR Master Learning Factory:** The CSIR has prepared a progress report and videos of the Learning Factory for merSETA (the funder) as one of the main contract deliverables for 2020/21, which was supposed to be supported by merSETA's site visit at the CSIR. Due to the Covid-19 restrictions, a Learning Factory video has been attached to the progress report.
- 2. TVET College Learning Factories:** The CSIR is leading the establishment of 18 Learning Factories at public TVET Colleges. The merSETA is engaging Falsebay TVET College to advise on the requirements and time-lines for its Learning Factory. The first draft of the National Framework was presented to the Project Steering Committee (PSC) and inputs incorporated for final presentation for approval by PSC in the first quarter of 2021/22.

WORK INTEGRATED LEARNING (WIL)

Funding from merSETA to the value of R3.52 million was secured to host 50 WIL candidates. The two clusters in Division 2 that have

indicated their interest in the WIL programme, funded by merSETA, are currently conducting background checks of the recommended students for appointment.

CORPORATE SOCIAL INVESTMENT

The CSIR donated facial masks to schools and care centres in July 2020, as part of its Mandela Day Celebration, to honour Nelson Mandela, and to celebrate the idea that each individual or organisation has the power to transform the world, the ability to make an impact.

Table 16: Corporate Social Investment

AREA	BENEFICIARY
Hammanskraal	Tswaranang Orphanage Masakhane Primary School Sekhululekile High School
Soshanguve	Luvuyo Orphanage Home Ikwezi le Themba Lerato la Bagolo Old Age Home
Letlhabile	Kutullo Disability and Day Care Centre Ikatisong High School
Mooiwooi	Grace of Help

TALENT ACQUISITION AND MANAGEMENT

TALENT REVIEWS

In the 2020/21 business plan, the Human Capital Portfolio committed to develop a Talent Management Framework to enhance the talent pipeline and succession plans. This includes the development of:

- Functional Talent Management system and succession planning.
- Succession planning policy and guidelines implemented:
 - A fit-for-purpose Talent Management System and Human Capital professionals, line managers and employees trained on the system;
 - Talent reviews; and
 - Succession planning reviews, assessment matrix, and identification of succession pool.

To this effect, Human Capital developed a talent review methodology, succession planning documents and templates during the 2020/21 financial year and these were enhanced and finalised in Q4. The Human Capital community at the CSIR was trained on the methodology and the relevant templates in preparation for the roll-out of the Talent Review process across the organisation. An implementation plan was also approved effective from March 2021.

In quarter 4, Human Capital began the process of engaging with business on the talent review process, roles and responsibilities as

well as the timelines. This included presentations at the Management Committee meetings to embed the basic principles of talent reviews and objectives. The focus in quarter 4 was on positions reporting directly to the extended Exco and Exco members and concerns positions at level D4 and above. The CSIR leadership has shown great interest in and support for the talent review process.

From March 2021, the extended Exco began the process of plotting employees who are on level D4 and above. The extended Exco was expected to:

- Map employees on the 9-Box Grid, a visual tool used to facilitate discussions about employee performance and potential;
- Prepare succession plans; and
- Identify developmental areas and develop action plans.

TALENT ACQUISITION AND UPSKILLING OF HUMAN CAPITAL STAFF

The impact of Covid-19, financial constraints and external competition for highly skilled staff remained a challenge and adversely affected attraction of staff throughout the year. Despite these challenges, the CSIR exceeded the target for the number of SET staff and managed to increase the total number of staff.

The Human Capital Portfolio finalised the MoU between the CSIR and the Federation for African Professional Staffing Organisation (APSO).

APSO is registered with the South African Qualifications Authority. On the 19th of March 2021, the CSIR was presented with a Corporate Membership by APSO, at no cost to the CSIR.

Human Capital began the process of upskilling the Human Capital community during 2020/21. The APSO Corporate Membership presents several benefits to the community, including different professional designations, staffing resources, an online learning platform, networking opportunities with other staffing professionals, and information on recruitment best practices and industry standards for conducting fair and ethical recruitment. These will contribute towards professionalising the Human Capital function. Through the APSO offerings, the Human Capital community will be capacitated and empowered with relevant skills and competencies, and this

will, in turn, improve efficiencies and provide fit-for-purpose human capital services to the CSIR. Furthermore, the recruiters will be able to engage on the following topics:

- Introduction to Recruitment – Codes of Ethics and Best Practice.
- The Recruitment Cycle – Behaviours of Super Recruiters.
- Interviewing – Fundamentals, Pitfalls, and Questioning techniques.
- The Job Specification – Understanding and qualifying, why is this critical.
- Candidate Management – Candidate Loyalty.
- Candidate Assessments – Verifications and Referencing.
- Candidate Sourcing – Sourcing Strategies and dealing with Passive Candidates.

REWARDS AND RECOGNITION

TOP EMPLOYER CERTIFICATION

The Top Employers Institute is the global authority on recognising excellence in people practices. The Human Capital Portfolio participated during 2020/21 in the survey of the Top Employers Institute to be recognised as an employer of choice. The submission was followed by a validation process during July 2020 and an independent audit by BDO during August and September 2020. The CSIR was officially notified of certification as a Top Employer on 14 October 2020.

The launch of the official international certification was on 25 January 2021. From this date onwards, the CSIR could make public use of the Top Employer Certification seal and title. The 2021 Top Employer certification status is valid from January to December 2021. Being certified as a Top Employer showcases an organisation's dedication to a better world of work and exhibits this through excellent human capital policies and people practices. The Top Employers Institute programme certifies organisations based on the participation and results of their Human Resources Best Practices Survey. The survey covers six human capital domains consisting of 20 topics and 362 questions.

Table 17: Summary of top employers topics

DOMAIN	TOPIC
Steer	Business Strategy
	People Strategy
	Leadership
Shape	Organisation and Change
	Digital HR
	Work Environment
Attract	Employer Branding
	Talent Acquisition
	On-Boarding

DOMAIN	TOPIC
Develop	Performance
	Career
	Learning
Engage	Well-being
	Engagement
	Rewards and Recognition
	Off Boarding
Unite	Values
	Ethics and Integrity
	Diversity and Inclusion
	Sustainability

The CSIR Communication team has issued a media release to announce the certification. The Top Employer branding is published on all the CSIR's social media platforms, website, and intranet. The branding was used in internal and external communication throughout 2021.

The CSIR will again this year participate in the survey, to be certified as a Top Employer in 2022.

EMPLOYEE VALUE PROPOSITION

The CSIR appointed a consultancy firm (Emergence Growth) to develop compelling Employee Value Proposition (EVP) statements that are aligned to the CSIR's vision; mission, strategy and values to create a positive candidate and employee experience. These statements should differentiate the CSIR from its competitors and other organisations. It should be aimed at both external and internal audiences and be relevant across generations. The EVP statements were presented to Exco for approval. Further refinement is needed.

CSIR RECOGNITION PROGRAMME

Currently at the CSIR, employee recognition is mostly focused on monetary rewards. A proposal to Exco, to introduce other considerations of non-monetary ways to recognise employees, was approved in March 2021. The Recognition Programme is a subset of the EVP and aims to attract, motivate, engage, and retain employees. It will further reinforce the CSIR's stature as a Top Employer.

The following categories of recognition were approved:

- Verbal Recognition and Written Recognition;
- Peer-to-Peer Recognition;
- Manager Recognition;
- Personal Recognition;
- Professional Achievement Recognition;
- Employee Milestone Recognition; and
- Safety and Values Recognition.

TOTAL REWARD STATEMENTS

Total rewards are 'everything' an employee gets from the employer that they find rewarding. The Total Reward Statements is a communication tool and supports the EVP and the Recognition Programme.

Exco approved the concept and the introduction of Total Reward Statements for the CSIR and approved that the team proceed with the design, development and implementation of Total Rewards Statements for employees.

JOB EVALUATION COMMITTEE

A proposal to establish a new job evaluation committee, comprising of representatives of the divisions/clusters and portfolios, was approved by Exco. Training on the Hay job evaluation methodology for the new committee is scheduled for April 2021.

EXCELLENCE AWARDS

As part of the CSIR's 75th Anniversary, the Excellence Awards was held together with the CSIR Biennial Conference. Nominations were submitted online and a total of 260 submissions, which also included teams, were received. A total number of 712 employees were nominated for Excellence Awards.

Different committees were established to identify the finalists and winners, namely the implementation team, collections team, adjudication panel and review team. Two finalists (including teams) were identified per category, with a total of 216 individuals who were invited to attend the event on 12 November 2020.

The Excellence Award ceremony was hosted as a combination of a physical and virtual event. A limited number of people, i.e. the finalists, CSIR Board, Exco and representatives from the different committees that were involved in the planning of the Awards, were invited to attend the event at the CSIR ICC. The CEO and Chairperson of the Board attended the event to handover the certificates and trophies to the winners.

The proceedings were live streamed to allow internal and external stakeholders to join the proceedings virtually. With the country having moved to lockdown level 1 at the time, the ICC venue could accommodate a maximum of 250 people. The event was subjected to all the safety measures set out as per the government regulations as well as the CSIR's Covid-19 protocols.

The trophies for the Excellence Awards were designed to entrench the EPIC values. Excellence Awards were presented to 47 winners. In addition to the framed certificates and trophies, the winners received prize money, paid with the December 2020 payroll. The prize money amounted to R620 000.

EMPLOYEE RELATIONS AND TRANSFORMATION

INTERNAL EMPLOYEE RELATIONS MATTERS

Table 18: Summary of internal employee relations matters

MATTERS	ATTENDED MATTERS	CONCLUDED MATTERS	PENDING MATTERS
GRIEVANCES	11	9	2
INVESTIGATIONS	20	15	5
DISCIPLINARY	11	8	3
INCAPACITY	11	7	4
TOTAL	53	39	14

EXTERNAL EMPLOYEE RELATIONS MATTERS

Table 19: Summary of external employee relations matters

MATTERS	ATTENDED MATTERS	CLOSED MATTERS	PENDING MATTERS
CCMA	11	9	2
LABOUR COURT	20	15	5

SUPPORT SERVICES STAFF REORGANISATION

Table 20: Summary of support staff reorganisation process

ACTIVITY	NUMBER
Total affected employees	232
Placed employees	181
Processed voluntary severance packages	34
Placed in other roles or resigned	14
Employees placed in temporary assignments (pending permanent placement)	3
Appeals	10

The Board has approved further alternative options to accommodate the three employees who remain unplaced, as follows:

- Extension of temporary placement for five months, ending on 31 July 2021;
- Extension of voluntary severance package for the employees to be applied for; and
- Forced termination (retrenchment), should any of the employees remain unplaced by 31 July 2021.

Human Capital is in the process of implementing the Board's resolution by extending the affected employees' temporary placements until 31 July 2021 and will thereafter be engaging the employees on the next option, which will be for them to consider applying for voluntary severance packages.

EMPLOYMENT EQUITY AND SKILLS DEVELOPMENT

Training of both Human Capital staff and Employment Equity and Skills Development Consultative Forums representatives took place on 25 and 26 February 2021, respectively. The training was provided by a service provider, Bruniquel & Associates (Pty) Ltd,

and 106 people attended the training. The Consultative Forums and Employment Equity Committee will meet quarterly and bi-annually, respectively.

The CSIR submitted the relevant report to the Department of Employment and Labour in January 2021, in terms of Section 21 of the Employment Equity Act No. 55 of 1998, as amended. The CSIR will therefore appear on the Employment Equity Public Register for 2020, which will be published by the Minister of Employment and Labour in terms of Section 41 of the Employment Equity Act.

Human Capital attended a workshop that was organised by the Department of Employment and Labour on 23 February 2021. The purpose of the workshop was to enable the Professional, Scientific and Technical Activities Sector, as designated by the Department of Employment and Labour, to discuss and agree on setting employment equity targets in the sector.

The CSIR started with the process to set its own employment equity targets in 2020, and will finalise such process, and use the information to influence the sector targets.

Following is the summary of employment equity activities and timelines, to date:

Table 21: Summary EE AND SDC activities

ACTIVITIES	TIME-LINE
Terms of Reference approved by Exco: 1. CSIR Consultative Committees 2. CSIR EE and SD Committee	October 2020
Call for Nominations	13 - 20 October 2020
Counting and Verification	21 October to 1 December 2020
Announcement of Consultative Committees Members	9 January 2021
Training of Consultative Committees Members	26 February 2021
Consultative Committee Meetings	5 March 2021 - 31 March 2022
Submission of the CSIR EE Report to DOEL	15 October 2021

EMPLOYEE WELLNESS

COVID-19 STAFF SUPPORT SERVICES

Table 22: Summary of Covid-19 support services

ACTIVITY	COMMENT
CSIR webinars	Employee Wellness procured the services of ICAS Southern Africa (Pty) Ltd for the presentation of 9 webinars on Covid-19 related topics during August and September 2020
Bestmed-sponsored webinars	Bestmed sponsored 8 webinars on Covid-19 related topics taking place from October to December 2020
Continued staff support	Procurement preparations are underway to roll-out further Covid-19 related staff support services for the year 2021. Webinars, covering various Covid-19 related topics, and Pilates exercises are planned to resume in April 2021 The following topics will, among others, be considered: • To vaccinate or not to vaccinate • Covid-19 aftermath • Financial management

HUMAN CAPITAL BUSINESS ENABLEMENT AND EFFICIENCIES

SYSTEMS APPROVAL TEMPLATES

- PeopleSoft approval templates were amended, and the routing aligned with the Approval Framework that was approved by the Board.
- Approvals are aligned according to the operating model and now include routing to the Operations Managers.
- Functionality was added to enable the submission of leave transactions on mobile devices.

HUMAN CAPITAL POLICIES AND PROCEDURES

Part of the Human Capital Portfolio's role is to ensure regulatory compliance and ensuring policies are reviewed periodically. The following policies were reviewed during 2020/21.

Table 23: Summary of policies approved during 2020/21

POLICY	APPROVED
Performance Management Policy	April 2020
Incapacity due to Ill Health and Injury Policy	April 2020
Poor Work Performance Policy	April 2020
Relocation Assistance Policy	April 2020
Professional Registration Policy	July 2020
Conditions of Service (revised)	July 2020
Corporate Social Investment (CSI) Policy	October 2020

POLICY	APPROVED
Remuneration Policy	October 2020
Disciplinary Code	October 2020
Talent Management Policy (with revisions)	October 2020

CONDITIONS OF SERVICE – LEAVE FORFEITURE AMENDMENT

The forfeit period for vacation leave was adjusted from 18 months to 21 months, allowing employees more time to take vacation leave.

The following procedures and guidelines were reviewed and approved during the year.

Table 24: Summary of procedures and guidelines approved during 2020/21

PROCEDURES / GUIDELINES	APPROVED
Pipeline Development Procedure	November 2020
Professional Registration Procedure	December 2020
Leave Guideline	January 2021
Retirement Procedure	February 2021
Termination Procedure	February 2021
Disciplinary Procedure	March 2021

HUMAN CAPITAL SYSTEM IMPROVEMENTS

TALENT REVIEWS AND IMPLEMENTATION OF THE PEOPLESFT TALENT MANAGEMENT FUNCTIONALITY

ICT assistance is required to attend to system issues (security, person-based succession planning, workflow). A service request to ICT was submitted. A decision was taken at the ICT and Human Capital collaboration meeting held mid-March to amend priorities and focus on completion of this process so that the functionality could be used as part of the talent review process in the organisation.

PERFORMANCE MANAGEMENT SYSTEM

The system was rolled-out during June 2020 and training videos made available to the organisation. The mid-year performance reviews commenced in October 2020; 97% of performance contracts are completed; 97% of employee mid-year performance evaluations completed and 74% of year-end performance evaluations completed.

The system development for the capturing of moderated scores was implemented and will be used as part of the year-end performance evaluation processes. The timeframe for completion of the year-end evaluation was 31 March but extended to 30 April 2021.

PEOPLESFT POSITION MANAGEMENT SYSTEM

The implementation of the Position Management system has been severely impacted and delayed due to unavailability of ICT

resources and conflicts with other projects. Discussions were held between Human Capital and ICT leadership on how the resourcing issues can be resolved to ensure project delivery. Alternatives discussed was to contract in a resource to assist with the operational human capital issues to free up the PeopleSoft resource to focus on the project. The delay in the finalisation of the ICT procurement process for enterprise resource planning services had a direct impact on this project. This project was put on hold and the implementation of the talent reviews and succession planning prioritised above this project.

BURSARY MANAGEMENT SYSTEM (INCLUDES ALL PIPELINE PROGRAMMES)

The procurement process and signing of the contract was finalised. The system implementation for the management of the bursars (MILA system) was concluded and the loading of the current bursar's information completed. The systems set-up of the advertising platform (AURA) is to commence. The plan is that advertising should be done during May 2021.

CAREER LADDER APPLICATION SYSTEM

The second phase of development for the career ladder app was completed. A training video was developed to assist staff, line management and Human Capital personnel on how to navigate the system.

HUMAN RESOURCE OVERSIGHT STATISTICS

Table 25: Personnel cost by programme/activity/objective

Programme/activity/objective	Total expenditure for the entity (R'000)	Personnel expenditure (R'000)	Personnel expenditure as a % of total exp. (R'000)	No. of employees	Average personnel cost per employee (R'000)
Div 1: Chemicals, Agriculture, Food and Health	298 210	145 705	49%	234	622,67
Div 2: Mining, Manufacturing, Defence and Security	840 498	433 055	52%	606	715
Div 3: Natural Resources, Enabling Infrastructure, Public and Professional Services	783 909	447 277	57%	656	682
Portfolio: Business Excellence and Integration	166 771	51 378	31%	70	734
Portfolio: Finance	117 757	96 971	82%	166	584
Portfolio: Human Capital and Communications	116 214	61 735	53%	157	393
Portfolio: Legal, Compliance and Business Enablement	80 239	95 946	120%	225	426
Portfolio: Leadership Team	49 757	38 435	77%	29	1 325
Total	2 453 354	1 370 502	56%	2 143	639.53

Table 26: Personnel cost by occupational levels *

Level	Personnel expenditure (R'000)	Percentage of personnel expenditure to total personnel cost (R'000)	No. of employees	Average personnel cost per employee (R'000)
Top management	52 407	3.82%	16	3 275
Senior management	157 531	11.49%	92	1 712
Professional qualified	740 401	54.02%	795	931
Skilled	367 729	26.83%	910	404
Semi-skilled	46 387	3.38%	221	210
Unskilled	6 047	0.44%	109	55
Total	1 370 502	100.00%	2143	640

Table 27: Performance rewards *

Programme/activity/objective	Performance rewards	Personnel expenditure (R'000)	Percentage of performance rewards to total personnel cost (R'000)
Top management	0	52 407	0%
Senior management	0	157 531	0%
Professional qualified	0	740 401	0%
Skilled	0	367 729	0%
Semi-skilled	0	46 387	0%
Unskilled	0	6 047	0%
Total	0	1 370 502	0%

Table 28: Training costs *

Programme/activity/objective	Personnel expenditure (R'000)	Training expenditure (R'000)	Training expenditure as a percentage of personnel cost.	No. of employees trained	Average training cost per employee (R'000)
Division 1: Chemicals, Agriculture, Food and Health	145 705	203	0%	42	5
Division 2: Mining, Manufacturing, Defence and Security	433 055	2 299	0,5%	277	8
Division 3: Natural Resources, Enabling Infrastructure, Public and Professional Services	447 277	2 133	0,5%	294	7
Portfolio: BEI	51 378	370	0,7%	57	6
Portfolio: Finance	96 971	186	0,2%	116	2
Portfolio: Human Capital and Communications	61 735	485	0,8%	36	13
Portfolio: LCBE	95 946	425	0,4%	70	6
Portfolio: Leadership Team	38 435	56	0,1%	19	3
Total	1 370 502	6 157	0,4%	911	51

Table 29: Employment and vacancies as at 31 March *

Programme/activity/objective	2019/2020 No. of employees	2020/2021 Approved posts	2020/2021 No. of employees	2020/2021 Vacancies	Percentage of vacancies
Division 1: Chemicals, Agriculture, Food and Health	216	255	234	21	8.97%
Division 2: Mining, Manufacturing, Defence and Security	594	683	606	77	12.71%
Division 3: Natural Resources, Enabling Infrastructure, Public and Professional Services	658	734	656	78	11.89%
Portfolio: BEI	74	83	70	13	18.57%
Portfolio: Finance	168	200	166	34	20.48%
Portfolio: Human Capital and Communications	118	163	157	6	3.82%
Portfolio: LCBE	251	257	225	32	14.22%
Portfolio: Leadership Team	25	31	29	2	6.90%
Total	2 104	2 406	2 143	263	12.27%

Table 30: Overview of staff complement, including vacancies, appointments and terminations

Programme/activity/objective	2019/20 No. of employees	2020/21 Approved posts	2020/21 No. of employees	2020/21 Vacancies	Percentage of vacancies
Top management	14	19	16	3	15.79%
Senior management	89	98	92	6	6.12%
Professional qualified	777	897	795	102	11.37%
Skilled	935	1033	910	123	11.91%
Semi-skilled	262	249	221	28	11.24%
Unskilled	27	110	109	1	0.91%
Total	2 104	2 406	2143	263	10.93%

* Personnel expenditure excludes the bonus accrual and post-retirement benefit adjustment.

Salary band	Employment at beginning of period	Appointments	Internal appointments, promotions and position changes	Terminations	Employment at end of the period
Top management	14	3	1	-2	15
Senior management	89	9	8	-14	84
Professional qualified	777	42	38	-62	757
Skilled	935	112	-31	-106	941
Semi-skilled	262	11	-16	-36	237
Unskilled	27	88	0	-6	109
Total	2 104	265	0	-226	2143

The total number of staff as at 31 March 2021 of 2 143 included 265 new appointments compared to 2 104 at 31 March 2020. Newly appointed employees numbered 265, while 226 employees left the CSIR during 2020/21.

Table 31: Reasons for staff leaving

Reason	Number	% of total no. of staff leaving
Death	6	1.34%
Resignation	88	44.07%
Dismissal	1	0.22%
Retirement	12	10.74%
Ill health	1	0.22%
End of contract	85	36.91%
Retrenchments	33	6.49%
Total	226	100.00%

Table 32: Labour relations - Misconduct and disciplinary action

Nature of disciplinary Action	Number
Verbal warning	0
Written warning	5
Final written warning	6
Dismissal	1

Table 33: Equity target and employment equity status

OCCUPATIONAL LEVELS	MALE							
	African		Coloured		Indian		White	
	Current	Target	Current	Target	Current	Target	Current	Target
Top management	6	4	0	0	2	0	3	2
Senior management	33	28	3	5	12	13	23	24
Professional qualified	203	263	23	39	61	59	223	355
Skilled	300	313	24	32	32	36	59	88
Semi-skilled	97	125	13	24	1	1	0	8
Unskilled	41	24	10	3	0	1	0	0
Total	680	757	73	103	108	110	308	482

Table 34: Female employees across occupational levels

OCCUPATIONAL LEVELS	FEMALE							
	African		Coloured		Indian		White	
	Current	Target	Current	Target	Current	Target	Current	Target
Top management	4	3	0	1	0	0	1	1
Senior management	10	16	1	2	0	2	10	9
Professional qualified	130	167	11	31	30	37	114	149
Skilled	367	331	25	41	29	40	74	112
Semi-skilled	92	117	11	23	1	5	6	13
Unskilled	57	20	1	1	0	0	0	4
Total	660	654	49	99	60	85	205	288

Table 35: People with disabilities across occupational levels

OCCUPATIONAL LEVELS	PEOPLE WITH DISABILITY			
	Male		Female	
	Current	Target	Current	Target
Top management	0	1	0	1
Senior management	0	1	0	1
Professional qualified	8	7	2	4
Skilled	8	9	3	5
Semi-skilled	0	0	0	0
Unskilled	15	0	23	0
Total	31	18	28	11



PART F CONSOLIDATED FINANCIAL STATEMENTS

The consolidated financial statements set out on pages 136 to 173, have been prepared on the going concern basis and were approved by the CSIR board on 29 July 2021.

Report of the Auditor-General	132
Statement of Profit or Loss and Other Comprehensive Income	136
Statement of Financial Position	137
Statement of Changes in Equity	138
Statement of Cash Flows	139
Accounting Policies	140
Notes to the Consolidated Financial Statements	153

REPORT OF THE AUDITOR-GENERAL

FOR THE YEAR ENDED 31 MARCH 2021

REPORT ON THE AUDIT OF THE CONSOLIDATED AND SEPARATE FINANCIAL STATEMENTS

Opinion

1. I have audited the consolidated and separate financial statements of the Council for Scientific and Industrial Research and its subsidiaries (the group), set out on pages 136 to 173, which comprise the consolidated and separate statement of financial position as at 31 March 2021, consolidated and separate statement of profit or loss and other comprehensive income, statement of changes in equity, and statement of cash flows for the year then ended, as well as notes to the consolidated and separate financial statements, including a summary of significant accounting policies.
2. In my opinion, the consolidated and separate financial statements present fairly, in all material respects, the financial position of the Council for Scientific and Industrial Research and its subsidiaries as at 31 March 2021, and their financial performance and cash flows for the year then ended, in accordance with the International Financial Reporting Standards (IFRS) and the requirements of the Public Finance Management Act 1 of 1999 (PFMA).

Basis for opinion

3. I conducted my audit in accordance with the International Standards on Auditing (ISAs). My responsibilities under those standards are further described in the auditor-general's responsibilities for the audit of the consolidated and separate financial statements section of my report.
4. I am independent of the group in accordance with the International Ethics Standards Board for Accountants' International code of ethics for professional accountants (including International Independence Standards) (IESBA code) as well as other ethical requirements that are relevant to my audit in South Africa. I have fulfilled my other ethical responsibilities in accordance with these requirements and the IESBA code.

5. I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my opinion.

Responsibilities of the accounting authority for the financial statements

6. The accounting authority is responsible for the preparation and fair presentation of the consolidated and separate financial statements in accordance with the IFRS and the requirements of the PFMA, and for such internal control as the accounting authority determines is necessary to enable the preparation of consolidated and separate financial statements that are free from material misstatement, whether due to fraud or error.
7. In preparing the consolidated and separate financial statements, the accounting authority is responsible for assessing the group's ability to continue as a going concern, disclosing, as applicable, matters relating to going concern and using the going concern basis of accounting unless the appropriate governance structure either intends to liquidate the group or to cease operations, or has no realistic alternative but to do so.

Auditor-general's responsibilities for the audit of the consolidated and separate financial statements

8. My objectives are to obtain reasonable assurance about whether the consolidated and separate financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes my opinion. Reasonable assurance is a high level of assurance but is not a guarantee that an audit conducted in accordance with the ISAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these consolidated and separate financial statements.
9. A further description of my responsibilities for the audit of the consolidated and separate financial statements is included in the annexure to this auditor's report.

REPORT ON THE AUDIT OF THE ANNUAL PERFORMANCE REPORT

Introduction and scope

10. In accordance with the Public Audit Act 25 of 2004 (PAA) and the general notice issued in terms thereof, I have a responsibility to report on the usefulness and reliability of the reported performance information against predetermined objectives for selected strategic objectives presented in the annual performance report. I performed procedures to identify material findings but not to gather evidence to express assurance.
11. My procedures address the usefulness and reliability of the reported performance information, which must be based on the entity's approved performance planning documents. I have not evaluated the completeness and appropriateness of the performance indicators included in the planning documents. My procedures do not examine whether the actions taken by the entity enabled service delivery. My procedures do not extend to any disclosures or assertions relating to the extent of achievements in the current year or planned performance strategies and information in respect of future periods that may be included as part of the reported performance information. Accordingly, my findings do not extend to these matters.
12. I evaluated the usefulness and reliability of the reported performance information in accordance with the criteria developed from the performance management and reporting framework, as defined in the general notice, for the following selected strategic objective presented in the entity's annual performance report for the year ended 31 March 2021:

Strategic objective	Pages in the annual performance report
SO 1 – conduct research, development and innovation, localise transformative technologies and accelerate their diffusion	75 to 77

14. I performed procedures to determine whether the reported performance information was consistent with the approved performance planning documents. I performed further procedures to determine whether the indicators and related targets were measurable and relevant, and assessed the reliability of the reported performance information to determine whether it was valid, accurate and complete.
15. I did not identify any material findings on the usefulness and reliability of the reported performance information for this selected strategic objective.
 - SO 1 – conduct research, development and innovation, localise transformative technologies and accelerate their diffusion.

Other matter

16. I draw attention to the matter below.

Achievement of planned targets

17. Refer to the annual performance report on pages 70 to 85 for information on the achievement of planned targets for the year.

REPORT OF THE AUDITOR-GENERAL

FOR THE YEAR ENDED 31 MARCH 2021 (CONTINUED)

REPORT ON THE AUDIT OF COMPLIANCE WITH LEGISLATION

Introduction and scope

18. In accordance with the PAA and the general notice issued in terms thereof, I have a responsibility to report material findings on the entity's compliance with specific matters in key legislation. I performed procedures to identify findings but not to gather evidence to express assurance.
19. I did not identify any material findings on compliance with the specific matters in key legislation set out in the general notice issued in terms of the PAA.

OTHER INFORMATION

20. The accounting authority is responsible for the other information. The other information comprises the information included in the annual report. The other information does not include the consolidated and separate financial statements, the auditor's report and the selected strategic objective presented in the annual performance report that have been specifically reported in this auditor's report.
21. My opinion on the financial statements and findings on the reported performance information and compliance with legislation do not cover the other information and I do not express an audit opinion or any form of assurance conclusion on it.
22. In connection with my audit, my responsibility is to read the other information and, in doing so, consider whether the other information is materially inconsistent with the consolidated and separate financial statements and the selected strategic objective presented in the annual performance report, or my knowledge obtained in the audit, or otherwise appears to be materially misstated.

23. I did not receive the other information prior to the date of this auditor's report. When I do receive and read this information, if I conclude that there is a material misstatement therein, I am required to communicate the matter to those charged with governance and request that the other information be corrected. If the other information is not corrected, I may have to retract this auditor's report and re-issue an amended report as appropriate. However, if it is corrected this will not be necessary.

INTERNAL CONTROL DEFICIENCIES

24. I considered internal control relevant to my audit of the consolidated and separate financial statements, reported performance information and compliance with applicable legislation; however, my objective was not to express any form of assurance on it.
25. I did not identify any significant deficiencies in internal control.

Auditor-General

Pretoria

31 July 2021



AUDITOR-GENERAL
SOUTH AFRICA

Auditing to build public confidence

ANNEXURE – AUDITOR-GENERAL’S RESPONSIBILITY FOR THE AUDIT

1. As part of an audit in accordance with the ISAs, I exercise professional judgement and maintain professional scepticism throughout my audit of the consolidated and separate financial statements and the procedures performed on reported performance information for selected strategic objectives and on the entity’s compliance with respect to the selected subject matters.

Financial statements

2. In addition to my responsibility for the audit of the consolidated and separate financial statements as described in this auditor’s report, I also:
 - identify and assess the risks of material misstatement of the consolidated and separate financial statements, whether due to fraud or error; design and perform audit procedures responsive to those risks; and obtain audit evidence that is sufficient and appropriate to provide a basis for my opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations or the override of internal control
 - obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity’s internal control
 - evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by the accounting authority
 - conclude on the appropriateness of the accounting authority’s use of the going concern basis of accounting in the preparation of the financial statements. I also conclude, based on the audit evidence obtained, whether a material uncertainty exists relating to events or conditions that may cast significant

doubt on the ability of the Council for Scientific and Industrial Research and its subsidiaries to continue as a going concern. If I conclude that a material uncertainty exists, I am required to draw attention in my auditor’s report to the related disclosures in the financial statements about the material uncertainty or, if such disclosures are inadequate, to modify my opinion on the financial statements. My conclusions are based on the information available to me at the date of this auditor’s report. However, future events or conditions may cause an entity to cease operating as a going concern

- evaluate the overall presentation, structure and content of the financial statements, including the disclosures, and determine whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation
- obtain sufficient appropriate audit evidence regarding the financial information of the entities or business activities within the group to express an opinion on the consolidated financial statements. I am responsible for the direction, supervision and performance of the group audit. I remain solely responsible for my audit opinion.

Communication with those charged with governance

3. I communicate with the accounting authority regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that I identify during my audit.
4. I also provide the accounting authority with a statement that I have complied with relevant ethical requirements regarding independence, and communicate with them all relationships and other matters that may reasonably be thought to bear on my independence and, where applicable, actions taken to eliminate threats or safeguards applied.

STATEMENT OF PROFIT OR LOSS AND OTHER COMPREHENSIVE INCOME

FOR THE YEAR ENDED **31 MARCH 2021**

	Note(s)	Group		CSIR	
		2021	2020	2021	2020
		R'000	R'000	R'000	R'000
Revenue	2	2 568 647	2 758 713	2 568 647	2 758 713
Other income		733	4 799	724	4 790
Total operating income		2 569 380	2 763 512	2 569 371	2 763 503
Expenses					
Employees' remuneration		(1 435 595)	(1 454 565)	(1 435 595)	(1 454 565)
Depreciation		(52 489)	(62 068)	(52 489)	(62 068)
Operating expenses		(1 024 887)	(1 240 683)	(1 025 105)	(1 240 742)
Operating profit		56 409	6 196	56 182	6 128
Finance income	3	41 255	51 423	40 980	50 968
Finance expense	4	(1 119)	(1 549)	(1 119)	(1 549)
Share of loss of joint ventures and associates		(252)	(98)	-	-
Profit for the year		96 293	55 972	96 043	55 547
Other comprehensive income:					
Items that will not be reclassified to profit or loss:					
Remeasurement of post-retirement medical benefit obligation		(22)	(45)	(22)	(45)
Gains on property revaluation		-	12 965	-	12 965
Total items that will not be reclassified to profit or loss		(22)	12 920	(22)	12 920
Other comprehensive income for the year net of taxation		(22)	12 920	(22)	12 920
Total comprehensive income for the year		96 271	68 892	96 021	68 467

STATEMENT OF FINANCIAL POSITION

AS AT **31 MARCH 2021**

	Note(s)	Group		CSIR	
		2021	2020	2021	2020
		R'000	R'000	R'000	R'000
Assets					
Non-Current Assets					
Property, plant and equipment	5	744 117	756 619	744 117	756 619
Right-of-use assets	6	9 580	17 390	9 580	17 390
Investments in subsidiaries	8	-	-	4 650	4 650
Investments in joint ventures and associates	7	2 394	2 417	2 394	2 418
		756 091	776 426	760 741	781 077
Current Assets					
Inventories	20	956	2 726	956	2 726
Other receivables from contracts with customers	21	134 341	112 466	134 341	112 466
Trade and other receivables	9	293 534	297 090	293 518	297 054
Contract assets	22	7 931	9 927	7 931	9 927
Cash and cash equivalents	16	1 435 133	1 253 837	1 427 019	1 245 991
		1 871 895	1 676 046	1 863 765	1 668 164
Total Assets		2 627 986	2 452 472	2 624 506	2 449 241
Equity and Liabilities					
Equity					
Reserves		133 602	133 602	133 602	133 602
Retained income		1 034 036	937 764	1 030 537	934 514
		1 167 638	1 071 366	1 164 139	1 068 116
Liabilities					
Non-Current Liabilities					
Lease liabilities	6	8 845	13 871	8 845	13 871
Retirement benefit obligation	11	12 881	11 800	12 881	11 800
		21 726	25 671	21 726	25 671
Current Liabilities					
Trade and other payables	10	440 178	391 956	440 197	391 975
Lease liabilities	6	3 196	5 673	3 196	5 673
Advances from customers	24	995 248	945 342	995 248	945 342
Provisions	23	-	12 464	-	12 464
		1 438 622	1 355 435	1 438 641	1 355 454
Total Liabilities		1 460 348	1 381 106	1 460 367	1 381 125
Total Equity and Liabilities		2 627 986	2 452 472	2 624 506	2 449 241

STATEMENT OF CHANGES IN EQUITY

FOR THE YEAR ENDED 31 MARCH 2021

	Revaluation reserve	Retained income	Total equity
	R'000	R'000	R'000
Group			
Opening balance as previously reported	-	1 002 474	1 002 474
Prior year adjustment	120 637	(120 637)	-
Balance at 01 April 2019 as restated	120 637	881 837	1 002 474
Profit for the year	-	55 972	55 972
Other comprehensive income	12 965	(45)	12 920
Total comprehensive income for the year	12 965	55 927	68 892
Balance at 01 April 2020	133 602	937 767	1 071 369
Profit for the year	-	96 293	96 293
Other comprehensive income	-	(24)	(24)
Total comprehensive income for the year	-	96 269	96 269
Balance at 31 March 2021	133 602	1 034 036	1 167 638
Company			
Balance at 01 April 2019	120 637	879 016	999 653
Profit for the year	-	55 547	55 547
Other comprehensive income	12 965	(49)	12 916
Total comprehensive income for the year	12 965	55 498	68 463
Balance at 01 April 2020	133 602	934 516	1 068 118
Profit for the year	-	96 043	96 043
Other comprehensive income	-	(22)	(22)
Total comprehensive income for the year	-	96 021	96 021
Balance at 31 March 2021	133 602	1 030 537	1 164 139

STATEMENT OF CASH FLOWS

FOR THE YEAR ENDED **31 MARCH 2021**

	Note(s)	Group		CSIR	
		2021	2020	2021	2020
		R'000	R'000	R'000	R'000
Cash flows from operating activities					
Cash receipts from external customers		1 903 510	1 918 973	1 903 511	1 918 994
Parliamentary grant received		670 045	758 068	670 045	758 068
Cash paid to suppliers and employees		(2 393 409)	(2 676 689)	(2 393 403)	(2 676 657)
Cash generated from operations	15	180 146	352	180 153	405
Finance income received		42 217	51 955	41 942	51 500
Finance expense		(894)	(103)	(894)	(103)
Net cash from operating activities		221 469	52 204	221 201	51 802
Cash flows from investing activities					
Purchase of property, plant and equipment	5	(36 193)	(44 009)	(36 193)	(44 009)
Sale of property, plant and equipment		-	750	-	750
Net cash from investing activities		(36 193)	(43 259)	(36 193)	(43 259)
Cash flows from financing activities					
Payments on lease liabilities		(2 745)	(675)	(2 745)	(675)
Net cash from financing activities		(2 745)	(675)	(2 745)	(675)
Unrealised exchange gains/(losses) on foreign cash balances		(1 235)	4 099	(1 235)	4 099
Total cash movement for the year		181 296	12 369	181 028	11 967
Cash at the beginning of the year		1 253 837	1 241 468	1 245 991	1 234 024
Total cash at end of the year	16	1 435 133	1 253 837	1 427 019	1 245 991

ACCOUNTING POLICIES

ENTITY INFORMATION

The CSIR is a national government business enterprise (enacted by The Scientific Research Council Act, 1988 (Act 46 of 1988) domiciled in the Republic of South Africa. The address of the CSIR's principal place of business is Meiring Naude' Road, Brummeria, Pretoria. The CSIR undertakes directed and particularly multi-disciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic.

The consolidated annual financial statements of the Group as at and for the year ended 31 March 2021 comprise the entity and its subsidiaries (together referred to as the Group) and the Group's interest in associates and jointly controlled entities.

1. SIGNIFICANT ACCOUNTING POLICIES

The principal accounting policies applied in the preparation of these consolidated and separate financial statements are set out below.

1.1 Basis of preparation

The consolidated and separate financial statements have been prepared on the going concern basis in accordance with, and in compliance with, International Financial Reporting Standards ("IFRS") and International Financial Reporting Interpretations Committee ("IFRIC") interpretations issued and effective at the time of preparing these consolidated financial statements and the Public Finance Management Act, 1999 (Act 1 of 1999) as amended by Act 29 of 1999.

These consolidated financial statements comply with the requirements of the South African Institute of Chartered Accountants Financial Reporting Guides as issued by the Accounting Practices Committee and the Financial Reporting Pronouncements as issued by the Financial Reporting Standards Council.

The consolidated financial statements have been prepared on the historic cost convention, unless otherwise stated in the accounting policies which follow and incorporate the principal accounting policies set out below. They are presented in rands, which is the Group and entity's functional currency.

These accounting policies are consistent with the previous period.

1.2 Consolidation

Basis of consolidation

The consolidated financial statements incorporate the separate financial statements of the CSIR and all subsidiaries. Subsidiaries are entities which are controlled by the Group.

The Group has control of an entity when it is exposed to or has rights to variable returns from involvement with the entity and it has the ability to affect those returns through the use of its power over the entity.

The results of subsidiaries are included in the consolidated financial statements from the effective date of acquisition to the effective date of disposal.

All inter-company transactions, balances, and unrealised gains on transactions between Group companies are eliminated in full on consolidation. Unrealised losses are also eliminated unless the transaction provides evidence of an impairment of the asset transferred.

Investments in subsidiaries in the separate financial statements

In the CSIR's separate financial statements, investments in subsidiaries are carried at cost less any accumulated impairment losses.

ACCOUNTING POLICIES

1.3 Joint arrangements

A joint arrangement is an arrangement where two or more parties have joint control. Joint control is the contractually agreed sharing of control of an arrangement, which exists only when decisions about the relevant activities require the unanimous consent of the parties sharing control. A joint arrangement is either a joint operation or a joint venture.

A joint operation is a joint arrangement whereby the parties that have joint control of the arrangement have rights to the assets, and obligations for the liabilities, relating to the arrangement. A joint venture is a joint arrangement whereby the parties that have joint control of the arrangement have rights to the net assets of the arrangement. The Group has assessed the nature of its joint arrangements and determined them to be joint ventures.

Joint ventures

An interest in a joint venture is accounted for using the equity method. Under the equity method, interests in joint ventures are carried in the statement of financial position at cost adjusted for post-acquisition changes in the CSIR's share of net assets of the joint venture, less any impairment losses.

The Group's share of post-acquisition profit or loss is recognised in profit or loss, and its share of movements in other comprehensive income is recognised in other comprehensive income with a corresponding adjustment to the carrying amount of the investment. Losses in a joint venture in excess of the Group's interest in that joint venture, including any other unsecured losses, are recognised only to the extent that the Group has incurred a legal or constructive obligation to make payments on behalf of the joint venture.

Profits or losses on transactions between the Group and a joint venture are eliminated to the extent of the Group's interest therein. Unrealised losses are eliminated unless the transaction provides evidence of an impairment of the asset transferred. Accounting policies of joint ventures have been changed where necessary to ensure consistency with the policies adopted by the Group.

Investments in joint ventures in the separate financial statements

In the company's separate financial statements, investments in joint ventures are carried at cost less any accumulated impairment losses.

1.4 Investments in associates

An associate is an entity over which the Group has significant influence and which is neither a subsidiary nor a joint arrangement. Significant influence is the power to participate in the financial and operating policy decisions of the investee but has no control or joint control over those policies. It generally accompanies a shareholding of between 20% and 50% of the voting rights.

Investments in associates are accounted for using the equity method. Under the equity method, investments in associates are carried in the Statement of Financial Position at cost adjusted for post-acquisition changes in the Group's share of net assets of the associate, less any impairment losses.

The Group's share of post-acquisition profit or loss is recognised in profit or loss, and its share of movements in other comprehensive income is recognised in other comprehensive income with a corresponding adjustment to the carrying amount of the investment. Losses in an associate in excess of the Group's interest in that associate, including any other unsecured losses, are recognised only to the extent that the Group has incurred a legal or constructive obligation to make payments on behalf of the associate.

Profits or losses on transactions between the Group and an associate are eliminated to the extent of the Group's interest therein. Unrealised losses are eliminated unless the transaction provides evidence of an impairment of the asset transferred. Accounting policies of associates have been changed where necessary to ensure consistency with the policies adopted by the Group.

1.5 Significant judgements and sources of estimation uncertainty

The preparation of consolidated financial statements in conformity with IFRS requires management, from time to time, to make judgements, estimates and assumptions that affect the application of policies and reported amounts of assets, liabilities, income and expenses. These estimates and associated assumptions are based on experience and various other factors that are believed to be reasonable under the

ACCOUNTING POLICIES

1.5 SIGNIFICANT JUDGEMENTS AND SOURCES OF ESTIMATION UNCERTAINTY (CONTINUED)

circumstances. Actual results may differ from these estimates. The estimates and underlying assumptions are reviewed on an ongoing basis. Revisions to accounting estimates are recognised in the period in which the estimates are revised and in any future periods affected.

Critical judgements in applying accounting policies

The critical judgements made by management in applying accounting policies, apart from those involving estimations, that have the most significant effect on the amounts recognised in the financial statements, are outlined as follows:

Revenue recognition

The nature of CSIR's business is varied, in that there are contracts with customers that give rise to single performance obligations, and others that give rise to multiple performance obligations. Judgement is applied in the determination of distinct performance obligations, as well as when transfer of control of the identified performance obligations is satisfied.

In identifying distinct performance obligations, judgement was applied in assessing whether certain deliverables are separately identifiable from other items to be transferred to the customer in terms of the contract.

Key sources of estimation uncertainty

Impairment of financial assets

As at 31 March 2021, the Group had R38 million (2020: R35 million) in allowance for doubtful accounts for trade and other receivables. The allowance for doubtful accounts is based on assumptions about risk of default. The Group uses judgement in making these assumptions and selecting the inputs to the calculation of the allowance for doubtful accounts, based on the expected credit loss model (used in IFRS 9).

Impairment testing

Impairment of property, plant and equipment.

At each reporting date, property, plant and equipment in use are assessed for impairment. To assess whether any impairment exists, estimates of expected future cash flows are used. Actual outcomes could vary significantly from such estimates. Factors such as changes in discount rates, the planned use of buildings, machinery or equipment or closure of facilities and technical obsolescence could lead to shorter useful lives or impairment.

Useful lives of property, plant and equipment

Management assess the appropriateness of the useful lives of property, plant and equipment at the end of each reporting period. The useful lives of motor vehicles, furniture and computer equipment are determined based on Group replacement policies for the various assets.

When the estimated useful life of an asset differs from previous estimates, the change is applied prospectively in the determination of the depreciation charge.

Provisions

Provisions are inherently based on assumptions and estimates using the best information available. Additional disclosure of these estimates of provisions are included in note 23.

Estimates of employee benefit liabilities

An updated actuarial valuation is carried out at the end of each financial year for the post-employment liabilities of the Group. Key assumptions used to determine the net assets and liabilities of these obligations and their sensitivities are set out in note 11.

1.6 Property, plant and equipment

Property, plant and equipment are tangible assets which the Group holds for its own use or for rental to others and which are expected to be used for more than one year.

An item of property, plant and equipment is recognised as an asset when it is probable that future economic benefits associated with the item will flow to the Group, and the cost of the item can be measured reliably.

ACCOUNTING POLICIES

1.6 PROPERTY, PLANT AND EQUIPMENT (CONTINUED)

Property, plant and equipment is initially measured at cost. Cost includes all of the expenditure which is directly attributable to the acquisition or construction of the asset, including the capitalisation of borrowing costs on qualifying assets and adjustments in respect of hedge accounting, where appropriate.

Expenditure incurred subsequently for major services, additions to or replacements of parts of property, plant and equipment are capitalised if it is probable that future economic benefits associated with the expenditure will flow to the Group and the cost can be measured reliably. Day to day servicing costs are included in profit or loss in the year in which they are incurred.

Major inspection costs which are a condition of continuing use of an item of property, plant and equipment and which meet the recognition criteria are included as a replacement in the cost of the item of property, plant and equipment. Any remaining inspection costs from the previous inspection are derecognised.

Major spare parts and stand by equipment which are expected to be used for more than one year are included in property, plant and equipment.

Property, plant and equipment is subsequently stated at cost less accumulated depreciation and any accumulated impairment losses, except for land which is stated at revalued amounts less any accumulated impairment losses.

Depreciation of an asset commences when the asset is available for use as intended by management. Depreciation is charged to write off the asset's carrying amount over its estimated useful life to its estimated residual value, using a method that best reflects the pattern in which the asset's economic benefits are consumed by the Group. Leased assets are depreciated in a consistent manner over the shorter of their expected useful lives and the lease term. Depreciation is not charged to an asset if its estimated residual value exceeds or is equal to its carrying amount. Depreciation of an asset ceases at the earlier of the date that the asset is classified as held for sale, or derecognised.

The useful lives of items of property, plant and equipment have been assessed as follows:

Item	Depreciation method	Average useful life
Buildings	Straight line	90 years
Furniture and fixtures	Straight line	3 to 20 years
Motor vehicles	Straight line	10 years
Office equipment	Straight line	3 to 20 years
IT equipment	Straight line	3 to 5 years
Land	Straight line	Indefinite

The residual value, useful life and depreciation method of each asset are reviewed at the end of each reporting year. If the expectations differ from previous estimates, the change is accounted for prospectively as a change in accounting estimate.

Each part of an item of property, plant and equipment with a cost that is significant in relation to the total cost of the item is depreciated separately.

The depreciation charge for each year is recognised in profit or loss unless it is included in the carrying amount of another asset.

Impairment tests are performed on property, plant and equipment when there is an indicator that they may be impaired. When the carrying amount of an item of property, plant and equipment is assessed to be higher than the estimated recoverable amount, an impairment loss is recognised immediately in profit or loss to bring the carrying amount in line with the recoverable amount.

An item of property, plant and equipment is derecognised upon disposal or when no future economic benefits are expected from its continued use or disposal. Any gain or loss arising from the derecognition of an item of property, plant and equipment, determined as the difference between the net disposal proceeds, if any, and the carrying amount of the item, is included in profit or loss when the item is derecognised.

ACCOUNTING POLICIES

1.7 Financial instruments

Financial instruments held by the Group are classified in accordance with the provisions of IFRS 9 Financial Instruments.

Broadly, the applicable classification possibilities, which are adopted by the Group, are as follows:

Financial assets which are debt instruments:

- Amortised cost. (This category applies only when the contractual terms of the instrument give rise, on specified dates, to cash flows that are solely payments of principal and interest on principal, and where the instrument is held under a business model whose objective is met by holding the instrument to collect contractual cash flows).

Financial liabilities:

- Amortised cost

Note 14 Financial instruments and risk management presents the financial instruments held by the Group based on their specific classifications.

All regular way purchases or sales of financial assets are recognised and derecognised on a trade date basis. Regular way purchases or sales are purchases or sales of financial assets that require the delivery of assets within the time frame established by regulation or convention in the marketplace.

The specific accounting policies for the classification, recognition and measurement of each type of financial instrument held by the Group are presented below:

Trade and other receivables

Classification

Trade and other receivables, excluding, when applicable, VAT and prepayments, are classified as financial assets subsequently measured at amortised cost (note 9).

They have been classified in this manner because their contractual terms give rise, on specified dates to cash flows that are solely payments of principal and interest on the principal outstanding. The Group's business model is to collect the contractual cash flows on trade and other receivables.

Recognition and measurement

Trade and other receivables are recognised when the Group becomes a party to the contractual provisions of the receivables. They are measured at initial recognition, at their transaction price if the trade receivables do not contain a significant financing component.

They are subsequently measured at amortised cost.

The amortised cost is the amount recognised on the receivable initially, minus principal repayments, plus cumulative amortisation (interest) using the effective interest method of any difference between the initial amount and the maturity amount, adjusted for any loss allowance.

Impairment

The Group recognises a loss allowance for expected credit losses on trade and other receivables, excluding VAT and prepayments. The amount of expected credit losses is updated at each reporting date.

The Group measures the loss allowance for trade and other receivables at an amount equal to lifetime expected credit losses (lifetime ECL), which represents the expected credit losses that will result from all possible default events over the expected life of the receivable.

Measurement and recognition of expected credit losses

The Group applies the simplified approach to trade receivables, contract assets and lease receivables of measuring the loss allowance at an amount equal to lifetime expected credit losses in terms of IFRS 9. The Group applies the ECL valuation model as follows:

ACCOUNTING POLICIES

1.7 FINANCIAL INSTRUMENTS (CONTINUED)

- It rebuts the more than 30 days past due presumption, instead the Group presumes that there is a significant increase in credit risk when payments are more than 90 days outstanding from dates of invoices. Based on historical experience for most of the Group debtors if contractual payments become more than 30 days past due, this does not represent a significant increase in the credit risk of a financial instrument. It is rather due to their extensive administrative systems for local debtors, or timing differences in moving money outside of the borders of their countries for international customers instead of financial difficulty of the debtors.
- When a receivable (i.e. and invoice) is more than 90 days outstanding, an allowance for loss is raised, for 100% of the outstanding amount excluding Value Added Tax (thus a 100% loss probability is assumed). However, no allowance is raised when there is a firm commitment by the debtor that they will settle the amount due even if the receivable is more than 90 days outstanding.
- An allowance for loss is raised even if a receivable (invoice) is less than 90 days outstanding when there is evidence indicating a significant increase in credit risk of a debtor.

Write off policy

The Group writes off a receivable when there is information indicating that the counterparty is in severe financial difficulty and there is no realistic prospect of recovery, e.g. when the counterparty has been placed under liquidation or has entered into bankruptcy proceedings. Receivables written off may still be subject to enforcement activities under the Group recovery procedures, taking into account legal advice where appropriate. Any recoveries made are recognised in profit or loss.

Credit risk

Details of credit risk are included in the trade and other receivables note (note 9) and the financial instruments and risk management note (note 14).

Derecognition

Refer to the derecognition section of the accounting policy for the policies and processes related to derecognition.

Trade and other payables

Classification

Trade and other payables (note 10), excluding VAT and amounts received in advance, are classified as financial liabilities subsequently measured at amortised cost.

Recognition and measurement

They are recognised when the Group becomes a party to the contractual provisions, and are measured, at initial recognition, at fair value plus transaction costs, if any.

Trade and other payables expose the Group to liquidity risk and possibly to interest rate risk. Refer to note 14 for details of risk exposure and management thereof.

Trade and other payables denominated in foreign currencies

When trade payables are denominated in a foreign currency, the carrying amount of the payables are determined in the foreign currency. The carrying amount is then translated to the rand equivalent using the spot rate at the end of each reporting period. Any resulting foreign exchange gains or losses are recognised in profit or loss.

Details of foreign currency risk exposure and the management thereof are provided in the financial instruments and risk management note (note 14).

Derecognition

Refer to the "derecognition" section of the accounting policy for the policies and processes related to derecognition.

Financial guarantee contracts

A financial guarantee contract is a contract that requires the issuer to make specified payments to reimburse the holder for a loss it incurs because a specified debtor fails to make payments when due in accordance with the terms of a debt instrument.

ACCOUNTING POLICIES

1.7 FINANCIAL INSTRUMENTS (CONTINUED)

Financial guarantee contracts issued by the Group are initially measured at their fair values and, if not designated as at Fair Value Through Profit or Loss and do not arise from a transfer of a financial asset, are subsequently measured at the higher of:

- The amount of the loss allowance determined in accordance with IFRS 9; and
- The amount initially recognised less, where appropriate, cumulative amount of income recognised in accordance with the revenue recognition policies.

Refer to note 26 for details of financial guarantee contracts.

Cash and cash equivalents

Cash and cash equivalents are stated at carrying amount which is deemed to be fair value.

Derecognition

Financial assets

The Group derecognises a financial asset only when the contractual rights to the cash flows from the asset expire, or when it transfers the financial asset and substantially all the risks and rewards of ownership of the asset to another party. If the Group neither transfers nor retains substantially all the risks and rewards of ownership and continues to control the transferred asset, the Group recognises its retained interest in the asset and an associated liability for amounts it may have to pay. If the Group retains substantially all the risks and rewards of ownership of a transferred financial asset, the Group continues to recognise the financial asset and also recognises a collateralised borrowing for the proceeds received.

Financial liabilities

The Group derecognises financial liabilities when, and only when, the Group obligations are discharged, cancelled or they expire. The difference between the carrying amount of the financial liability derecognised and the consideration paid and payable, including any non-cash assets transferred or liabilities assumed, is recognised in profit or loss.

1.8 Tax

Income tax

The CSIR is exempt from South African income tax in terms of section 10 (1) (t) (i) of the Income Tax Act, 1962 (Act 58 of 1962).

1.9 Leases

The group assesses whether a contract is, or contains a lease, at the inception of the contract.

A contract is, or contains a lease if the contract conveys the right to control the use of an identified asset for a period of time in exchange for consideration.

In order to assess whether a contract is, or contains a lease, management determine whether the asset under consideration is "identified", which means that the asset is either explicitly or implicitly specified in the contract and that the supplier does not have a substantial right of substitution throughout the period of use. Once management has concluded that the contract deals with an identified asset, the right to control the use thereof is considered. To this end, control over the use of an identified asset only exists when the group has the right to substantially all of the economic benefits from the use of the asset as well as the right to direct the use of the asset.

In circumstances where the determination of whether the contract is or contains a lease requires significant judgement, the relevant disclosures are provided in the significant judgments and sources of estimation uncertainty section of these accounting policies.

Group as lessee

A lease liability and corresponding right-of-use asset are recognised at the lease commencement date, for all lease agreements for which the group is a lessee, except for short-term leases of 12 months or less, or leases of low value assets. For these leases, the group recognises the lease payments as an operating expense on a straight-line basis over the term of the lease unless another systematic basis is more representative of the time pattern in which economic benefits from the leased asset are consumed.

ACCOUNTING POLICIES

1.9 LEASES (CONTINUED)

The various lease and non-lease components of contracts containing leases are accounted for separately, with consideration being allocated to each lease component on the basis of the relative stand-alone prices of the lease components and the aggregate stand-alone price of the non-lease components (where non-lease components exist).

However as an exception to the preceding paragraph, the group has elected not to separate the non-lease components for leases of land and buildings.

Details of leasing arrangements where the group is a lessee are presented in note 6 Leases (group as lessee).

Lease liability

The lease liability is initially measured at the present value of the lease payments that are not paid at the commencement date, discounted by using the rate implicit in the lease. If this rate cannot be readily determined, the group uses its incremental borrowing rate.

Lease payments included in the measurement of the lease liability comprise the following:

- fixed lease payments, including in-substance fixed payments, less any lease incentives;
- variable lease payments that depend on an index or rate, initially measured using the index or rate at the commencement date;
- the amount expected to be payable by the group under residual value guarantees;
- the exercise price of purchase options, if the group is reasonably certain to exercise the option;
- lease payments in an optional renewal period if the group is reasonably certain to exercise an extension option; and
- penalties for early termination of a lease, if the lease term reflects the exercise of an option to terminate the lease.

Variable rents that do not depend on an index or rate are not included in the measurement of the lease liability (or right-of-use asset). The related payments are recognised as an expense in the period incurred and are included in operating expenses (note 6).

The lease liability is presented as a separate line item on the Statement of Financial Position.

The lease liability is subsequently measured by increasing the carrying amount to reflect interest on the lease liability (using the effective interest method) and by reducing the carrying amount to reflect lease payments made. Interest charged on the lease liability is included in finance expense (note 4).

The group remeasures the lease liability (and makes a corresponding adjustment to the related right-of-use asset) when:

- there has been a change to the lease term, in which case the lease liability is remeasured by discounting the revised lease payments using a revised discount rate;
- there has been a change in the assessment of whether the group will exercise a purchase, termination or extension option, in which case the lease liability is remeasured by discounting the revised lease payments using a revised discount rate;
- there has been a change to the lease payments due to a change in an index or a rate, in which case the lease liability is remeasured by discounting the revised lease payments using the initial discount rate (unless the lease payments change is due to a change in a floating interest rate, in which case a revised discount rate is used);
- there has been a change in expected payment under a residual value guarantee, in which case the lease liability is remeasured by discounting the revised lease payments using the initial discount rate;
- a lease contract has been modified and the lease modification is not accounted for as a separate lease, in which case the lease liability is remeasured by discounting the revised payments using a revised discount rate.

When the lease liability is remeasured in this way, a corresponding adjustment is made to the carrying amount of the right-of-use asset, or is recognised in profit or loss if the carrying amount of the right-of-use asset has been reduced to zero.

Right-of-use assets

Right-of-use assets are presented as a separate line item on the Statement of Financial Position.

Lease payments included in the measurement of the lease liability comprise the following:

- the initial amount of the corresponding lease liability;
- any lease payments made at or before the commencement date;
- any initial direct costs incurred;

ACCOUNTING POLICIES

1.9 LEASES (CONTINUED)

- any estimated costs to dismantle and remove the underlying asset or to restore the underlying asset or the site on which it is located, when the group incurs an obligation to do so, unless these costs are incurred to produce inventories; and
- less any lease incentives received.

Right-of-use assets are subsequently measured at cost less accumulated depreciation and impairment losses.

Right-of-use assets are depreciated over the shorter period of lease term and useful life of the underlying asset. However, if a lease transfers ownership of the underlying asset or the cost of the right-of-use asset reflects that the group expects to exercise a purchase option, the related right-of-use asset is depreciated over the useful life of the underlying asset. Depreciation starts at the commencement date of a lease.

For right-of-use assets which are depreciated over their useful lives, the useful lives are determined consistently with items of the same class of property, plant and equipment. Refer to the accounting policy for property, plant and equipment for details of useful lives.

The residual value, useful life and depreciation method of each asset are reviewed at the end of each reporting year. If the expectations differ from previous estimates, the change is accounted for prospectively as a change in accounting estimate. Each part of a right-of-use asset with a cost that is significant in relation to the total cost of the asset is depreciated separately.

The depreciation charge for each year is recognised in profit or loss unless it is included in the carrying amount of another asset.

Group as lessor

Leases for which the group is a lessor are classified as finance or operating leases. Whenever the terms of the lease transfer substantially all the risks and rewards of ownership to the lessee, the contract is classified as a finance lease. All other leases are classified as operating leases. Lease classification is made at inception and is only reassessed if there is a lease modification.

When the group is an intermediate lessor, it accounts for the head lease and the sublease as two separate contracts. The sublease is classified as a finance or operating lease by reference to the right-of-use asset arising from the head lease. If the head lease is a short-term lease to which the group applies the exemption described previously, then it classifies the sub-lease as an operating lease.

The various lease and non-lease components of contracts containing leases are accounted for separately, with consideration being allocated by applying IFRS 15.

1.10 Inventories

Inventories are measured at the lower of cost and net realisable value on the weighted average cost method.

Net realisable value is the estimated selling price in the ordinary course of business less the estimated costs of completion and the estimated costs necessary to make the sale.

The cost of inventories comprises all costs of purchase, costs of conversion and other costs incurred in bringing the inventories to their present location and condition.

Inventories includes a 'right to returned goods asset', which represents the group right to recover products from customers where customers exercise their right of return under the group returns policy. The group uses its accumulated historical experience to estimate the number of returns on a portfolio level using the expected value method. A corresponding adjustment is recognised against cost of sales.

1.11 Other receivables from contracts with customers

This accounting policy needs to be read in conjunction with the accounting policies for revenue from contracts with customers, contract assets and advances on contracts with customers. The Group presents as an asset the gross amount due from customers for contract work for all contracts in progress for which costs incurred plus recognised profits (less recognised losses) exceed progress billings. These are included in other receivables from contracts with customers under current assets. Progress billings that are invoiced but not yet paid by customers are included in trade and other receivables.

ACCOUNTING POLICIES

1.12 Impairment of assets

The Group assesses at each end of the reporting period whether there is any indication that an asset may be impaired. If any such indication exists, the Group estimates the recoverable amount of the asset.

If there is any indication that an asset may be impaired, the recoverable amount is estimated for the individual asset. If it is not possible to estimate the recoverable amount of the individual asset, the recoverable amount of the cash-generating unit to which the asset belongs is determined.

The recoverable amount of an asset or a cash-generating unit is the higher of its fair value less costs to sell and its value in use.

If the recoverable amount of an asset is less than its carrying amount, the carrying amount of the asset is reduced to its recoverable amount. That reduction is an impairment loss.

An impairment loss of assets carried at cost less any accumulated depreciation or amortisation is recognised immediately in profit or loss.

An entity assesses at each reporting date whether there is any indication that an impairment loss recognised in prior periods for assets other than goodwill may no longer exist or may have decreased. If any such indication exists, the recoverable amounts of those assets are estimated.

The increased carrying amount of an asset other than goodwill attributable to a reversal of an impairment loss does not exceed the carrying amount that would have been determined had no impairment loss been recognised for the asset in prior periods.

A reversal of an impairment loss of assets carried at cost less accumulated depreciation or amortisation other than goodwill is recognised immediately in profit or loss. Any reversal of an impairment loss of a revalued asset is treated as a revaluation increase.

1.13 Employee benefits

Short-term employee benefits

The cost of short-term employee benefits, (those payable within 12 months after the service is rendered, such as paid vacation leave and sick leave, bonuses, and non-monetary benefits such as medical care), are recognised in the period in which the service is rendered and are not discounted.

The expected cost of compensated absences is recognised as an expense as the employees render services that increase their entitlement or, in the case of non-accumulating absences, when the absence occurs.

Defined contribution plans

Payments to defined contribution retirement benefit plans are charged as an expense as they fall due.

Pension fund

The Group operates a defined contribution plan, the assets of which are held in a separate trustee-administered fund. The benefits payable by the fund in the future, due to retirements and withdrawals from the fund, are contributions to the fund together with fund interest at a rate determined by the valuator with the consent of the trustees. The rate is so determined that the value of the total of the fund shall not exceed the value of the total assets of the fund.

ACCOUNTING POLICIES

1.13 EMPLOYEE BENEFITS (CONTINUED)

Post-retirement benefits other than pensions

The Group provides post-retirement medical benefits to qualifying employees, which is deemed to be a defined benefit plan.

The expected costs of these benefits are determined using the projected unit credit method, with actuarial valuations being carried out at each reporting date. Contributions are made to the relevant funds over the expected service lives of the employees entitled to those funds. The estimated cost of providing such benefits is charged to profit or loss on a systematic basis over the employees' working lives within the Group.

Actuarial gains and losses are recognised in other comprehensive income in the year when actuarially determined. The amount recognised in the statement of financial position represents the present value of the post-retirement medical fund benefit obligation. Any asset resulting from this calculation is limited to actuarial losses and the present value of available refunds and reductions in future contributions to the plan.

Defined benefit plans

For defined benefit plans the cost of providing the benefits is determined using the projected unit credit method.

Actuarial valuations are conducted on an annual basis by independent actuaries separately for each plan.

Consideration is given to any event that could impact the funds up to the end of the reporting period where the interim valuation is performed at an earlier date.

Past service costs are recognised immediately to the extent that the benefits are already vested, and are otherwise amortised on a straight line basis over the average period until the amended benefits become vested.

To the extent that, at the beginning of the financial year, any cumulative unrecognised actuarial gain or loss exceeds ten percent of the greater of the present value of the projected benefit obligation and the fair value of the plan assets (the corridor), that portion is recognised in profit or loss over the expected average remaining service lives of participating employees. Actuarial gains or losses within the corridor are not recognised.

Actuarial gains and losses are recognised in the year in which they arise, in other comprehensive income.

Gains or losses on the curtailment or settlement of a defined benefit plan is recognised when the group is demonstrably committed to curtailment or settlement.

When it is virtually certain that another party will reimburse some or all of the expenditure required to settle a defined benefit obligation, the right to reimbursement is recognised as a separate asset. The asset is measured at fair value. In all other respects, the asset is treated in the same way as plan assets. In profit or loss, the expense relating to a defined benefit plan is presented as the net of the amount recognised for a reimbursement.

The amount recognised in the statement of financial position represents the present value of the defined benefit obligation as adjusted for unrecognised actuarial gains and losses and unrecognised past service costs, and reduces by the fair value of plan assets.

Any asset is limited to unrecognised actuarial losses and past service costs, plus the present value of available refunds and reduction in future contributions to the plan.

1.14 Provisions and contingencies

Provisions are recognised when:

- The Group has a present obligation as a result of a past event;
- It is probable that an outflow of resources embodying economic benefits will be required to settle the obligation; and
- A reliable estimate can be made of the obligation.

The amount of a provision is the present value of the expenditure expected to be required to settle the obligation.

ACCOUNTING POLICIES

1.14 PROVISIONS AND CONTINGENCIES (CONTINUED)

A constructive obligation to restructure arises only when an entity:

- Has a detailed formal plan for the restructuring, identifying at least:
 - The business or part of a business concerned;
 - The principal locations affected;
 - The location, function, and approximate number of employees who will be compensated for terminating their services;
 - The expenditures that will be undertaken; and
 - When the plan will be implemented; and
- Has raised a valid expectation with those affected that it will carry out the restructuring by starting to implement that plan or announcing its main features to those affected by it.

Contingent assets and contingent liabilities are not recognised. Contingencies are disclosed in note 13.

1.15 Government grants

Government grants are recognised when there is reasonable assurance that:

- The Group will comply with the conditions attached to them; and
- The grants will be received.

Government grants are recognised as income over the periods necessary to match them with the related costs that they are intended to compensate.

A government grant that becomes receivable as compensation for expenses or losses already incurred or for the purpose of giving immediate financial support to the entity with no future related costs is recognised as income for the period in which it becomes receivable.

Government grants related to assets, including non-monetary grants at fair value, are presented in the statement of financial position by deducting the grant to arrive at the carrying amount of the asset.

Grants related to income are presented as a credit in the profit or loss and other comprehensive income (separately).

1.16 Revenue from contracts with customers

The Group derives revenue from contracts with customers for the following:

- Contract income, including CSIR International Convention Centre revenue
- Operating leases
- Royalty income

The Group measures and accounts for revenue based on the specifications of each individual contract with a customer, excluding any amounts received on behalf of third parties, and based on the contractual obligations either accounts for the revenue at a specific point in time or over time as control of the goods or services are transferred to the customer.

The Group recognises revenue over time if a customer simultaneously receives and consumes all of the benefits provided by the Group.

The Group recognises revenue at a point in time if the over-time criteria is not met. Revenue is recognised when control is transferred to the customer which is usually when legal title passes to the customer and the business has the right to payment. Refer below for further explanation of the different products and services and when control is transferred to the customer and when the Group has right to payment.

Contract income (including CSIR International Convention Centre revenue)

Contract income comprises the consideration received or receivable on contracts entered into with customers in the ordinary course of the CSIR's activities. Revenue is shown net of amounts collected on behalf of third parties (e.g. VAT). Revenue is recognised at the amount of the transaction price that is allocated to each performance obligation, determined at an amount that depicts the consideration to which CSIR expects to be entitled in exchange for transferring the goods and services promised to the customer. Where a contract contains multiple performance obligations, the transaction price is allocated to each performance obligation based on their relative stand-alone selling prices.

ACCOUNTING POLICIES

1.16 REVENUE FROM CONTRACTS WITH CUSTOMERS (CONTINUED)

Contract income is recognised when the transfer of control of the identified performance obligation(s) has been satisfied. In term contracts, where milestones and invoicing dates are not aligned, revenue is recognised according to the stage of completion. Stage of completion is measured based on costs incurred as a percentage of total estimated costs required to satisfy the performance obligation.

Operating leases

Contract income from operating leases is recognised on a straight-line basis over the lease term.

Royalty income

Royalties income is recognised when the underlying transactions triggering their payment occurs. Royalty income is measured at the rate per customer contract.

1.17 Contract assets and advances on contracts with customers

The accounting policy for contract assets needs to be read in conjunction with the accounting policy for revenue from contract with customers. Contract assets arise on the basis that costs are incurred to satisfy performance obligations, the related payment timing is determined based on each individual contract. These costs include costs to fulfil a contract; costs such as direct labour, materials, professional/consulting services and allocation of overhead cost, which relate directly to satisfy the performance obligations of the contract.

Contract assets are recovered from the customer when the relevant performance obligations are completed and payment can be obtained from the customer. If costs are incurred on a contract without a corresponding payment received it is shown as contract asset at the reporting period.

If the customer has paid in advance for performance obligations to satisfied it is shown as an advance on contract with customers within current liabilities. The Group presents as a liability the gross amount due to customers for contract work for all contracts in progress for which progress billings exceed costs incurred plus recognised profits (less recognised losses).

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

	Group		CSIR	
	2021 R'000	2020 R'000	2021 R'000	2020 R'000
2. REVENUE				
Revenue				
Parliamentary Grant	657 846	731 202	657 846	731 202
Contract income	1 633 293	1 760 591	1 633 293	1 760 591
Royalty income	3 691	3 616	3 691	3 616
Other government grants	273 817	263 305	273 817	263 305
	2 568 647	2 758 713	2 568 647	2 758 713
The group disaggregates revenue from customers as follows:				
Parliamentary Grant				
Parliamentary Grant received	670 045	758 068	670 045	758 068
Less:				
Grant received for projects started before year-end but not completed	(58 242)	(46 043)	(58 242)	(46 043)
Add:				
Grant received in prior year for projects completed in this year	46 043	19 177	46 043	19 177
	657 846	731 202	657 846	731 202
Contract income				
Local private sector	332 092	175 197	332 092	175 197
Local public sector	1 164 879	1 455 919	1 164 879	1 455 919
International sector (including Africa)	136 322	129 475	136 322	129 475
	1 633 293	1 760 591	1 633 293	1 760 591
Royalty income				
Royalty income	3 691	3 616	3 691	3 616
Other government grants				
Other government grants	273 817	263 305	273 817	263 305
Total revenue	2 568 647	2 758 713	2 568 647	2 758 713
Parliamentary Grant				
Parliamentary Grant received	26 %	27 %	26 %	27 %
Contract income				
Local private sector	13 %	5 %	13 %	5 %
Local public sector	45 %	53 %	45 %	53 %
International sector (including Africa)	5 %	5 %	5 %	5 %
Other government grants				
Other government grants	11 %	10 %	11 %	10 %
	100 %	100 %	100 %	100 %

Included in other government grants is R104 million (2020: R74 million) ring-fenced allocation from the Department of Science and Technology for specific initiatives managed through memorandums of agreement.

Included in contract income is rental income amounting to R 60,7 million (2020: R54 million) and revenue of R2,9 million (2020: R36,7 million) earned by the CSIR International Convention Centre.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

2. REVENUE (CONTINUED)

Estimates on Parliamentary Grant recognition are based on cost to completion, budgets and percentage of completion.

Other government grants relate to income from contracts with government that impose specified performance conditions on the CSIR.

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
3. FINANCE INCOME				
Interest income				
Investments in financial assets:				
Finance income	41 255	51 423	40 980	50 968
Finance income				
Interest on bank balances and investments	41 246	51 343	40 971	50 888
Interest on trade and other receivables	9	80	9	80
Total	41 255	51 423	40 980	50 968
4. FINANCE EXPENSE				
Finance leases	1 119	1 549	1 119	1 549

5. PROPERTY, PLANT AND EQUIPMENT

	2021			2020		
	Cost or revaluation	Accumulated depreciation	Carrying value	Cost or revaluation	Accumulated depreciation	Carrying value
<i>Figures in Rand</i>						
Group						
Land	138 400	-	138 400	138 400	-	138 400
Buildings	528 743	(91 280)	437 463	517 917	(85 568)	432 349
Furniture and fixtures	15 794	(13 039)	2 755	15 870	(12 351)	3 519
Motor vehicles	8 405	(6 785)	1 620	8 401	(6 539)	1 862
Office equipment	534 088	(414 231)	119 857	538 187	(397 612)	140 575
IT equipment	212 524	(168 502)	44 022	197 217	(157 303)	39 914
Total	1 436 273	(693 837)	744 117	1 415 992	(659 373)	756 619

	2021			2020		
	Cost or revaluation	Accumulated depreciation	Carrying value	Cost or revaluation	Accumulated depreciation	Carrying value
<i>Figures in Rand</i>						
CSIR						
Land	138 400	-	138 400	138 400	-	138 400
Buildings	528 743	(91 280)	437 463	517 917	(85 568)	432 349
Furniture and fixtures	15 794	(13 039)	2 755	15 870	(12 351)	3 519
Motor vehicles	8 405	(6 785)	1 620	8 401	(6 539)	1 862
Office equipment	534 083	(414 226)	119 857	538 187	(397 612)	140 575
IT equipment	212 524	(168 502)	44 022	197 217	(157 303)	39 914
Total	1 437 954	(693 837)	744 117	1 415 992	(659 373)	756 619

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

5. PROPERTY, PLANT AND EQUIPMENT (CONTINUED)

Reconciliation of property, plant and equipment - Group - 2021

	Opening balance	Additions	Other changes, movements	Depreciation	Total
Land	138 400	-	-	-	138 400
Buildings	432 349	9 202	1 624	(5 712)	437 463
Furniture and fixtures	3 519	72	3	(839)	2 755
Motor vehicles	1 862	17	-	(259)	1 620
Office equipment	140 575	6 390	(416)	(26 692)	119 857
IT equipment	39 914	20 512	(206)	(16 198)	44 022
	756 619	36 193	1 005	(49 700)	744 117

Reconciliation of property, plant and equipment - Group - 2020

	Opening balance	Additions	Disposals	Revaluations	Depreciation	Total
Land	125 435	-	-	12 965	-	138 400
Buildings	422 108	15 858	-	-	(5 617)	432 349
Furniture and fixtures	4 358	132	(8)	-	(963)	3 519
Motor vehicles	2 139	-	-	-	(277)	1 862
Office equipment	159 862	13 337	(97)	-	(32 527)	140 575
IT equipment	44 770	14 682	(349)	-	(19 189)	39 914
	758 672	44 009	(454)	12 965	(58 573)	756 619

Reconciliation of property, plant and equipment - Company - 2021

	Opening balance	Additions	Other changes, movements	Depreciation	Total
Land	138 400	-	-	-	138 400
Buildings	432 349	9 202	1 624	(5 712)	437 463
Furniture and fixtures	3 519	72	3	(839)	2 755
Motor vehicles	1 862	17	-	(259)	1 620
Office equipment	140 575	6 390	(416)	(26 692)	119 857
IT equipment	39 914	20 512	(206)	(16 198)	44 022
	756 619	36 193	1 005	(49 700)	744 117

Reconciliation of property, plant and equipment - Company - 2020

	Opening balance	Additions	Disposals	Revaluations	Depreciation	Total
Land	125 435	-	-	12 965	-	138 400
Buildings	422 108	15 858	-	-	(5 617)	432 349
Furniture and fixtures	4 358	132	(8)	-	(963)	3 519
Motor vehicles	2 139	-	-	-	(277)	1 862
Office equipment	159 862	13 337	(97)	-	(32 527)	140 575
IT equipment	44 770	14 682	(349)	-	(19 189)	39 914
	758 672	44 009	(454)	12 965	(58 573)	756 619

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

5. PROPERTY, PLANT AND EQUIPMENT (CONTINUED)

Revaluations

The group's land is stated at revalued amounts, being the fair value at the date of revaluation, less any subsequent accumulated impairment losses. Revaluations are performed every five years and in intervening years if the carrying amount of the land differs materially from their fair value.

The fair value measurements as of Tuesday, 31 March 2020 were performed by Mr Potela Peter Mabelane, an independent valuer not related to the group. Mr Mabelane is member of the South African Council for the Property Valuers Profession and has the appropriate qualifications and recent experience in the fair value measurement of properties in the relevant locations.

The carrying value of the revalued assets under the cost model would have been:

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Land	4 829	4 829	4 829	4 829

Details of properties

Land and buildings are unencumbered and full details of the titles are available at the registered office of the CSIR.

A change in the depreciation estimate due to a change in the useful lives of equipment, ICT equipment, furniture and fittings and vehicles resulted in a R7 million (2020: R3,9 million) decrease in the depreciation amount for the current financial year.

During the current financial year, assets to the value of R45,6 million (2020: R41,9 million) were purchased with government grant funds. At year-end, the cumulative value of assets purchased with government grant funds and shown at a nil cost is R881,7 million (2020: R762,3 million).

6. LEASES (GROUP AS LESSEE)

The group leases several assets, including buildings, motor vehicles and office equipment. The average lease term is four years.

Details pertaining to leasing arrangements, where the group is lessee, are presented below:

Net carrying amounts of right-of-use assets

The carrying amounts of right-of-use assets are included in the following line items:

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Buildings	9 262	16 544	9 262	16 544
Motor vehicles	189	625	189	625
Office equipment	129	221	129	221
	9 580	17 390	9 580	17 390
Additions to right-of-use assets				
Buildings	-	19 357	-	19 367
Motor vehicles	269	1 252	269	1 252
Office equipment	-	276	-	276
	269	20 885	269	20 895

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

6. LEASES (GROUP AS LESSEE) (CONTINUED)

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Depreciation recognised on right-of-use assets				
Depreciation recognised on each class of right-of-use assets, is presented below.				
Buildings	2 261	2 813	2 261	2 813
Motor vehicles	436	627	436	627
Office equipment	92	55	92	55
	2 789	3 495	2 789	3 495
Other disclosures				
Interest expense on lease liabilities	1 119	1 549	1 119	1 549
Lease liabilities				
The maturity analysis of lease liabilities is as follows:				
Within one year	3 910	6 335	3 910	6 335
Two to five years	10 182	16 507	10 182	16 507
More than five years	-	1 858	-	1 858
	14 092	24 700	14 092	24 700
Non-current liabilities	8 845	13 871	8 845	13 871
Current liabilities	3 196	5 673	3 196	5 673
	12 041	19 544	12 041	19 544

7. INTEREST IN JOINT VENTURES AND ASSOCIATES

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Joint ventures and associates				
The following joint ventures and associates are material to the group:				
Cost of investments	25 254	25 254	26 325	26 325
Loans to joint ventures and associates	18 116	18 116	18 116	18 116
Share of post-acquisition losses of joint ventures	(14 903)	(14 879)	-	-
Share of post-acquisition losses of associates	(5 913)	(5 746)	-	-
Subtotal	22 554	22 745	44 441	44 441
Impairment of joint ventures and associates	(20 160)	(20 328)	(42 047)	(42 023)
	2 394	2 417	2 394	2 418

The loans to joint ventures and associates are interest free, unsecured and have no fixed terms of repayment. In substance, they form part of the Group's net investment in joint ventures and associates.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

7. INTEREST IN JOINT VENTURES AND ASSOCIATES (CONTINUED)

Joint ventures and associates

The following table lists all of the joint ventures and associates in the group:

Group

Group

Name of company	Place of incorporation	Principal activity	Portion of ownership interest	Portion of voting power held	Carrying amount	Carrying amount
					2021	2020
			2021	2020	R'000	R'000
Joint ventures						
Sera (Pty) Ltd -	South Africa	Commercialisation and licensing of patents	50,00 %	50,00 %	3 213	3 238
Associates						
Persomics AB	Sweden	Commercialisation of novel printing technology	35,03 %	35,03 %	19 341	19 508
Impairment of investments in joint ventures and associates					22 554 (20 160)	22 746 (20 329)
					2 394	2 417

The following are details of the significant joint ventures' and associates' assets, liabilities, income and expenses:

	Joint ventures		Associates	
	2021 R'000	2020 R'000	2021 R'000	2020 R'000
Current assets	4 826	4 826	181	284
Non-current assets	33 665	33 665	7 511	7 511
Current liabilities	33 675	33 693	2 145	898
Non-current liabilities	36 232	36 232	6 282	6 304
Income	140	252	121	6
Expenses	190	24	797	621

8. INTERESTS IN SUBSIDIARIES INCLUDING CONSOLIDATED STRUCTURED ENTITIES

	Group		CSIR	
	2021 R'000	2020 R'000	2021 R'000	2020 R'000
Shares at cost less impairment losses	-	-	4 650	4 650
Indebtedness				
- by subsidiaries	-	-	7 976	7 976
- impairment of loans	-	-	(7 976)	(7 976)
	-	-	4 650	4 650

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

8. INTERESTS IN SUBSIDIARIES INCLUDING CONSOLIDATED STRUCTURED ENTITIES (CONTINUED)

Indebtedness

The loans to subsidiaries are interest free, unsecured and have no fixed terms of repayment.

Agreements have been entered into between the CSIR and certain subsidiaries to subordinate the loans made to those subsidiaries. The subordination agreements will remain in force for as long as the liabilities of the relevant subsidiaries exceed their assets, fairly valued.

The following table lists the entities that are controlled directly by the CSIR, and the carrying amounts of the investments in the CSIR's separate financial statements.

CSIR

Name of company	Held by	% voting power	% voting power	% holding	% holding	Carrying amount	Carrying amount
		2021	2020	2021	2020	2021	2020
Technology Finance Corporation		100 %	100,00 %	100 %	100,00 %	4 650	4 650
SOC Ltd							
Technovent SOC Ltd		100 %	100,00 %	100 %	100,00 %	-	-
						4 650	4 650

Subsidiaries under the process of de-registration

Subsidiary Technovent SOC is being deregistered. Request for deregistration was filed at the Companies and Intellectual Property Commission on Thursday, 05 March 2020.

9. TRADE AND OTHER RECEIVABLES

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Financial instruments:				
Trade receivables	273 612	288 824	273 604	288 798
Accrued income	8	10	-	-
Loss allowance	(38 180)	(35 208)	(38 180)	(35 208)
Trade receivables at amortised cost	235 440	253 626	235 424	253 590
Other receivables	2 150	2 727	2 150	2 727
Non-financial instruments:				
Prepayments	55 944	40 737	55 944	40 737
Total trade and other receivables	293 534	297 090	293 518	297 054
Split between non-current and current portions				
Current assets	293 534	297 090	293 518	297 054

Trade receivables are shown net of impairment losses. Refer to note 14 for more details on risk management of trade receivables.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

9. TRADE AND OTHER RECEIVABLES (CONTINUED)

The net carrying amounts, in rand, of trade and other receivables, excluding non-financial instruments, are shown below.

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Rand Amount				
Rand	237 590	-	237 574	-

10. TRADE AND OTHER PAYABLES

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Financial instruments:				
Trade payables	234 042	283 101	234 061	283 120
Salary related payables	143 254	52 752	143 254	52 752
Non-financial instruments:				
VAT	62 882	56 103	62 882	56 103
	440 178	391 956	440 197	391 975

11. RETIREMENT BENEFITS OF EMPLOYEES

CSIR Pension Fund

The fund is registered in terms of the Pension Funds Act, 1956 (Act 24 of 1956), and is a defined contribution plan. The CSIR's liability to the fund was limited to paying the employer contributions up until 29 February 2016. The impact of the tax reform effective from 1 March 2016 is that the CSIR package structure was changed to reflect all retirement fund contributions as employee contributions. All permanent CSIR employees are members of the fund.

Employee contributions of R174 million (2020: R178,1 million) were expensed during the year.

Associated Institutions Pension Fund (AIPF)

The fund is a defined benefit plan. The formula used to determine pensions was based on the pensionable earnings of the final year, and the aggregate period of uninterrupted membership.

The CSIR had one employee who was a member of the AIPF as at 31 March 2020. The fund is controlled by the state, which has assumed responsibility for the unfunded portion of this fund.

Employee contributions of R12 101 were expensed during the year ended 31 March 2020. The employee concerned has since passed away, thus no contributions during the year ended 31 March 2021.

Post-retirement medical benefits

The CSIR has a post-retirement medical benefit obligation to certain qualifying retired CSIR employees (pensioners) who joined the CSIR prior to 30 September 1996. An offer was made to qualifying pensioners in December 2005 to accept an annuity, payable from an independent source, equivalent to the value of their medical subsidy. The pensioners who accepted the offer are no longer entitled to a subsidy from the CSIR.

The accumulated benefit obligation and the annual cost of accrual of benefits are assessed by independent, qualified actuaries using the projected unit credit method. The estimated present value of the anticipated expenditure for the remaining 18 continuation members (2020: 18 continuation members) was recalculated by the actuaries as at 31 March 2021 and will be funded through cash and cash equivalents. These cash and cash equivalents have not been set aside specifically for this benefit.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

11. RETIREMENT BENEFITS OF EMPLOYEES (CONTINUED)

The amount included in the statement of financial position arising from the CSIR's obligation in respect of post-retirement medical benefits is as follows:

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Carrying value				
Present value of the defined benefit obligation – wholly unfunded	(12 881)	(11 800)	(12 881)	(11 800)

Amounts recognised in the statement of profit or loss and other comprehensive income in respect of the scheme are as follows:

Net amount recognised				
Interest cost	1 059	849	1 059	849
Actuarial gains	22	45	22	45
	1 081	894	1 081	894
Movements for the year				
Opening balance	11 800	10 906	11 800	10 906
Net expense recognised in profit or loss	1 081	894	1 081	894
Net liability at the end of the year	12 881	11 800	12 881	11 800
Key assumptions used				
Principal actuarial assumptions at the reporting date.				
Discount rates used	7,67 %	9,73 %	7,67 %	9,73 %
Expected rate of return on assets	4,03 %	4,42 %	4,03 %	4,42 %

The above results are sensitive to changes in the assumed future rate of medical inflation.

Defined contribution plan

The effect of a one percent increase in the assumed future rate of medical inflation would have the following effects;

The total group contribution to such schemes	720	636	720	636
--	-----	-----	-----	-----

The effect of a one percent decrease in the assumed future rate of medical inflation would have the following effects:

Effect on defined benefit obligation	(661)	(583)	(661)	(583)
--------------------------------------	-------	-------	-------	-------

The above sensitivity analyses are based on a change in an assumption while all other assumptions are assumed to remain unchanged. This may not always be realistic as some of the assumptions tend to be correlated. When calculating the sensitivity of the defined benefit obligation to significant actuarial assumptions, the same method (present value of the defined benefit obligation calculated with the projected unit credit method at the end of the reporting period) has been applied as when calculating the liability recognised within the statement of financial position.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

11. RETIREMENT BENEFITS OF EMPLOYEES (CONTINUED)

Historical information (R'000):	2021	2020	2019	2018	2017
Present value of the defined benefit obligation	12 881	11 800	10 906	10 963	10 764

The average term (undiscounted) of the defined benefit obligation is 8.3 years (2020: 8.8 years) and the average duration (discounted) of the defined benefit obligation is 5.8 years (2020: 5.6 years).

12. BOARD MEMBERS, DIRECTORS AND EXECUTIVE MANAGEMENT'S REMUNERATION

2021	Emoluments	Directors' fees	Total
Board members and Executive Directors Dr TH Dlamini	5 273	-	5 273
Non-executive Board members			
Prof. T Majozi	-	549	549
Dr AR Childs	-	128	128
Dr R Masango	-	163	163
Mr S Masie	-	163	163
Ms T Mokhabuki	-	117	117
Dr Mthethwa	-	175	175
Mr J Netshitenzhe	-	112	112
Dr C Render	-	175	175
Mr CE Shariff	-	175	175
Executive management			
Mr MA Dindar (from 1 July 2020)	2 717	-	2 717
Dr RK Chikwamba	3 379	-	3 379
Dr MS Maserumule	3 642	-	3 642
Mr MC Mabindisa	2 300	-	2 300
Mrs PN Monama (acting CFO until 30 June 2020)	533	-	533
Ms K Njobe	2 673	-	2 673
Adv. E Kennedy	2 673	-	2 673
	23 190	1 757	24 947

2020	Emoluments	Other benefits *	Compensation for loss of office	Directors' fees	Total
Board members and Executive Directors					
Dr TH Dlamini	5 001	-	-	-	5 001
Non-executive Board members					
Prof. T Majozi	-	-	-	439	439
Dr AR Childs	-	-	-	128	128
Dr R Masango	-	-	-	163	163
Ms T Mokhabuki	-	-	-	93	93
Mr S Masie	-	-	-	105	105
Dr V Mthethwa	-	-	-	175	175
Mr J Netshitenzhe	-	-	-	101	101
Dr C Render	-	-	-	175	175
Mr CE Shariff	-	-	-	175	175

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

12. BOARD MEMBERS, DIRECTORS AND EXECUTIVE MANAGEMENT'S REMUNERATION 2021 (CONTINUED)

2020	Emoluments	Other benefits *	Compensation for loss of office	Directors' fees	Total
Executive Management					
Ms SM Bhengu	33	-	3 000	-	3 033
Dr RK Chikwamba	3 255	-	-	-	3 255
Ms ZL Ngwepe	519	10	-	-	529
Dr Maserumule	3 565	-	-	-	3 565
Ms C Howell (acting CFO from 1 July 2019 to 6 December 2019)	950	50	-	-	1 000
Adv E Kennedy (from 1 August 2018)	2 610	-	-	-	2 610
Mr MC Mabindisa (acting HR Executive from 1 April 2019)	1 977	-	-	-	1 977
Mrs PN Monama (acting CFO from 6 December 2019)	705	-	-	-	705
Ms K Njobe (from 1 March 2019)	2 620	-	-	-	2 620
	21 235	60	3 000	1 554	25 849

* Accrued leave paid out at end of contract.

13. CONTINGENCIES

In the nature of the CSIR's business, agreements with complex deliverables may be entered into. All necessary steps are taken to manage the risks inherent to these transactions. If and when it is evident that there is a reasonable probability that a dispute on a transaction could lead to costs against the CSIR, such costs will be disclosed. Refer to note 26 for financial guarantees issued by the CSIR.

14. FINANCIAL INSTRUMENTS AND RISK MANAGEMENT

Financial risk management

Overview

The group is exposed to the following risks from its use of financial instruments:

- Credit risk;
- Liquidity risk; and
- Market risk (currency risk, interest rate risk and price risk).

This note presents information about the Group's exposure to each of the above risks and the Group's objectives, policies and processes for measuring and managing risk. Further quantitative disclosures are included throughout these consolidated financial statements.

The Board has overall responsibility for the establishment and oversight of the Group's risk management framework.

The Group's risk management policies are established to identify and analyse the risks faced by the Group, to set appropriate risk limits and controls, and to monitor risks and adherence to limits. Risk management policies and systems are reviewed regularly to reflect changes in market conditions and the Group's activities. The Group, through its training and management standards and procedures, aims to develop a disciplined and constructive control environment in which all employees understand their roles and obligations.

The Audit and Risk Committee oversees how management monitors compliance with the Group's risk management policies and procedures and reviews the adequacy of the risk management framework in relation to the risks faced by the Group. The Audit and Risk Committee is assisted in its oversight role by Internal Audit. Internal Audit undertakes both regular and ad hoc reviews of risk management controls and procedures, the results of which are reported to the Audit and Risk Committee.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

14. FINANCIAL INSTRUMENTS AND RISK MANAGEMENT (CONTINUED)

The estimated net fair values, as at the reporting date, have been determined using available market information and appropriate valuation methodologies as outlined below. This value is not necessarily indicative of the amounts that the Group could realise in the normal course of business. The fair values of the financial assets and financial liabilities are sensitive to exchange rate movements. A sensitivity analysis of a 10% increase/decrease in exchange rate fluctuation on the bank balances held in foreign currency bank accounts as at 31 March 2021 is performed. The fair value of receivables, bank balances, repurchase agreements and other liquid funds, payables and accruals, approximate their carrying amount due to the short-term maturities of these instruments.

14.1 Market risk

Market risk is the risk that changes in market prices, such as foreign exchange rates and interest rates which affect the Group's income or the value of its holdings of financial instruments. The objective of market risk management is to manage and control market risk exposures within acceptable parameters, while optimising the return.

Foreign currency risk

The Group is exposed to currency risk on sales and purchases that are denominated in a currency other than the respective functional currency of the Group entities.

The Group does not use derivative financial instruments for speculative purposes.

The Group's exposure to foreign currency risk was as follows:

	ZAR	EURO	USD	GBP	OTHER	Total
31 March 2021	R'000	R'000	R'000	R'000	R'000	R'000
Trade receivables	244 477	5 736	19 454	-	807	270 474
Bank accounts	103 180	8 896	25 209	6 995	135	144 415
Trade and other payables	(377 296)	-	-	-	-	(377 296)
Gross statement of financial position exposure	(29 639)	14 632	44 663	6 995	942	37 593
Net exposure	(29 639)	14 632	44 663	6 995	942	37 593

	ZAR	EURO	USD	GBP	OTHER	Total
31 March 2020	R'000	R'000	R'000	R'000	R'000	R'000
Trade receivables	201 322	22 099	45 886	2 323	737	272 367
Bank accounts	52 505	4 597	15 903	4 563	1 523	79 091
Trade and other payables	(335 290)	(176)	(387)	-	-	(335 853)
Gross statement of financial position exposure	(81 463)	26 520	61 402	6 886	2 260	15 605
Net exposure	(81 463)	26 520	61 402	6 886	2 260	15 605

The following closing exchange rates were applied at reporting date:

Rand per unit of foreign currency:

US Dollar	15,000	18,158	-	-
Euro	17,605	20,045	-	-
GBP	20,618	22,438	-	-

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

14.1 MARKET RISK (CONTINUED)

Sensitivity analysis

A 10% strengthening of the rand against the following currencies at 31 March would have decreased profit or loss by the amounts shown below. This analysis assumes that all other variables remain constant. The analysis is performed on the same basis for 2020.

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Euro	(1 463)	(2 652)	-	-
USD	(4 466)	(6 140)	-	-
GBP	(700)	(689)	-	-
Other	(94)	(74)	-	-

Interest rate risk

Interest rate exposure and investment strategies are evaluated by management on a regular basis. Interest-bearing investments are held with several reputable banks in order to minimise exposure.

At the reporting date the interest rate profile of the Group's interest-bearing financial instruments was as follows:

Fixed rate instruments: Carrying amount

Financial assets: Fixed deposits	1 262 607	1 078 656	-	-
----------------------------------	-----------	-----------	---	---

The Group does not account for any fixed rate financial assets and liabilities at fair value through profit or loss, and the Group does not designate derivatives as hedging instruments under a fair value hedge accounting model. Therefore, a change in interest rates at the reporting date would not affect profit or loss.

Variable rate instruments: Carrying amount

Financial assets: Call deposits	28 000	97 500	-	-
Financial assets: Bank balances	144 415	77 567	-	-
	172 415	175 067	-	-

Sensitivity analysis

An increase of 100 basis points in interest rates at the reporting date would have increased equity and profit and loss by the amounts shown below. This analysis assumes that all other variables, in particular foreign currency rates, remain constant. The analysis is performed on the same basis for 2019.

Variable rate instruments	1 724	1 751	-	-
---------------------------	-------	-------	---	---

A decrease of 100 basis points would have had the equal but opposite effect to the amounts shown above.

14.2 Credit risk

Credit risk is the risk of financial loss to the Group if a customer or counterparty to a financial instrument fails to meet its contractual obligations, and arises principally from the Group's bank balances and deposits, trade and other receivables and loans to joint ventures, associates and subsidiaries.

Trade and other receivables and loans to joint ventures, associates and subsidiaries

Trade and other receivables and loans to joint ventures, associates and subsidiaries are presented net of impairment losses. Credit risk with respect to trade receivables is limited due to the large number of customers comprising the Group's customer base and their dispersion across different industries and geographical areas.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

14.2 CREDIT RISK (CONTINUED)

Bank balances and deposits

The Group's bank balances and cash are placed with high credit, quality financial institutions with no significant exposure to any one financial institution.

Guarantees

Refer to note 26 for details on bank guarantees issued with respect to facilities.

Exposure to credit risk

The carrying amount of financial assets represents the maximum credit exposure.

The maximum exposure to credit risk at the reporting date was:

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Current fixed deposits	1 262 607	1 078 656	-	-
Call deposits	28 000	97 500	-	-
Bank balances	144 415	77 567	-	-
Cash on hand and cash deposits	112	114	-	-
Trade and other receivables	293 534	297 090	-	-
Contracts in progress less provision for losses	134 341	112 466	-	-
	1 863 009	1 663 393	-	-

The maximum exposure to credit risk for trade receivables at the reporting date by type of customer was:

Local public sector	120 974	121 083	-	-
Local private sector	77 682	38 532	-	-
International sector	33 638	77 545	-	-
	232 294	237 160	-	-

The Group's most significant customers are various local public sector customers.

The aging of the Group's trade receivables at the reporting date was:

	2021	2021	2020	2020
	Gross	Impairment	Gross	Impairment
	R'000	R'000	R'000	R'000
The aging of the Group's trade receivables at the reporting date was:				
Not past due	160 242	1 143	195 594	-
Past due 0 – 30 days	25 390	195	19 833	250
Past due 31 – 120 days	35 526	3 210	20 590	4 068
Past due more than 120 days	49 316	33 632	36 350	30 889
	270 474	38 180	272 367	35 207

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

14.2 CREDIT RISK (CONTINUED)

The movement in the allowance for impairment in respect of trade receivables during the year was as follows:

	Group 2021 R'000	Group 2020 R'000
Balance at 1 April	35 207	25 006
Movement for the year		
Recoveries	(219)	(248)
Utilisation	(13 402)	(6 324)
New impairment allowances	16 594	16 773
Balance at 31 March	38 180	35 207

The allowance account in respect of trade receivables is used to record impairment losses unless the Group is satisfied that no recovery of the amount owing is possible; at that point the amount considered irrecoverable is written off against the financial asset directly.

The fully performing trade receivables are considered to be of high credit quality.

14.3 Liquidity risk

Liquidity risk is the risk that the Group will not be able to meet its financial obligations as these fall due. The Group's approach to managing liquidity is to ensure, as far as possible, that it will always have sufficient liquidity to meet its liabilities when due, under both normal and stressed conditions, without incurring unacceptable losses or risking damage to the Group's reputation.

The Group monitors its cash flow on a daily basis. Typically, the Group ensures that it has sufficient cash on demand to meet expected operational expenses for a period of 60 days, including the servicing of financial obligations; this excludes the potential impact of extreme circumstances that cannot be predicted reasonably, such as natural disasters.

The following are the contractual maturities of financial liabilities, including interest payments but excluding the impact of netting agreements for the Group:

	2021			2020		
	Contractual cash flows			Contractual cash flows		
	Carrying amount	6 months or less	6 - 12 months	Carrying amount	6 months or less	6 - 12 months
Non-derivative financial liabilities	R'000	R'000	R'000	R'000	R'000	R'000
Trade and other payables	(377 296)	(377 296)	-	(335 853)	(335 853)	-

14.4 Fair values

As at 31 March 2021 the carrying amount of bank balances and cash, deposits, trade and other receivables, contracts in progress and trade and other payables approximated their fair values due to the short-term maturities of these assets and liabilities.

Basis for determining fair values

Trade and other receivables and trade and other payables

The fair value of trade and other receivables and trade and other payables is calculated based on the present value of future cash flows, discounted at the average return on investment rate at the reporting date.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

14.4 FAIR VALUES (CONTINUED)

15. RECONCILIATION OF OPERATING PROFIT TO CASH GENERATED FROM OPERATING ACTIVITIES

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Profit before taxation	96 293	55 972	96 043	55 547
Adjustments for:				
Depreciation and amortisation	52 489	62 068	52 489	62 068
(Profit)/losses on disposal and write-off of property, plant and equipment	194	(307)	194	(307)
Gains on foreign exchange	(3 211)	(16 517)	(3 211)	(16 517)
Bad debt written off	2 549	982	2 549	982
Interest income	(41 255)	(51 423)	(40 980)	(50 968)
Finance expense	1 119	1 549	1 119	1 549
Impairments (reversal of impairments)	2 761	12 644	2 998	12 866
Movements in retirement benefit assets and liabilities	1 059	849	1 059	849
Movements in provisions	(12 464)	1 277	(12 464)	1 277
Leave and bonus accrual	93 872	10 558	93 872	10 558
Share of losses from joint venture and associate	252	98	-	-
Other non-cash items	6 754	24 569	6 771	24 445
Changes in working capital:				
Inventories	1 770	(1 342)	1 770	(1 342)
Trade and other receivables	(1 770)	(119 696)	(1 790)	(119 680)
Contract assets	1 996	(3 009)	1 996	(3 009)
Other receivables from contracts with customers	(21 496)	(1 379)	(21 496)	(1 379)
Trade and other payables	(45 650)	(3 582)	(45 650)	(3 575)
Advances from customers	44 884	27 041	44 884	27 041
	180 146	352	180 153	405

16. CASH AND CASH EQUIVALENTS

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Cash and cash equivalents consist of:				
Cash on hand	112	114	112	114
Bank balances	144 414	77 567	143 662	76 877
Short-term deposits	1 290 607	1 176 156	1 283 245	1 169 000
	1 435 133	1 253 837	1 427 019	1 245 991

Cash on hand comprises of petty cash.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

17. RELATED PARTIES

Relationships

The CSIR is a schedule 3B National Government Business Enterprise in terms of the Public Finance Management Act, 1999 (Act 1 of 1999) as amended by Act 29 of 1999, and therefore falls within the national sphere of government. As a consequence, the CSIR has a significant number of related parties, being entities that fall within the national and provincial sphere of government. Amounts due from/to these entities are subject to the same terms and conditions as normal trade receivables and trade payables.

In addition, the CSIR has a related party relationship with its subsidiaries and joint ventures and associates (see notes 7 and 8). Unless specifically disclosed, these transactions are concluded at arm's length and the Group is able to transact with any entity.

Transactions with related parties

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Constitutional institutions				
Services rendered	2 029	-	2 029	-
Services received	-	5 710	-	5 710
Amount due (to) from	1 593	454	1 593	454
Major public entities				
Services rendered	335 783	-	335 783	-
Services received	45 526	190 770	45 526	190 770
Amount due from	51 181	41 652	51 181	41 652
National public entities				
Services rendered	117 260	-	117 260	-
Services received	16 551	16 458	16 551	16 458
Amount due from	17 717	20 297	17 717	20 297
National government business enterprises				
Services rendered	5 056	-	5 056	-
Services received	661	899	661	899
Amount due from	2 061	600	2 061	600
Provincial public entities				
Services rendered	2 428	-	2 428	-
Amount due from	1 978	703	1 978	703
Provincial government business enterprises				
Services received	-	1 050	-	1 050
Government departments				
Services rendered	1 569 724	1 736 901	1 569 724	1 736 901
Services received	8 717	4 601	8 717	4 601
Amount due from	47 282	26 140	47 282	26 140
Subsidiaries				
Amount due (to) from	-	-	(13)	(13)

The above is a summary of transactions with related parties during the year and balances due at year-end.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

17. RELATED PARTIES (CONTINUED)

Transactions with key management

Total remuneration of key management is included in employees' remuneration (refer to note 12 for Executive Management's remuneration).

18. IRREGULAR AND FRUITLESS AND WASTEFUL EXPENDITURE

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Irregular expenditure				
Opening balance	9 888	7 905	9 888	7 905
Irregular expenditure relating to the current financial year:				
– Non-compliance to PPPFA and/or PFMA*	-	1 369	-	1 369
Irregular expenditure relating to prior financial years:				
– Non-compliance to PPPFA and/or PFMA*	372	1 852	372	1 852
Amounts condoned	(2 073)	(1 238)	(2 073)	(1 238)
	8 187	9 888	8 187	9 888

Included in the balance of R8,1 million above is a total of R5,3 million's worth of transgressions that the CSIR Board has requested National Treasury to condone. At the time of preparation of these financial statements the CSIR was waiting for confirmation of condonation.

- No loss was incurred by the CSIR.

Corrective actions taken by the CSIR:

- During the 2018/19 financial year, ten transgressions were detected which constitute irregular expenditure. Procurement training and awareness have been provided to the employees concerned relating to eight offences, while no action was taken in two instances because the employees have left the employ of the CSIR and no loss was suffered by the public entity.
- During the 2019/20 financial year, four transgressions were detected which constitute irregular expenditure. Of the four transgressions detected one was committed prior to 2019/20. Disciplinary action has been taken against officials who committed two of the four offences, while no action was taken in two instances because the employees have left the employ of the CSIR and no loss was suffered by the public entity.
- During the 2020/21 financial year, four transgressions were detected all of which occurred in years prior to the current financial year. Disciplinary action has been taken against officials who committed two of the four offences, while no action was taken in two instances because the employees have left the employ of the CSIR and no loss was suffered by the public entity.

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Fruitless and wasteful expenditure				
Balance at the beginning of the year	174	174	174	174

Fruitless and wasteful expenditure of R72 960 (due to settlement of an employee's liability for recruitment fee towards a recruitment agent in lieu of retaining the employee as a key resource to the organisation) and R22 127 (unnecessary service rendered to CSIR due to lack of consultation of line manager by an employee) was incurred in the 2018/19 financial year.

Fruitless and wasteful expenditure of R42 526 (due to a cancellation fee and interest paid) and R36 416 (due to two suppliers being appointed and paid for the same project) was incurred in the 2017/18 financial year.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

19. NEW STANDARDS AND INTERPRETATIONS

19.1 Standards and interpretations not yet effective

The Group has decided against the early adoption of the following standard, which has been published and is mandatory for the Group's accounting periods beginning on or after 1 June 2020 or later periods:

- IAS 37 Provisions, Contingent Liabilities and Contingent Assets : Onerous Contracts—Cost of Fulfilling a Contract: The amendments specify which costs should be included in an entity's assessment whether a contract will be loss-making.
- IAS 16 Property, Plant and Equipment : Property, Plant and Equipment: Proceeds before Intended Use: The amendments prohibit an entity from deducting from the cost of an item of property, plant and equipment any proceeds from selling items produced while bringing that asset to the location and condition necessary for it to be capable of operating in the manner intended by management. Instead, an entity recognises the proceeds from selling such items, and the cost of producing those items, in profit or loss.
- IFRS 9 Financial Instruments: Annual Improvements to IFRS Standards 2018–2020: The amendment clarifies which fees an entity includes when it applies the '10 per cent' test in assessing whether to derecognise a financial liability.
- IFRS 17 Insurance contracts: IFRS 17 creates one accounting model for all insurance contracts in all jurisdictions that apply IFRS.
- IAS 1 Presentation of Financial Statements: Classification of Liabilities as Current or Non-current: Narrow-scope amendments to IAS 1 to clarify how to classify debt and other liabilities as current or non-current.
- IAS 1 Presentation of Financial Statements : Disclosure of Accounting Policies: The amendments require companies to disclose their material accounting policy information rather than their significant accounting policies, with additional guidance added to the Standard to explain how an entity can identify material accounting policy information with examples of when accounting policy information is likely to be material.
- IAS 8 Accounting Policies, Changes in Accounting Estimates and Errors: Definition of Accounting Estimates: The amendments clarify how companies should distinguish changes in accounting policies from changes in accounting estimates, by replacing the definition of a change in accounting estimates with a new definition of accounting estimates. Under the new definition, accounting estimates are "monetary amounts in financial statements that are subject to measurement uncertainty". The requirements for recognising the effect of change in accounting prospectively remain unchanged.

20. INVENTORIES

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Finished goods	956	2 726	956	2 726

21. OTHER RECEIVABLES FROM CONTRACTS

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Other receivables from contracts with customers	134 341	112 466	134 341	112 466

Other receivables from contracts with customers arise as result of the time lag between customer billing and revenue recognition. Contract assets (refer to note 22) constitute capitalised costs on point-in-time contracts with customers. Advances received in excess of work completed are included in advances on contracts with customers under current liabilities.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

22. CONTRACT ASSETS

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Contract assets	7 931	9 927	7 931	9 927
Summary of contract assets				
Contract assets	7 931	9 927	7 931	9 927
Reconciliation of contract assets				
Opening balance	9 927	6 918	9 927	6 918
Transfers of contract assets to receivables	(1 996)	-	(1 996)	-
New contracts	-	3 009	-	3 009
	7 931	9 927	7 931	9 927

23. PROVISIONS

	Opening balance	Utilised during the year	Total
Reconciliation of provisions - Group - 2021			
Restructuring	12 464	(12 464)	-
Reconciliation of provisions - Group - 2020			
Restructuring	11 187	1 277	12 464

	Opening balance	Utilised during the year	Total
Reconciliation of provisions - Company - 2021			
Restructuring	12 464	(12 464)	-
Reconciliation of provisions - Company - 2020			
Restructuring	11 187	1 277	12 464

The restructuring provision relates to redundancy costs incurred as result of the reorganisation that took place at the CSIR. On 13 April 2018, the Board approved a targeted intervention that focused on the aspects of the CSIR operations that were not sustainable.

24. ADVANCES FROM CUSTOMERS

Advances from customers constitute income received from customers in advance.

25. CAPITAL COMMITMENTS

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Property, plant and equipment	53 594	41 734	53 594	41 734

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS AS AT 31 MARCH 2021

26. FINANCIAL GUARANTEES

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Local and foreign payments and performance guarantees issued as at 31 March	43 979	38 530	43 979	38 530

27. PRIOR PERIOD ERRORS

R74 million ring-fenced allocation from the Department of Science and Technology had erroneously been classified as part of local public sector contract income instead of other government grants. The effect of the error was an understatement of other government grants and overstatement of local public sector contract income per prior year statement of profit or loss and other comprehensive income. There was no impact on profit for the year, assets or liabilities.

The correction of the error results in adjustments as follows:

	Group		CSIR	
	2021	2020	2021	2020
	R'000	R'000	R'000	R'000
Profit or Loss				
Local public sector contract income	-	(74 000)	-	(74 000)
Other government grants	-	74 000	-	74 000

28. FAIR VALUE INFORMATION

Fair value hierarchy

The table below analyses assets and liabilities carried at fair value. The different levels are defined as follows:

- Level 1:** Quoted unadjusted prices in active markets for identical assets or liabilities that the group can access at measurement date.
- Level 2:** Inputs other than quoted prices included in level 1 that are observable for the asset or liability either directly or indirectly.
- Level 3:** Fair value measurements are derived from valuation techniques that include inputs (such as recent transactions for similar assets) that are not based on observable market data.

Reconciliation of assets and liabilities measured at level 3

	Note(s)	Opening balance	Gains (losses) recognised in other comprehensive income	Closing balance
Group - 2020				
Assets				
Property, plant and equipment	5			
Land		125 435	12 965	138 400
Total		125 435	12 965	138 400

Gains and losses recognised in other comprehensive income are included in Gains and losses on property revaluation.





PART G CSIR PUBLICATIONS

Journal Articles.....	176
Conference papers	188
Books and book chapters	192

CSIR PUBLICATIONS

JOURNAL ARTICLES (307)

- Adams, JB, Taljaard, Susan, Van Niekerk, Lara, Lemley, DA. **2020**. Nutrient enrichment as a threat to the ecological resilience and health of South African microtidal estuaries. *African Journal of Aquatic Science*, 45(1-2), p.18pp.
- Adams, JB, Van Niekerk, Lara. **2020**. Ten principles to determine environmental flow requirements for temporarily closed estuaries. *Water*, 12(7), p.28pp.
- Adams, JB, Whitfield, AK, Van Niekerk, Lara. **2020**. A socio-ecological systems approach towards future research for the restoration, conservation and management of southern African estuaries. *African Journal of Aquatic Science*, 45(1-2), p.231-241.
- Adawaren, EO, Du Plessis, M, Suleman, Essa, Kindler, Duodane, Oosthuizen, AO, Mukandiwa, L, Naidoo, V. **2020**. The complete mitochondrial genome of Gyps coprotheres (Aves, Accipitridae, Accipitriformes): Phylogenetic analysis of mitogenome among raptors. *PeerJ*, p.14pp.
- Adeniyi, A, Gonzalez-Ortiz, D, Pochat-Bohatier, B, Oyewo, O, Sithole, Bishop B, Onyango, M. **2020**. Incorporation of Cellulose Nanocrystals (CNC) derived from sawdust into polyamide thin-film composite membranes for enhanced water recovery. *Alexandria Engineering Journal*, 59(6), p.4201-4210.
- Adeyeye, K, Gibberd, Jeremy T, Chakwizira, J. **2020**. Water marginality in rural and peri-urban communities. *Journal of Cleaner Production*, 273, p.16pp.
- Akande, Amos, Mosuang, T, Ouma, CNM, Benecha, EM, Tesfamichael, T, Roro, Kittessa T, Machatine, AGJ, Mwakikunga, BW. **2020**. Ammonia gas sensing characteristics of V2O5 nanostructures: A combined experimental and ab initio density functional theory approach. *Journal of Alloys and Compounds*, 821, p.9pp.
- Akhalwaya, Imraan, Smit, Michandre A, Rust, FC, Du Plessis, L. **2020**. Heavy Vehicle Simulator (HVS) testing of innovative pavement structures in South Africa. In: Chabot, A, Hornych, P, Harvey, J, Loria-Salazar, L (eds.). *Lecture Notes in Civil Engineering*, 96, p.251-260.
- Akolade, Jubril O, Olubukola Nasir-Naeem, K, Swanepoel, Andri, Yusuf, AA, Balogun, Mohammed, Labuschagne, Philip W. **2020**. CO₂-assisted production of polyethylene glycol / lauric acid microparticles for extended release of Citrus aurantifolia essential oil. *Journal of CO₂ Utilization*, 38, p.375-384.
- Akpakwu, GA, Hancke, GP, Abu-Mahfouz, Adnan MI. **2020**. CACC: Context-aware congestion control approach for lightweight CoAP/UDP-based Internet of Things traffic. *Transactions on Emerging Telecommunications Technologies*, 31(2), p.19pp.
- Alexander, B, Bollinger, JJ, Uys, Hermann. **2020**. Generating Greenberger-Horne-Zeilinger states with squeezing and postselection. *Physical Review A*, 101, p.8pp.
- Alexander, Kabamba, Malatji, Kanyane, Mulaudzi, Takalani. **2020**. Comparison of the antiviral activity of the microbicide candidate griffithsin and its tandem derivatives against different modes of HIV-1 transmission. *Virology*, 544, p.12-20.
- Alexandre, Kabamba B, Malatji, Kanyane, Mulaudzi, Takalani. **2020**. Modification and optimization of the inhibition of HIV-1 cell-to-cell transmission assay. *MethodsX*, 7, p.7pp.
- Alimi, KOA, Ouahada, K, Abu-Mahfouz, Adnan MI, Rimer, S. **2020**. A survey on the security of low power wide area networks: Threats, challenges, and potential solutions. *Sensors*, 20(20), p.19pp.
- Alimi, OA, Ouahada, K, Abu-Mahfouz, Adnan MI. **2020**. A review of machine learning approaches to power system security and stability. *IEEE Access*, 8, p.113512-113531.
- Alufasi, R, Parawira, W, Stefanakis, AI, Lebea, P, Chakauya, Ereck, Chingwaru, W. **2020**. Internalisation of Salmonella spp. by Typha latifolia and Cyperus papyrus in vitro and implications for pathogen removal in Constructed Wetlands. *Environmental Technology*, p.13pp.
- Ama, OM, Khoele, Khotso, Anku, WW, Ray, Suprakas S, Osifo, PO, Delport, DJ. **2020**. Synthesis and application of MnO₂/Exfoliated graphite electrodes for enhanced photoelectrochemical degradation of Methylene Blue and Congo Red dyes in water. *Electrocatalysis*, 11, p.413-421.
- Ameh, AE, Fatoba, OO, Musyoka, Nicholas M, Louis, B, Petrik, LF. **2020**. Transformation of fly ash based nanosilica extract to BEA zeolite and its durability in hot liquid. *Microporous and Mesoporous Materials*, 305, p.1-12.
- Andrew, Jerome E, Masetlwa, J, Tesfaye, T, Sithole, Bishop B. **2020**. Beneficiation of eucalyptus tree barks in the context of an integrated biorefinery – Optimisation of accelerated solvent extraction (ASE) of polyphenolic compounds using response surface methodology. *Sustainable Chemistry and Pharmacy*, 18, p.7pp.
- Arabi, Sumaiya, Nahman, Anton. **2020**. Impacts of marine plastic on ecosystem services and economy: State of South African research. *South African Journal of Science*, 116(5/6), p.7pp.
- Ayele, M, Tesfaye, T, Alemu, D, Limeneh, M, Sithole, Bishop B. **2020**. Natural dyeing of cotton fabric with extracts from mango tree: A step towards sustainable dyeing. *Sustainable Chemistry and Pharmacy*, 17, p.8pp.
- Baichan, P, Naicker, Previn, Devar, JWS, Smith, M, Candy, GP, Nweke, E. **2020**. Targeting gallbladder cancer: A pathway based perspective. *Molecular Biology Reports*, 47, p.2361-2369.
- Bambalaza, Sonwabo E, Langmi, HW, Mokaya, R, Musyoka, Nicholas M, Khotseng, LE. **2020**. Co-pelletization of a zirconium-based metalorganic framework (UiO-66) with polymer nanofibers for

improved useable capacity in hydrogen storage. *International Journal of Hydrogen Energy*, 46(12), p.8607-8620.

Bambalaza, Sonwabo E, Langmi, HW, Mokaya, R, Musyoka, Nicholas M, Khotseng, LE. **2020**. Experimental demonstration of dynamic temperature-dependent behavior of UiO-66 metal-organic framework: Compaction of hydroxylated and dehydroxylated forms of UiO-66 for high-pressure hydrogen storage. *ACS Applied Materials and Interfaces*, 12(22), p.24883-24894.

Banerjee, F, Ray, Suprakas S. **2020**. Foamability and special applications of microcellular thermoplastic polymers: A review on recent advances and future direction. *Micromolecular Materials and Engineering*, p.49pp.

Banerjee, R, Ray, Suprakash S, Ghosh, AK. **2020**. Rheology and foaming behaviour of styrene-ethylene-butylene-styrene nanocomposites. *Colloid and polymer science*, p.1-16.

Bell, Lebohang T, Kgomo, Mosima B, Ngcobo, Sandile. **2020**. Digital laser for on-demand intracavity selective excitation of second harmonic higher-order modes. *Optics Express*, 28(11), p.16907-16923.

Bello-Salau, H, Onumanyi, AJ, Abu-Mahfouz, Adnan MI, Adejo, AO, Mu'azu, MB. **2020**. New discrete cuckoo search optimization algorithms for effective route discovery in IoT-based vehicular ad-hoc networks. *IEEE Access*, 8, p.145469-145488.

Bergh, J, Snedden, Glen C, Dunn, Dwain I. **2020**. Optimization of nonaxisymmetric endwall contours for the rotor of a low speed, 1 1/2-stage research turbine with unshrouded blades— optimization and experimental validation. *Journal of turbomachinery*, 142(4), p.12pp.

Bergh, J, Snedden, Glen C, Reddy, D. **2020**. Development of an automated non-axisymmetric endwall contour design system for the rotor of a 1-stage research turbine - Part 2 Computed and experimental results. *Proceedings of the Institution of Mechanical Engineers Part A- Journal of power energy*, p.16pp.

Bhagwat, G, Gray, K, Wilson, SP, Muniyasamy, Sudhakar, Vincent, SGT, Bush, R, Palanisam, T. **2020**. Benchmarking bioplastics: A natural step towards a sustainable future. *Journal of Polymers and the Environment*, 28, p.3055-3075.

Bhatt, AS, Ranjitha, R, Santosh, MS, Ravikumar, CR, Prashantha, SC, Maphanga, Rapela R, Lenz e Silva, GFB. **2020**. Optical and electrochemical applications of Li-Doped NiO nanostructures synthesized via facile microwave technique. *Materials*, 13(13), p.17pp.

Bhaumik, M, Raju, Kumar, Arunachellan, Iviwe C, Ludwig, T, Mathe, Mahlanyane K, Maity, Arjun, Mathur, S. **2020**. High-performance supercapacitors based on S-doped polyaniline nanotubes decorated with Ni(OH)₂ nanosponge and onion-like carbons derived from used car tyres. *Electrochimica Acta*, 342, p.10pp.

Bhembe, YA, Lukhele, LP, Hlekelele, Lerato, Ray, Suprakas S, Sharma, A, Vo, Dai-Viet N, Dlamini, LN. **2020**. Photocatalytic degradation of nevirapine with a heterostructure of few-layer black phosphorus coupled with niobium (V) oxide nanoflowers (FL-BP@Nb₂O₅). *Chemosphere*, 261, p.10pp.

Bolokang, Amogelang S, Mathabathe, Maria N, Chikosha, Silethelwe, Motaung, DE. **2020**. Investigating the heat resistant properties of the

TiNi shape memory alloy on the B19' B2 phase transformation using the alloy powder. *Surfaces and Interfaces*, 20, p.11 pp.

Bolokang, Amogelang S, Modiba, Rosinah, Motaung, DE, Ngoepe PE. **2020**. Synthesis of the porous spinel Co-Al₂O₄ powder produced by ball milling and annealing. *Advanced Powder Technology*, 31(7), p.2742-2748.

Braby, L, Backeberg, B, Krug, Marjolaine J, Reason, C. **2020**. Quantifying the impact of wind-current feedback on mesoscale variability in forced simulation experiments of the Agulhas current using an eddy-tracking algorithm. *Journal of geophysical research: Oceans*, 125, p.23pp.

Breytenbach, Andre. **2020**. 3D evaluation of fine-scale normalised DSMs in urban settings. *South African Journal of Geomatics*, 9(2), p.18pp.

Bugan, Richard DH, García, CL, Jovanovic, Nebojsa, Teich, I, Fink, M, Dzikiiti, Sebinasi. **2020**. Estimating evapotranspiration in a semi-arid catchment: A comparison of hydrological modelling and remote-sensing approaches. *Water SA*, 46(2), p.158-170.

Cele, Zamani ED, Somboro, AM, Amoako, DG, Ndlandla, Lindokuhle F, Balogun, Mohammed O. **2020**. Fluorinated quaternary chitosan derivatives: Synthesis, characterization, antibacterial activity, and killing kinetics. *ACS Omega*, 5(46), p.29657-29666.

Chakraborty, A, Singh, JK, Sen, D, Pityana, Sisa L, Manna, I, Krishna, S, Dutta Majumdar, J. **2020**. Microstructures, wear and corrosion resistance of laser composite surfaced austenitic stainless steel (AISI 304 SS) with tungsten carbide. *Optics and Laser Technology*, 134, p.12pp.

Chime, UK, Nkele, AC, Ezugwu, S, Nwanya, AS, Shinde, NM, Kebede, Mesfin A, Ejikeme, PM, Maaza, M, Ezema, FI. **2020**. Recent progress in nickel oxide-based electrodes for high-performance supercapacitors. *Current Opinion in Electrochemistry*, 21, p.175-181.

Claassens, L, Barnes, RSK, Wasserman, J, Lamberth, SJ, Miranda, AF, Van Niekerk, Lara, Adam, JB. **2020**. Knysna Estuary health: Ecological status, threats and options for the future. *African Journal of Aquatic Science*, 45(1-2), p.65-82.

Cooper, Antony K, Coetzee, Serena. **2020**. On the ethics of using publicly-available data [article]. *Lecture Notes in Computer Science*, 12067, p.159-171.

Cox, MA, Mphuthi, N, Nape, I, Mashaba, Nikiwe P, Cheng, L, Forbes, A. **2020**. Structured light in turbulence. *IEEE Journal of Selected Topics in Quantum Electronics*, 27(2), p.22pp.

Crookes, DJ, Blignaut, JN, Le Maitre, David C. **2020**. The effect of accessibility and value addition on the costs of controlling invasive alien plants in South Africa: A three-species system dynamics model in the fynbos and grassland biomes. *Southern Forests: A Journal of Forest Science*, 8292, p.125-134.

Da Veiga, A, Astakhova, LV, Botha, Adéle, Herselman, Marlien E. **2020**. Defining organisational information security culture—Perspectives from academia and industry. *Computers & Security*, 92, p.23pp.

Dada, M, Popoola, P, Mathe, Ntombizodwa R, Pityana, Sisa L, Adeosun, S. **2020**. Parametric optimization of laser deposited high entropy alloys using response surface methodology (RSM). *The International Journal of Advanced Manufacturing Technology*, 109, p.2719-2732.

- Dada, M, Popoola, P, Mathe, Ntombizodwa R, Pityana, Sisa L, Adeosun, S, Lengopeng, Thabo. **2020**. Fabrication and hardness behaviour of high entropy alloys. In: The Minerals, Metals & Materials Society (eds.). *Minerals, Metals & Materials Series*, p.1581-1591.
- David, AN, Sewsynker-Sukai, B, Sithole, Bishop B, Gueguim Kana, EB. **2020**. Development of a green liquor dregs pretreatment for enhanced glucose recovery from corn cobs and kinetic assessment on various bioethanol fermentation types. *Fuel*, 274, p.12pp.
- Devi, Nishu, Ray, Suprakas S. **2020**. Performance of bismuth-based materials for supercapacitor applications: A review. *Materials Today Communications*, 25, p.19pp.
- Dima, Ratshilumela S, Maluta, NE, Maphanga, Rapela R. **2020**. First-principles investigation of Ru- and Pt-Doped TiO₂ brookite surfaces. *International Journal of Electrochemical Science*, 15(1), p.1757-1770.
- Dlamini, Sifiso B, Turpin, M. **2020**. Towards a resilience framework for integrating and using mobile technologies in South African public rural schools: Theoretical considerations. In: Junio, DR Koopman, C (eds.). *Communications in Computer and Information Science*, 1236, p.127-140.
- Dlamini, Thandokuhle M, Venter, H, Eloff, J, Eloff, M. **2020**. Digital deception in cybersecurity: An information behaviour lens. *Information Research-An International Electronic Journal*, 25(4), p.14pp.
- Domínguez-Andrés, J, Fanucchi, Stephanie, Joosten, LAB, Mhlanga, Musa M, Netea, MG. **2020**. Advances in understanding molecular regulation of innate immune memory. *Current Opinion in Cell Biology*, 63, p.68-75.
- Dumani, Nozonke, Mapiravana, Joseph. **2020**. Evaluation of age strengths of metakaolin blend pastes with varying fineness of grind. *RILEM Bookseries*, 25, p.10pp.
- Dutta, S, Sengupta, S, Chanda, J, Das, A, Wiessner, S, Ray, Suprakas S, Bandyopadhyay, A. **2020**. Distribution of nanoclay in a new TPV/nanoclay composite prepared through dynamic vulcanization. *Polymer Testing*, 83,
- Duvenhage, DF, Brent, AC, Stafford, William HL, Van Den Heever, D. **2020**. Optimising the concentrating solar power potential in South Africa through an improved GIS analysis. *Energies*, 13(12), p.10pp.
- Duvenhage, F, Brent, AC, Stafford, William HL, Grobbelaar, S. **2020**. Water and CSP—Linking CSP water demand models and national hydrology data to sustainably manage CSP development and water resources in arid regions. *Sustainability*, 12(8), p.32pp.
- Dzikiti, Sebinasi, Lumsden, Trevor, Ntshidi, Zanele, Mobe, Nompumelelo, Gush, Mark. **2020**. Water use in orchards. *Water Wheel*, 19(4), p.42-45.
- Eccles, R, Van der Linde, J, Le Roux, M, Holloway, Jennifer P, MacCutcheon, D, Ljung, R, Swanepoel, D. **2020**. Effect of music instruction on phonological awareness and early literacy skills of five- to seven-year-old children. *Early child development and care*, p.16pp.
- Egambaram, Orielia P, Kesavan Pillai, Sreejarani, Ray, Suprakas S. **2020**. Materials science challenges in skin UV protection: A review. *Photochemistry and Photobiology*, 96(4), p.779-797.
- Egoh, BN, Ntshotsho, Phumza, Maoela, Malebajoa A, Blanchard, Ryan, Ayompe, LM, Rahlao, S. **2020**. Setting the scene for achievable post-2020 convention on biological diversity targets: A review of the impacts of invasive alien species on ecosystem services in Africa. *Journal of Environmental Management*, 261, p.8pp.
- Ekwanzala, MD, Lehutso, Raisibe F, Kasonga, TK, Dewar, JB, Momba, MNB. **2020**. Environmental dissemination of selected antibiotics from hospital wastewater to the aquatic environment. *Antibiotics*, 9(7), p.16pp.
- El-Hussein, A, Manoto, Sello L, Ombinda-Lemboumba, Saturnin, Alrowaili, ZA, Mthunzi-Kufa, Patience. **2020**. A review of chemotherapy and photodynamic therapy for lung cancer treatment. *Anti-Cancer Agents in Medicinal Chemistry*, p.13pp.
- Fagbemi, Olajumoke D, Sithole, Bishop B, Tesfaye, Tamrat. **2020**. Optimization of keratin protein extraction from waste chicken feathers using hybrid pre-treatment techniques. *Sustainable Chemistry and Pharmacy*, 17, p.12pp.
- Fasakin, O, Oyedotun, KO, Kebede, Mesfin, Rohwer, Mark B, Le Roux, Lukas, Mathe, Mahlanyane K, Eleruja, MA, Ajayi, EOB, Manyala, Ncholu. **2020**. Preparation and physico-chemical investigation of anatase TiO₂ nanotubes for a stable anode of lithium-ion battery. *Energy Reports*, 6(7), p.92-101.
- Foko, Thato E, Mahwai, Nare J, Phiri, Charles A. **2020**. Lessons from the field: What researchers learned from evaluating ICT platforms for rural development and education. *The Journal of Community Informatics*, 16, p.141-153.
- French, H, Peterson, E, Schulman, M, Roth, Robyn L, Crampton, Michael, Conan, A, Marchi, S, Knobel, D, Bertschinger, H. **2020**. Efficacy and safety of native and recombinant zona pellucida immunocontraceptive vaccines in donkeys. *Theriogenology*, 153, p.27-33.
- Froebrich, J, Ludi, E, Bouarfa, S, Rollin, D, Jovanovic, Nebojsa, Roble, M, Ajmi, T, Albasha, R, Bah, S, Musvoto, Constansia D. **2020**. Transdisciplinary innovation in irrigated smallholder agriculture in Africa. *Irrigation and Drainage*, 69(1), p.06-22.
- Funke, Nicola S, Huitema, D, Petersen, A, Nienaber, S. **2020**. The roles of experts and expert-based information in the advocacy coalition framework: Conceptual and empirical considerations based on the acid mine drainage case study in Gauteng, South Africa. *Policy Studies Journal*, p.26pp.
- Gangat, R, Van Deventer, Heidi, Naidoo, Laven, Adam, E. **2020**. Estimating soil moisture using Sentinel-1 and Sentinel-2 sensors for dryland and palustrine wetland areas. *South African Journal of Science*, 116(7/8), p.9pp.
- Gangire, Y, Da Veiga, A, Herselman, Martha E. **2020**. Information security behavior: Development of a measurement instrument based on the self-determination theory. *IFIP Advances in Information and Communication Technology*, 593, p.144-157.
- Gbadamosi, SA, Hancke, GP, Abu-Mhafouz, Adnan MI. **2020**. Building upon NB-IoT networks: A roadmap towards 5G new radio networks. *IEEE Access*, 8, p.188641 - 188672.
- Gbadeyan, OJ, Adali, S, Bright, G, Sithole, Bishop B, Awogbemi, O. **2020**. Studies on the mechanical and absorption properties of achatina fulica snail and eggshells reinforced composite materials. *Composite Structures*, 239, p.9pp.

- Gbadeyan, OJ, Adali, S, Bright, G, Sithole, Bishop B, Onwubu, S. **2020**. Optimization of milling procedures for synthesizing nano-CaCO₃ from *Achatina fulica* shell through mechanochemical techniques. *Journal of Nanomaterials*, p.9pp.
- Gbadeyan, OJ, Bright, G, Sithole, Bishop B, Adali, S. **2020**. Physical and morphological properties of snail (*Achatina Fulica*) shells for beneficiation into biocomposite materials. *Journal of Bio- and Tribo-Corrosion*, 35(6), p.5pp.
- Genthe, Bettina, Ndlela, Luyanda L, Madlala, Tebogo. **2020**. Antimicrobial resistance screening and profiles: A glimpse from the South African perspective. *Journal of Water and Health*, 18(6), p.925–936.
- Geode, MF, Cho, Moses A, Chirwa, PW, Geldenhuys, CJ. **2020**. Land use land cover change and the comparative impact of co-management and government-management on the forest cover in Malawi (1999–2018). *Journal of Land Use Science*, 14(4–6), p.281–305.
- George, Theresa B, Anochie-Boateng, Joseph K, Jenkins, KJ. **2020**. Laboratory performance and modelling behaviour of hot-mix asphalt with recycled crushed glass. *Journal of the South African Institution of Civil Engineering*, 62(3), p.10–22.
- Gibberd, Jeremy T. **2020**. Rapid identification and evaluation of interventions for improved water performance at South Africa schools. In: Littlewood, J Howlett, RJ Jain, LC (eds.). *Smart Innovation, Systems and Technologies*, 203, p.173–182.
- Giering, SLC, Cavan, EL, Basedow, SL, Briggs, N, Burd, AB, Darroch, LJ, Guidi, L, Irisson, JO, Iverson, MH, Thomalla, Sandy J. **2020**. Sinking organic particles in the ocean—flux estimates from in situ optical devices. *Frontiers in marine science*, 6(834), p.23pp.
- Godfrey, Linda K. **2020**. Are there gaps in our understanding of marine plastic pollution?. *South African Journal of Science*, 116(5/6), p.1 pp.
- Gondwe, MFK, Geldenhuys, CJ, Chirwa, PWC, Assédé, ESP, Syampungani, S, Cho, Moses A. **2020**. Tree species composition and diversity in Miombo woodlands between co-managed and government-managed regimes, Malawi. *African Journal of Ecology*, p.32pp.
- Gusain, Rashi, Kumar, Neeraj, Ray, Suprakas S. **2020**. Recent advances in carbon nanomaterial-based adsorbents for water purification. *Coordination Chemistry Reviews*, 405,
- Gxowa-Penxa, Zizo, Daswa, Pfarelo, Modiba, Rosinah, Mathabathe, Maria N, Bolokang, Amogelang S. **2020**. Development and characterization of Al–Al₃Ni–Sn metal matrix composite. *Materials Chemistry and Physics*, p.9pp.
- Hamann, M, Biggs, R, Pereira, L, Preiser, R, Blanchard, Ryan, Warrington CH, King, N, Merrie, A, Nilsson, W, Odendaal, P. **2020**. Scenarios of good Anthropocenes in southern Africa. *Futures*, 118, p.13pp.
- Hanslo, Ridewaan, Vahed, A, Mnkandla, E. **2020**. Quantitative analysis of the scrum framework. In: Przybylek, Adam Morales-Trujillo, Miguel Ehécatl (eds.). *Lecture Notes in Business Information Processing*, 376, p.82–107.
- Harvey, PJ, Grab, SW, Malherbe, Johan. **2020**. Major volcanic eruptions and their impacts on Southern Hemisphere temperatures during the late 19th and 20th centuries, as simulated by CMIP5 models. *Geophysical Research Letters*, 47(14), p.10pp.
- Haywood, Lorren K, Boihang, Mothusi. **2020**. Business and the SDGs: Examining the early disclosure of the SDGs in annual reports. *Development Southern Africa*, p.15pp.
- Haywood, Lorren K, Nortje, Karen, Dafuleya, G, Nethengwe, T, Sumbana, F. **2020**. An assessment for enhancing sustainability in rural tourism products in South Africa. *Development Southern Africa*, 37(6), p.1033–1050.
- Henrico, S, Coetzee, S, Cooper, Antony K, Rautenbach, V. **2020**. Acceptance of open source geospatial software: Assessing QGIS in South Africa with the UTAUT2 model. *Transactions in GIS*, p.23pp.
- Henrico, S, Coetzee, S, Cooper, Antony K. **2020**. Is open source GIS feasible in military operations? Evaluation by applying a USE case. *Scientia Militaria: South African Journal of Military Studies*, 48(1), p.41–60.
- Herbst, K, Scherer, K, Ferreira, SES, Baalman, LR, Engelbrecht, E, Fichtner, H, Kleimann, J, Du Toit Strauss, R, Moeketsi, Daniel M, Mohamed, S. **2020**. On the diversity of M-star astrospheres and the role of galactic cosmic rays within. *Astrophysical Journal Letters*, 897(2), p.10pp.
- Hou, S, Ye, Y, Liao, S, Ren, Jianwei, Wang, H, Yang, P, Du, K, Li, J, Peng, H. **2020**. Enhanced low-humidity performance in a proton exchange membrane fuel cell by developing a novel hydrophilic gas diffusion layer. *International Journal of Hydrogen Energy*, 45(1), p.937–944.
- Hurdal, R, Nieuwenhuizen, NE, Khutlang, Rethabile, Brombacher, F. **2020**. Inflammatory dendritic cells, regulated by IL-4 receptor alpha signaling, control replication, and dissemination of *Leishmania* major in mice. *Frontiers in Cellular and Infection Microbiology*, p.17pp.
- Ipadeola, AK, Mwonga, PV, Ray, SC, Maphanga, Rapela R, Ozoemena, KI. **2020**. Palladium-stannic oxide interfacial chemistry promotes hydrogen oxidation reactions in alkaline medium. *ChemElectroChem*, 7(22), p.35pp.
- Ipadeola, AK, Mwonga, PV, Ray, SC, Maphanga, Rapela R, Ozoemena, KI. **2020**. Bifunctional behavior of Pd/Ni nanocatalysts on MOF-derived carbons for alkaline water-splitting. *Electroanalysis*, 32(12), p.3060–3074.
- Iroegbu, AOC, Sadiku, RE, Ray, Suprakas S, Hamam, Y. **2020**. Plastics in municipal drinking water and wastewater treatment plant effluents: Challenges and opportunities for South Africa - a review. *Environmental Science and Pollution Research*, 27, p.12953–12966.
- Isong, B, Molose, RRS, Abu-Hafouz, Adnan MI, Dladlu, N. **2020**. Comprehensive review of SDN controller placement strategies. *IEEE Access*, 8, p.170070–170092.
- James, NC, Adams, JB, Connell, AD, Lamberth, SJ, MacKay, CF, Snow, GC, Van Niekerk, Lara, Whitfield, AK. **2020**. High flow variability and storm events shape the ecology of the Mbashe Estuary, South Africa. *African Journal of Aquatic Science*, 45(1), p.131–151.
- Jeje, SO, Shongwe, MB, Maledi, N, Ogunmuyiwa, EN, Tshabalala, Lerato C, Babalola, BJ, Olubambi, PA. **2020**. Sintering behavior and alloying elements effects on the properties of CP-Titanium sintered using pulsed electric current. *Materials Chemistry and Physics*, 256, p.12pp.

- Jiba, Zetu, Focke W, Kalombo, Lonji, Madito MJ. **2020**. Coating processes towards selective laser sintering of energetic material composites. *Defence Technology*, 16(2), p.316-324.
- Jovanovic, Nebojsa, Pereira, LS, Paredes, P, Pocas, I, Cantore, D, Todorovic, M. **2020**. A review of strategies, methods and technologies to reduce non-beneficial consumptive water use on farms considering the FAO56 methods. *Agricultural water management*, 239, p.20pp.
- Kabongo, GL, Mbule, PS, Mhlongo, Gugu H, Mothudi, BM, Dhlamini, MS. **2020**. Time-resolved fluorescence decay and Gaussian analysis of P3HT-derived Ho3+- and Tm3+-doped ZnO nanostructures. *Bulletin of Materials Science*, 43(48), p.8pp.
- Kakonke, Grace, Tesfaye, Tamrat, Sithole, Bishop B, Ntunka, M. **2020**. Production and characterization of cotton-chicken feather fibres blended absorbent fabrics. *Journal of Cleaner Production*, 243, p.12pp.
- Keating, ST, Groh, L, Van der Heijden, CDCC, Rodriguez, H, Dos Santos, JC, Fanucchi, Stephanie, Okabe, J, Kaipanickal, H, Van Puffelen, JH, Helder, L. **2020**. The Set7 Lysine Methyltransferase regulates plasticity in Oxidative Phosphorylation necessary for trained immunity induced by β -Glucan. *Cell Reports*, 31(3), p.22pp.
- Kebede, Mesfin A. **2020**. Tin oxide-based anodes for both lithium-ion and sodium-ion batteries. *Current Opinion in Electrochemistry*, 21, p.182-187.
- Kemmegne-Mbougwen, JC, Tchoumi, FP, Mouafo-Tchinda, E, Langmi, HW, Bambalaza, Sonwabo E, Musyoka, Nicholas M, Kowenje, C, Mokaya, R. **2020**. Simultaneous quantification of acetaminophen and tryptophan using a composite graphene foam/Zr-MOF film modified electrode. *New Journal of Chemistry*, 44(30), p.13108-13117.
- Kemp, N, Breetzke, GD, Cooper, Antony K. **2020**. Modeling the risk of robbery in the city of Tshwane, South Africa. *Cartography and Geographic Information Science*, p.14pp.
- Kesavan Pillai, Sreejarani, Kleyi, Phumelele E, De Beer, Marinda, Mudaly, Prenscha. **2020**. Layered double hydroxides: An advanced encapsulation and delivery system for cosmetic ingredients-an overview. *Applied Clay Science*, 199, p.12pp.
- Khumalo, Mduduzi, Sithole, Bishop B, Tesfaye, Tamrat. **2020**. Valorisation of waste chicken feathers: Optimisation of keratin extraction from waste chicken feathers by sodium bisulphite, sodium dodecyl sulphate and urea. *Journal of Environmental Management*, 262, p.1-7.
- Kilinkissa, OEY, Govender, Krishna, Báthori, NB. **2020**. Melting point-solubility-structure correlations in chiral and racemic model cocrystals. *CrystEngComm*, 16, p.2766-2771.
- Koen, Wayne S, Jacobs, Cobus, Esser, MJD, Strauss, Hencharl J. **2020**. Optically pumped HBr master oscillator power amplifier operating in the mid-infrared region. *Journal of the Optical Society of America B- Optical Physics*, 37(11), p.A154-A162.
- Kravitz, J, Matthews, M, Bernard, Stewart, Griffith, Derek J. **2020**. Application of Sentinel 3 OLCI for chl-a retrieval over small inland water targets: Successes and challenges. *Remote Sensing of Environment*, 237, p.21pp.
- Kriek, M, Monyai, K, Magcwebaba, TU, Du Plessis, N, Stoychev, SH, Tabb, David L. **2020**. Interrogating fractionation and other sources of variability in shotgun proteomes using quality metrics. *Proteomics*, p.8pp.
- Kufakunesu, R, Hancke, GP, Abu-Mahfouz, Adnan MI. **2020**. A survey on adaptive data rate optimization in LoRaWAN: Recent solutions and major challenges. *Sensors*, 20(18), p.10pp.
- Kumar, Neeraj, Kumar, S, Gusain, Rashi, Manyala, N, Eslava, N, Ray, Suprakas S. **2020**. Polypyrrole-promoted rGO-MoS2 nanocomposites for enhanced photocatalytic conversion of CO2 and H2O to CO, CH4, and H2 products. *Applied Energy Materials*, 3(10), p.9897-9909.
- Kuruma, Malkappa, Sinha Roy, Jayita, Ray, Suprakas S. **2020**. Design of poly(cyclotriphosphazene)-functionalized zirconium phosphate nanoplatelets to simultaneously enhance the dynamic mechanical and flame retardancy properties of polyamide 6. *ACS Omega*, 5(23), p.13867-13877.
- Lau, WWY, Shiran, J, Bailey, RM, Cook, E, Stuchtey, MR, Koskella, J, Velis, CA, Godfrey, Linda K, Boucher, J, Murphy, MB. **2020**. Evaluating scenarios toward zero plastic pollution. *Science*, 369, p.1455-1461.
- Lehutso, Raisibe F, Tancu, Yolanda, Maity, Arjun, Thwala, Melusi. **2020**. Aquatic toxicity of transformed and product-released engineered nanomaterials: An overview of the current state of knowledge. *Process Safety and Environmental Protection*, 138, p.39-56.
- Lekoadi, Paul M, Maledi, N, Tlotleng, Monnamme, Masina, Bathusile N. **2020**. Investigation of martensite α' phase transformation during heat treatment of high-speed selective laser melted Ti6Al4V components. *Minerals, Metals & Materials Series*, p.385-393.
- Liu, Y, Ma, X, Shu, L, Hancke, GP, Abu-Mahfouz, Adnan MI. **2020**. From Industry 4.0 to Agriculture 4.0: Current status, enabling technologies, and research challenges. *IEEE Transactions on Industrial Informatics*, 17(6), p.13pp.
- Louw, Johannes A. **2020**. Text-to-speech duration models for resource-scarce languages in neural architectures. In: Gerber, A (eds.). *Communications in Computer and Information Science*, 1342, p.141-153.
- Loveday, Philip W, Long, Craig S, Ramatlo, Dineo A. **2020**. Ultrasonic guided wave monitoring of an operational rail track. *Structural Health Monitoring*, 19(6), p.1666-1684.
- Lukman, V, Odeyemi, SW, Roth, Robyn L, Mbabala, L, Tshililo, N, Vlok, NM, Dewar, MJB, Kenyon, Colin P. **2020**. Novel kinase platform for the validation of the anti-tubercular activities of Pelargonium sidoides (Geraniaceae). *BMC Biotechnology*, 20(50), p.11pp.
- Maaake, Popoti J, Bolokang, Amogelang S, Arendse, CJ, Vohra, V, Iwuoha, EI, Motaung, DE. **2020**. Metal oxides and noble metals application in organic solar cells. *Solar Energy*, 207, p.347-366.
- Mabalane, PN, Oboirien, BO, Sadiku, ER, Masukume, Mike. **2020**. A techno-economic analysis of anaerobic digestion and gasification hybrid system: Energy recovery from municipal solid waste in South Africa. *Waste and Biomass Valorization*, p.18pp.

- Mabena, Chemist M, Roux, FS. **2020**. Quantum channel correction with twisted light using compressive sensing. *Physical Review A*, 101(1), p.9pp.
- Machio, Christopher N, Mathabathe, Maria N, Bolokang, Amogelang S. **2020**. A comparison of the microstructures, thermal and mechanical properties of pressed and sintered Ti–Cu, Ti–Ni and Ti–Cu–Ni alloys intended for dental applications. *Journal of Alloys and Compounds*, 848, p.13pp.
- Madikizela, LM, Ncube, S, Tutu, H, Richards, H, Newman, Brent, Ndungu, K, Chimuka, L. **2020**. Pharmaceuticals and their metabolites in the marine environment: Sources, analytical methods and occurrence. *Trends in Environmental Analytical Chemistry*, 28, p.17pp.
- Mafa, MS, Dirr, HW, Malgas, S, Krause, RWM, Rashamuse, Konanani, Pletschke, BI. **2020**. A novel dimeric exoglucanase (GH5_38): Biochemical and structural characterisation towards its application in alkyl cellobioside synthesis. *Molecules*, 25(3), p.20pp.
- Mafa, MS, Malgas, S, Bhattacharya, A, Rashamuse, Konanani, Pletschke, BI. **2020**. The effects of alkaline pretreatment on agricultural biomasses (Corn Cob and Sweet Sorghum Bagasse) and their hydrolysis by a termite-derived enzyme cocktail. *Agronomy*, 10(8), p.13pp.
- Mafa, MS, Malgas, S, Rashamuse, Konanani, Pletschke, B. **2020**. Delineating functional properties of a cello-oligosaccharide and β -glucan specific cellobiohydrolase (GH5_38): Its synergism with Cel6A and Cel7A for β -(1,3)-(1,4)-glucan degradation. *Carbohydrate Research*, p.9pp.
- Mahato, SK, Acharya, C, Wellington, Kevin W, Bhattacharjee, P, Jaisankar, P. **2020**. InCl₃: A versatile catalyst for synthesizing a broad spectrum of heterocycles. *ACS Omega*, 5, p.2503-2519.
- Makgabutlane, B, Nthunya, LN, Nxumalo, EN, Musyoka, Nicholas M, Mhlanga, SD. **2020**. Microwave irradiation-assisted synthesis of zeolites from coal fly ash: An optimization study for a sustainable and efficient production process. *ACS Omega*, 5(39), p.25000-25008.
- Malapermal, Veshara, Naicker, Prisha, Mgangira, Martin B, Mukaratirwa, Samson, Lalloo, Rajesh, Ramchuran, Santosh O. **2020**. Establishing miniaturised structural testing techniques to enable high-throughput screening of microorganisms and microbial components for unpaved road stabilisation application. *Journal of Advanced Research*, 21, p.151-159.
- Malatji, N, Lengopeng, T, Pityana, Sisa L, Popoola, API. **2020**. Effect of heat treatment on the microstructure, microhardness, and wear characteristics of AlCrFeCuNi high-entropy alloy. *The International Journal of Advanced Manufacturing Technology*, 111, p.2021–2029.
- Malatji, N, Popoola, API, Lengopeng, T, Pityana, Sisa L. **2020**. The effect of Nb addition on the microstructural, mechanical and electrochemical characteristics of AlCrFeNiCu high entropy alloy. *International Journal of Minerals, Metallurgy and Materials*, 27(10), p.1332–1340.
- Malherbe, Johan, Smit, IPJ, Wessels, KJ, Beukes, P. **2020**. Recent droughts in the Kruger National Park as reflected in the extreme climate index. *African Journal of Range & Forage Science*, 37(1), p.1-17.
- Malibo, Petrus M, Makgwane, Peter R, Baker, PG. **2020**. Heterostructured redox-active V₂O₅/SnO₂ oxide nanocatalyst for aqueous-phase oxidation of furfural to renewable maleic acid. *ChemistrySelect*, 5(21), p.6255–6267.
- Malkappa, Kuruma, Salehiyan, Reza, Ray, Suprakas S. **2020**. Supramolecular poly(cyclotriphosphazene) functionalized graphene oxide/polypropylene composites with simultaneously improved thermal stability, flame retardancy, and viscoelastic properties. *Macromolecular Materials and Engineering*, p.14pp.
- Manoto, Sello L, El-Hussein, A, Malabi, Rudzani, Thobakgale, Setumo L, Ombinda-Lemboumba, Saturnin, Attia, YA, Kasem, MA, Mthunzi-Kufa, Patience. **2020**. Exploring optical spectroscopic techniques and nanomaterials for virus detection. *Saudi Journal of Biological Sciences*, 28(1), p.78-89.
- Maponya, TC, Ramohlola, Kabelo Edmond, Kera, Nazia H, Modibane, KD, Maity, Arjun, Katata-Seru, LM, Hato, MP. **2020**. Influence of magnetic nanoparticles on modified polypyrrole/m-phenyldiamine for adsorption of Cr(VI) from aqueous solution. *Polymers*, 12(3), p.17pp.
- Marais, A, Grobbelaar, SS, Meyer, Isabella A, Kennon, D, Herselman, Martha E. **2020**. Supporting the formation and functioning of innovation platforms in healthcare value chains. *Science and Public Policy*, p.17pp.
- Marais, JM, Abu-Mahfouz, Adnan MI, Hancke, GP. **2020**. A survey on the viability of confirmed traffic in a LoRaWAN. *IEEE Access*, 8, p.9296-9311.
- Marivate, V, Sefara, Tshephisho J. **2020**. Improving short text classification through global augmentation methods. *Lecture Notes in Computer Science*, 12279, p.385-399.
- Marivate, Vukosi N, Combrink, H. **2020**. Use of available data to inform the Covid-19 outbreak in South Africa: a case study. *Data Science Journal*, 19(1), p.1-7.
- Marondedze, EF, Govender, Krishna K, Govender, PP. **2020**. Ligand-based pharmacophore modelling and virtual screening for the identification of amyloid-beta diagnostic molecules. *Journal of Molecular Graphics and Modelling*, 101, p.10pp.
- Marondedze, EF, Govender, Krishna, Govender, PP. **2020**. Computational investigation of the binding characteristics of β -amyloid fibrils. *Biophysical chemistry*, 256, p.1-13.
- Marumbwa, FM, Cho, Moses A, Chirwa, PW. **2020**. An assessment of remote sensing-based drought index over different land cover types in southern Africa. *International Journal of Remote Sensing*, 41(19), p.7368-7382.
- Masemola, C, Cho, Moses A, Ramoelo, A. **2020**. Sentinel-2 time series based optimal features and time window for mapping invasive Australian native Acacia species in KwaZulu Natal, South Africa. *International Journal of Applied Earth Observation and Geoinformation*, 93, p.13pp.
- Masemola, C, Cho, Moses A, Ramoelo, A. **2020**. Towards a semi-automated mapping of Australia native invasive alien Acacia trees using Sentinel-2 and radiative transfer models in South Africa. *ISPRS Journal of Photogrammetry and Remote Sensing*, 166, p.153-168.
- Mashweu, AR, Chhiba-Govindjee, Varsha P, Bode, ML, Brady, D. **2020**. Substrate profiling of the cobalt nitrile hydratase from *Rhodococcus rhodochrous* ATCC BAA 870. *Molecules*, 25(1), 238, p.16pp.

Masika, Wendy S, Moonsamy, Ghaneshree, Mandree, Prisha, Ramchuran, Santosh O, Lalloo, Rajesh, Kudanga, T. **2020**. Biodegradation of petroleum hydrocarbon waste using consortia of *Bacillus* sp. *Bioremediation Journal*, 25(1), p.72-79.

Mateyisi, Mohau J, Maoela, Malebajoa A, Maluleke, Amukelani, Moeletsi, ME, Von Maltitz, Graham. **2020**. Changes in annual extreme temperature and heat indices in Limpopo province: Period 1941–2016. *Theoretical and Applied Climatology*, p.14pp.

Mathabathe, Maria N, Bolokang, Amogelang S, Govender, Gonasagren, Siyasiya, CW, Mostert, RJ. **2020**. Characterization of the nitrided -Ti-46Al–2Nb and -Ti-46Al–2Nb-0.7Cr-0.3Si intermetallic alloys. *Materials Chemistry and Physics*, p.10pp.

Mathebula, Christina R, Matizanhuka, W, Bolokang, Amogelang S. **2020**. Effect of Nb content on phase transformation, microstructure of the sintered and heat-treated Ti (10–25) wt.% Nb alloys. *International Journal of Advanced Manufacturing Technology*, 108, p.23-34.

Mathoho, Ipfi, Akinlabi, ET, Arthur, Nana KK, Tlotleng, Monnamme, Makoana, Nkutwane W. **2020**. The effects of LENS process parameters on the behaviour of 17-4 PH stainless steel. In: The Minerals, Metals & Materials Society (eds.). *Minerals, Metals & Materials Series*, p.481-490.

Matseke, Mphoma S, Zheng, Haitao, Wang, Y. **2020**. The ultrasonication boosts the surface properties of CoFe₂O₄/C nanoparticles towards ORR in alkaline media. *Applied surface science*, 516, p.8pp.

Matthews, MW, Bernard, Stewart, Evers-King, H, Robertson Lain, L. **2020**. Distinguishing cyanobacteria from algae in optically complex inland waters using a hyperspectral radiative transfer inversion algorithm. *Remote Sensing of Environment*, 248, p.11pp.

Matusowsky, M, Ramotsoela, DT, Abu Mahfouz, Adnan MI. **2020**. Data imputation in wireless sensor networks using a machine learning-based virtual sensor. *Journal of Sensor and Actuator Networks*, 9(2), p.20pp.

Mavuso, MA, Makgwane, Peter R, Ray, Suprakas S. **2020**. Heterostructured CeO₂-M (M = Co, Cu, Mn, Fe, Ni) oxide nanocatalysts for the visible-light photooxidation of pinene to aroma oxygenates. *ACS Omega*, 5(17), p.9775-9788.

Mavuso, MA, Makgwane, Peter R, Ray, Suprakash S. **2020**. Morphology modulated photocatalytic activity of CeO₂ nanostructures for selective oxidation of biobased alphaPinene to oxygenates. *ChemistrySelect*, 5(42), p.12940-12951.

McNeil, J, Snider, G, Weagle, CL, Walsh, B, Bissonnette, P, Stone, E, Abboud, Ibad, Akoshile, C, Anh, NX, Garland, Rebecca M. **2020**. Large global variations in measured airborne metal concentrations driven by anthropogenic sources. *Scientific reports*, 10, p.12pp.

Mdakane, Lizwe W, Kleynhans, W. **2020**. Feature selection and classification of oil spill from vessels using Sentinel-1 wide-swath synthetic aperture radar data. *IEEE Geoscience and Remote Sensing Letters*, p.5pp.

Mdlalose, Lindani M, Balogun, Mohammed O, Setshedi, Katlego Z, Chimuka, L, Chetty, Avashnee. **2020**. Performance evaluation of polypyrrole-montmorillonite clay composite as a re-usable adsorbent for Cr(VII) remediation. *Polymer Bulletin*, p.13pp.

Mdutyana, M, Thomalla, Sandy J, Philibert, R, Ward, BB, Fawcett, SE. **2020**. The seasonal cycle of nitrogen uptake and nitrification in the Atlantic sector of the Southern Ocean. *Global Biogeochemical Cycles*, 34(7), p.29pp.

Menya, E, Olupot, PW, Storz, H, Lubwama, M, Kiros, Y, Mathew, Maya J. **2020**. Effect of alkaline pretreatment on the thermal behavior and chemical properties of rice husk varieties in relation to activated carbon production. *Journal of Thermal Analysis and Calorimetry*, 139(3), p.1681-1691.

Merryfield, WJ, Baehr, J, Batte, L, Becker, E, Butler, AH, Coelho, CA, Danabasoglu, G, Dirmeyer, PA, Doblas-Reyes, FJ, Beraki, Asmerom F. **2020**. Current and emerging developments in subseasonal to decadal prediction. *Bulletin of the American Meteorological Society*, 101(6), p.869-896.

Mgaga, Sboniso S, Tapamo, JR. **2020**. Optical coherence tomography latent fingerprint image denoising. *Lecture Notes in Computer Science*, 12510, p.694-705.

Midgley, SJE, Dziki, Sebinasi, Volschenk, T, Zirebwa, FS, Taylor, NJ, Gush, Mark B, Lotze, E, Ntshidi, Zanele, Mobe, Reuben N. **2020**. Water productivity of high performing apple orchards in the winter rainfall area of South Africa. *Acta Horticulturae*, 1281, p.479-486.

Miller, T, Oyewobi, SS, Abu-Mahfouz, Adnan MI, Hancke, GP. **2020**. Enabling a battery-less sensor node using dedicated radio frequency energy harvesting for complete o-grid applications. *Energies*, 13(20), p.21pp.

Mkuzangwe, Nenekazi N, Khan, Zubeida. **2020**. Cyber-threat information-sharing standards: A review of evaluation literature. *The African Journal of Information and Communication*, 25, p.12pp.

Mo, L, Zheng, Haitao. **2020**. Solid coated Li₄Ti₅O₁₂ (LTO) using polyaniline (PANI) as anode materials for improving thermal safety for lithium ion battery. *Energy Reports*, 6, p.2913-2918.

Mobe, Nompumelelo T, Dziki, Sebinasi, Volschenk, T, Zirebwa, AD, Ntshidi, Zanele, Midgley, SJE, Steyn, WJ, Lötze, E, Mpandeli, S, Mazvimavi, D. **2020**. Using sap flow data to assess variations in water use and water status of apple orchards of varying age groups in the Western Cape Province of South Africa. *Water SA*, 46(2), p.213-224.

Mobe, Nompumelelo T, Dziki, Sebinasi, Zirebwa, SF, Midgley, SJE, Von Loeper, W, Mazvimavi, D, Ntshidi, Zanele, Jovanovic, Nebojsa. **2020**. Estimating crop coefficients for apple orchards with varying canopy cover using measured data from twelve orchards in the Western Cape Province, South Africa. *Agricultural Water Management*, 233, p.13pp.

Mochane, MJ, Sefadi, JS, Motsoeneng, TS, Mokoena, TE, Mofokeng, Tladi G, Mokheba, Teboho C. **2020**. The effect of filler localization on the properties of biopolymer blends, recent advances: A review. *Polymer Composites*, p.22pp.

Moganedi, Mapoung S, Pottas, D. **2020**. Identification of information security controls for fitness wearable manufacturers. *Communications in Computer and Information Science*, 1339, p.112-128.

Mohanrasu, K, Guru Raj Rao, R, Dinesh, GH, Zhang, K, Siva Prakash, G, Song, D, Muniyasamy, Sudhakar, Pugazhendhi, A, Jeyakanthan, J, Arun, A. **2020**. Optimization of media components and culture conditions for polyhydroxyalkanoates production by *Bacillus megaterium*. *Fuel*, 271, p.9pp.

- Mohlameane, M, Ruxwana, Nkqubela. **2020**. Exploring the impact of cloud computing on existing South African regulatory frameworks. *South African Journal of Information Management*, 22(1), p.9pp.
- Mokhena, Teboho C, John, Maya J. **2020**. Cellulose nanomaterials: New generation materials for solving global issues. *Cellulose*, 27, p.1149-1194.
- Mokhena, Teboho C, Mochane, MJ, Mtibe, Asanda, Mathew, Maya J, Sadiku, ER, Sefadi, JS. **2020**. Electrospun alginate nanofibers toward various applications: A review. *Materials*, 13(4), p.24pp.
- Mokoena, Teboho P, Hillie, Kenneth T, Swart, HC, Leshabane, N, Tshilongo, J, Motaung, DE. **2020**. Fabrication of a propanol gas sensor using p-type nickel oxide nanostructures: The effect of ramping rate towards luminescence and gas sensing characteristics. *Materials Chemistry and Physics*, 253, p.15pp.
- Mokoena, Teboho P, Mathew, Maya J. **2020**. Esterified cellulose nanofibres from saw dust using vegetable oil. *International Journal of Biological Macromolecules*, 148, p.1109-1117.
- Mokoena, Teboho P, Tshabalala, Zamaswazi P, Hillie, Kenneth T, Swart, HC, Motaung, DE. **2020**. The blue luminescence of p-type NiO nanostructured material induced by defects: H₂S gas sensing characteristics at a relatively low operating temperature. *Applied Surface Science*, 525, p.19pp.
- Molefe, Lerato Y, Musyoka, Nicholas M, Ren, Jianwei, Langmi, Henrietta W, Mathe, Mahlanyane K, Ndungu, PG. **2020**. Effect of inclusion of MOF-polymer composite onto a carbon foam material for hydrogen storage application. *Journal of Inorganic and Organometallic Polymers and Materials*, 173, p.9pp.
- Moonsamy, Ghaneshree, Zulu, Nodumo Nokulunga, Lalloo, Rajesh, Ramchuran, Santosh O, Singh, S. **2020**. Large-scale production of an abalone probiotic, *Vibrio midae*, isolated from a South African abalone, *Halitotis midae* for use in aquaculture. *Biocatalysis and Agricultural Biotechnology*, 29, p.10pp.
- Moshokoa, Nthabiseng, Raganya, Mampai L, Obadele, BA, Machaka, Ronald, Makhatha, ME. **2020**. Microstructural and mechanical properties of Ti-Mo alloys designed by the cluster plus glue atom model for biomedical application. *The International Journal of Advanced Manufacturing Technology*, 111, p.1237-1246.
- Mostert, Frikkie J, Rwexwana, A, Tseki, PF. **2020**. Remarks on the modelling of molecular binding forces in the Glue-DNT interaction. *Indian Journal of Chemistry Section A*, 59A, p.948-951.
- Motsoeneng, Rapelang G, Kortidis, I, Rikhotso, Rirhandzu, Swart, HC, Ray, Suprakash S, Motaung, David E. **2020**. Temperature-dependent response to C₃H₇OH and C₂H₅OH vapors induced by deposition of Au nanoparticles on SnO₂/NiO hollow sphere-based conductometric sensors. *Sensors and Actuators B: Chemical*, 316, p.15pp.
- Mouane, O, Sideras-Haddad, E, Wamwangi, D, Forbes, A, Peters, G, Erasmus, RM, Mwakikunga, Bonex W, Gkanetsos, T. **2020**. Formation of monodispersed carbon nanospheres by pulsed laser irradiation of HOPG. *Materials Chemistry and Physics*, 253, p.10pp.
- Msomu, PF, Nonjola, Patrick N, Ndungu, PG, Ramontja, J. **2020**. Poly (2, 6-dimethyl-1, 4-phenylene)/polysulfone anion exchange membrane blended with TiO₂ with improved water uptake for alkaline fuel cell application. *International Journal of Hydrogen Energy*, 45(53), p.29465-29476.
- Mukwevho, N, Gusain, Rashi, Fosso-Kankeua, E, Kumar, Neeraj, Waanders, F, Ray, Suprakash S. **2020**. Removal of naphthalene from simulated wastewater through adsorption-photodegradation by ZnO/Ag/GO nanocomposite. *Journal of Industrial and Engineering Chemistry*, 81, p.393-404.
- Munonde, Tshimangadzo S, Zheng, Haitao, Matseke, Mphoma S, Nomngongo, PN, Wang, Y, Tsiakaras, P. **2020**. A green approach for enhancing the electrocatalytic activity and stability of NiFe₂O₄/CB nanospheres towards hydrogen production. *Renewable Energy*, 154, p.704-714.
- Musyoka, Nicholas M, Mutuma, BK, Manyala, N. **2020**. Onion-derived activated carbons with enhanced surface area for improved hydrogen storage and electrochemical energy application. *RSC Advances*, 10(45), p.26928-26936.
- Musyoka, Nicholas M, Wdowin, M, Rambau, Khavharendwe MA, Franus, W, Panek, R, Madej, J, Czarna-Juszkiewicz, D. **2020**. Synthesis of activated carbon from high-carbon coal fly ash and its hydrogen storage application. *Renewable Energy*, 155, p.1264-1271.
- Naicker, JE, Govinden, R, Lekha, Prabashni S, Sithole, Bishop B. **2020**. Transformation of pulp and paper mill sludge (PPMS) into a glucose-rich hydrolysate using green chemistry: Assessing pretreatment methods for enhanced hydrolysis. *Journal of Environmental Management*, 270(110914), p.11 PP.
- Naidoo, K, Marivate, Vukosi N. **2020**. Unsupervised anomaly detection of healthcare providers using generative adversarial networks. *Lecture Notes in Computer Science*, 12066, p.419-430.
- Naidu, Darrel S, Mathew, Maya J. **2020**. Effect of clay nanofillers on the mechanical and water vapor permeability properties of xylan-alginate films. *Polymers*, 12(10), p.23pp.
- Ncube, EN, Steenkamp, Lucia H, Dubery, IA. **2020**. Ambrafuran (AmbroxTM) synthesis from natural plant product precursors. *Molecules*, 25(17), p.13pp.
- Ncube, Ntombizodwa M, Zheng, Haitao. **2020**. The effect of synthesis temperature on the properties of TiO₂ (B) nanorods and its precursors as anode materials for lithium-ion batteries. *Materials Research Express*, 7(1), p.6pp.
- Ndiaye, M, Oyewobi, SS, Abu-Mahfouz, Adnan MI, Hancke, GP, Kuriem, AM, Djouani, K. **2020**. IoT in the wake of Covid-19: A survey on contributions, challenges and evolution. *IEEE Access*, 8, p.186821-186839.
- Nkosi, Funeka, Palaniyandy, Nithyadharseni, Raju, Kumar, Ozoemena, K. **2020**. Influence of microwave irradiation and combustion fuels on the rate capability and cycle performance of Li_{1.2}Mn_{0.52}Ni_{0.13}Co_{0.13}Al_{0.02}O₂ layered material. *Electroanalysis*, p.27pp.
- Nofar, M, Salehiyan, Reza, Ciftci, U, Jalali, A, Durmus, A. **2020**. Ductility improvements of PLA-based binary and ternary blends with controlled morphology using PBAT, PBSA, and nanoclay. *Composites Part B: Engineering*, 182, p.13pp.

- Nunes, M, Adams, JB, Van Niekerk, Lara. **2020**. Changes in invasive alien aquatic plants in a small closed estuary. *South African Journal of Botany*, 135, p.317-329.
- Nyamaka, AT, Botha, Adele, Van Biljon, J, Marais, Mario A. **2020**. The components of an innovation ecosystem framework for Botswana's mobile applications. *Electronic Journal of Information Systems in Developing Countries*, p.23pp.
- Nyangiwe, Nangamso N, Ouma, Cecil NM. **2020**. Adsorption and coadsorption of single and multiple natural organic matter on Ag (111) surface: A DFT-D study. *Applied Surface Science*, 505, p.9pp.
- Oladipo, Folorunso, Hamam, Y, Sadiku, R, Ray, Suprakas S, Adekoya, GJ. **2020**. Statistical characterization and simulation of graphene-loaded polypyrrole composite electrical conductivity. *Journal of Materials Research and Technology*, 9(6), p.15788-15801.
- Olaiya, NG, Nuryawan, A, Oke, PK, Abdul Khalil, HPS, Rizal, S, Mogaji, PB, Sadiku, ER, Ray, Suprakas S, Farayibi, PK, Ojijo, Vincent O, Paridah, MT. **2020**. The role of two-step blending in the properties of starch/chitin/poly(lactic acid) biodegradable composites for biomedical applications. *Polymers*, 12(3), p.13pp.
- Olakanmi, EO, Malikongwa, K, Nyadongo, ST, Hoosain, Shaik E, Pityana, Sisa L. **2020**. Consolidation mechanism, microstructural evolution and corrosion resistance of Inconel 625 coatings. *Surface Engineering*, p.14pp.
- Olaleru, S Akin, Wamwangi, D, Kirui, JK, Roro, Kittessa T, Mwakikunga, Bonex W, Palaniyandy, Nithyadharseni, El-Mahallawy, N, Rashad, M. **2020**. The impact of synthesis techniques on the properties of hybrid perovskite materials for photovoltaic application. *Materials Express*, 10(7), p.1127-1134.
- Olaleru, SA, Kirui, JK, Wamwangi, D, Roro, Kittessa T, Mwakikunga, Bonex W. **2020**. Perovskite solar cells: The new epoch in photovoltaics. *Solar Energy*, 196, p.295-309.
- Omarjee, Aadila, Taljaard, Susan, Weerts, Steven P, Adams, JB. **2020**. The influence of mouth status on pH variability in small temporarily closed estuaries. *Estuarine, Coastal and Shelf Science*, 246, p.6pp.
- Onumanyi, AJ, Abu-Mahfouz, Adnan MI, Hancke, GP. **2020**. Adaptive threshold techniques for cognitive radio-based low power wide area network. *Transactions on Emerging Telecommunications Technologies*, 31 (e), p.19pp.
- Onumanyi, AJ, Abu-Mahfouz, Adnan MI, Hancke, GP. **2020**. Low power wide area network, cognitive radio and the Internet of Things: Potentials for integration. *Sensors*, 20(23), p.41 pp.
- Osifeko, MO, Hancke, GP, Abu-Mahfouz, Adnan MI. **2020**. Artificial intelligence techniques for cognitive sensing in future IoT: State-of-the-Art, potentials, and challenges. *Journal of Sensor and Actuator Networks*, 9(21), p.pp31.
- Oyewo, OA, Adeniyi, A, Sithole, Bishop B, Onyango, MS. **2020**. Sawdust-based cellulose nanocrystals incorporated with ZnO nanoparticles as efficient adsorption media in the removal of methylene blue dye. *ACS Omega*, 5(30), p.18798-18807.
- Palaniyandy, Nithyadharseni, Rambau, Khavharendwe MA, Musyoka, Nicholas M, Ren, Jianwei. **2020**. A facile segregation process and restoration of LiMn₂O₄ cathode material from spent lithium-ion batteries. *Journal of the Electrochemical Society*, 167(9), p.8pp.
- Palaniyandy, Nithyadharseni. **2020**. Recent developments on layered 3d-transition metal oxide cathode materials for sodium-ion batteries. *Current Opinion in Electrochemistry*, 21, p.319-326.
- Pancham, A, Withey, Daniel J, Bright, G. **2020**. Amore: CNN-based moving object detection and removal towards slam in dynamic environments. *South African Journal of Industrial Engineering*, 31 (4), p.46-58.
- Pandey, S, Fosso-Kankeu, E, Spiro, MJ, Waanders, F, Kumar, Neeraj, Ray, Suprakas S, Kim, J, Kang, M. **2020**. Equilibrium, kinetic, and thermodynamic studies of lead ion adsorption from mine wastewater onto MoS₂-clinoptilolite composite. *Materials Today Chemistry*, 18, p.11 pp.
- Pandit, R, Parrotta, JA, Chaudhary, AK, Karlen, DL, Vieira, DLM, Anker, Y, Chen, R, Morris, J, Harris, J, Ntshotsho, Phumza. **2020**. A framework to evaluate land degradation and restoration responses for improved planning and decision-making. *Ecosystems and People*, 16(1), p.18pp.
- Pereira, LS, Paredes, P, Jovanovic, Nebojsa. **2020**. Soil water balance models for determining crop water and irrigation requirements and irrigation scheduling focusing on the FAO56 method and the dual Kc approach. *Agricultural water management*, 241, p.22pp.
- Petersen, Chantel R, Jovanovic, Nebojsa, Grenfell, MC. **2020**. The effectiveness of riparian zones in mitigating water quality impacts in an agriculturally dominated river system in South Africa. *African Journal of Aquatic Science*, 45(3), p.336-349.
- Phasha, MJ, Bolokang, Amogelang S, Kebede, Mesfin A. **2020**. First-principles investigation of W-V and W-Mo alloys as potential plasma facing materials (PFMs) for nuclear application. *International Journal of Refractory Metals and Hard Materials*, p.6pp.
- Pieterse, Amy, Du Toit, J, Van Niekerk, Cornelia W. **2020**. Climate change adaptation mainstreaming in the planning instruments of two South African local municipalities. *Development Southern Africa*, p.16pp.
- Radebe, T, Huan, Z, Baloyi, Jeffrey. **2020**. Simulation of eutectic plates in medium refrigerated transport. *Journal of Engineering, Design and Technology*, p.19pp.
- Raji, Sadiq Abiola, Popoola, API, Pityana, Sisa L, Popoola, OM. **2020**. Characteristic effects of alloying elements on β solidifying titanium aluminides: A review. *Heliyon*, 6(7), p.15pp.
- Raju, Kumar, Han, H, Velusamy, DB, Jiang, Q, Yang, H, Nkosi, FP, Palaniyandy, Nithyadharseni, Makgopa, K, Bo, Z, Ozoemena, KI. **2020**. Rational design of 2D manganese phosphate hydrate nanosheets as pseudocapacitive electrodes. *ACS Energy Letters*, 5(1), p.23-30.
- Raju, Kumar. **2020**. Ammonium metal phosphates: Emerging materials for energy storage. *Current Opinion in Electrochemistry*, 21, p.351-357.
- Ramlucken, U, Lallo, Rajesh, Roets, Yrielle, Moonsamy, Ghaneshree, Jansen van Rensburg, C, Thantsha, MS. **2020**. Advantages of Bacillus-based probiotics in poultry production. *Livestock Science*, 241, p.15pp.

- Ramlucken, Uraisha, Roets, Yrielle, Ramchuran, Santosh O, Moonsamy, Ghaneshree, Van Rensburg, CJ, Thantsh, MS, Lalloo, Rajesh. **2020**. Isolation, selection and evaluation of *Bacillus* spp. as potential multi-mode probiotics for poultry. *Journal of General and Applied Microbiology*, 66(4), p.228-238.
- Ramotsoela, TD, Hancke, GP, Abu-Mahfouz, Adnan MI. **2020**. Behavioural intrusion detection in water distribution systems using neural networks. *IEEE Access*, 8, p.190403 - 190416.
- Ratshidi, L, Grobbelaar, S, Botha, Adele. **2020**. Categorization of factors influencing community health workers from a socio-technical systems perspective. In: Hattingh, M Matthee, M Smuts, H Pappas, I Dwivedi, Y Mäntymäki, M (eds.). *Lecture Notes in Computer Science*, 12067, p.84-95.
- Rebelo, AJ, Jarmain, C, Esler, KJ, Cowling, RM, Le Maitre, David C. **2020**. Water-use characteristics of Palmiet (*Prionium serratum*), an endemic South African wetland plant. *Water SA*, 46(4), p.558-572.
- Reddy Goddeti, SM, Bhaumik, M, Maity, Arjun, Ray, Suprakas S. **2020**. Removal of Congo red from aqueous solution by adsorption using gum ghatti and acrylamide graft copolymer coated with zero valent iron. *International Journal of Biological Macromolecules*, 149, p.21-30.
- Robbins, SL, Heyns, PS, Heyns, Johan A. **2020**. Feasibility of rotor fault detection from a fluid dynamics perspective. *Journal of Applied Fluid Mechanics*, 13(6), p.1743-1758.
- Rominiyi, AL, Shongwe, MB, Tshabalala, Lerato C, Ogunmuyiwa, EN, Jeje, SO, Babalola, BJ, Olubambi, PA. **2020**. Spark plasma sintering of Ti-Ni-TiCN composites: Microstructural characterization, densification and mechanical properties. *Journal of Alloys and Compounds*, 848, p.10pp.
- Rother, HA, John, Juanette, Wright, CY, Irlam, J, Oosthuizen, Rietha, Garland, Rebecca M. **2020**. Perceptions of occupational heat, sun exposure, and health risk prevention: A qualitative study of forestry workers in South Africa. *Atmosphere*, 11(1)37, p.19pp.
- Roux, Rina N, Van der Lingen, E, Botha, AP, Botes, AE. **2020**. The fragmented nature of the titanium metal value chain. *Journal of the Southern African Institute of Mining and Metallurgy*, 120(11), p.633-640.
- Rust, FC, Smit, Michelle A, Akhalwaya, Imraan, Jordaan, GJ, Du Plessis, L. **2020**. Evaluation of two nano-silane-modified emulsion stabilised pavements using accelerated pavement testing. *International Journal of Pavement Engineering*, p.14pp.
- Ryan-Keogh, Thomas J, Thomalla, Sandy J. **2020**. Deriving a proxy for iron limitation from chlorophyll fluorescence on buoyancy gliders. *Frontiers in Marine Science*, p.13pp.
- Saasa, Valentine R, Malwela, Thomas, Lemmer, Yolandy, Beukes, M, Mwakikunga, Bonex W. **2020**. The hierarchical nanostructured Co-doped WO₃/carbon and their improved acetone sensing performance. *Materials Science in Semiconductor Processing*, 117, p.9pp.
- Saasa, Valentine, Lemmer, Yolandy, Malwela, Thomas, Akande, Amos A, Beukes, M, Mwakikunga, Bonex W. **2020**. Effect of varying ethanol and water compositions on the acetone sensing properties of WO₃ for application in diabetes mellitus monitoring. *Materials Research Express*, 7(3), p.13pp.
- Salehiyan, Reza, Nofar, M, Makwakwa, Dimakatso M, Ray, Suprakas S. **2020**. Shear-induced carbon nanotube migration and morphological development in polylactide/poly(vinylidene fluoride) blend nanocomposites and their impact on dielectric constants and rheological properties. *Journal of Physical Chemistry: C*, 124(17), p.9536-9547.
- Salehiyan, Reza, Nofar, M, Malkappa, Kuruma, Ray, Suprakas S. **2020**. Effect of nanofillers characteristics and their selective localization on morphology development and rheological properties of melt-processed polylactide/poly(butyleneadipate-co-terephthalate) blend composites. *Polymer Engineering and Science*, p.1-12.
- Sanchez, AG, You, C, Leering, M, Glaser, Daniel, Furfari, D, Fitzpatrick, ME, Wharton, J, Reed, PAS. **2020**. Effects of laser shock peening on the mechanisms of fatigue short crack initiation and propagation of AA7075-T651. *International Journal of Fatigue*, 143, p.14pp.
- Scholefield, Janine. **2020**. Racism in science: A perspective from Gene Therapy. *Gene Therapy*, p.2pp.
- Scholtz, D, Kritzing, E, Botha, Adele. **2020**. Cyber safety awareness framework for South African schools to enhance cyber safety awareness. In: R. Silhavy (eds.). *Advances in Intelligent Systems and Computing*, p.216-223.
- Sebogodi, Keolebogile R, Johakimu, Jonas K, Sithole, Bruce B. **2020**. Beneficiation of pulp mill waste green liquor dregs: Applications in treatment of acid mine drainage as new disposal solution in South Africa (Article). *Journal of Cleaner Production*, 246, p.13pp.
- Selatile, Mantsopa K, Ojijo, Vincent O, Sadiku, R, Ray, Suprakas S. **2020**. Development of bacterial-resistant electrospun polylactide membrane for air filtration application: Effects of reduction methods and their loadings. *Polymer Degradation and Stability*, 178, p.10pp.
- Serwale, Matsie R, Coetsee, T, Fazluddin, Shahed. **2020**. Purification of crude titanium powder produced by metallothermic reduction by acid leaching. *Journal of the Southern African Institute of Mining and Metallurgy*, 120(5), p.349-354.
- Shela, E, Liu, F, Wang, T, Farrag, M, Liu, J, Yacout, N, Kebede, Mesfin, Sharma, N, Fan, LZ. **2020**. Dual polymer/liquid electrolyte with BaTiO₃ electrode for magnesium batteries. *ACS Applied Energy Materials*, 3(6), p.5882-5892.
- Shen, Y, Wang, Z, Fu, X, Naidoo, Darryl, Forbes, Andrew. **2020**. SU(2) Poincaré sphere: A generalized representation for multidimensional structured light. *Physical review A*, 102(3), p.5pp.
- Shen, Y, Yang, X, Naidoo, Darryl, Fu, X, Forbes, A. **2020**. Structured ray-wave vector vortex beams in multiple degrees of freedom from a laser. *Optica*, 7(7), p.820-831.
- Shingange, Katekani, Swart, HC, Mhlongo, Gugu H. **2020**. Design of porous p-type LaCoO₃ nanofibers with remarkable response and selectivity to ethanol at low operating temperature. *Sensors and Actuators B: Chemical*, 308, p.12pp.

- Shingange, Katekani, Swart, HC, Mhlono, Gugu H. **2020**. LaBO3 (B $\frac{1}{4}$ Fe, Co) nanofibers and their structural, luminescence and gas sensing characteristics. *Physica B: Physics of Condensed Matter*, 578, p.7pp.
- Sibisi, Percival N, Popoola, API, Arthur, Nana KK, Pityana, Sisa L. **2020**. Review on direct metal laser deposition manufacturing technology for the Ti-6Al-4V alloy. *International Journal of Advanced Manufacturing Technology*, 107, p.1163-1178.
- Singh, Advaita Acarya, Poee, O, Kwezi, Lusizwe, Lotter-Stark, T, Stoychev, Stoyan H, Alexandra, Kabamba B, Gerber, Isak B, Bhiman, JN, Vorster, J, Pauly, M, Zeitlin, L, Whaley, K, Mach, L, Steinkellner, H, Morris, L, Tsekoo, Tsepo L, Chikwamba, Rachel K. **2020**. Plant-based production of highly potent anti-HIV antibodies with engineered posttranslational modifications. *Scientific Reports*, 10(6201), p.9pp.
- Singh, M, Mukoma, Peter, North, Brian C, Majazi, T. **2020**. A mathematical model for optimum design and synthesis of a hybrid electrolyser-fuel cell system: Production of hydrogen and freshwater from seawater. *Journal of Cleaner Production*, 277, p.70pp.
- Skosana, Sifiso J, Khoathane, C, Malwela, Thomas. **2020**. Enhancing the adhesion strength of polyurethane coatings by dispersing layered silicates via sonication and high-shear mixing method. *Polymer Bulletin*, 69, p.19pp.
- Smit, AJ, Fitchett, JM, Engelbrecht, FA, Scholes, RJ, Dzihvhuo, G, Sweijd, Neville A. **2020**. Winter is coming: A southern hemisphere perspective of the environmental drivers of SARS-CoV-2 and the potential seasonality of Covid-19. *International Journal of Environmental Research and Public Health*, 17(16), p.29pp.
- Smith, Marie E, Bernard, Steward. **2020**. Satellite ocean color based harmful algal bloom indicators for aquaculture decision support in the southern Benguela. *Frontiers in Marine Science*, 7(61), p.13pp.
- Smith-Adao, Lindie, Jovanovic, Nebojsa, Le Maitre, David C, Petersen, Chantel. **2020**. Investing in ecological infrastructure to improve drought resilience and enhance water security. *Water Wheel*, 19(1), p.25-27.
- Somers, MJ, Walters, Michele, Measey, J, Strauss, WM, Turner, AA, Venter, JA, Nel, L, Kerley, GIH, Taylor, WA, Moodley, Y. **2020**. The implications of the reclassification of South African wildlife species as farm animals. *South African Journal of Science*, 116(1/2), p.2pp.
- Somses, S, Bopape, M-J M, Ndarana, T, Fridlind, A, Matsui, T, Phaduli, E, Limbo, A, Maikhudumu, S, Maisha, R, Rakate, Edward M. **2020**. Convection parametrization and multi-nesting dependence of a heavy rainfall event over Namibia with weather research and forecasting (WRF) model. *Climate*, 8(10), p.19pp.
- Sotenga, PZ, Djouani, K, Kurien, AM, Mwila, Martin. **2020**. Implementation of an indoor localisation algorithm for Internet of Things. *Future Generation Computer Systems - The International Journal of eScience*, 107, p.1037-1046.
- Spies, R, Grobbelaar, S, Botha, Adele. **2020**. A scoping review of the application of the task-technology fit theory. *Lecture Notes in Computer Science*, 12066, p.397-408.
- Sroor, H, Huang, Y, Sephton, B, Naidoo, Darryl, Vallés, A, Ginis, V, Qiu, C, Ambrosio, A, Capasso, F, Forbes, A. **2020**. High-purity orbital angular momentum states from a visible metasurface laser. *Nature Photonics*, 14, p.498-503.
- Stafford, William H, De Lange, Willem J, Nahman, Anton, Chunilall, Viren, Lekha, Prabashni S, Andrew, Jerome E, Johakimu, Jonas K, Sithole, Bishop B, Trotter, Douglas D. **2020**. Forestry biorefineries. *Renewable Energy*, 54, p.461-475.
- Steyn, Maronel, Genthe, Bettina, Banoo, Ismail, Thwala, Melusi, Roos, Thomas H, Walters, Chavon R, Ramakhwatho, F. **2020**. A decision support tool for industrial water reuse in South Africa. *Water Wheel*, 19(4), p.38-41.
- Suleman, Shuaib, Chetty, KT, Clark, DJ, Kapangaziwiri, Evison. **2020**. Assessment of satellite-derived rainfall and its use in the ACRU agro-hydrological model. *Water SA*, 46(4), p.547-557.
- Swart, S, Du Plessis, MD, Thompson, AF, Biddle, LC, Giddy, I, Linders, T, Mohrmann, M, Nicholson, Sarah-Anne. **2020**. Submesoscale fronts in the antarctic marginal ice zone and their response to wind forcing. *Geophysical Research Letters*, 47(6), p.10pp.
- Tabb, DL, Murugan, BD, Okendo, J, Nair, O, Blackburn, JM, Buthelezi, Sindisiwe G, Stoychev, Stoyan H. **2020**. Open search unveils modification patterns in formalin-fixed, paraffin-embedded thermo HCD and SCIEX TripleTOF shotgun proteomes. *International Journal of Mass Spectrometry*, 448, p.10pp.
- Taljaard, Susan, Slinger, JH, Arabi, Sumaiya, Weerts, Steven P, Vreugdenhil, H. **2020**. The natural environment in port development: A 'green handbrake' or an equal partner?. *Ocean & Coastal Management*, 199, p.11pp.
- Tambani, Mulalo T, Machio, Christopher N, Madyira, DM. **2020**. Machinability of green titanium powder compacts during drilling using HSS twist drills. *The International Journal of Advanced Manufacturing Technology*, 106, p.1723-1735.
- Tazvinga, Tenerica, Dzobo, O, Mapako, Maxwell C. **2020**. Towards sustainable energy system options for improving energy access in Southern Africa. *Journal of Energy in Southern Africa*, 31(2), p.59-72.
- Teklehaimanot, WH, Ray, Suprakas S, Emmambux, MN. **2020**. Characterization of pre-gelatinized maize starch-zein blend films produced at alkaline pH. *Journal of Cereal Science*, 95, p.9pp.
- Tesfaye, T, Ayele, M, Ferede, E, Gibril, M, Kong, F, Sithole, Bishop B. **2020**. A techno-economic feasibility of a process for extraction of starch from waste avocado seeds. *Clean Technologies and Environmental Policy*, 23, p.581-595.
- Theerthagiri, J, Senthil, RA, Nithyadharseni, Palaniyandy, Lee, SJ, Durai, G, Kuppusami, P, Madhavan, J, Choi, MY. **2020**. Recent progress and emerging challenges of transition metal sulfides based composite electrodes for electrochemical supercapacitive energy storage. *Ceramics international*, 46(10), p.14317-14345.
- Theron, Marita, Van Rooyen, Corney, Malabi, Khorommbi P. **2020**. Investigation into laser refurbishment and transformation hardening of cast iron forming dies for the automotive industry. *Journal of Laser Applications*, 32, p.7pp.
- Thimiri Govindaraj, Deepal, Khan, NA, Venkatachalam, S, Arumugam, S. **2020**. Efficient nanobiotechnology method for magnetic lysosome enrichment using DMSA-SPMNP 2.0. *BioNanoScience*, 10, p.529-533.
- Thothela, NP, Markus, ED, Masinde, M, Abu-Mahfouz, Adnan MI. **2020**. A survey of intelligent agro-climate decision support tool for small-

scale farmers: An integration of indigenous knowledge, mobile phone technology and smart sensors. In: Fong, S Dey, N Joshi, A (eds.). *Lecture Notes in Networks and Systems*, 154, p.715-730.

Troch, Christophe NA, Terblanche, L, Henning, H. **2020**. Modelling and measurement of low-frequency surge motion associated with extreme storm conditions in the Port of Cape Town. *Applied Ocean Research*, p.19pp.

Troch, Christophe NA, Terblanche, L, Rossouw, M, Ntantala, Z, Du Plessis, G. **2020**. Long-wave mitigation study for the Port of Ngqura. In: Lynett, P (eds.). *Coastal Engineering*, 36, p.14pp.

Tsekoa, Tsepo L, Singh, Advaita A, Buthelezi, Sindisiwe G. **2020**. Molecular farming for therapies and vaccines in Africa. *Current Opinion in Biotechnology*, 61, p.89-95.

Tshabalala, Zamaswazi P, Mokoena, Teboho P, Jozela, M, Tshilongo, J, Hillie, Thembela K, Swart, HC, Motaung, DE. **2020**. TiO₂ nanowires for humidity-stable gas sensors for toluene and xylene. *ACS Applied Nano Materials*, 4(1), p.702-716.

Tshwane, David M, Modiba, Rosinah, Bolokang, Amogelang S. **2020**. Surface analysis of the stress-induced, impurity driven face centered cubic titanium phase and the ranging lattice parameter sizes. *Materials Today Communications*, 24, p.9pp.

Tshweu, Lesego L, Shemis, MA, Abdelghany, C, Gouda, A, Pilcher, LA, Sibuyi, NRS, Meyer, M, Dube, A, Balogun, Mohammed O. **2020**. Synthesis, physicochemical characterization, toxicity and efficacy of a PEG conjugate and a hybrid PEG conjugate nanoparticle formulation of the antibiotic moxifloxacin. *RSC advances*, 34, p.19770-19780.

Van der Merwe, MD, Grobbelaar, SS, Meyer, Isabella A, Schutte, CL, Von Leipzig, KH. **2020**. A framework of key growth factors for small enterprises operating at the base of the pyramid. *Sustainability*, 12(22), p.34pp.

Van der Westhuizen, CJ, Van Greunen, DG, Cordier, W, Nell, M, Steenkamp, V, Stander, A, Panayides, Jenny-Lee, Riley, DL. **2020**. Binding pose analysis of hydroxyethylamine based β -secretase inhibitors and application thereof to the design and synthesis of novel indeno[1,2-b]indole based inhibitors. *ARKIVOC*, Part V, p.84-107.

Van der Westhuyzen, Christiaan W, Haynes, J, Panayides, Jenny-Lee, Wiid, I, Parkinson, C. **2020**. Anti-mycobacterial peroxides: A new class of agents for development against tuberculosis. *Medicinal Chemistry*, 16(3), p.392-402.

Van Deventer, Heidi, Van Niekerk, Lara, Adams, J, Dinala, MK, Gangat, R, Lamberth, SJ, Lotter, M, Mbona, N, MacKay, F, Nel, JL, Ramjukadh, CL, Skowno, A, Weerts, Steven P. **2020**. National Wetland Map 5: An improved spatial extent and representation of inland aquatic and estuarine ecosystems in South Africa. *Water SA*, 46(1), p.66-79.

Van Niekerk, Cornelia W, Pieterse, Amy, Le Roux, Alize. **2020**. Introducing the Green Book: A practical planning tool for adapting South African settlements to climate change. *Town and Regional Planning*, 77, p.103-119.

Van Niekerk, Lara, Adams, JB, James, NC, Lamberth, SJ, MacKay, CF, Turpie, JK, Rajkaran, A, Weerts, Steven P, Whitfield, AK. **2020**. An Estuary Ecosystem Classification that encompasses biogeography and a high diversity of types in support of protection and management. *African Journal of Aquatic Science*, 45(1-2), p.199-216.

Vicedo-Cabrera, AM, Sera, F, Liu, C, Armstrong, B, Lavigne, E, Kyselý, J, Urban, A, Orru, H, Indermitte, E, Garland, Rebecca M. **2020**. Short term association between ozone and mortality: Global two stage time series study in 406 locations in 20 countries. *BMJ-British Medical Journal*, 368, p.10pp.

Waldeck, Louis, Van Heerden, Quintin, Holloway, Jennifer P. **2020**. Integrated land use and transportation modelling and planning: A South African journey. *Journal of Transport and Land Use*, 13(1), p.227-254.

Walubita, LF, Fuentes, F, Faruk, NM, Komba, Julius J, Prakoso, A, Naik, B. **2020**. Mechanistic-empirical compatible traffic data generation: Portable WIM versus cluster analysis. *Journal of Testing and Evaluation*, 48(3), p.2377-2392.

Walubita, LF, Fuentes, L, Prakoso, A, Pianeta, LM, Komba, Julius J, Naik, B. **2020**. Correlating the HWTT laboratory test data to field rutting performance of in-service highway sections. *Construction and Building Materials*, 236, p.33pp.

Walubita, LF, Mahmoud, E, Fuentes, L, Prakoso, A, Lee, SI, Souliman, M, Komba, Julius J. **2020**. Correlating the asphalt-binder high-temperature properties (DSR) to HMA permanent deformation (RLPD) and field rutting: A laboratory-field study. *Construction and Building Materials*, 262, p.11pp.

Werneck, B, Millar, DA, Walters, Michele, Ganswindt, A, Dziba, L, Wright, CY. **2020**. 'Preventing the next pandemic' - A 2020 UNEP Frontiers Series Report on zoonotic diseases with reflections for South Africa. *South African Journal of Science*, 116(7-8), p.4pp.

Willcock, S, Hooffman, DA, Blanchard, Ryan, Dawson, TP, Hickler, T, Lindeskog, M, Martinez-Lopez, J, Reyers, B, Watts, SM, Eigenbrod, F. **2020**. Ensembles of ecosystem service models can improve accuracy and indicate uncertainty. *Science of the total environment*, 747, p.11pp.

Williams, LL, Luck-Vogel, Melanie. **2020**. Comparative assessment of the GIS based bathtub model and an enhanced bathtub model for coastal inundation. *Journal of Coastal Conservation*, 24(23), p.15pp.

Xaba, Nqobile, Modibedi, Remegia M, Mathe, Mahlanyane K, Khotseng, LE. **2020**. Electrochemical deposition of PdBiSn catalyst for glycerol oxidation in alkaline medium. *Electroanalysis*, 32(12), p.2852-2859.

Xulu, NA, Piketh, SJ, Feig, GT, Lack, DA, Garland, Rebecca M. **2020**. Characterizing light-absorbing aerosols in a low-income settlement in South Africa. *Aerosol and Air Quality Research*, 20(8), p.21pp.

Zulu, B, Oyewo, OA, Sithole, Bishop B, Leswif, TY, Onyango, MS. **2020**. Functionalized sawdust-derived cellulose nanocrystalline adsorbent for efficient removal of vanadium from aqueous solution. *Frontiers in Environmental Science*, p.11pp.

CONFERENCE PAPERS

Adekoya, Gholahan J, Sadiku, RE, Hamam, Y, Ray, Suprakas S, Mwakikunga, Bonex W, Folorunso, O, Adekoya, OC, Lolu, OJ, Biotidara, OF. **2020**. Pseudocapacitive material for energy storage application: PEDOT and PEDOT:PSS. *AIP Conference Proceedings* 2289, 020073, 30 November 2020, Published Online, 2289, p.6pp.

Albertyn, J, Cheng, L, Abu-Mahfouz, Adnan MI. **2020**. Solving MKP applied to IoT in smart grid using meta-heuristics algorithms: A parallel processing perspective. *2nd International Multidisciplinary Information Technology and Engineering Conference (IMITEC)*, Sol Plaatje University, Kimberley, 25-27 November 2020, p.10pp.

Baloyi, ME, Modiba, Rosinah, Ngoepe, PE, Chauke, HR. **2020**. Ab initio study of Ti50Pt50-xHf_x (x = 6.25, 18.75, 25) potential shape memory alloys. *The Proceedings of SAIP2019, the 64th Annual Conference of the South African Institute of Physics, 08 July 2019 - 12 July 2019 Polokwane*, p.18-22.

Bandyopadhyay, Jayita, Mekoa, Raphaale C, Skosana, Sifiso, Ray, Suprakas S. **2020**. Thermal properties and nonisothermal crystallization behaviour of polypropylene nanocomposite. *AIP Conference Proceedings* 2289, 020072, 30 November 2020, Published Online, p.6pp.

Bell, Teboho, King, Gary, Litvin, I. **2020**. Extra-cavity laser beam shaping using an Nd: YAG amplifier. *Proceedings of SPIE, Volume 11266, Laser Resonators, Microresonators, and Beam Control XXII; 112661D (2020)*, San Francisco, California, United States, 1-6 February 2020, p.7pp.

Blaauw, Ciara, Potgieter, Monique, Cilliers, Jacques E. **2020**. Performance modelling of a cost effective COTS UHF Log-periodic antenna. *2020 IEEE International Radar Conference (RADAR)*, 27 April - 1 May 2020, Washington DC USA (Virtual), p.4pp.

Blomerus, ND, Cilliers, Jacques E, De Villiers, JP. **2020**. Development and testing of a low cost audio based ISAR imaging and machine learning system for radar education. *2020 IEEE International Radar Conference (RADAR)*, Washington DC USA (Virtual), 28-30 April 2020, p.6pp.

Botha, Johannes G, Pieterse, Heloise. **2020**. Fake news and deepfakes: A dangerous threat for 21st century information security. *Proceedings of the 15th International Conference on Cyber Warfare and Security*, Norfolk, Virginia, 12-13 March 2020, p.10pp.

Botha, Natasha, Coetzer, R, Inglis, H, Labuschagne, J. **2020**. Understanding the influence of manufacturing and material parameters on the mechanical properties of polymerclay composites: An exploratory statistical analysis. *AIP Conference Proceedings* 2289, 020061 (2020), Pretoria, South Africa, 30 November 2020, p.5pp.

Burke, Ivan D, Herbert, A. **2020**. Tracking botnets on Nation Research and Education Network. *Proceedings of the 19th European Conference on Cyber Warfare and Security, A Virtual Conference Hosted By The University of Chester, United Kingdom*, 25-26 June 2020, p.10pp.

Chetty, Dhayalan, Botha, Adele, Herselman, Martha E. **2020**. An instantiation of a process model towards health interoperability. *South African Institute for Computer Scientist and Information Technologists Conference (SAICSIT)*, Cape Town, 14-16 September 2020, p.180-188.

Cilliers, Jacques E, Potgieter, Monique, Blaauw, Ciara, Odendaal, JW, Joubert, J, Woodbridge, K, Baker, CJ. **2020**. Comparison of the mutual information content between the polarimetric monostatic and bistatic measured RCS data of a 1:25 Boeing 707 model. *2020 IEEE International Radar Conference*, 27 April - 1 May, 2020, Washington, United States of America, p.5pp.

Dlamini, Sifiso B, Meyer, Isabella A. **2020**. Community perspectives as an essential element of resilience thinking: Resilience from a view of inequality. *The Future of Digital Work: The Challenge of Inequality; IFIP Joint Working Paper Conference*, Hyderabad, India, 10-11 December 2020, p.255-262.

Gcaza, N, Mtsweni, Jabu S. **2020**. A strategic roadmap for cybersecurity capability engineering across different environments. In: Payne, BK Wu, H (eds.). *15th International Conference on Cyber Warfare and Security*, Norfolk, USA, 12-13 March 2020, p.187-203.

Gibberd, Jeremy T. **2020**. A sustainability specification for emergency housing. *9th Icat International Conference on Appropriate Technology*, South Africa, Pretoria, 25-28 November 2020, p.13pp.

Gibberd, Jeremy T. **2020**. Synergistic interventions for sustainability improvement. *9th International Conference on Appropriate Technology (9th ICAT Conference)*, Pretoria, South Africa, 24-28 November 2020, p.11p.

Hanslo, Ridewaan, Tanner, M. **2020**. Machine learning models to predict agile methodology adoption. *Federated Conference on Computer Science and Information Systems (Virtual Conference)*, Sofia, Bulgaria, 6-9 September 2020, p.697-704.

Herselman, Martha E, Botha, Adele, Maremi, Keneilwe J, Dlamini, Sifiso B, Marais, Mario A. **2020**. Mobile technology affecting teaching and learning in rural schools. *16th International Conference on Mobile Learning (ML 2020)*, Bulgaria, Sofia, 2-4 April 2020, p.23-30.

Herselman, Martha E, Botha, Adele. **2020**. Applying Design Science research as a methodology in post graduate studies: A South African perspective. *South African Institute for Computer Scientists and Information Technologist (SAICSIT) Conference*, Cape Town, South Africa, 14-16 September 2020, p.251-258.

Isaac, Nithin. **2020**. Electric vehicle user behaviour and demand response. *SAUPEC/RobMech/PRASA, University of Cape Town*, 29-31 January 2020, p.7pp.

Jafta, Y, Leenen, L, Chan, Ka Fai P. **2020**. An ontology for the South African Protection of Personal Information Act. In: Eze, T Speakman, L Onwubiko, C (eds.). *Proceedings of the 19th European Conference on Cyber Warfare and Security, a Virtual Conference Hosted by the University of Chester, United Kingdom*, 25-26 June 2020, p.158-166.

Jahoor, F, Botha, Adèle, Herselman, Martha E. **2020**. Conceptualizing mobile literacy skills for educators. *16th International Conference on Mobile Learning (ML 2020)*, Bulgaria, Sofia, 1-4 April 2020, p.8pp.

John, RS, Erasmus, Louwrence D. **2020**. A study of system development in a research and development environment with a focus on radar systems. *30th Annual INCOSE International Symposium, Virtual Event*, 20-22 July 2020, p.1093-1105.

Joshua, AO, Mabuza-Hocquet, Gugulethu P, Nelwamondo, Fulufhelo V. **2020**. Assessment of the Cup-to-Disc ratio method for Glaucoma

detection. *2020 International SAUPEC/RobMech/PRASA Conference, University of Cape Town, South Africa, 29-31 January 2020*, p.5pp.

Katzis, K, Mfupe, Luzango P, Hussien, HM. **2020**. Opportunities and challenges of bridging the digital divide using 5G enabled high altitude platforms and TVWS spectrum. *IEEE Eighth International Conference on Communications and Networking (ComNet), Hammamet, Tunisia, 27-30 October 2020*, p.8pp.

Kesavan Pillai, Sreejarani, Sivakumar, D, Ray, Suprakas S, Obianom, P, Eggers, Sharon K, Mhlabe, T. **2020**. Active nanocomposite films based on low density polyethylene/organically modified layered bouble hydroxides/thyme oil to retain retail shelf life and quality of hass avocados. *AIP Conference Proceedings 2289, 020073, 30 November 2020, Published Online*, 2289, p.5pp.

Khoza, Mary N, Sinha Roy, Jayita, Ray, Suprakas S, Ojijo, Vincent O. **2020**. Qualitative assessment on the surfactant traces from the organically modified nanoclay containing polymer nanocomposite. *AIP Conference Proceedings 2289, 020072, 30 November 2020, Published Online*, p.6pp.

Khumalo, Nosipho N, Oyerinde, O, Mfupe, Luzango P. **2020**. Reinforcement learning-based computation resource allocation scheme for 5G fog-radio access network. *The Fifth International Conference on Fog and Mobile Edge Computing, Paris, France, 30 June to 3 July 2020*, p.3pp.

Kruger, Carel P, Hancke, GP. **2020**. Enhanced security in industrial internet of things networks using latency based fingerprinting. *18th IEEE International Conference on Industrial Informatics (INDIN), 20-23 July 2020, China, (Online Conference)*, p.6pp.

Kruger, Rynhardt P, De Wet, F, Niesler, T. **2020**. Interactive image exploration for visually impaired readers using audio-augmented touch gestures. *2020 24th International Conference Information Visualisation (IV), Online Victoria University, Melbourne, Australia, TU Wien, Vienna, Austria, 7-11 September 2020*, p.6pp.

Ledwaba, LPI, Hancke, GP, Mitroksotsa, A, Isaac, Sherrin J. **2020**. A delegated proof of proximity scheme for industrial internet of things consensus. *46th Annual Conference of the IEEE Industrial Electronics Society (IECON), Singapore, Singapore, 18-21 October 2020*, p.6pp.

Lehong, C, Isong, B, Luyagizi, F, Abu-Mahfouz, Adnan MI. **2020**. A survey of LoRaWAN adaptive data rate algorithms for possible optimization. *2nd International Multidisciplinary Information Technology and Engineering Conference (IMITEC), Kimberley, South Africa, 25-27 November 2020*, p.9pp.

Lugongolo, Masixole Y, Ombinda-Lemboumba, Saturnin, Manoto, Sello L, Mthunzi-Kufa, Patience. **2020**. Characterisation of a Bessel beam optical cell sorting system using microspheres. *Proceedings of SPIE 11238, Optical Interactions with Tissue and Cells XXXI, 1123804, San Francisco, California, February 2020*, p.12pp.

Maasdorp, Francois DV, Cilliers, Jacques E, Tong, Craig A. **2020**. Propeller modulation analysis of 4-blade, 4-engine aircraft in FM-band multistatic passive radar. *2020 IEEE International Radar Conference (RADAR), 28-30 April 2020, Washington, DC, USA*, p.6pp.

Madzivhandila, Thingahangwi, Maledi, N, Fazluddin, Shahed. **2020**. Characterization of particulate matter in the process of manufacturing

titanium metal powder. *22nd International Conference on Data Science for Air Quality Monitoring, Cape Town, South Africa, 16-17 April 2020*, p.11pp.

Magubane, Z, Tarwireyi, P, Abu-Mahfouz, Adnan MI, Adigun, MO. **2020**. Performance evaluation of ETXPC-RPL routing algorithm in IoT Network. *2nd International Multidisciplinary Information Technology and Engineering Conference (IMITEC), Sol Plaatje University, Kimberley, 25-27 November 2020*, p.8pp.

Manoto, Sello L, Mabena, Chemist M, Malabi, Khorommbi P, Ombinda-Lemboumba, Saturnin, El-Hussein, A, Kasem, M, Lugongolo, Masixole Y, Mthunzi-Kufa, Patience. **2020**. Smartphone biosensing for point of care diagnostics. *Proceedings of SPIE 11258, Frontiers in Biological Detection: From Nanosensors to Systems XII, San Francisco, California, United States, 1-6 February 2020*, p.1-8.

Manyatshe, Alusani, Balogun, Mohammed O, Nkambule, TTI, Cele, Zamani ED, Msagati, TAM. **2020**. Chemical modification of sugarcane bagasse with chitosan for the removal of phosphates in aqueous solution. *Proceedings of PPS2019 Europe-Africa Regional Conference of the Polymer Processing Societ, AIP Conference Proceedings 2289, 020064, 2020*, p.6p.

Maphanga, Charles P, Manoto, Sello L, Ombinda-Lemboumba, Saturnin, Hlekelele, Lerato, Mthunzi-Kufa, Patience. **2020**. Optical biosensing of mycobacterium tuberculosis for point-of-care diagnosis. *Proceedings of SPIE 11251, Label-free Biomedical Imaging and Sensing (LBIS) 12510R, San Francisco, California, USA, 23 February 2020*, p.13pp.

Marais, Laurette, Louw, Johannes A, Badenhorst, Jacob AC, Calteaux, Karen V, Wilken, Ilana, Van Niekerk, Nina, Stein, Glenn. **2020**. AwezaMed: A multilingual, multimodal speech-to-speech translation application for maternal health care. *2020 IEEE 23rd International Conference on Information Fusion (FUSION), Rustenburg, South Africa, 6-9 July 2020*, p.669-676.

Marais, Laurette, Pretorius, L. **2020**. Exploiting a multilingual semantic Machine translation architecture for knowledge representation of patient information for Covid-19. In: Gerber, A (eds.). *Proceedings of the 1st South African Conference for Artificial Intelligence Research, (SACAIR 2020), Muldersdrift, South Africa, 22-26 February 2021*, p.264-279.

Maremi, Keneilwe J, Herselman, Martha E, Botha, Adele. **2020**. Interoperability maturity models for consideration when using School Management Systems (SMS) in South Africa: A scoping review. *Proceedings of the International Research Conference, IRC 2020, ix, Prague, 3-4 September 2020*, p.75-83.

Marivate, Yukosi, Sefara, Tshephisho J, Chabalala, V, Makhaya, K, Mokgonyane, T, Mokoena, R, Modupe, A. **2020**. Investigating an approach for low resource language dataset creation, curation and classification: Setswana and Sepedi. *Proceedings of the First Workshop on Resources for African Indigenous Languages, Marseille, France, 16 May 2020*, p.6pp.

Mashaba, Nikiwe P, Griffith, DJ. **2020**. Analysing real-world turbulence at low cost. In: Fosso-Kankeu, E Waanders, F Bulsara, HKP (eds.). *Proceedings of the 18th South Africa International Conference on Agricultural, Chemical, Biological & Environmental Sciences (ACBES-20), Birchwood Hotel & OR Tambo Conference Centre, Johannesburg, South Africa, 16-17 November 2020*, p.219-221.

Mashaba, Nikiwe P, Griffith, DJ. **2020**. Characterizing optical filters for wildfire detectors. In: Fosso-Kankeu, E Waanders, F Bulsara, hkp (eds.). *18th South Africa International Conference on Agricultural, Chemical, Biological and Environmental Sciences (ACBES-20)*, Johannesburg, South Africa, 16-17 November 2020, p.212-215.

Mashaba, Nikiwe P, Griffith, DJ. **2020**. Comparing optical turbulence using a pair of sonic anemometers. *18th South Africa International Conference on Agricultural, Chemical, Biological & Environmental Sciences (ACBES-20)*, Birchwood Hotel & OR Tambo Conference Centre, Johannesburg, South Africa, 16-17 November 2020, p.216-218.

Matebese, Belinda T, Withey, Daniel J, Banda, MK. **2020**. Leapfrog and optimal kinodynamic motion planning. *ICONIC '20: Proceedings of the 2nd International Conference on Intelligent and Innovative Computing Applications, Virtual*, 24 September 2020, p.7pp.

Mathebula, I, Isong, B, Gasela, N, Abu-Mahfouz, Adnan MI. **2020**. Analysis of energy-efficient techniques for SDWSN energy usage optimization. *The 2nd International Multidisciplinary Information Technology and Engineering Conference (IMITEC)*, Kimberley, South Africa, 25 - 27 November 2020, p.8pp.

Mattheus, J, Grobler, H, Abu-Mahfouz, Adnan MI. **2020**. A review of motion segmentation: Approaches and major challenges. *2nd International Multidisciplinary Information Technology and Engineering Conference (IMITEC)*, Sol Plaatje University, Kimberley, 25-27 November 2020, p.8pp.

May, Siyasanga I, Pratt, Lawrence E, Bokoro, P. **2020**. Thin film photovoltaic module characterisation based in indoor and outdoor methods. *SAUPEC 2020, University of Cape Town, South Africa*, 29 -31 January 2020, p.5pp.

McDonald, Andre M, Van Wyk, M. **2020**. A novel approach to solving the generalized inverse Frobenius-Perron problem. *IEEE International Symposium on Circuits & Systems, Virtual*, 10-21 October 2020, p.5pp.

Mdakane, Lizwe W, Meyer, Rory GV, Sibolla, Bolelang H. **2020**. Bilge dump automatic alert system in southern Africa oceans. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLIII-B1-2020, 2020 XXIV ISPRS Congress, (2020 edition)*, Virtual Conference, 31 August - 2 September 2020, p.627-630.

Meyer, Heloise. **2020**. Mobile forensics: Beyond traditional sources of digital evidence. *Proceedings of the 19th European Conference on Cyber Warfare and Security, a virtual conference hosted by the University of Chester, United Kingdom*, 25-26 June 2020, p.9pp.

Mnisi, VC, Sithole, ME, Modiba, Rosinah, Machaka, Ronald. **2020**. Investigation of beta Ti-Mo phase stability employing the first principle approach. *Proceedings of SAIP2019, the 64th Annual Conference of the South African Institute of Physics*, 08 July 2019 - 12 July 2019 Polokwane, p.35-40.

Mntuwaphi, ND, Isong, B, Gasela, N, Abu-Mahfouz, Adnan MI. **2020**. Comprehensive analysis of energy efficiency schemes in the Internet of Things. *2nd International Multidisciplinary Information Technology and Engineering Conference (IMITEC)*, Kimberley, South Africa, 25 to 27 November 2020, p.7pp.

Modiba, Rosinah, Ngoepe, PE. **2020**. Effect of Co addition on the structural, electronic and magnetic properties of Fe₁₆N₂ employing first principles approach. *Proceedings of SAIP2019, 64th Annual*

Conference of the South African Institute of Physics, 8-12 July 2019, Polokwane, South Africa, p.77-81.

Mokgonyane, TB, Sefara, Tshephiso J, Manamela, MJ, Modipa, TI, Masekwameng, MS. **2020**. The effects of acoustic features of speech for automatic speaker recognition. *2020 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems*, Durban, South Africa, 6-7 August 2020, p.5pp.

Moloja, D, Mpekoa, Noluntu, Van Greunen, D. **2020**. Evaluating two security systems for mobile voting fortification. *ICONIC 2020: Proceedings of the 2nd International Conference on Intelligent and Innovative Computing Applications, Plaine Magnien, Mauritius*, 24-25 September 2020, p.6pp.

Motlatle, Abesach M, Bothloko, Orebotse J, Scriba, Manfred R, Ojijo, Vincent, Ray, Suprakas S. **2020**. The thermal degradation kinetics and morphology of poly(vinyl butyral) cast films prepared using different organic solvents. *Proceedings of PPS2019 Europe-Africa Regional Conference of the Polymer Processing Society, AIP Conference Proceedings, Volume 2289, Issue 1, November 2020*, p.6pp.

Mtsetwa, SN, Sibeko, N, Tarwireyi, P, Abu-Mahfouz, Adnan MI. **2020**. OTA firmware updates for LoRaWAN using blockchain. *2nd International Multidisciplinary Information Technology and Engineering Conference (IMITEC)*, Kimberley, South Africa, 25-27 November 2020, p.8pp.

Mtsweni, Jabu S, Modiba, FS. **2020**. Inclusive development using a micro-tasking approach for building smart communities. *The 5th Annual International Conference on Public Administration and Development Alternatives*, 7-9 October 2020, Virtual Conference, p.8pp.

Mvango, Sindisiwe, Mthimkhulu, N, Fru, PA, Pilcher, LA, Balogun, Mohammed O. **2020**. Physico-chemical characterization of polyethylene glycol-conjugated betulonic acid. *Proceedings of PPS2019 Europe-Africa Regional Conference of the Polymer Processing Society, AIP Conference Proceedings 2289, November 2020*, p.6pp.

Nair, Kishor K, Pillai, MM, Lefophane, Samuel, Nair, HD. **2020**. Adaptation of smart cities in the South African Internet of Things context. *2020 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD)*, Durban, South Africa, South Africa, 6-7 August 2020, p.6pp.

Nelufule, Nthatheni, Mabuza-Hocquet, Gugulethu P, De Kock, Antonie J. **2020**. Circular interpolation techniques towards accurate segmentation of iris biometric images for infants. In *2020 International SAUPEC/RobMech/PRASA Conference*, Cape Town, South Africa, South Africa, 29-31 January 2020, p.6pp.

Nice, Jako A. **2020**. Appropriate renewable energy for education infrastructure in rural South Africa: The Cofimvaba science centre model. *9th International Conference on Appropriate Technology (ICAT)*, 24-28 November 2020, Pretoria, South Africa, p.168-177.

Nice, Jako A. **2020**. Microbiology of the Built Environment (MoBE) for architects, a review of applied spatial metrics for application in healthy building design. *The 16th Conference of the International Society of Indoor Air Quality & Climate (Indoor Air 2020) COEX*, Seoul, Korea, 20-24 July 2020, p.8pp.

- Nigussie, E, Olwal, T, Musumba, G, Tegegne, T, Lemma, A, Mekuria, Fisseha. **2020**. IoT-based irrigation management for smallholder farmers in rural Sub-Saharan Africa. *The 11th International Conference on Emerging Ubiquitous Systems and Pervasive Networks, Madeira, Portugal, 2-5 November 2020*, 177, p.86-93.
- Ogunniyi, Samuel O, Withey, Daniel J, Marais, Stephen T, Crafford, Gerhardus J. **2020**. LiDAR-based 3D mapping and localisation system for Ground Penetrating Radar. *2020 International SAUPEC/RobMech/PRASA Conference, Cape Town, South Africa, 29-31 January 2020*, p.9pp.
- Oloo, Fiona RA, Molefyan, Basetsana, Rampokanyo, Mpeli J. **2020**. Modelling and optimisation studies for generator dispatch strategies for deployment of an off-grid micro-grid in South Africa. *2020 6th IEEE International Energy Conference (ENERGYCon), Gammarth, Tunisia, 28 September-1 October 2020*, p.6pp.
- Olukanmi, P, Nelwamondo, Fulufhelo V, Marwala, T. **2020**. HP: A light-weight hybrid algorithm for accurate data partitioning. *2020 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD), Durban, South Africa, 6-7 August 2020 (Virtual)*, p.5pp.
- Olukanmi, S, Nelwamondo, Fulufhelo V. **2020**. Digital influenza surveillance: The prospects of Google Trends data for South Africa. *2020 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD), urban, South Africa, South Africa, 6-7 Aug 2020*, p.6pp.
- Ombinda-Lemboumba, Saturnin, Manoto, Sello L, Maphanga, Charles P, Malabi, Khorommbi P, Thobakgale, Setumo L, Lugongolo, Masixole Y, Mthunzi-Kufa, Patience. **2020**. Raman spectroscopy and gold thin film for biosensing and detection. *Proceedings of SPIE 11251, Label-free Biomedical Imaging and Sensing (LBIS) 2020, 112512P, 20 February 2020*, p.9pp.
- Ombinda-Lemboumba, Saturnin, Manoto, Sello L, Maphanga, Charles P, Malabi, Khorommbi P, Mthunzi-Kufa, Patience. **2020**. Development of collinear transmission plasmonic biosensor for detection of HIV-1. *Proceedings of SPIE 11257, Plasmonics in Biology and Medicine XVII, 112570L, 21 February 2020*, p.10pp.
- Oosthuizen, Rudolph, Pretorius, L. **2020**. A bibliometric method for analysis of systems engineering research. *30th Annual INCOSI International Symposium, Cape Town, 18 - 23 July 2020*, p.15pp.
- Oosthuizen, Rudolph, Pretorius, L. **2020**. Bibliometric analysis of technology management research topic trends. In: Pretorius, L Pretorius, MW (eds.). *29th International Conference of the International Association for Management of Technology (IAMOT), Towards the Digital World & Industry X.0.Egypt, 13-17 September 2020 (Online)*, p.701-712.
- Phahlamohlaka, Kholofelo J, Pedro, JO. **2020**. Application of two time-scale separation NDI controller to a dual aerodynamically-controlled missile. *2020 Australian & New Zealand Control Conference (ANZCC), Virtual Conference Live Broadcast from Griffith University the City of Gold Coast, Australia, 26-27 November 2020*, p.220 - 225.
- Potgieter, Monique, Cilliers, Jacques E, Blaauw, Ciara. **2020**. The use of sigmaHat for modelling of electrically large practical radar problems. *2020 IEEE International Radar Conference (RADAR), 28-30 April 2020, Washington, DC, USA*, p.6pp.
- Rapiya, XL, Malik, Humna H, Pretorius, JHC. **2020**. The importance of understanding the market before introducing a new product: A case study. *International Association for Management of Technology (IAMOT), Cairo, Egypt, 14-17 September 2020*, p.14pp.
- Ravanbach, B, Kühnel, M, Hanke, B, Von Maydell, K, Van Dyk, EE, Vumbugwa, M, Makaka, G, Lesala, ME, Shambira, N, Roro, Kittessa. **2020**. Development of a smart monitoring and evaluation framework for hybrid renewable mini-grids. *2020 Fifteenth International Conference on Ecological Vehicles and Renewable Energies (EVER), Monte Carlo, May 28 - May 30, 2020*, p.14pp.
- Roodt, JH, Koen, Hildegard. **2020**. A review of hurdles to adopting industry 4.0 in developing countries. *30th Annual INCOSI International Symposium, 18-23 July 2020, Cape Town, South Africa, 30(1), p.1079-1092*.
- Roodt, JH, Leenen, L, Van Vuuren, JJ, Dawood, Zubeida C. **2020**. Modelling of the complex societal problem of establishing a national energy sufficiency competence. *IEEE 23rd International Conference on Information Fusion (FUSION), Rustenburg, South Africa, 6-9 July 2020*, p.8pp.
- Sefara, Tshephisho J, Mokgonyane, TB. **2020**. Emotional speaker recognition based on machine and deep learning. *2nd International Multidisciplinary Information Technology and Engineering Conference (IMITEC), Sol Plaatje University, Kimberley, South Africa, 25 - 27 November 2020*, p.8pp.
- Sello, Manoto L, Ahmed, E, Malabo, Rudzani, Thobakgale, Setumo L, Ombinda-Lemboumba, Saturnin, Attia, Y, Kasem, M, Mthunzi-Kufa, Patience. **2020**. Immobilization of HIV GP41 antibodies on glass substrates for HIV biosensing. *Proceedings of SPIE Volume 11258, Frontiers in Biological Detection: From Nanosensors to Systems XII, San Francisco, California, United States, 1-6 February 2020*, p.10pp.
- Skosana, V, Abu-Mahfouz, Adnan MI. **2020**. Video encoding for wireless multimedia sensor networks: A review. *2nd International Multidisciplinary Information Technology and Engineering Conference (IMITEC), Sol Plaatje University, Kimberley, 25-27 November 2020*, p.6pp.
- Skosana, Vusi J, Ngxande, M. **2020**. The effects of image smoothing on CNN-based detectors. *2020 International SAUPEC/RobMech/PRASA Conference, Cape Town, South Africa*, p.6pp.
- Sroor, H, Huang, YW, Sephton, B, Naidoo, Darryl, Valles, A, Ginis, Vincent, Zhan, Qiwen, Qiu, CW, Ambrosio, A, Capasso, F. **2020**. Generation of arbitrary Higher-Order Poincare beams from a visible metasurface laser. *SPIE LASE, 2020, San Francisco, California, United States*, p.8pp.
- Sroor, H, Huang, YW, Sephton, B, Naidoo, Darryl, Valles, A, Ginis, V, Zhan, Q, Qiu, CW, Ambrosio, A, Capasso, F. **2020**. High purity twisted light from a metasurface solid state resonator. *SPIE LASE, 2020, San Francisco, California, United States*, p.7pp.
- Stoltz, George G, Nel, AL. **2020**. Improving spatial domain based image formation through compressed sensing. In: Yuan, X-C Carney, PS Shi, K (eds.). *Proceeding of SPIE, 11549, Advanced Optical Imaging Technologies III, September 2020 (online)*, p.9pp.
- Stoltz, George G, Stoltz, M. **2020**. Performance estimation of a real-time Rosette imager. In: Hickman, DL Bürsing, H (eds.). *Proceedings of SPIE, Volume 11537, Electro-Optical and Infrared Systems: Technology and Applications XVII, 21-25 September 2020*, p.16pp.

Thobakgale, Setumo L, Manoto, Sello L, Ombinda- Lembumba, Saturnin, Mithunzi-Kufa, Patience. **2020**. Gelatine-based biosensor for molecular screening of aspirin and paracetamol via surface enhanced Raman spectroscopy. In: Dubowski, JJ Geohegan, DB Kabashin, AV (eds.). *Proceedings of SPIE 11269, Synthesis and Photonics of Nanoscale Materials XVII, 1126905, San Francisco California, 1-4 February 2020*, p.09pp.

Thobakgale, Setumo L, Manoto, Sello L, Ombinda-Lembumba, Saturnin, Mithunzi-Kufa, Patience. **2020**. Surface enhanced raman spectroscopy on polymer-graphene oxide scaffolds for drug screening applications. *Proceedings volume 11246, Single Molecule Spectroscopy and Superresolution Imaging XIII, SPIE BIOS, San Francisco, California, United States, 1-6 February 2020*, p.11 pp.

Thulare, Tumiso, Herselman, Martha E, Botha, Adele. **2020**. A scoping review on identifying aspects of data integrity in health information systems for South Africa. *2020 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD), Durban, South Africa, 6-7 August 2020*, p.8pp.

Tikam, Mayur, Withey, Daniel J, Theron, NJ. **2020**. Posture control for a low-cost commercially-available hexapod robot*. *2020 IEEE International Conference on Robotics and Automation, Paris, France, 31 May - 31 August 2020*, p.4498-4504.

Tshwane, David M, Modiba, Rosinah, Chauke, HR, Govender, Gonasagren. **2020**. Computer simulation studies of HF adsorption on TiO₂ (001) and (110) surfaces. *The Proceedings of SAIP2019, the 64th Annual Conference of the South African Institute of Physics, 08 July 2019 - 12 July 2019 Polokwane*, p.23-28.

Twala, B, Pillay, R, Nkoana, Ramapulana. **2020**. Classifying incomplete vectors using decision trees. *Proceedings of the 12th International Joint Conference on Computational Intelligence, 2 - 4 November 2020, Budapest, Hungary*, p.9pp.

Van der Walt, P, Naidoo, Mogesh, Burger, R, Garland, Rebecca M. **2020**. "Simulated PM_{2.5} attributable to coal-fired power plants in the Highveld". *Proceedings of the 2020 Conference of the National Association for Clean Air, Virtual (Online Conference), South Africa, 16 - 20 November 2020*, p.166-171.

Van Reenen, Tobias H, Grobler, Jan-Hendrik. **2020**. Developing demand driven ventilation criteria for airborne infection control in congregate spaces. *16th Conference of the International Society of Indoor Air Quality & Climate (Indoor Air 2020), COEX, Seoul, Korea, 20-24 July 2020*, p.6pp.

Van Schalkwyk, A, Grobelaar, S, Herselman, Martha E. **2020**. A scoping review of the use of data analytics for the evaluation of mHealth applications. In: Pretorius, L Pretorius, MW (eds.). *29th International Conference of the International Association for Management of Technology, Nile University, Cairo, Egypt, 13-17 September 2020*, p.1326-1343.

Withey, Daniel J, Mogokonyane, Katlego C, Tikam, Mayur, Holder, Ross P, Veeraragoo, Mahalingam, Gambushe, Mxolisi I. **2020**. Context-aware action with a small mobile robot. *2020 International SAUPEC/RobMech/PRASA Conference, Cape Town, South Africa, 29-31 January 2020*, p.6pp.

BOOKS AND BOOK CHAPTERS

Ananthi, V, Mohanrasu, K, Boobalan, T, Anand, K, Sudhakar, Muniyasamy, Chuturgoon, A, Balasubramanian, V, Yuvakkumar, R, Arun, A. **2020**. An overview of nanotoxicological effects towards plants, animals, microorganisms and environment. In: Krishnan, A, Chuturgoon, A (eds.). *Integrative Nanomedicine for New Therapies*, p.113-146.

Coelho, ST, Bouille, DH, Mani, SK, Stafford, WHL. **2020**. Chapter One - Introduction. In: Coelho, ST, Pereira, SA, Bouille, DH, Mani, SK, Recalde, MY, Savino, AA, Stafford, WHL (eds.). *Municipal Solid Waste Energy Conversion in Developing Countries: Technologies, Best Practices, Challenges and Policy - 1st Edition*, p.1-7.

Coelho, ST, Recalde, MY, Mani, SK, Stafford, WHL. **2020**. Overview of developing countries. In: Coelho, ST, Pereira, SA, Bouille, DH, Mani, SK, Recalde, MY, Savino, AA, Stafford, WHL (eds.). *Municipal Solid Waste Energy Conversion in Developing Countries: Technologies, Best Practices, Challenges and Policy - 1st Edition*, p.9-62.

Dawood, ZC, Keet, CM. **2020**. Structuring abstraction to achieve ontology modularisation. *Advanced Concepts, Methods, and Applications in Semantic Computing*, p.72-92.

El Enshasy, HA, Ambehbat, KK, El Baz, AF, Ramchuran, SO, Sayyed, RZ, Amalin, D, Dailin, DJ, Hanapi, SZ. **2020**. Trichoderma: Biocontrol agents for promoting plant growth and soil health. In: Yadav, AN, Mishra, S, Kour, D, Yadav, N, Kumar, A (eds.). *Agriculturally Important Fungi for Sustainable Agriculture. Volume 2. Functional Annotation for Crop Protection, 2*, p.239-259.

Enshasy, HE, Dailin, DJ, Malek, RA, Nordin, NZ, Keat, HC, Eyahmalay, J, Ramchuran, SO, Ghong, JNC, Ramda, VM, Lalloo, R. **2020**. Biocement: A novel approach in the restoration of construction materials. In: Yadav, AN, Rastegari, AA, Gupta, VK, Yadav, N (eds.). *Microbial Biotechnology Approaches to Monuments of Cultural Heritage*, p.177-198.

Gibberd, JT. **2020**. An alternative rainwater harvesting system design methodology. *Sustainability Handbook. Volume 1*, p.118-125.

Le Maitre, DC, Blignaut, JN, Clulow, A, Dziki, S, Everson, CS, Gorgens, AHM, Gush, MB. **2020**. Impacts of plant invasions on terrestrial water flows in South Africa. In: Van Wilgen, BW, Measey, J, Richardson, DM, Wilson, JR, Zengeya, TA (eds.). *Biological Invasions in South Africa*, p.431-456.

Le Roux, WJ, Schaefer, LM, Venter, SN. **2020**. Vibrio cholerae and cholera: A recent African perspective (Chapter). In: Abia, A, Lanza, G (eds.). *Current Microbiological Research in Africa*, p.69-113.

Mdlalose, LM, Chauke, VP, Nomadolo, EN, Msomi, P, Setshedi, KZ, Chimuka, L, Chetty, A. **2020**. Metal oxide nanocomposites for adsorption and photoelectrochemical degradation of pharmaceutical pollutants in aqueous solution. In: Ama, OM, Ray, Suprakas S (eds.). *Nanostructured Metal-Oxide Electrode Materials for Water Purification*, p.167-189.

Mkhwebane, SE, Semelane, MS. **2020**. Renewable Energy SMME Guide. *Sustainability Handbook 2020: Volume 1*, p.195-203.

Mohanrasu, K, Guru Raj Rao, R, Sudhakar, M, Raja, R, Jeyakanthan, J, Arun, A. **2020**. Marine microbial pharmacognosy: Prospects and perspectives. In: Nathani, NM, Mootapally, C, Gadhi, IR, Maitreya, B, Joshi, CG (eds.). *Marine Niche: Applications in Pharmaceutical Sciences*, p.89-110.

Mohanrasu, K, Siva Prakash, G, Boobalan, T, Ananthi, V, Dinesh, GH, Anand, K, Muniyasamy, S, Chuturgoon, A, Arun, A. **2020**. Synthetic, natural derived lipid nanoparticles and polymeric nanoparticles drug delivery applications. In: Krishnan, A, Chuturgoon, A (eds.). *Integrative Nanomedicine for New Therapies*, p.147-165.

Mokhena, TC, John, MJ, Mochane, MJ, Mtibe, A, Motsoeneng, TS, Mokhothu, TH, Tshifularo, CA. **2020**. Cellulose nanocrystals-based composites. In: Jamil, N, Kumar, P, Batool, R (eds.). *Soil Microenvironment for Bioremediation and Polymer Production*, p.283-306.

Mokhena, TC, John, MJ, Mochane, MJ, Sadiku, ER, Motsoeneng, TS, Mtibe, A, Tsipa, PC. **2020**. Antibiotic 3D printed Materials for healthcare applications. In: Kokkarachedu, V, Kanikireddy, V, Sadiku, R (eds.). *Antibiotic Materials in Healthcare*, p.141-158.

Mokhena, TC, John, MJ, Mochane, MJ, Tsipa, PC. **2020**. Application of electrospun materials in oil–water separations. In: Boddula, RI, Ahamed, MI, Asiri, AM (eds.). *Electrospun Materials and their Allied Applications*, p.185-209.

Mokhena, TC, John, MJ, Sibeko, MA, Agbakoba, VC, Mochane, MJ, Mtibe, A, Mokhothu, TH, Motsoeneng, TS, Phiri, MM, Mofokeng, Tladi G. **2020**. Nanomaterials: Types, synthesis and characterization. In: Srivastava, M, Srivastava, N, Mishra, PK, Gupta, VK (eds.). *Nanomaterials in Biofuels Research*, p.115-141.

Motsoeneng, TS, Mochane, MJ, Mokhena, TC, Mathew, MJ. **2020**. Structure and properties of lignin-based biopolymers in polymer production. In: Jamil, N, Kumar, P, Batool, R (eds.). *Soil Microenvironment for Bioremediation and Polymer Production*, p.375-392.

Naidoo, J, Fok, E, Grobler, LR, Molaoa, R, Nxumalo, Z, Selvamani, P, Latha, S, Thimiri Govindaraj, Deepak B. **2020**. Recent advances in genetic engineering tools for metabolic engineering. In: Singh, V, Singh, AK, Bhargava, P, Joshi, M, Joshi, CG (eds.). *Engineering of Microbial Biosynthetic Pathways*, p.93-109.

Nxumalo, PZ, Thimiri Govindaraj, DB. **2020**. Application and challenges of synthetic biology. In: Singh, V (eds.). *Advances in Synthetic Biology*, p.307-320.

Oelofse, SHH, Nahman, A, Barjees, M, Saleemdeen, R, Nizami, A-S, Reynolds, C. **2020**. Food waste in South Africa and Saudi Arabia. In: Reynolds, C, Soma, T, Lazell, J (eds.). *Routledge Handbook of Food Waste. 1st Edition*, p.23pp.

Ojijo, VO, Kesavan Pillai, S. **2020**. Compatibilization of polymer blends by shear pulverization. In: Ajitha, AR, Sabu, T (eds.). *Compatibilization of Polymer Blends: Micro and Nano Scale Phase Morphologies, Interphase Characterization, and Properties*, p.277-297.

Ray, SS, Gusain, R, Kumar, N. **2020**. Carbon nanomaterial-based adsorbents for water purification: Fundamentals and applications. In: Henriques, MC (eds.). p.420pp.

Richardson, DM, Foxcroft, LC, Latombe, G, Le Maitre, DC, Rouget, M, Wilson, JR. **2020**. The biogeography of South African terrestrial plant invasions. In: Van Wilgen, B, Measey, J, Richardson, DM, Wilson, JR, Zengeya, TA (eds.). *Biological Invasions in South Africa*, p.67-92.

Rust, C, Smit, MA, Schoeman, D. **2020**. Benefits of a photo voltaic solar system in a private dwelling. In: De Jager, P (eds.). *Sustainability Handbook 2020: Volume 1*, p.85-96.

Schaefer, LM, Le Roux, WJ, Abia, ALK. **2020**. Reservoirs of *Cryptosporidium* and *Giardia* in Africa. In: Lanza, Guy L, Abia, Akebe Luther King (eds.). *Current microbiological research in Africa: Selected applications for sustainable environmental management*, p.115-135.

Slinger, J, Taljaard, S, D'Hont, F. **2020**. Chapter 1: Introduction. *Complex Coastal Systems: Transdisciplinary learning on international case studies*, p.18pp.

Slinger, J, Taljaard, S. **2020**. Transdisciplinary learning across case studies. In: Slinger, J, Taljaard, S, d'Hont, F (eds.). *Complex Coastal Systems: Transdisciplinary Learning on International Case Studies*, p.10pp.

Snyman-Van der Walt, L, Schreiner, GO, Laurie, S, Audouin, MA, Lochner, PA, Marivate, VN, Pasquini, L, Davidson, A, Hadingham, T, Cameron, R. **2020**. Pathways for mainstreaming resilience thinking into climate change adaptation and planning in the city of Cape Town. In: Brears, RC (eds.). *The Palgrave Handbook of Climate Resilient Societies*, p.22pp.

Stafford, WHL. **2020**. WtE best practices and perspectives in Africa. In: Coelho, ST, Pereira, SA, Bouille, DH, Mani, SK, Recalde, MY, Savino, AA, Stafford, WHL (eds.). *Municipal Solid Waste Energy Conversion in Developing Countries: Technologies, Best Practices, Challenges and Policy - 1st Edition*, p.185-217.

Todorovic, M, Jovanovic, N. **2020**. Climate change and agriculture. In: Maurice, PA (eds.). *Encyclopedia of Water: Science, Technology, and Society, 5 Volume Set*, p.2463-2478.

Van Niekerk, L, Adams, JB, Taljaard, S, Huizinga, P, Lamberth, S. **2020**. Advancing mouth management practices in the Groot Brak Estuary, South Africa. In: Slinger, J, Taljaard, S, D'Hont, F, Mittal, A (eds.). *Complex Coastal Systems: Transdisciplinary Learning on International Case Studies. First edition*, p.89-104.

Van Reenen, C, Nkosi, M. **2020**. Environmental benefits of telecommuting - a hypothetical case study. *Sustainability Handbook 2020: Volume 1*, p.97-105.

Van Reenen, CA, Van Reenen, TH, Nice, JA, Motsatsi, LL, Conradie, D, Van Wyk, LV, Bhikoo, J, Kuschke, U. **2020**. Hybrid design strategies for recommended indoor air quality: The case of Hillside Clinic, Beaufort West. In: de Jager, P (eds.). *Sustainability Handbook 2020: Volume 1*, p.107-113.



PO Box 395, Pretoria, 0001, South Africa

Published by: CSIR Communication

Enquiries: Tel +27 12 841 2911 • Email: Enquiries@csir.co.za

ISBN: 978-0-7988-5662-1