

ANNUAL REPORT 2021 | 2022



science & innovation

Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA



CSIR
Touching lives through innovation



"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.."

(Scientific Research Council Act, 1988 (Act No. 46 of 1988), as amended by Act 27 of 2014)



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CSIR GENERAL INFORMATION

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LIST OF ABBREVIATIONS

AECI	African Explosives and Chemical Industries	LRA	Labour Relations Act
AGSA	Auditor General of South Africa	MerSETA	Manufacturing, Engineering and Related Services Sector Education and Training Authority
AISI	Aerospace Industry Support Initiative	MoU	Memorandum of Understanding
ARDP	Accelerated Researcher Development Programme	MQA	Mining Qualifications Authority
ATC	Announcements, Tablings and Committee	NDP	National Development Plan
B-BBEE	Broad-Based Black Economic Empowerment	NRF	National Research Foundation
BIDC	Biomufacturing Industry Development Centre	NSF	National Science Foundation
CIP	Capital Investment Planning	NT	National Treasury
CEO	Chief Executive Officer	OSH Act	Occupational Safety and Health Act
CFO	Chief Financial Officer	PCR	Polymerase Chain Reaction
C4IR	Centre for the Fourth Industrial Revolution	PESTEL	Political, Economic, Social, Technological, Legal and Environmental
CHIETA	Chemical Industries Education & Training Authority	PFMA	Public Finance Management Act
CILLA	CSIR Innovation Leadership and Learning Academy	PG	Parliamentary Grant
CoroCAM	Corona Camera	POPI Act	Protection of Personal Information Act
COP10	Conference of Parties to the Nairobi Convention	PPE	Property, Plant, and Equipment
CSI	Corporate Social Investment	PPPFA	Preferential Procurement Policy Framework Act
CSIR	Council for Scientific and Industrial Research	PV	Photovoltaic
DHET	Department of Higher Education and Training	RCL	Researcher Career Ladder
DSI	Department of Science and Innovation	R&D	Research and Development
dtic	Department of Trade, Industry and Competition	RD&I	Research, Development & Innovation
ECL	Expected Credit Losses	RFP	Request for Proposal
EE Act	Employment Equity Act	RIR	Recordable Incident Rate
EPIC	Excellence People-centered Integrity Collaboration	SAR	Synthetic Aperture Radar
ERRP	Economic Reconstruction and Recovery Plan	SASSETA	Safety and Security Sector Education and Training Authority
EU	European Union	SANDF	South African National Defence Force
EWSETA	Energy and Water Sector Education and Training Authority	SANReN	South African National Research Network
EVP	Employee Value Proposition	SDG	Sustainable Development Goals
EXCO	Executive Committee	SET	Science, Engineering and Technology
FASSET	Finance and Accounting Services Sector Education and Training	SHEQ	Safety Health Environment and Quality
FPMP	Fraud Prevention and Management Policy	SHE	Safety, Health and Environment
FPP	Fraud Prevention Plan	SKA	Square Kilometre Array
FY	Financial Year	SMME	Small, Medium and Micro Enterprises
4IR	Fourth Industrial Revolution	SOCCO	Southern Ocean Carbon-Carbon Observatory
GCC	Grand Challenges Canada	SO	Strategic Objectives
GDP	Gross Domestic Products	TB	Tuberculosis
GIT	Graduate-in-Training	TETA	Transport Education Training Authority
GERD	Gross domestic Expenditure on Research and Development	TVET	Technical Vocational Education and Training
HC	Human Capital	TVWS	Television Whitespaces
HCD	Human Capital Development	UAV	Unmanned Aerial Vehicle
HCM	Human Capital Management	UCT	University of Cape Town
HIV	Human Immunodeficiency Virus	UNFCCC	United Nations Framework Convention on Climate Change
HRM	Human Resource Management	UNIDO	United Nations Industrial Development Organisation
IBS	Inter-Bursary Support	VAT	Value Added Tax
ICC	International Convention Centre	WAITRO	World Association of Industrial and Technological Research Organisations
ICT	Information and Communication Technology	WEF	World Economic Forum
IEEE	Institute of Electrical and Electronics Engineers	WIO	West Indian Ocean
KPI	Key Performance Indicator	YES	Youth Employment Service
KZN	KwaZulu-Natal		



CHAIRPERSON'S OVERVIEW

Professor Thokozani Majozi
CSIR Board Chairperson

Legally and procedurally, it falls on the Accounting Authority of the CSIR – its Board – to ensure that systems of good corporate governance are in place at the CSIR, reviewed continuously and benchmarked against world-class standards.

The Accounting Authority also assures compliance with the provisions of the Scientific Research Council Act, 1998 (Act 46 of 1998) and other regulatory mandates, and it must carefully consider the science council's continued relevance in addressing the pressing socioeconomic priorities of the country. In addition, it ensures that the CSIR upholds and sets in place review mechanisms and protocols to confirm that reports and publications are based on sound scientific analysis.

On behalf of the Accounting Authority, I can, with confidence, say that the CSIR has acquitted itself admirably in all these measures.

I would, however, like to take a step back from this somewhat cerebral synopsis of what is expected of both the Board and the CSIR to focus briefly on change – the impact and extent of which cannot be captured in the sterile diction of a regulatory environment.

Maturing through change

This is the seventh CSIR Annual Report that I have had the pleasure of reviewing. During this time, there have been changes at Board level. I have worked with two Chief Executive Officers (CEOs), experienced more than one organisational review, one major repositioning of the organisation, a new organisational strategy, one global health pandemic, an increase in regional wars, alarming increases in living costs and all that this means for an already compromised economy.

Two years ago, at the organisation's 75th anniversary, when the devastation of Covid-19 was new, I said that we are all children, all in wonder, trying to make sense of what is unfolding before our eyes. I then hoped that we would learn as much as possible so that as we reach adulthood, we have what it takes to survive.

Subsequently, I have seen the resilience of this organisation to adapt, not just for the sake of survival, but to bring to life what happens in laboratories and in boardrooms in a way that benefits South Africans tangibly. Albert Einstein is reported to have said, "The measure of intelligence is the ability to change." If not presumptuous, I would like to add that perhaps it is the measure of maturity that is the ability to change. Have we reached adulthood? I would risk an answer in the affirmative, tempered with the caveat that our growth in wisdom must continue as must our willingness to continue to learn as children.

Losses, but also wins

The CSIR has not been immune to the impacts of low economic growth. This affected the implementation of the new organisational strategy, with its added emphasis on industrial research, contract research and development (R&D), productivity during higher lockdown levels earlier in the reporting year, lease agreements with tenants, delays in acquiring public sector-funded equipment, and constrained energy supply.



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**.

Yet, the CSIR has achieved or exceeded more than 80% of its key performance indicators for the 2021/22 reporting year. Publication equivalents are up, as are priority patent applications, the number of technology demonstrators, the number of localised technologies and the number of small, medium and micro enterprises supported. Technology licence agreements – an area of slow growth in years past – grew by 300%.

The CSIR's research programmes address national priorities as articulated by the President of South Africa, and are aligned with various national strategies and frameworks, such as the National Development Plan, the Medium-Term Strategic Framework 2019-2024, and the national policies, particularly those of the Department of Science and Innovation (DSI). The CSIR Strategy also seeks to give meaning to the DSI's 2019 White Paper on Science, Technology and Innovation. Considering the imperative of supporting the state, it is heartening to see that the number of projects that contributed to increasing the state's capability increased by nearly 50%.

In addition to existing strategies, plans, policies and frameworks, the CSIR also responds and contributes to the implementation of the South African Government's Economic Reconstruction and Recovery Plan (ERRP). The ERRP is the guiding policy framework in response to the impact of the Covid-19 pandemic on the South African economy. This framework identified the defence and aerospace industry – an area well serviced by the CSIR – as key to economic growth.

Other key initiatives where the CSIR played and will continue to play a meaningful role are the Re-imagining Industrialisation Strategy for South Africa by the Department of Trade, Industry and Competition (**the dtic**); **the dtic's** sector master plans and the District Development Model.

All these initiatives have, as their main tenet, the creation of new and the strengthening of existing industries in the pursuit of exponential employment growth. With the 13th edition of the South Africa Economic Update stating that job losses in Covid-19 times are disproportionately concentrated among low-income earners, worsening already severe inequalities, despite the government's decisive and pro-poor response, the CSIR has its work cut out to empower existing industries, develop new ones and ensure adequate skills development and representativity.

The industrial policies continue to highlight science, technology and innovation as key to industrial development, acknowledging that many sectors can – and should – be transformed and reinvigorated through technological innovations and impact-oriented partnerships between the public and private sectors.

People with purpose

In January 2022, we had the honour of extending CSIR CEO Dr Thulani Dlamini's contract for a further five years. Under his leadership, the CSIR has been repositioned to align with South Africa's industrial needs through the commercialisation of its technologies and transformation of the science, engineering and technology base. The organisation is more visible and more accessible.

Certainly, there is much work ahead. However, the changes that the organisation has undergone to cement its growth trajectory and relevance to the people of our nation under Dr Dlamini's tenure serve as a solid foundation, considering the unforeseen socioeconomic upheaval of the past two years.

I extend my gratitude to Dr Dlamini, his leadership team and CSIR employees for their commitment to navigating the inevitable uncertainty of 'adulthood' – taking responsibility to consistently apply both intelligence and maturity to the issues that hinder our nation's growth.

While laws, regulations and codes of conduct are essential guiding instruments, their inherent sterility to effect change becomes apparent when juxtaposed with the passionate human beings appointed and equipped to embrace and leverage change. This is what we have seen from the CSIR during the past year.

I thank the Minister of Higher Education, Science and Innovation, Dr Bonginkosi 'Blade' Nzimande, and his department for their continued support and guidance, as well as my fellow Board members for their commitment to the good cause of the organisation.

Professor Thokozani Majozo
Chairperson of the Board

ISIZULU – AMAZWI AMAFUSHANE KASIHLELO

UMphathi Ophendula ngezinqumo ezithathwe yinhlangano uphinde aqinisekise ukuthi okwenziwa yinhlangano kuyahambisana nokuhlinzekwe uMthetho Womkhandlu Wezocwaningo Wezesayensi, we-1998 (uMthetho wama-46 we-1998) kanye nezinye iziqondiso zokulawula, futhi kumele acubungule ngokucophelela ukuqhubeka nokufaneleka komkhandlu wezesayensi ngendlela obhekana ngayo nezinto eziseqhulwini neziphuthumayo zezehlalo nezomnotho zezwe. Ukwengeza kulokho, uqinisekisa ukuthi abakwa-CSIR baqhakambisa futhi basungula izindlela zokubukeza kanye nezinqubo zokuqinisekisa ukuthi imibiko nezishicilelo kusekelwe ekuhlaziyeni okuphusile ngokwesayensi.

Egameni loMphathi okunguye Ophendula ngezinqumo ezithathwe yinhlangano, ngingasho nje, ngokuzethemba, ukuthi abakwa-CSIR bazikhululile ngendlela encomekayo kuzo zonke lezi zinyathelo.

Nokho-ke, ngingathanda ukuhlela kulokhu kulesi sifingqo esinikeziwe ngalokho okulindeleke kuko kokubili iBhodi kanye nabakwa-CSIR bese ngixila ngamafuphi ezinguqukwini – umthelela wazo nobubanzi balo okungekwazi ukuqoqwa ngamagama anomkhawulo wokulawulwa yimvelo.

Ukuvuthwa ngokwengqondo ngenxa yoshintsho

Lona uMbiko Wonyaka wakwa-CSIR wesikhombisa engibe negunya elikhethekile lokuwubukeza. Kulesi sikhathi, kube nezinguquko kuBhodi. Ngisebenze nabaPhathi Abaphezulu ababili (ama-CEO), ngibone ukubukezwa kwenhlangano okungaphezu kokukodwa, ukuhlelwa kabusha okukhulu okwenzeke kanye, isu lokuhlelwa kabusha kwenhlangano, ubhubhane oluhlasele impilo yomhlaba wonke, ukwanda kwezimpi ezizindeni ngezizinda, ukwenyuka okwesabekayo kwezindleko zokuphila kanti konke lokhu kukhomba umnotho osuvele usengozini.

Eminyakeni emibili edlule, emgubhweni weminyaka engama-75 yenhlangano, ngenkathi lesi sikhala sobhubhane lwe-Covid-19 sisesisha, ngathi sonke singabantwana, sonke simangele, sizama ukuqondisa konke okwakwenzeka phambi kwamehlo ethu. Ngaleso sikhathi nganginethemba lokuthi sasizokwazi ukufunda okuningi ngangokunokwenzeka ukuze njengoba sikhula, sithole konke esikudingayo ukuze sikwazi ukuphila.

Okwalandela lapho, ngibone kahle amandla ale nhlangano okukwazi ukumelana nokubhekana nezimo, hhayi nje ukuze izisindise yona, kodwa ukuze iphumelelise konke lokho okwenzeka emalabhorethri nasemagumbini abo okusebenzela ngendlela ezohlomulisa abantu baseNingizimu Afrika ngendlela ephathekayo nebonakalayo. Kubikwa ukuthi u-Albert Einstein wake wathi, "Isilinganiso sangempela sobuhlakani yikhono lokukwazi ukushintsha." Ngaphandle kokugababala, ngithanda nami ukwengeza lapho ngithi mhlawumbe yisilinganiso sokuvuthwa ngokomqondo esiyikhono loshintsho. Ingabe sesifinyelele esigabeni sokukhula sibe abantu abadala?

Ngingazibeka engcupheni ngiphendule ngithi yebo, ngiqinisekise isixwayiso sokuthi ukukhula kwethu ngobuhlakani kufanele kuqhubeka njengokuzimisela kwethu ukuqhubeka nokufunda njengabantwana.

Ukulahlekelwa, kodwa futhi nokunqoba

I-CSIR ayizange isinde emitheleleni yokukhahlaneywa umnotho odonsa kanzima. Lokhu kuthikameze ukuqaliswa kokusebenza kwesu elisha lenhlangano, nokugxila kwalo okwengeziwe ocwaningweni lwezimboni, ucwaningo nokuthuthukiswa kwezinkontileka (i-R&D), ukukhiqiza ngesikhathi sokuvalwa kwezwe obekuninile ngasekuqaleni konyaka okubikwa ngawo, izivumelwano zokuqashisa nabaqashi, ukubambezeleka ekutholeni imishini exhaswa imboni kahulumeni, kanye nokuphakelwa kwamandla kagesi okunezithiyo.

Kodwa noma kunjalo, ngonyaka okubikwa ngawo wezi-2021/22 abakwa-CSIR bazuze noma baze beqa kuma-80% ezinkomba zabo zokusebenza ezisemqoka. Ezinye izindlela zokushicilela zenyukile, ngokunjalo nezicelo zelungelo lobunikazi eziseqhulwini, inani lababonisi bezobuchwepheshe, inani lobuchwepheshe bendawo kanye nenani lamabhezini amancane, aphakathi nendawo nasafufusa athole ukwesekwa. Izivumelwano zamalaysensi ezobuchwepheshe – umkhakha obuvame ukukhula ngolonwabo eminyakeni edlule – ukhule ngama-300%.

Izinhlelo zezocwaningo zakwa-CSIR zikhuluma ngezinto eziseqhulwini kuzwelonke njengoba zibaluliwe nguMengameli waseNingizimu Afrika, futhi zihambisana namasu nezinhlelo ezahlukene zikazwelonke, njengoHlelo Lukazwelonke Lwentuthuko, uHlelo Lwesu Lesikhathi Esimaphakathi lowezi-2019-2024, kanye nezinqubomgomo zikazwelonke, ikakhulukazi lezo zoMnyango wezeSayensi nokuSungula Okusha (i-DSI). Isu lakwa-CSIR liphinde lizame ukunikeza incinane eMthethweni Owuhlaka wakwa-DSI lowezi-2019 leSayensi, Ubuchwepheshe kanye Nokusungula. Uma kucatshangwa ngokubaluleka kokweseka umbuso, kuyajabulisa kakhulu ukubona ukuthi inani lamaphrojekthi abe neqhaza ekwandiseni amandla kahulumeni lenyuke cishe ngama-50%.

Ngaphezu kwamasu avele ekhona, izinhlelo, izinqubomgomo nezinhlelo, abakwa-CSIR baphinde basabele futhi bafake isandla ekuqalisweni kokusebenza koHlelo lukahulumeni waseNingizimu Afrika Lokwakhiwa Kabusha NokuVuselelwa Komnotho (ERRP). I-ERRP iwuhlaka lwenqubomgomo oluyisiqondiso oluzama ukugadla emva komthelela wobhubhane lwe-Covid-19 emnothweni waseNingizimu Afrika. Lolu hlelo luhlonze imboni yezokuvikela kanye nobuchwepheshe bezindiza emkhathini – indawo ehlinzekwa kakhulu yi-CSIR – njengesemqoka ekukhuleni komnotho.

Ezinye izinhlelo ezibalulekile lapho i-CSIR ibambe khona futhi esazokhubeka nokubamba iqhaza elikhulu yileyo yeSu Lokucatshangwa Kabusha Kwezimboni eNingizimu

Afrika nokwenziwa uMnyango Wezohwebo, Izimboni kanye Nokuncintisana (i-**dtic**); izinhlelo ezinkulu zomkhakha we-**dtic** kanye neModeli yokuThuthukiswa kwesiFunda.

Zonke lezi zinhlelo, njengomgomo wazo oyinhloko, ziye zasungula izimboni ezintsha futhi zaziqinisa lezo ezivele zikhona emizamweni yokuphishekela ukukhula ngokuphindaphindiwe kwamathuba omsebenzi. Njengoba isishicilelo se-13 se-South Africa Economic Update sichaza ukuthi ukuphela kwemisebenzi ezikhathini zobhubhane lwe-Covid-19 kubhubhise kakhulu kubantu abahola kancane, nokubhebhethekisa nakakhulu isihlava sokungalingani okuvele kudlulele kakhulu phakathi kwabantu bakuleli, naphezu kwemizamo kahulumeni efike ngokushesha futhi eyeseka abampofu, abakwa-CSIR bamelwe umsebenzi omkhulu wokuba bahlomise izimboni ezikhona, bathuthukise lezo ezintsha futhi baqinisekise ukuthuthukiswa kwamakhono anele nokumeleleka.

Izinqubomgomo zezimboni ziyaqhubeka nokugqamisa ezesayensi, ezobuchwepheshe kanye nokusungulwa kwezinto ezintsha njengento esemqoka ekuthuthukisweni kwezimboni, nokuvumelana ukuthi imikhakha eminingi kungenzeka – futhi kufanele – iguqulwe futhi ivuselelwe ngokusebenzisa okusha okusunguliwe kwezobuchwepheshe kanye nobudlelwane obuqhutshwa umthelela owenziwayo phakathi kwezinkampani zikahulumeni nezizimele.

Abantu abanenjongo

NgoMasingana wezi-2022, sibe nenhlanhla yokuba sikwazi ukwelula inkontileka ye-CSIR noMphathi wethu Omkhulu uDkt Thulani Dlamini ngeminye iminyaka emihlanu. Ngaphansi kobuholi bakhe, abakwa-CSIR babekwe kabusha ukuze bahambisane nezidingo zezimboni zaseNingizimu Afrika ngokwenza ukuhweba kobuchwepheshe bayo kanye noguquko lwesisekelo sezesayensi, ezobunjiniyela kanye nezobuchwepheshe. Inhlangothi manje seyaziwa kakhulu futhi isifinyeleleka kalula kubantu.

Kuyinto engephikiswe ukuthi mkhulu umsebenzi osasibhekile. Kodwa-ke, izinguquko inhlangothi eya yabhekana nazo ukuze iqinise umgudu wayo wokukhula kanye nobudlelwane bayo nabantu besizwe sakithi ngaphansi kobuholi bukaDkt Dlamini ziyisisekelo esiqinile, ikakhulukazi uma ucabanga ukuntengantenga obekungalindelekile kwesimo somnotho emphakathini kule minyaka emibili edlule.

Ngedlulisa ukubonga kwami kuDkt Dlamini, ithimba lakhe lobuholi kanye nabasebenzi bakwa-CSIR ngokuzibophezela kwabo ekubhekaneni nokungaqiniseki okungenakugwenywa 'kwesigaba sokuba mdala' – ukuthatha isibopho sokusebenzisa ngokungaguquki kokubili ubuhlakani nokuvuthwa ngokomqondo uma kuza ezindabeni ezithiya ukukhula kwesizwe sethu.

Nakuba imithetho, iziqondiso kanye nezindlela zokuziphatha kungamathuluzi okuqondisa abalulekile, ukwehluleka kwako ukuletha ushintsho kubonakala ngokucace bha lapho sekugqathaniiswa nentshisekelo esuke iqhuba labo abaqokwe futhi bahlonyiswa ukuba bamukele kuhlangukiswa nabantu abashisekayo abaqokwe futhi bahlonyiselwe ukwamukela nokukhuthaza ushintsho. Yilokhu esikubonile kwa-CSIR kulo nyaka odlule.

Ngibonga uNgqongqoshe wezeMfundo ePhakeme, ezeSayensi Nokusungula, uDkt Bonginkosi 'Blade' Nzimande, nomnyango wakhe ngokuqhubeka njalo nokungeseka kanye nokusiqondisa endleleni yethu, kanye namalungu engikanye nawo kuBhodi ngokuzibophezela kwawo ekufezeni injongo enhle yehlangothi.



USolwazi Thokozani Majosi
USihlalo weBhodi

SEPEDI - KAKARETŠO YA MODULASETULO

Boto ya Maikarabelo e kgonthišetša gape phethagatšo ya dinyakwa tša Molao wa Khansele ya Dinyakišišo tša Saense, wa 1988 (Molao wa 46 wa 1998) le ditaolelo tše dingwe tšeo di hlalago, gape e swanetše go lekodišiša gabotse go ba maleba mo go tšwelago pele ga khansele mo go šoganeng le dilo tše bohlokwa tša tšhoganešo tša ekonomi ya leago ya naga. Go tlaleletša, e kgonthiše gore CSIR e thekga le go baekanya mekgwa ya go sekaseka le dišhepedišo go kgonthiše gore dipego le diphatlatatšo di theilwe godimo ga dišhekatsho tša go kwagala.

Legatong la Boto ya Maikarabelo, nka, ka boitshepo, bolela gore CSIR e itokotše gabotse go magato a ka moka.

Le ge go le bjalo, ke rata go boela morago go tšwa go kakaretšo ya tšhekatsho ya bobedi Boto le CSIR go nepiša ka bokopana go phetogo – khuetšo le legato leo le ka se swarego ka polelo ye botse ya tikologo ya taolo.

Go gola ka diphetogo

Ye ke Pego ya Ngwaga le Ngwaga ya CSIR ya bošupa yeo ke thabetšego go e sekaseka. Nakong ye, go bile le diphetogo mo legatong la Boto. Ke šomile le Bahlankedibagolophethiši (diCEO) ba babedi, ka itemogela tšhekatsho ya mekgatlo ya go feta o tee, phetogo ye kgolo ye tee ya mokgatlo, mekgwa wo moswa wa mokgatlo, leuba la maphelo la lefase le tee, kokešego ya dintwa tša dilete, kokešego ya go hlobaetša dišhenyagelo tša go phela gomme tše ka moka di bolelang go ekonomi yeo e šetšego e gwahlafetše.

Mengwaga ye mebedi ya go feta, mo matswalong a mokgato a bo 75, ge tšhenyo ya Covid-19 e sa le ye mpsha, ke boletše gore ka moka re sa le bana, ka moka re makatše, re leka go kwešiša seo se diragalago mahlong a rena. Ka ba le tšhepo ya gore re tla ithuta kudu ka moo go kgonegago, gore ge re gola, re na le se sengwe sa go re phediša.

Ke moka, ke bone maatla a mokgatlo go fetoga, e sego fela gore re phele, eupša go dira gore seo se diragalago ka dilaporotoring le diphapošing tša dikopano se kgahliše ka tsela yeo di tla holago Mafrika Borwa mo go bonagalago. Albert Einstein o begilwe go ba a boletše ka tsela ye, “Bogolo bja bohloke ke bokgoni bja go fetoga.” Ntle le go ikgantšha, ke rata go tlaleletša gore mohlomongwe ke tekanyo ya go gola yeo e lego bokgoni bja go fetoga. Naa re gotše? Ke tla leka karabo ka moya wo mobotse, yeo e matlafatšago ke temošo ya gore kgolo ya rena ka bohloke e swanetše go tšwela pele gammogo le boikgafo bja rena bja go tšwela pele go ithuta bjalo ka bana.

Go lahlegelwa, eupša gape le go thopa

CSIR e dutše e se ya bolokega go dikhuešo tša kgolo ya fase ya ekonomi. Se se amile phethagatšo ya mekgwa wa mokgatlo wo moswa, le dikgatelelo tšeo di okedišwego mo dinyakišišong tša intasteri, dinyakišišo tša dikontraka le tšweletšopele (R&D),

tšweletšo nakong ya magato a go dula ka gae a godimo mo ngwageng wa go bega, ditumelelano tša go hira le badudi, diitelego tša go hwetša didirišwa tšeo di thekgwago ka diitšhelete ke mmušo, le kabo ya mohlaga yeo e imelwago.

Le ge go le bjalo, CSIR e fihleletše goba e fetile go feta 80% ya ditaetši tša diphephagatšo tša yona tša motheo tša ngwaga wa go bega wa 2021/22. Tša go lekana le diphatlatatšo di gona, ka ge e le dikgopelo tša molaleng tše bohlokwa, palo ya bathekgi ba theknološi, palo ya diheknološi tša gae le palo ya dikgwebo tše dinnyane, dikgwebo tša magareng le dikgwebopotlana. Ditumelelano tša laesense ya theknološi – karolo ya kgolo ya fase mo mengwageng ya go feta – e gotše ka 300%.

Mananeo a dinyakišišo tša CSIR a šogana le dilo tše bohlokwa tša setšhaba bjale ka ge Mopresidente wa Afrika Borwa a boletše, gomme a sepelelana le mekgwa ya setšhaba ya go fapana le ditlhako, go swana le Leano la Tlhabollo la Setšhaba, Tlhako ya Peakanyo ya Kotara ya Gare ya 2019-2024, le dipholisi tša setšhaba, kudu tša Kgoro ya Saense, Theknološi le Kaonafatšo. Go lebeletšwe bohlokwa bja go thekga mmušo, go kweša bohloko go bona gore palo ya diprotšeke tšeo di kgathago tema go oketšeng bokgoni bja mmušo di oketšega ka tekano ya 50%.

Go tlaleletša mekgwa ye e šetšego e le gona, maano, dipholisi le ditlhako, CSIR e araba gape le go kgatha tema phethagatšo ya Leano la Kagoleswa ya Ekonomi le Tsošološo ya Mmušo wa Afrika Borwa (ERRP). ERRP ke tlhako ya pholisi ya tlhahlo go arabela khuetšo ya leuba la Covid-19 mo ekonoming ya Afrika Borwa. Tlhako ye e utollago tšhireletšo le intasteri ya lefaufau – karolo yeo e lekolwa gabotse ke CSIR – bjalo ka motheo wa kgolo ya ekonomi.

Mananeo a mangwe ao CSIR e kgathilego tema gomme e tla tšwelago pele go kgatha tema ye bohlokwa ke Mokgwa wa Intasteri ya Go thoma Leswa wa Afrika Borwa ka Kgoro ya Kgwebo, Intasteri le Phadišano (**dtic**); maano a magolo a lekala la **dtic** le Mmotlolo wa Tlhabollo ya Selete.

Mananeo a ka moka a na le, bjalo ka molao wo motheo, tlhoko ya diintasteri le matlafatšo ya diintasteri tše di lego gona go kgahlego ya kgolo ya thwalo ye e oketšegegago. Ka kgatišo ya 13 ya Mpshafatšo ya Ekonomi ya Afrika Borwa yeo e bolelago gore tahlegelo ya mošomo nakong ya Covid-19 ga e lekanele go lebeletšwe bao ba hwetšago letseno la fase, seo se šetšego se mpafetše ke go se lekalekane go go šoro, go se na taba le karabo ye bohlokwa ya mmušo le go lwantšha bohloki, CSIR e fokoditše mošomo wa yona go matlafatša diintasteri tšeo di lego gona, ya dira tše diswa le go kgonthiše gore go godiša mabokgoni a maleba le kemelo.

Dipholisi tša intasteri di tšwela pele go gatelela saense, theknolotši le kaonafatšo bjalo ka motheo go tšweletšopele ya intasteri, go amogela gore makala a mantši a ka dira – gape a swanetše – go fetošwa le go matlafatša ka dikaonafatšo tša theknolotši le diitirishano tša khuetšo ye e nepišwago gare ga makala a setšhaba le a praebete.

Batho ba go ba le nepo

Ka Pherekong 2022, re hlomphele ka go katološa kontraka ya CEO ya CSIR Ngaka Thulana Dlamini ka mengwaga ye mengwe gape ye mehlano. Ka fase ga boetapele bja gagwe, CSIR e fetošitšwe go sepelelana le dinyakwa tša intasteri tša Afrika Borwa ka go bapatša ditheknolotši tša yona le phetošo yeo e theilwego go saense, boentšhenere le theknolotši. Mokgatlo o bonagala kudu gape o fihlelelega kudu.

Ka nnete, go na le mošomo wo montši kua pele. Le ge go le bjalo, diphetogo tšeo mokgatlo o di dirilego go matlafatša tsela ya kgolo ya yona le go ba maleba go batho ba naga ya rena ka fase ga nako ya Ngaka Dlamini di šoma bjalo ka motheo wo o tiilego, go lebeletšwe tšhitišo ya ekōnomi ya leago yeo e bego e se ya letelwa ya mengwaga ye mebedi ya go feta.

Ke leboga Ngaka Dlamini, sehlopha sa gagwe sa boetapele le bašomi ba CSIR ka boikgafo bja bona go sepedišeng seo se tlwaelegilego sa go se belatša 'bogolo' – go tšea maikarabelo a go phethagatša nako le nako bohale le go gola go ditaba tšeo di ditelago kgolo ya naga ya rena.

Le ge melao, melawana le melao ya maitshwaro e le didirišwa tšeo di hlalago tša bohlokwa, go se be le mohola ga tšona ga motheo go dira diphetogo go bonagala gabotse ge di kopantšhwa le batho bao ba nago le lerato bao ba thwetšwego le go matlafatšwa go amogela le go huetša phetogo. Se ke seo re se bonego go CSIR mo ngwageng wa go feta.

Ke leboga Tona ya Thuto ya Godimo, Saense le Kaonafatšo, Ngaka Bonginkosi "Blade" Nzimande, le kgoro ya gagwe ka thekgo le tlhahlo ya bona yeo e tšwelago pele, gammogo le maloko a badirišani ba Boto ka boikgafo go hola mokgatlo.



Profesa. Thokozani Majosi
Modulasetulo wa Boto

MESSAGE FROM THE CEO



Dr Thulani Dlamini
Chief Executive Officer

It is my pleasure to present the CSIR's 2021/22 Annual Report. This report serves two purposes. Firstly, as is customary and legislated, it accounts for the organisation's use of its resources, from financial and human to infrastructure, and the prudent governance of the myriad building blocks that contribute to achieving its mandate.

Against the backdrop of the relevant Acts, policy documents, priority interventions led by government and needs articulated by industry, it tells the story of how we work and what we have to show for our efforts. This has become increasingly important in a changed world of work, but it also reminds us and our stakeholders that within the borders of the impressive campuses of the CSIR, or working from home, or in the field with partners, is a cohort of knowledgeable and determined people sharing and honing their expertise in collaboration with others for the improvement of life for all.

Several international and local reports give a gloomy projection of economic recovery post-Covid-19. It would be unwise to completely "bury one's head in the sand" and ignore such a sobering reality. That said, it would be equally unwise to accept the reports as a fait accompli, simply bracing for the worst as a last course of action.

Fortunately, that is not the way of South Africans nor is it that of the CSIR. So, while we are cognisant of the risks, the rising unemployment levels, increasing poverty and so forth, we take comfort in the knowledge that our strategy had incorporated means to mitigate these challenges long before the pandemic. What has changed is the urgency – the need to scale up sooner than anticipated. It has confirmed one of our strategy's main foundations – that we must work more closely and more intentionally with industry, government, academia and civil society. It has confirmed that the enhanced industrial focus of our strategy is spot on, and strengthened our focus on fourth industrial

revolution technologies, and our empowering of entrepreneurs and small, medium and micro enterprises (SMMEs) (we supported 99 SMMEs in the areas of agriculture, health, ICT, aerospace and defence during the reporting year). The studies that I refer to also mention that these areas will be key in effecting a much-needed turnaround in the global economy.

The issue of unemployed youth has also been highlighted as one of the country's key priorities. In response, in 2020, the CSIR partnered with the Youth Employment Service (YES) as part of its commitment to the inclusive advancement of society through youth empowerment. The initiative prepares young people for employment by providing them with technical skills and relevant work opportunities. During the reporting year, we enrolled 55 unemployed youths in the YES programme, who were placed at the CSIR and in partner SMMEs.

By aligning our offerings with market needs, we address funding constraints by increasing private sector and international income. However, income from the public sector remains key as services and technology solutions to public institutions enable the fulfilment of the CSIR mandate and our strategic objectives. During the year under review, we increased our performance in joint technology development activities with industry and international partners.

As our Annual Financial Statements attest, the CSIR is in a strong financial position. We have exceeded our target margin and continue to drive the diversification of our income streams. Our current and liquidity ratios have improved compared to the



Good governance is non-negotiable as **an enabler of excellent and sustainable work**. We aim to maintain an unqualified audit outcome, keep a good safety record and **maintain our Level 1 Broad-Based Black Economic Empowerment** rating.

previous financial year and so has our overall cash position. While contract income (R1 917 million) has exceeded that of 2020/21 by 1%, it is 10% less than the target for 2021/22. At R726 million, the baseline Parliamentary Grant income has increased by 8%.

The multidisciplinary nature of the CSIR allows us to support many sectors in industry, namely, mining, healthcare, chemicals, agriculture and food, defence and security, manufacturing, built environment, water, environmental sustainability, energy and smart mobility sectors, together with the digitisation of government and public and private institutions.

I am pleased to report an overall performance improvement compared to the previous financial year. We have also exceeded a number of our KPI targets. To mention a few highlights, we realised a:

- 127% achievement in the number of new localised technologies;
- 114% achievement in the number of joint technology agreements implemented for industry;
- 132% achievement in the number of SMMEs supported;
- 129% achievement in the number of reports contributing to national policy development; and
- 215% achievement in the number of projects implemented to increase the capability of the state.

The CSIR instituted a 'work from home' policy, making sure that our employees have what they need to do their work, not just from a technical perspective, but also from an emotional and mental health perspective.

The CSIR's staff headcount increased to 2 209, of whom 70% (1 551) comprise the science, engineering and technology base. New appointments include 118 permanent staff, consisting of 108 black South Africans and 45 female South Africans. We also realised a 238% achievement in the number of employees involved in industry exchange programmes.

Good governance as an enabler of excellent and sustainable work is non-negotiable. We have maintained an unqualified audit outcome, kept a good safety record and maintained our Level 1 Broad-Based Black Economic Empowerment rating.

While the advent of Covid-19 has delayed the full implementation of our strategy, the next five years will see the CSIR further unlocking the potential of its innovations to make a difference, in collaboration with our partners in industry and government.

I would like to thank the CSIR Board and the Ministry of Higher Education, Science and Innovation for their continued and considerable support. The CSIR has made great strides in expanding its stakeholder base and the dialogues with partners in the public and private sectors have been invigorating, contributing immensely to the weight of our offering. Thank you to every stakeholder, partner, client and service provider who has contributed to the CSIR's 2021/22 performance.

A word of gratitude also goes to all CSIR colleagues who remain committed to our mandate and strategy.

Dr Thulani Dlamini
Chief Executive Officer

IsiZulu - Umyalezo ovela kuMphathi Omkhulu

Uma kuqhathaniswa nesendlelelo seMithetho efanele, imibhalo yenqubomgomo, imizamo yokungenelela ebalulekile okuholwa uhulumeni kanye nezidingo ezichasiswa yimboni, konke lokhu kuxoxa indaba yokuthi sisebenza kanjani nokuthi yini okufanele siyibonise ngemizamo yethu. Lokhu sekuphenduke into ebaluleke kakhulu kulesi simo sokusebenza sanamuhla esesiguqukile kwesakudala kodwa futhi kukhumbuzwa thina kanye nababambiqhaza bethu ukuthi ngaphakathi kwemingcele yezakhiwo eziithathekisiyo zakwa-CSIR, noma ukusebenzela ekhaya, noma emkhakheni nozakwethu, eqoqweni labantu abanolwazi futhi abantu abazimisele ukwabelana kanye nokucija ubuchwepheshe babo ngokubambisana nabanye ukuze kuthuthukiswe impilo yabo bonke.

Imibiko eminingana yamazwe ngamazwe neyakuleli idweba isithombe esiluvindi ngokusimama komnotho ngemuva kobhubhane lwe-Covid-19. Kungaba ubuwula ngempela “ukukushaya indiva lokhu” futhi singalinaki iqiniso elisigqolozele emehlweni nelisangulukisa ingqondo ngalolu hlobo. Sesikushilo lokho, kungaba ubuwula ngokufanayo futhi ukwamukela imibiko njengento esizoyamukela injengoba injalo, sivele nje samukele izindaba ezimbi kakhulu njengesinyathelo sokugcina.

Ngenhlahlala, leyo akuyona indlela abantu baseNingizimu Afrika noma abakwa-CSIR abenza ngayo izinto. Ngakho-ke, nakuba sibazi ubungozi, ukukhuphuka kwamazinga okuntuleka kwemisebenzi, ukwanda kobubha nokunye, sithola ukududuzeka ngokwazi ukuthi isu lethu lididiyele izindlela zokudambisa lezi zinselele nangaphambi kokuhlasela kwalolu bhubhane. Okushintshile nje indlela okuphuthuma ngayo – isidingo sokukhuphula ngokushesha kunalokho obekulindelwe. Kuqinisekise esinye sezisekelo eziyinhloko zesu lethu – ukuthi kufanele sisebenzisane eduze nangokwengeziwe nangokuyinhloso nezimboni, uhulumeni, ezemfundo kanye nezinhlangano zomphakathi. Kuqinisekise ukuthi ukugxila okuthuthukisiwe ezimbonini zesu lethu kushaya emhloveni, futhi kuqinise ukugxila kwethu kwezobuchwepheshe besine benguquko yezimboni, kanye nokuhlomisa kwethu osomabhizinisi kanye namabhizinisi amancane, aphakathi nendawo nasafufusa (ama-SMME) (seseke ama-SMME angama-99 emikhakheni yezolimo, ezempilo, i-ICT, ezobuchwepheshe bezindiza nasemkhathini kanye nezokuvikela phakathi nonyaka okubikwa ngawo). Ucwangingo engikhuluma ngalo luphinde luveze ukuthi le mikhakha izoba semqoka ekwenzeni izinguquko ezidingeka kakhulu emnothweni womhlaba.

Udabalwentsha engasebenzi luphindelwagqanyiswanjengenye yezinto eziseqhulwini kuleli. Ukuphendula kulokhu, ngonyaka wezi-2020, abakwa-CSIR babambisane ne-Youth Employment Service (i-YES) njengengxenywe yokuzibophezela kwabo ekuthuthukisweni komphakathi okubandakanya wonke umuntu ngokuhlomisa intsha. Lo mzamo ulungiselela abantu abasha ukuthi balungele ukungena emisebenzini ngokubahlinzeka ngamakhono obuchwepheshe kanye namathuba omsebenzi afanelekile. Kulo nyakamali okubikwa ngawo, sibhalise intsha engasebenzi engama-55 ohlelweni lwe-YES, eyabe isifakwa kwa-CSIR kanye nakuma-SMME esisebenzisana nawo.

Ngokuqondanisa izinsizakalo esizihlinzekayo nezidingo zezimakethe, sibhekana nezingqinamba zokuthola izimali ngokwandisa imali engenayo ivela embonini ezimele kanye nasemazweni ngamazwe. Kodwa-ke, imali evela embonini kahulumeni kuselokhu kuyiyona esemqoka kakhulu ngoba izinsizakalo nezixazululo zezobuchwepheshe ezihlinzekwa izikhungo zikahulumeni yizo ezisiza ukufeza igunya labakwa-CSIR kanye nezinjongo zamasu ethu. Kulo nyaka obukezwayo, sikhulise ukusebenza kwethu emisebenzini ehlanganyelwe yokuthuthukisa ubuchwepheshe nezimboni kanye nozakwethu bamazwe ngamazwe.

Njengoba izitatimende zethu Zezezimali Zonyaka zifakaza, abakwa-CSIR bami kahle kakhulu ngokwezezimali. Size saweqa nomkhawulo ebesizibekele wona futhi siyaqhubeka nokugugquzela imithombo yethu eyahlukahlukeni esingenisela imali. Izilinganiso zethu zamanje kanye namandla okukwazi ukukhokha izikweletu zethu kungcono kakhulu uma kuqhathaniswa nonyakamali odlule kanjalo nesimo sethu nje sonkana sezimali. Nakuba imali yenkontileka (izigidi eziyi-R1 917) yeqe leyo yonyaka wezi-2020/21 ngo-1%, ingaphansi ngama-10% kunobekuhlosiwe ngonyakamali wezi-2021/22. Njengoba isisekelo seSabelomali semali engenayo sePhalamende siyizi-R726 million, kusho ukuthi senyuke ngama-8%.

Ukusebenza ngemikhakha eyahlukahlukeni kwe-CSIR kusivumela ukuthi seseke imikhakha eminingi yezimboni, lapha sibala, ezezimayini, ezokunakekelwa kwempilo, ezamakhemikhali, ezolimo nokudla, ezokuvikela nokuvikeleka, ezokukhiqiza, imvelo eyakhiwe, ezamanzi, ukusimama kwemvelo, ezamandla kanye nemikhakha yokuhamba ngobuhlakani, kanye nokuqaliswa kokusebenza ngokudijithali kwezikhungo zikahulumeni nezikhungo ezizimele.

Nginentokozo enkulu ukubika ngendlela esiqhube ngayo umsebenzi wethu wonkana uma kuqhathaniswa nonyakamali odlule. Siphinde seqa inani lezinjongo zethu ebesizihlosile zama-KPI. Ukubala nje amaphuzu ambalwa avelele, siqaphele lokhu:

- impumelelo ye-127% enanini lobuchwepheshe obusha bendawo;
- impumelelo ye-114% enanini lezivumelwane ezihlanganyelwe kwezobuchwepheshe eziqaliswe ukusebenza embonini;
- impumelelo ye-132% enanini lama-SMME asekiwe;
- impumelelo ye-129% enanini lemibiko eneqhaza ekuthuthukisweni kwenqubomgomo kazwelonke; kanye
- nempumelelo yama-215% enanini lamaprojekthi aqalisiwe ukuze kukhuliswe amandla kahulumeni.

Abasebenzi bethu

Abakwa-CSIR basungule inqubomgomo 'yokusebenzela ekhaya', baqinisekisa ukuthi abasebenzi babo banalokho abakudingayo ukuze benze umsebenzi wabo, hhayi nje ngasohlangothini lwezobuchwepheshe, kodwa nangasohlangothini lwezempilo yemizwa nengqondo.

Isibalo sabasebenzi bakwa-CSIR sikhuphuke safinyelela ezi-2 209, kanti kuleso sibalo ama-70% (1 551) aso abandakanya abasebenzi besizinda sezesayensi, ezobunjiniyela nezobuchwepheshe. Abasanda kuqashwa ngokugcwele babandakanya abasebenzi abayi-118, okuhlanganisa abamnyama baseNingizimu Afrika abayi-108 nabesifazane baseNingizimu Afrika abangama-45. Siphinde sakwazi ukufinyelela ama-238% enani labasebenzi ababandakanyeka ezinhlelweni zokushintshisana ezimbonini.

Ukuphathwa kwabasebenzi okuhle njengesizathu okuyisona imbangela yomsebenzi oncomekayo futhi ozinzile kuyinto edingekayo. Sikwazile ukugcina umphumela wocwaningomabhuku ongenagcobho, sagcina irekhodi lethu elihle lokuphepha futhi sangaphunyukwa isilinganiso sethu ezingeni loku-1 lokuHlonjiswa Ngokubanzi Kwabantu Abamnyama Kwezomnotho, phecelezi i-Broad-Based Black Economic Empowerment.

Nakuba ukufika kobhubhane lwe-Covid-19 kubambezele ukuqaliswa kokusebenza ngokugcwele kwesu lethu, eminyakeni emihlanu ezayo sizobona i-CSIR iqhubeka nokuvulela amandla ezinhlelo zayo ezintsha zokwenza umehluko, ngokubambisana nozakwethu embonini nakuhulumeni.

Ngithanda ukubonga iBhodi lakwa-CSIR kanye noMnyango Wezemfundo Ephakeme, Isayensi Nokuyanjiwa Kwezinto ngokuqhubeka kwabo ukweseka okukhulu. Abakwa-CSIR sebehamba ibanga elide ekwandiseni isisekelo sababambiqhaza babo nezingxoxiswano nabalingani emikhakheni kahulumeni nembali ezimele bezilokhu zivuselela, zaba negalelo elikhulu esisindweni somsebenzi esiwuhlinzekayo. Sibonga bonke ababambiqhaza, ozakwethu, amakhasimende kanye nabahlinzeki ngezinsizakalo abafake isandla ekusebenzeni kwe-CSIR kunyakamali wezi-2021/22.

Sidlulisa amazwi okubonga kubo bonke ozakwethu bakwa-CSIR abalokhu beqhubekile nokuzibophezela emigomweni namacebo ethu.



UDkt Thulani Dlamini
Isikhulu Esiphezulu, CEO

SEPEDI - Molaetša go tšwa go CEO

Kgahlanong le botšo bja Melao ya maleba, ditokumente tša pholisi, diisenogare tše bohlokwa tše di etilego pele mmušo gomme e swanetše go bolelwa ke intasteri, e anega kanegelo ya ka moo re šomago le seo re swanetšego go se bontšha go maitapišo a rena. Se se bohlokwa kudu mo lefaseng le le fetogago la mošomo, eupša e gopotša gape rena le bakgathatema ba rena gore ka gare ga mellwane ya dikhamphase tša go kgahliša tša CSIR, goba go šoma o le gae, goba ka ntle le badirišani, ke lekala la batho ba go ba le tsebo gape ba maikemišetšo bao ba abelanago le go kaonafatša bokgoni bja bona ka tirišano le ba bangwe go kaonafatšeng bophelo bja batho ka moka.

Dipego tše mmalwa tša boditšhabatšhaba le tša gae di tšweletša kakanyo ya go se kgahliša ya tsošološo ya ekonomi ka morago ga Covid-19. E ka se be bohlale “go boloka hlogo ya motho ka mohlaleng” ka botlalo gomme wa hlokomologa nnete ye ye šoro. Ka gona, e ka se be bohlale gape go amogela dipego bjalo ka dilo tše di šetšego di diragetše, go no hlohletša tše dibe le go feta bjalo ka kgato ya mafelelo.

Mahlatse, se ga se mokgwa wa Maafrika Borwa goba wa CSIR. Ka gona, ka ge re lemoga dikotsi, magato ao a golelago pele a mošomo, koketšego ya bohloki le tše dingwe, re thabela go tseba gore mokgwa wa rena o na le mekgwa ye e kopantšwego ya go fokotša ditlholo pele ga leuba. Seo se fetogilego ke tšhoganešo – tlhokego ya go oketša ka pela go feta ka moo go bego go gopotšwe. Go matlafadiše wo mongwe wa metheo ya mekgwa ya rena – le gore re swanetše go šoma kgauswi kudu le go šoma ka boditšhabatšhaba le intasteri, mmušo, thuto le setšhaba sa selegae. Go kgonthišetšwe nepo ya intasteri ye e kaonafadišwego ya mokgwa wa rena wa thwii, le go matlafatša nepo ya rena mo ditheknološing tša phetogo ya intasteri ya bone, le go matlafatša borakgwebo ba rena le dikgwebo tše dinnyane, dikgwebo tša magareng le dikgwebopotlana (diSMME) (re thekgile diSMME tše 99 mo dikarolong tša temo, maphelo, ICT, le faufau le tšhireletšo mo ngwageng wa go bega). Dinyakišišo tše ke bolelago ka tšona di bolela gape gore dikarolo tše e tla ba motheo mo go tšweletšeng kaonafatšo ye e nyakegago mo ekonoming ya lefase.

Bothata bja go hloka mošomo le bjona bo tšweleditšwe bjalo ka selo seo se swanetšego go hlokomelwa kudu mo nageng. Go arabela, ka 2020, CSIR e šomišane le Tirelo ya Mešomo ya Bafsa (YES) bjalo ka karolo ya boikgafo bja yona go tlhabollo ya kakaretšo ya setšhaba ka matlafatšo ya bafsa. Lenaneo le beakanyetša bafsa mošomo ka go ba fa mabokgoni a sethekniki le dibaka tša mošomo tša maleba. Nakong ya ngwaga wa go bega, re ngwadišetšwe bafsa ba go se šome ba 55 mo lenaneong la YES, bao ba thwetšwego ke CSIR ka tirišano le diSMME.

Ka go nyalantšha dikabo tša rena le dinyakwa tša mmaraka, re šogana le mathata a thekgo ka go oketša letseno la lekala la praebete le la boditšhabatšhaba. Le ge go le bjalo, letseno

go tšwa lekaleng la setšhaba le dula e le motheo ka ge ditirelo le diharollo tša theknološi mo diinstitušeneng tša setšhaba di kgontšha go phethagatšwa ga taolelo ya CSIR le dinepo tša rena tše di beakantšwego. Mo ngwageng wa tshekatsheko, re okeditše phethagatšo ya rena ka mešongwana ya kaonafatšo ya ditheknološi tše di kopanetšwego le badirišani ba intasteri le ba boditšhabatšhaba.

Ka ge Ditatamente tša Dišhelete tša Ngwaga le Ngwaga di bontšha, CSIR e maemong a maatla a dišhelete. Re fetile magomo a selebanywa sa rena gomme re tšwela pele go hlohletša phapano ya dikarolo tša letseno la rena. Dišhelete tša rena di kaonafetše ge di bapetšwa le ngwaga wa dišhelete wa go feta le maemo a rena a tšhelete ya kheše ka kakaretšo. Mola letseno la dikontraka (R1 917 milione) le fetile la 2020/21 ka 1%, le fase ka 10% go feta selebanywa sa 2021/22. Ka R726 milione, letseno la motheo la Thekgo ya Palamente ya moagomo le oketšegile ka 8%.

Mokgwa wa kakaretšo wa CSIR o re dumelela go thekga makala a mantši ka intasteri, e lego, meepo, maphelo, dikhemikhale, temo le dijo, tšhireletšo, tšweletšo, tikologo ya kago, meetse, tshwarelelo ya tikologo, enetši le makala a dinamelwa tša theknološi, gammogo le go dira gore mmušo le diinstitušene tša setšhaba le tša praebete di šomiše didirišwa tša tišitale.

Ke thaba go bega kaonafalo ya phethagatšo ya kakaretšo go bapetša le ngwaga wa dišhelete wa go feta. Re fetile gape palo ya dilebanywa tše rena tša KPI. Go bolela dintlha tše bohlokwa, re lemogile:

- Katlego ya 127% ka palo ya ditheknološi tša gae;
- Katlego ya 114% ka palo ya ditumelelano tša ditheknološi tša kopanelo tše di phethagadišeditšwego intasteri;
- Katlego ya 132% ka palo ya diSMME tše di thekgwago;
- Katlego ya 129% ka palo ya dipego tše di kgathago tema go tlhabollo ya dipholisi tša setšhaba; le
- Katlego ya 215% ka palo ya diprotšeke tše di phethagadišwego go oketša bokgoni bja mmušo.

Bašomi ba rena

CSIR e thomile pholisi ya go šomela gae, ya kgonthiša gore bašomi ba rena ba na le seo ba se hlokago go kgona go dira mošomo wa bona, e sego fela lehlakoreng la sethekniki, eupša le ka lehlakoreng la maikutlo le maphelo a monagano.

Palo ya bašomi ba CSIR e goletše go 2 209, moo 70% (1 551) e akaretšago saense, boentšenera le theknološi. Dithwalo tše diswa di akaretša bašomi ba go ya go ile ba 118, bao Maafrika Borwa a Bathobaso e lego 108 gomme 45 ke Maafrika Borwa a basadi. Re lemogile gape gore dikatlego tša 238% mo palong ya bašomi e amaga mananeong a kgwebišano ya intasteri.

Taolo ye botse bjalo ka mokgontšhi wa bokgoni le mošomo wa go swarelela ke kgapeletšo. Re hweditše dipelo tša tlhakišo ye botse, ra swara rekoto ya polokego ye botse gomme ra swarelela Legato la 1 la tekanyetšo ya Matlafatšo ya Ekonomi ya Bathobaso ya Motheo wa Kakaretšo.

Le ge go thoma ga Covid-19 go ditetše phethagatšo ka botlalo ya mokgwa wa rena, mengwaga ye mehlano yeo e latelago re tla bona CSIR e tšwela pele go bula bokgoni bja dikaonafatšo tša yona go dira phapano, ka tirišano le badirišani ba rena mo intastering le mo mmušong.

Ke rata go lebaoga Boto ya CSIR le Tona ya Thuto ya Godimo, Saense le Kaonafatšo ka thekgo ya bona ye kgolo yeo e tšwelago pele. CSIR e dirile dikaonafatšo tše dikgolo ka go katološa bakgathatema ba yona gomme dipoledišano le badirišani makaleng a setšhaba le a praebe di dutše di hlohleletša, di kgatha tema kudu go maatla a tšeo re di abago. Ke leboga mokgathatema yo mongwe le yo mongwe, modirišani, modirelwa le moabi wa ditirelo yoo a kgathilego tema go phethagatšo ya CSIR ya 2021/22.

Ke leboga gape badirišani ba CSIR bao ba dulago ba ikgafile go taolelo le mokgwa wa rena.



Ngaka Thulani Dlamini
Mohlankedimogolophethiši

STATEMENT OF RESPONSIBILITY FOR AND CONFIRMATION OF ACCURACY OF THE ANNUAL REPORT

To the best of our knowledge and belief, we confirm the following:

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

The annual report is complete, accurate and free of 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 F) 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 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 capital 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, performance information, human resources information and financial affairs of the CSIR for the financial year ended 31 March 2022.

Yours faithfully



Chief Executive Officer
Dr Thulani Dlamini
23 August 2022



Chairperson of the Board
Prof. Thokozani Majazi
23 August 2022

STRATEGIC OVERVIEW



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 reindustrialisation 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 worldclass 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

Focuses on the commercialisation of our technologies and innovations for industrial development, as well as technology and knowledge transfer that enable 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 strive for excellence and quality in everything that we do. We always strive to deliver solutions that surpass the expectations of our stakeholders. We hold each other to the highest possible standard in research, development and innovation, as well as all other facets of CSIR business. We believe that excellence is a product of investing in the continuous development of our people, processes and ways of doing business.



PEOPLE-CENTRED

Our business is about touching the lives of people our employees and business partners. We care about people. We respect each other's diversity and conduct ourselves in a manner that upholds the dignity of every person. We believe in continuous personal development and encourage one another to seize opportunities for personal growth. We treat our stakeholders the way we like to be treated.



INTEGRITY

We act with integrity. We are honest and fair when dealing with one another and our business partners. We respect the trust that our colleagues and 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 that our work has the best chance of innovating a better future for South Africans. We actively share our knowledge and expertise by design, formally and informally, so that we can realise large-scale impact.

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



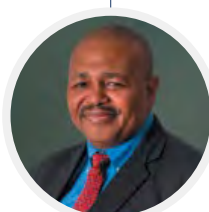
***Dr Kaven Naidoo**
Acting Group Executive:
Business Excellence and
Integration



Andile Mabindisa
Group Executive:
Human Capital and
Communications



Ashraf Dindar
Chief Financial
Officer



**Dr Motodi
Maserumule**
Group Executive:
Advanced Production
and Security



**Dr Rachel
Chikwamba**
Group Executive:
Advanced Chemistry
and Life Sciences



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

*Kaven was appointed Acting Group Executive: Business Excellence and Integration effective 1 January 2022
Khungeka Njobe was Group Executive: Business Excellence and Integration until 31 December 2021



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.

PART B

ORGANISATIONAL HIGHLIGHTS

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INVENTING A SMARTPHONE TOOL TO DIAGNOSE HIV, COVID-19, TB, HYPERTENSION AND DIABETES



An image of diffracted light that contains information about the properties of a bodily fluid sample.

Biophotonics experts at the CSIR have created a diagnostic tool that can detect illnesses in bodily fluid samples like urine, saliva and blood – using a smartphone.

The technology measures the level of light absorbed by different samples to detect and distinguish between various classes of pathogens, such as HIV, SARS-CoV-2 and Mycobacterium tuberculosis, as well as non-communicable diseases, including high blood pressure and type 2 diabetes.

Acting like a glass prism, the technology splits white light into a colour spectrum of different wavelengths. Different samples, containing different markers for illnesses, absorb light differently, and these differences are measured to detect diseases. The technology is based on a unique geometry and composition, and both hardware and software are protected as CSIR intellectual property.

Such spectroscopical measurements are typically done in sophisticated laboratories using specialised, costly equipment. By fitting the technology onto a disk the size of a South African 10 cent coin, it can be built into any smartphone. The invention of a multipurpose diagnostic product that is inexpensive, simple to use and does not need lab equipment or technicians will significantly benefit clinics and health worker teams in remote areas.

NEW DRUG SCREENING PLATFORM FOR CANCER PATIENTS



The CSIR's cancer precision medicine platform.

The CSIR has developed a high-throughput screening platform that can identify drug combinations that are effective in treating individual cancers, a key aspect in precision medicine. The platform was developed to specifically test the efficacy of approved cancer drug treatment in South African patients.

The research team aims to test the effectiveness of the drug on blood cancer samples and solid tumours, such as ovarian cancer. The platform is part of a three-year project supported by a National Research Foundation Competitive Grant, with the objective of validating and expanding the drug screening platform. This is done by screening and identifying drug candidates for diseases that affect blood-producing organs (bone marrow) and solid tumours in patients who have relapsed or are currently undergoing treatment.

The main issue with cancer treatment is the eventual resistance to standard chemotherapy, which leads to patient relapse. Relapsing or overcoming therapeutic challenges remains an unmet medical challenge in cancer patients. Therefore, it is important to develop innovative strategies that will allow the prescribing oncologist to make an informed decision when selecting or prescribing drug combinations for cancer patients.

DETECTING HIV AND TB, SIMULTANEOUSLY



A high-throughput microarray printer is used to print HIV and TB antigens on glass slides when developing assays.

The CSIR has used microarray technology to develop a point-of-care diagnostic technology that can detect the human immunodeficiency virus (HIV) and tuberculosis (TB), simultaneously.

HIV/Aids mortality is caused by opportunistic illnesses that take advantage of the weakened immune system in infected individuals. In Africa, the most common of these opportunistic illnesses include infection by *Mycobacterium tuberculosis* (M.tb), responsible for TB.

HIV and M.tb coinfection has a negative implication for disease management, because each pathogen accelerates the morbidity caused by the other. Effective management of patients infected with HIV and M.tb is restricted by the fact that their diagnosis is done separately. The situation becomes difficult in rural and remote areas where patients wait longer to obtain their TB diagnostic results.

The innovation of a multiplex HIV/TB point-of-care diagnostic technology is aimed at addressing these limitations through the simultaneous detection of HIV and M.tb in blood, which will reduce the time and cost associated with the diagnosis of these diseases.

In addition, the simultaneous detection of HIV/TB will reduce the death rate of individuals co-infected with both pathogens, as the shortening of diagnostic time provides the opportunity for quicker initiation of treatment.

The microarray-based diagnostic technology includes the development of a portable battery-powered and low-cost fluorescence detector for the detection of immune responses against the HIV p24 (viral protein) antigen and M.tb antigens.

ULTRASOUND TECHNOLOGY LICENSED



A healthcare worker uses Umbiflow to monitor fetal blood flow.

The CSIR signed an exclusive licence agreement with global medical imaging device company Lodox Systems for the transfer of its Umbiflow ultrasound technology.

Umbiflow is a medical device that uses sonar to measure the blood flow between a mother and her fetus while in the womb. The device assesses the rate of blood flow as a function of gestational age. The technology has been proven to identify pregnancy risks in women who would have been sent home as healthy mothers due to a false negative result from conventional ante-natal care protocols.

Local clinical trials were conducted in all provinces of South Africa and found that Umbiflow was able to reduce stillbirth rates by up to 50%. The World Health Organization further conducted independent trials on Umbiflow in Ghana, India, Kenya and Rwanda. Results of these studies, published in early 2022, confirmed the effectiveness of Umbiflow in reducing the stillbirth rate in other countries as well.

The Industrial Development Corporation of South Africa is the major shareholder in Lodox Systems and continues to support and fund ongoing research, development and product improvements. Umbiflow has additionally benefited from grant funding from Grand Challenges Canada (GCC) to upgrade Umbiflow to a mobile version that operates wirelessly on Android and Windows devices. GCC also funded in-country studies of target markets internationally to aid the widespread distribution and adoption of the technology.

Implementation studies are underway under the clinical leadership of the University of Pretoria, including an imminent roll out to some 70 clinics in the Tshwane district. Various organisations are expected to assist with funding for this roll out, with the first to come on board being the Clinton Health-Access Initiative, a philanthropic entity that was started by former US President Bill Clinton.

DRONE TECHNOLOGY TO SUPPORT EMERGING FARMERS WITH PRECISION FARMING

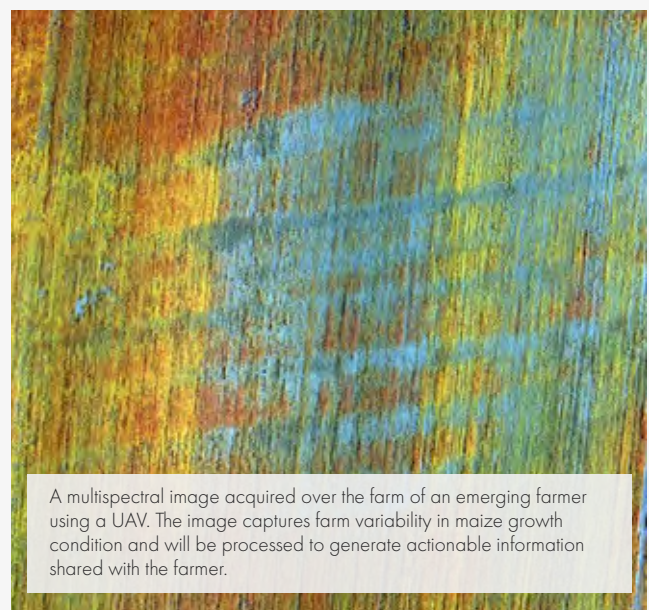


The CSIR has partnered with FarmSol Holdings, a South African Breweries partner and agricultural services company that has, to date, seeded 982 emerging farmers across nine provinces, to digitally transform its maize farming extension services using unmanned aerial vehicles (UAVs), satellite technologies and big data analytics.

The CSIR and the Agricultural Research Council worked with emerging farmers during the 2019/20 and 2020/21 growing seasons to collect data using UAVs, demonstrate the usefulness of such data, and refine precision farming methods. This forms part of efforts by the CSIR and stakeholders in agriculture to develop a precision agriculture information system. The goal is to optimise input cost, survey pests and diseases and predict yield.

UAVs (also called drones) are re-usable aircraft, piloted by remote control or onboard computers. They offer cost-effective means of bringing near real-time actionable information to support precision agriculture. Using drone imaging technology, farmers can detect and observe changes in crop growth conditions timeously, thus enabling timely decision-making to improve yield and the quality of farm produce.

The solutions under development will help emerging farmers with decision-making in the context of changing environmental conditions that present new challenge for crop health and growth.



ENABLING SMES AND RURAL COMMUNITIES TO DERIVE VALUE FROM FOOD WASTE



Thandiwe Mchunu, a CSIR bursar and small-scale farmer, produces biocompost and biogas.

The CSIR has collaborated with the United Nations Development Programme to pilot technologies to beneficiate food waste. The organisation demonstrated and transferred technologies for the efficient conversion of food waste into biogas and high-value compost, using the Bokashi process.

The CSIR-developed technology, which utilises Bokashi enzymes, demonstrated a cost-effective way to produce biogas

for cooking and heating purposes in rural and township-based households; and a biocompost that replaces chemical fertiliser applications in subsistence farming.

The researchers showed that the biogas from the food waste and cow dung contained 53.71% methane and 35.77% carbon dioxide. A one-cubic-metre digester produces 0.35 m³ of biogas per day, which is the equivalent of 2.24 to 2.91 kWh/day. They also proved that food waste can be converted into high-grade compost that can improve vegetable garden productivity by more than 20%.

From supporting a family of five in a rural setting in Umkomaas in KwaZulu-Natal as part of the technology demonstrator, the biodigester technology has been transferred to TMGG (Pty) Ltd and will be scaled up by the small and medium enterprise to bolster the use of biogas by local industries.

TMGG and Durban Green Corridors, the supplier of the Bokashi enzymes, are implementing the compost technology in a business context, selling the compost for home gardens.

Both technologies have been demonstrated at pilot scale and will be scaled up across South Africa to support green solutions in the energy and agricultural industries, while driving rural economies, using grassroots innovations.

JOINT RESEARCH ON INSECT-BASED FOOD SOURCES SECURES A 2021 WAITRO INNOVATION AWARD



Dr Nomusa Dlamini, CSIR principal researcher, and Dr Blessed Okole, CSIR research group leader for agro-processing, with the organisations' WAITRO 2021 Innovation Awards.

The CSIR and its international partners won the World Association of Industrial and Technological Research Organization (WAITRO) 2021 Innovation Award for their work on insect-based food sources to supplement nutrient deficiencies in vulnerable areas.

The project was undertaken in response to the 2021 WAITRO Innovation competition call and focused on using insect farming

technology to produce food and feed products. The call focused on new sources of marine and terrestrial food, through new forms of agriculture (such as hydroponics) that are less vulnerable to the effects of climate change.

The CSIR had undertaken earlier research on alternative protein sources for feed and food to address nutrition security and sustainability in vulnerable areas through a circular bioeconomy.

The project provided the CSIR with the opportunity to network and collaborate with international partners. Phase two of the project will focus on piloting case study demonstrations through the European Union Horizon Farm2Fork programme.

The CSIR and its partners, Spain's Leitat Technology Centre, Nigeria's Federal Institute of Industrial Research and the Thailand Institute of Scientific and Technological Research, will each receive a share of the US \$25 000 prize to continue work on their food security and sustainable agriculture projects. The research will contribute to the United Nations Sustainable Development Goal 2 that centres on achieving zero hunger by 2030.

CSIR LICENSES TECHNOLOGY FOR NEXT-GENERATION CORONA-DETECTING CAMERA



The QUVIR camera system is the latest offering in the CSIR-patented range of powerline inspection products.

The CSIR has licensed its latest corona-detecting camera system to local company UViRCO. The quantifiable ultraviolet infrared camera system, or QUVIR, is the latest in the CSIR's patented range of powerline inspection products, and a world first because of a unique, radiometric ultraviolet quantification feature.

The camera detects and visualises ultraviolet emissions – or corona – caused by electrical discharge on high-voltage transmission powerlines. Such releases indicate damage or bad installations that will result in power failures and wastage. The cameras make use of multispectral imaging technologies that are invisible to the naked eye to detect corona and can operate in daylight or darkness.

Since high-voltage installations are typically high-towering structures, which makes it difficult to spot problems from the ground, the cameras can also be used in aerial applications on helicopters or unmanned aerial vehicles to perform diagnostic inspections. Ultraviolet quantification, however, can only be performed during static inspections. Aside from powerlines, the cameras are also used for routine inspections of power substations and distribution networks.

The latest camera performs imaging in three wavebands, namely, visible, ultraviolet C and infrared. It not only detects corona emissions, but also radiometrically determines the intensity of the

ultraviolet C radiated at the source (which is a world first in such detection systems) and the temperature of the discharge location. The ultraviolet image of the discharge is overlaid on either the visible or infrared background image to accurately locate the source of the discharge, find visible damages and perform proper diagnostics and repairs.

QUVIR is the ninth product in the corona camera – or CoroCAM® – family. The first camera systems were developed by the CSIR nearly 30 years ago in response to a request from energy supplier, Eskom, for a means of detecting electricity discharges on powerlines, which were causing significant energy wastage and financial losses, and threatened electricity outages. Development of the early camera systems was funded jointly by Eskom and the CSIR, and the latest QUVIR was co-funded by Eskom and South Africa's Technology Innovation Agency.

CoroCAM® products are manufactured, assembled, tested, qualified and maintained in South Africa by UViRCO, contributing to job creation. The company was established by the CSIR in 2008 as a spin-out venture to market and manufacture the CoroCAM® brand of corona cameras. The CSIR has since sold its shares in UViRCO to the black economic empowerment company, Menston Holdings, although it continues to support UViRCO as a research and development partner.

UViRCO has captured significant market share and sold cameras internationally to utility companies in over 50 countries.

REDUCING TRACKLESS MOBILE MACHINE COLLISIONS IN MINES THROUGH A DIGITAL TWIN



The collision avoidance system can generate heat maps, which indicate mining operation areas that are vulnerable to collisions.

The CSIR has developed a trackless mobile machine collision avoidance system digital twin to predict the performance of traffic management systems in mines.

Automation in mining focuses on the development of technologies to digitalise mining operations for the enhancement of daily operations. However, collisions involving trackless mobile machines are a significant contributor to the fatalities reported in the industry.

The CSIR-led project demonstrated that a digital twin can be used by the mining sector to model the effectiveness of vehicle interaction controls, identify high-risk accident areas in the mine and evaluate the effectiveness of the risk mitigation controls. A digital twin is a virtual representation of a physical product or process, used to understand and predict the physical counterpart's performance characteristics. The use of a digital twin in this context will contribute to timely and evidence-based decision-making, including the formulation and implementation of appropriate controls to prevent trackless mobile machine accidents. The digital twin can generate heat maps, indicating which areas are more prone to such collisions.

The digital twin was developed in consultation with stakeholders in the mining sector, while the Department of Science and Innovation, Mandela Mining Precinct and Minerals Council supported a second phase of the project. The work resulted from exploration into various digital innovations that would improve operational efficiency, safety and compliance in the sector.



CSIR researcher Mvikeli Mpofu demonstrates the trackless mobile machine collision avoidance software.

CSIR-DEVELOPED TEXT-TO-SPEECH TECHNOLOGY RELEASED TO THE MARKET



CSIR technologist Moipone Ramokone using Qfrenzy text-to-speech to read websites.

The CSIR signed a licence agreement with ReadSpeaker Holding BV, a global voice specialist, for a first-of-its-kind software product that converts digital text into synthetic speech, in all 11 official South African languages.

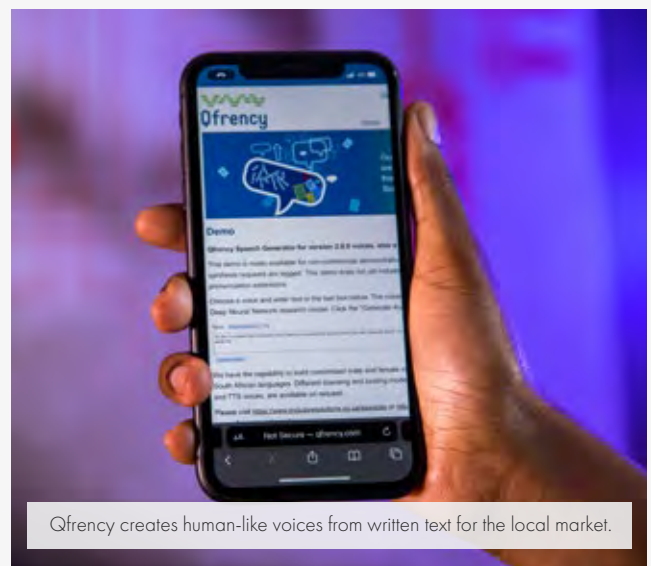
The text-to-speech system consists of a text-to-speech engine and voices that enable a computer to create and reproduce synthesised speech from written text. The text-to-speech voices can be used to read out text in South Africa's 11 official languages on a wide range of devices, such as cell phones, tablets and computers and on platforms such as Windows, Android, iOS and MacOS for a variety of clients, and is suitable for use by industry, developers and individuals.

The technology generates synthetic speech that is close to human speech in terms of articulation and accent.

The current focus of commercialisation efforts is the business-to-business sector, specifically large-volume users such as call centres for telecommunications companies, adding speech channels to chatbots employed for self-service applications by large corporations, and adding a speech modality to online learning platforms.

Ten of South Africa's official languages have been classified as resource-scarce, where resources in this context refer to digital language resources (text and speech) and research resources (research into linguistics).

While conventional reading is currently accessible only to traditionally literate individuals, uptake of the technology will help many who face barriers to reading – and consequently learning.



Qfrenzy creates human-like voices from written text for the local market.

FINDINGS ON HOW STORMS DRIVE OUTGASSING OF CARBON DIOXIDE IN THE SUBPOLAR SOUTHERN OCEAN



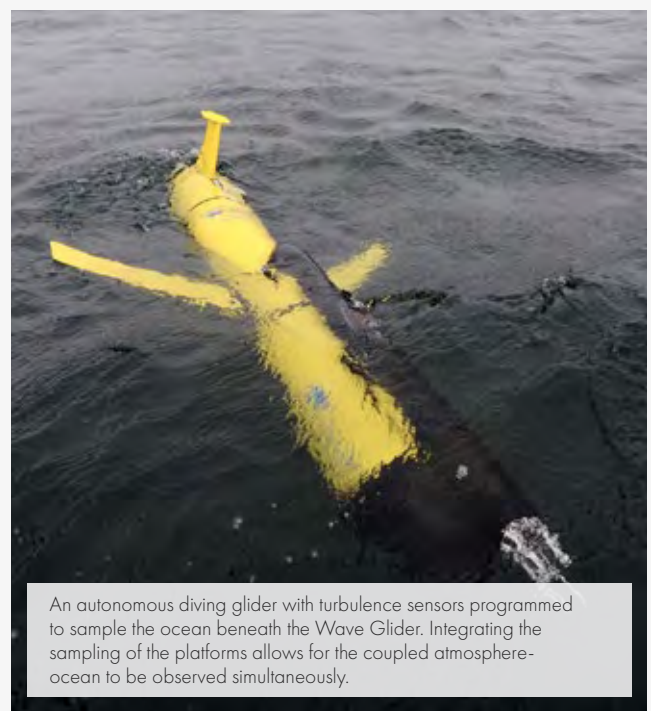
An autonomous surface vehicle, the SV3 Wave Glider, undergoing sea trials off the coast in the Western Cape. The Wave Glider measures the fluxes of momentum and carbon dioxide across the air-sea interface.

In January 2022, *Nature Communications* published CSIR-led research findings that showed, through new high-resolution observations using ocean robotics, that the impact of storms on ocean mixing is critical to understanding the present and future of the Southern Ocean carbon dioxide sink.

CSIR scientists from the Southern Ocean Carbon-Climate Observatory (SOCCO) worked with international scientists from the National Center for Atmospheric Research and the National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory (both in the United States of America), the University of Cape Town, the University of Bergen (Norway) and the University of Gothenburg (Sweden). The researchers highlighted the importance of the frequent strong storms in modulating the mean seasonal transport of carbon dioxide within and across the mixed-layer and surface ocean. The results support the hypothesis put forward by SOCCO, that storm-driven ocean physics is a significant driver in the Southern Ocean carbon cycle.

The research interest in the Southern Ocean stems from the fact that it is responsible for 50% of the ocean uptake of anthropogenic carbon dioxide and more than 70% of the excess heat generated by the accumulation of anthropogenic carbon dioxide in the atmosphere.

The study was funded by the Department of Science and Innovation, the National Research Foundation and strategic international collaborations.



An autonomous diving glider with turbulence sensors programmed to sample the ocean beneath the Wave Glider. Integrating the sampling of the platforms allows for the coupled atmosphere-ocean to be observed simultaneously.

NANOMATERIALS EXPERTS OPTIMISE BIODEGRADABLE PLASTICS FOR AGRICULTURAL USE



Compression-moulded material, suitable for use in biodegradable products.

Local biomanufacturing company LignOrganic (Pty) Ltd (formerly Eco Invader Solutions) drew on the CSIR's expertise in nanomaterials and its well-equipped Nanomaterials Industrial Development Facility for the development of new biopolymer solutions.

A new polymer formulation enables LignOrganic to produce biodegradable pellets for products such as tree-planting containers and other biodegradable plastics used in agriculture.

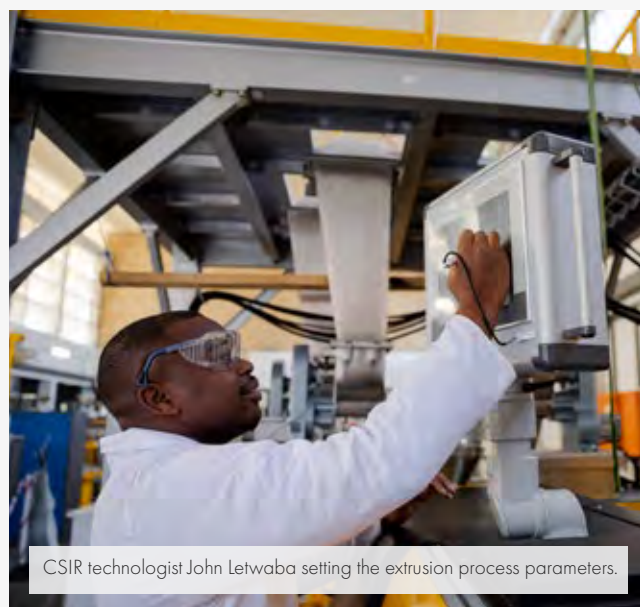
LignOrganic is known for using waste plant material to make water-soluble bioplastics. The company approached the CSIR to assist with the optimisation of its biodegradable polymer formulation. Funded by the Department of Science and Innovation Industry Innovation Partnership, the CSIR developed a new formulation and process for sustainable polymeric materials.

The research team used its knowledge in biodegradable polymers and special additives to develop a material that can be compression-moulded into usable biodegradable products.

The solutions mean that the company now has a new biodegradable plastics formulation, well-established processing parameters and quality controls, as well as a thorough understanding of what type of applications to target.

Following the signing of a licence agreement, the CSIR has transferred the technology data pack to LignOrganic to allow the company to commence with its commercialisation activities.

DEVELOPING CONSTRUCTION BRICKS WITH ENHANCED PROPERTIES



CSIR technologist John Letwaba setting the extrusion process parameters.

The CSIR assisted local carbon nanotube manufacturer SabiNano with the development of carbon nanotubes containing polymer nanocomposites suitable for the manufacture of construction bricks.

SabiNano called on the CSIR to assist with the formulation and test-scale production of polymer composites that contain filler materials such as bitumen, rubber waste powder and carbon nanotubes intended for plastic bricks.

The CSIR research team explored an iterative development process entailing the development of a carbon nanotube polymer composite material and a processing method with standardised dispersion and distribution of these carbon nanotubes in the recycled polyethylene matrix, a processing method to incorporate the aggregates in the above nanocomposites, and the assessment of the physical and mechanical properties of the masterbatch. The steps led to the successful production of carbon nanotube-reinforced polymer nanocomposites suitable for use in construction bricks.

The CSIR transferred the development work to produce building and construction bricks with enhanced properties to SabiNano, which enabled the company to approach AECL, a fly ash producer, Hydraform, a building technology company, and the V&A Waterfront Group for further development and commercialisation. The company also established a partnership with start-up company Dziphathu Green Surfacing, which shares similar aspirations in harnessing waste to building and construction products.

NOVEL FOOD PACKAGING WITH OXYGEN BARRIER AND LINER TECHNOLOGY EXTENDS FOOD SHELF LIFE



A bag-in-box packaging solution that preserves the flavour of wine, while extending its shelf life.

The CSIR, in collaboration with the Technology Innovation Agency, has developed a novel polymer composite packaging solution that prolongs the shelf life of food.

Using their skills in advanced polymer formulation and the well-equipped Nanomaterials Industrial Development Facility, CSIR researchers were able to develop a packaging solution that prolongs food shelf life. It features a nanocomposite technology that confers a superior passive oxygen barrier property to packages, and an active composite liner technology that interacts with packaged foodstuff to help preserve its quality over extended periods.

The technology went through several trials with different industrial partners to validate the manufacturability and quality of the formulated pellets, which are used to make film and, thereafter, integrated into the packaging design. In one of its first applications, the technology was incorporated into a bag-in-box packaging solution for wine. The research team designed and manufactured 100 5 L bags for wine packaging, featuring the novel active liner technology.

An industry partner has shown interest in commercialising the technology. Once commercialised, this locally developed technology will offer the food industry an alternative solution to extend the shelf life of food products and beverages.



Production of the new packaging film at the CSIR Nanomaterials Industrial Development Facility.



Pellets used in the development of the CSIR polymer-based food packaging technology.

CO-DEVELOPING ROOT-STIMULATING PRODUCTS WITH LEADING ENVIRONMENTAL COMPANY



CSIR intern Kefilwe Mmoiemang inspecting the inoculum culture used to start fungal cultivation processes in bioreactors.

The CSIR has assisted I-CAT Environmental, a leading environmental management and products company, to reformulate its hydrogel product, used in agriculture for plant growth trials.

I-CAT has been using a chemical polymer-based product that swells like a gel when hydrated and targets the root zone of plants to ensure water retention for plant growth. However, the company wanted to replace this imported product with a locally produced solution.

The CSIR drew on its skills in bio-based product and process development to develop several prototypes that resulted in two product variants. The first is a powdered product that has fertiliser ingredients combined with an agricultural biological agent and hydrogel properties, and the second is a product in the form of a tablet that contains a fungal agent and has hydrogel properties. Additionally, an efficient bioprocess technology was demonstrated for the fungal active agent.

The research team manufactured market samples and transferred them to I-CAT to conduct field trials. Additionally, the technology dossier has been transferred and a licence agreement signed.

I-CAT will register the products with the Department of Agriculture Forestry and Fisheries before selling them in the agricultural, horticultural and paper and pulp markets.



Liquid culture of fungal organism, *Trichoderma asperellum*.



Assessment of the bioreactor prior to start of fungal cultivation.

BIOMANUFACTURING EXPERTISE CALLED ON FOR SHELF-STABLE NATURAL OKRA BEVERAGE



CSIR researcher Pumeza Melane observing the consistency of the Okra shake.

The CSIR assisted small business VEISA to develop a shelf-stable vitamin-fortified natural okra beverage.

Okra, or *Abelmoschus esculentus* (L.) Moench, is an annual fruit vegetable crop produced through seed, and commonly grown commercially in tropical and sub-tropical regions. It is highly nutritious and rich in several important antioxidants, such as quercetin and kaempferol. Okra can also be a great source of manganese and vitamin C.

Drawing on its biomanufacturing experts and specialised equipment, the Biomanufacturing Industrial Development Centre at the CSIR helped give VEISA an edge in the market by developing a shelf-stable product. With market samples manufactured, technology transferred and a licence agreement signed, VEISA can manufacture and sell the beverage.

GROWING MUSHROOMS IN A LIQUID, AND ON A MEGA SCALE, FOR LOCAL SKINCARE PRODUCTS



Enokitake, also called needle mushrooms, grown in a liquid medium.

The CSIR and biotechnology company Sawubona Mycelium have produced 800 litres of liquid cultivated mushroom, called Enokitake, for a local skincare product range.

The CSIR assisted the small, medium and micro enterprise (SMME) to scale up the production of high-value products from the Enokitake mushroom, using liquid cultivation.

Conventionally, mushrooms are grown using a solid state cultivation process that uses agricultural residues and other organic waste products that can support the growth of mushrooms. The CSIR Biomanufacturing Industrial Development Centre (BIDC) availed its world-class equipment, and research and development expertise to the biotech company, which was founded by two fermentation scientists, Busi Moloi and Neo Moloi, in 2018. The company joined the BIDC programme in 2019.

From the liquid-based production process designed by CSIR researchers, a high-value compound, beta-glucan was extracted. This compound is used in cosmetic products as an effective humectant and is beneficial for the skin microbiome in cosmeceutical formulations. Additionally, as part of the production process, the researchers produced enough biomass to convert it to a dried mushroom powder, useful in food products such as thickeners or in supplements as a form of immuno-boosters.

The company has two technology products that have been developed by the CSIR and the process has been assigned a technology readiness level of eight. The BIDC has developed market samples for the Enokitake-derived products and licensed the production technology to the SMME.

FIRST COMPANIES BENEFIT FROM SA'S NEW INDUSTRIAL BIOCATALYSIS HUB



APBio staff at the CSIR, are, from left, Lungile Mguni, Tawanda Chakanya, Stephanus Marais and Deidre Davids.

South Africa's Industrial Biocatalysis Hub has been established and started its operations at the CSIR. Biocatalysis entails the use of enzymes and microorganisms in manufacturing processes to produce chemical products.

Three companies have benefitted from the support provided in technology and product development in its first year. The hub, which was commissioned by the Department of Science and Innovation, together with the Technology Innovation Agency, will contribute towards the development of a sustainable bioeconomy sector in South Africa.

Applied Protein Biotechnologies was one of the first companies to benefit, drawing on the expert base in biocatalysis and the CSIR's proven track record of transferring technology demonstrators to industry. The company, which was selected following an expression of interest issued by the hub, had developed a potent natural insect repellent and insecticide, but needed support manufacturing the product at commercial scale. The research team used biocatalysis to convert precursor compounds in a natural oil to more valuable compounds that have insect repellent and insecticidal properties.

To foster collaboration, the hub has nodes at five universities, namely, Rhodes University, the University of Fort Hare, the University of the Free State, the University of the Western Cape and the University of the Witwatersrand. Through this partnership, the CSIR and the nodes of the Industrial Biocatalysis Hub are able to extend their reach to more enterprises that require support in developing and localising technologies in biocatalysis for implementation on a commercial scale.



Moloko Mathiba-Mdikane, a postdoctoral fellow, demonstrating the scaling-up process in the sealed fermenter.

SUPPORTING A LOCAL COMPANY IN DEVELOPING THE FIRST LOCAL COMMERCIAL METAL 3D PRINTER



The CSIR assisted local tech start-up Adiviv Solutions in the testing and calibration of a high-power optical system for use in its first commercial additive manufacturing machine for printing metal parts.

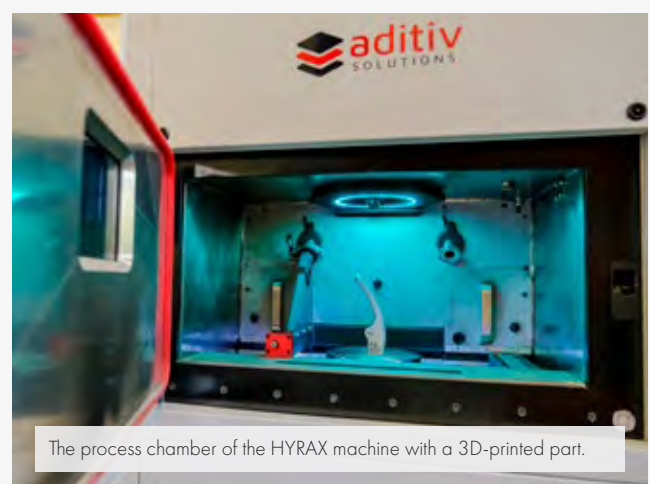
The assembly, testing and calibration of this system were performed at the CSIR Photonics Prototyping Facility. Funded by the Department of Science and Innovation, the facility was launched in March 2021, with the aim of supporting product development of photonic technology and devices. It offers state-of-the-art cleanroom facilities where the environment is controlled and contaminants are removed from the air.

The Adiviv Solutions system was launched at the 2021 Rapid Product Development Association of South Africa conference. The company specialises in developing and manufacturing high-quality affordable additive manufacturing equipment. Several metal-printing systems have since been put in production to be deployed at local organisations.

The CSIR Photonics Prototyping Facility is available to companies 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.

Advanced manufacturing is a key CSIR capability and a priority area for expansion and skills creation in the context of the fourth industrial revolution.



SUPPORTING THE LOCAL AEROSPACE, DEFENCE AND MARINE MANUFACTURING SECTORS TO BECOME GLOBALLY COMPETITIVE



Hydrofoil manufactured with the support of the Marine Programme's technology enhancement support.

Numerous South African manufacturing companies in the aeronautics, marine and defence manufacturing sectors received support to boost their competitiveness through the Aerospace Industry Support Initiative (AISI).

In the defence sector, AISI assisted Micromax, a small, medium and micro enterprise (SMME) with the localisation of a manufacturing capability for the Berretta 9 mm short gun frame. Berretta is a global original equipment manufacturer for firearms design and manufacture.

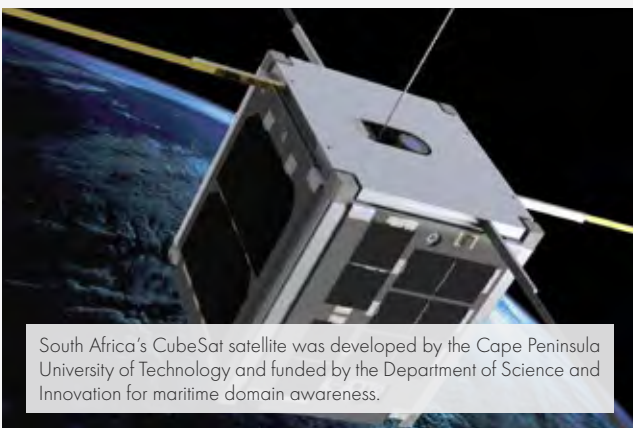
AISI also supported the development of a local capability at ETION Create for a video tracking solution (auto-tracker). The project will ensure that a locally developed auto-tracking function is built into a video-based surveillance and targeting system, which will reduce dependence on foreign suppliers. Paramount Aerospace, too, received support during which CSIR photonics experts assisted with the qualification of aircraft parts manufactured using additive manufacturing.

Two SMMEs were supported to achieve ISO accreditation – Luvhone Engineering, a 100% black woman-owned SMME focusing on technology solutions for aerospace and security, satellite and terrestrial broadcast and information and communications technology, and Aero Metals, a 51% black woman-owned sheet metal manufacturer.

As part of a programme directed at the marine sector, four SMMEs, CAD, SAMCD, Symbytech and Skye Advance Africa were supported with technology enhancement. Support towards standards and accreditations was provided to 11 beneficiaries, seven of these beneficiaries are newly contracted.

AISI is an initiative of the Department of Trade, Industry and Competition, managed and hosted by the CSIR. It provides industry with relevant tools, support and responses to sector-specific needs.

BENEFITS AND BENEFICIARIES OF A SOUTH AFRICAN SPACE PROJECT OUTLINED IN CSIR STUDY



South Africa's CubeSat satellite was developed by the Cape Peninsula University of Technology and funded by the Department of Science and Innovation for maritime domain awareness.

A CSIR study has outlined the economic case for a South African space programme for the Department of Science and Innovation. The study showed the various benefits and beneficiaries of such a programme.

The study aimed to define the potential of space science and technology for advanced skills development and addressing

poverty, inequality and joblessness, as well as illustrate South African success stories in this domain.

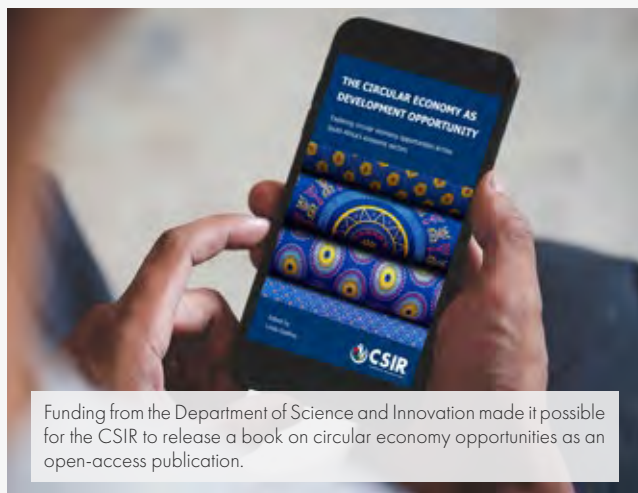
The study focused on three thematic areas, namely, Earth observation, global navigation satellite systems and satellite communication.

The creation of an internationally comparable value chain, the population of the value chain with existing capability in South Africa, and the quantification of the social and economic value of space science and technology were aspects under consideration.

The study explored the impacts of the investment into space science and technology by defining economic, social, environmental and strategic impacts and linking the impacts of such an investment to the United Nation's sustainable development goals.

The CSIR had worked with public and private industry expert groups on aspects of the study, such as developing an Earth observation roadmap.

EXPLORING THE COMPLEXITIES AND OPPORTUNITIES OF TRANSITIONING TO A CIRCULAR ECONOMY



Funding from the Department of Science and Innovation made it possible for the CSIR to release a book on circular economy opportunities as an open-access publication.

CSIR researchers compiled and published a book on circular economy opportunities for the country's economic sectors. The book, titled, *The Circular Economy as Development Opportunity: Exploring circular economy opportunities across South Africa's economic sectors* presents the CSIR's position and interpretation of the circular economy through the lens of science, technology and innovation.

A circular economy and sustainable resource management are important for South Africa because the country has a very linear, resource-extractive-based economy, with large throughputs of resources and export of raw resources. It is a carbon-intensive

economy, with many water-use inefficiencies.

Drawing on the CSIR's expertise across various disciplines, the book is intended to drive discussions between government, business and civil society on the immediate circular economy opportunities in the country to address current challenges facing various economic sectors.

The CSIR has selected seven resource-intensive sectors – mining, agriculture, manufacturing, human settlements, mobility, energy and water – for further assessment, and has since released the first three technical reports on the mining, agriculture and manufacturing sectors.

Many economic sectors have seen significant declines over the past years, with agriculture, manufacturing, transport and construction all showing negative growth pre-Covid-19. These are all sectors that are under economic stress and in need of regeneration.

Research indicates that transitioning to a more circular economy will provide South Africa with the opportunity to address many national priorities, including manufacturing competitiveness; food security; sustainable, resilient and liveable cities; efficient transport and logistics systems; and energy and water security, while, at the same time, decarbonising the economy. As such, the book will be of benefit to practitioners and decision-makers wanting to improve efficiency and competitiveness within their organisation; entrepreneurs looking to start innovative new businesses in South Africa; and policymakers who have an important role to play in creating the right enabling environment in South Africa.

UNLOCKING THE POTENTIAL OF A MINING CIRCULAR ECONOMY

A CSIR circular economy study has demonstrated the relevance and opportunities of a circular economy for the South African mining industry as the sector continues to seek to improve its sustainability. Many of the opportunities identified aligned with the three circular economy principles of designing out waste and pollution, keeping products and materials in use and regenerating natural systems.

The studies have highlighted that new and emerging technologies could be explored for increased precision and efficiency of ore extraction, resulting in reduced water and energy use, waste production and capital intensity. Water recovery and recycling may reduce dependence on freshwater in mining operations, which can contribute positively to ecological systems. The research also demonstrated that interventions such as the

substitution of raw materials could potentially minimise the overall production of waste, reduce health and environmental impacts, as well as carbon emissions from excessive mining operations by, for example, using thiosulphate leaching as an alternative to cyanide in gold processing.

Under the principle of regenerating natural systems, circular interventions include taking up renewable energy, producing green hydrogen, repurposing post-mining landscapes and eradicating alien invasive plants for water reutilisation. The transition to renewable energy, through a green industrialisation strategy, is critical to the transition to a circular economy. The production of green hydrogen has significant economic potential in that, through the increased demand for platinum group metals, the South African economy has the potential to significantly expand.

COASTAL VULNERABILITY MAPPING STRENGTHENS THE HAND OF SA'S DECISION-MAKERS



Coastal mapping collaborators, from left, Melanie Lück-Vogel, CSIR; Jessica Eichhoff and Dr André Theron, Stellenbosch University; and Gert Wessels, CSIR.

CSIR researchers teamed up with their counterparts at Nelson Mandela University and Stellenbosch University to document activities and vulnerabilities along South Africa's coast. The resulting geospatial layers and maps can be used by government to manage the potential risks and assets of the country's coastal areas. Both assessments were commissioned by the Department of Forestry, Fisheries and the Environment.

South Africans are living in dense coastal settlements, expanding cities into delicate coastal estuaries, and polluting stretches of the country's 3 000 km of coast. At the same time, climate change is impacting these areas through sea level rise and increased storms and wind, resulting in more severe flooding and erosion. This has necessitated government to invest in integrated coastal management, which integrates human land use, the natural environment and climate change.

The research team commissioned to undertake the National Coastal Climate Change Vulnerability Assessment, for the first time ever, assessed the whole of the South African coast in a methodologically homogenous way. The geospatial layers and maps show where the coast is likely to be affected by flooding due to storms and sea level rise, as well as storm-related erosion and sea level rise-related coastal retreat.

The researchers have held workshops with officials at district level to interrogate the data specific to the district and provide examples of how to use the data. The assessments are valuable in implementing South Africa's Integrated Coastal Management Act, 2008 (Act 24 of 2008), as well as the National Climate Change Adaptation Strategy.

ENHANCING AND SUSTAINING THE AQUATIC ENVIRONMENT IN SA'S PORTS



South Africa's ports are key for trade, but also provide environmental and ecological services, which benefit wider society.

The CSIR and Transnet National Ports Authority have embarked on a long-term ecological monitoring programme in seven South African ports. The project aims to generate science-based information to help manage and protect the aquatic environment in the ports.

South Africa's ports are gateways for maritime trade with the world. Ports are often regarded as polluted by virtue of the activities

that take place in them and their location in city catchments. Increasingly, it is being recognised that ports provide benefits other than trade. They are sites for residential, recreational and tourism opportunities through waterfront developments and tourist pleasure cruises. Recreational use, such as fishing, is common in some ports. Despite being highly modified environments, ports can still have an important ecological role. The ports of Durban and Richards Bay, for example, provide important nursery habitats for commercially important fish and shellfish. The success of ports in sustaining these added services, which benefit the wider society, depends on a healthy aquatic environment.

The monitoring will comprehensively cover physical, chemical and biological indicators of water and sediment quality. Based on many years of experience, the CSIR has developed port-specific baselines, models and indices to assess aquatic ecosystem health in South African ports. These will be applied and refined as necessary to support Transnet National Ports Authority to manage South African ports in accordance with their own internal governance policies, and South Africa's international obligations as a signatory to the International Convention for the Prevention of Pollution from Ships, various biodiversity conventions and the London Convention.

CSIR AND NELSON MANDELA UNIVERSITY ASSESS SA'S BLUE CARBON SINKS



Mangrove trees in the Umgazana River in the Eastern Cape.

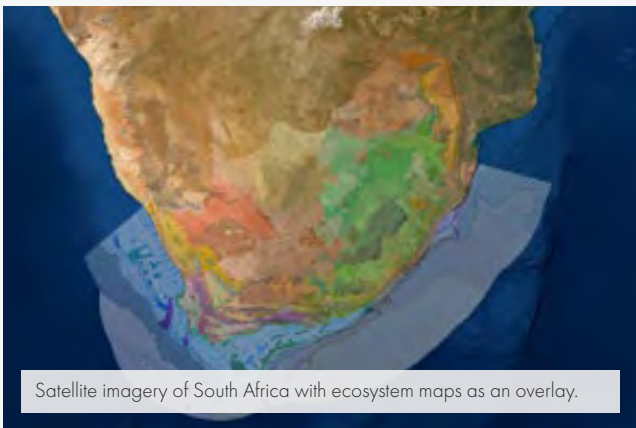
The CSIR and Nelson Mandela University completed an assessment of blue carbon sinks in South Africa for the Department of Forestry, Fisheries and Environment and the German development agency, GIZ. The study provided an overview of the carbon storage and sequestration potential of blue carbon ecosystems, such as mangroves, salt marshes and seagrass in South Africa, and identified climate change mitigation opportunities from these ecosystems.

Blue carbon ecosystems are regarded as highly productive coastal ecosystems that are important for their ability to store carbon within the plants and in the sediments below, making them a key component of nature-based solutions to climate change. Following the Intergovernmental Panel on Climate Change Guidelines on wetlands, a greenhouse gas emissions baseline for South African blue carbon ecosystems was developed, so that projections could be made to 2050 as required by the strategic framework for the agriculture, forestry and other land use sectors. Historical greenhouse gas emissions and removal trends for blue carbon ecosystems were determined to form a trajectory to predict future emissions and removals.

Outputs for the assessment include a national blue carbon database; a technical report detailing impacts, trends and opportunities in this sector, as well as a policy brief to assist the department in distilling key findings and actions needed to mainstream the research outputs and, thus, enable science-to-policy in the estuarine space.

Information generated will also be included in South Africa's National Greenhouse Gas Inventory as part of the agriculture, forestry and other land use sectoral ambitions.

CSIR LEADS ESTUARINE AND FRESHWATER RESEARCH FOR THE SOUTH AFRICAN NATIONAL ECOSYSTEM CLASSIFICATION SYSTEM



Satellite imagery of South Africa with ecosystem maps as an overlay.

The CSIR supported the South African National Biodiversity Institute with the development and implementation of the South African National Ecosystem Classification System – leading inputs regarding the estuarine and freshwater realms.

All ecosystems are connected through a gradient of changing species and structural and environmental characteristics that are often difficult to divide into discrete components. Classifying these systems into ecologically meaningful units is invaluable

to biodiversity science, conservation and planning sustainable resource use. The South African landmass and seascape were divided into four realms (terrestrial, marine, estuarine and freshwater), each with its own classification system that is supported by full descriptions of each ecosystem type. These classification systems are collectively referred to as the South African National Ecosystem Classification System.

In developing a South African classification system, *The South African National Ecosystem Classification System Handbook* was compiled, providing detailed information on the system and how it should be used and integrated into other legislative processes. The classification system underpins a variety of applications relating to natural resources management, spatial biodiversity planning, land-use planning, marine spatial planning, allocating environmental flows, ecosystems accounting, environmental assessment, and monitoring in all realms. Ecosystem types are also increasingly being used as units of assessment in national and international processes.

While the classification system draws on work done for the National Biodiversity Assessment 2018, the handbook represents the culmination of several decades of work by the CSIR and other collaborating scientists across the terrestrial, freshwater (inland aquatic), estuarine and marine realms.

NEW FRAMEWORK FOR MONITORING AND REPORTING ON CLIMATE CHANGE ADAPTATION IN THE WATER SECTOR



Aerial image over a dry Theewaterskloof Dam in the Western Cape. Between 2015 and 2017, the Western Cape experienced three consecutive years of below-average rainfall.

The CSIR has co-developed a framework that will help monitor and report optimally on climate change adaptation in the water sector.

Climate change poses a serious and immediate threat to the livelihoods and wellbeing of South Africans. Moreover, through its impacts on water security, climate change could constrain the country's sustainable development aspirations. To address this double threat, South Africa has committed to contributing to the global goals of combating climate change and promoting sustainable development under the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Sustainable Development Goals (SDGs), respectively. By signing the UNFCCC Paris Climate Change Agreement (often referred to as the Paris Agreement) in April 2016, the country's pledge to promote climate change adaptation was further cemented.

The reporting obligations under the SDGs and the Paris Agreement require holistic policy development, implementation, monitoring and reporting to minimise duplication of effort, optimise resource use and communicate a coherent message to the international audience. Through a consultative project funded by the Water Research Commission, the CSIR – in collaboration with the Department of Forestry, Fisheries and the Environment,

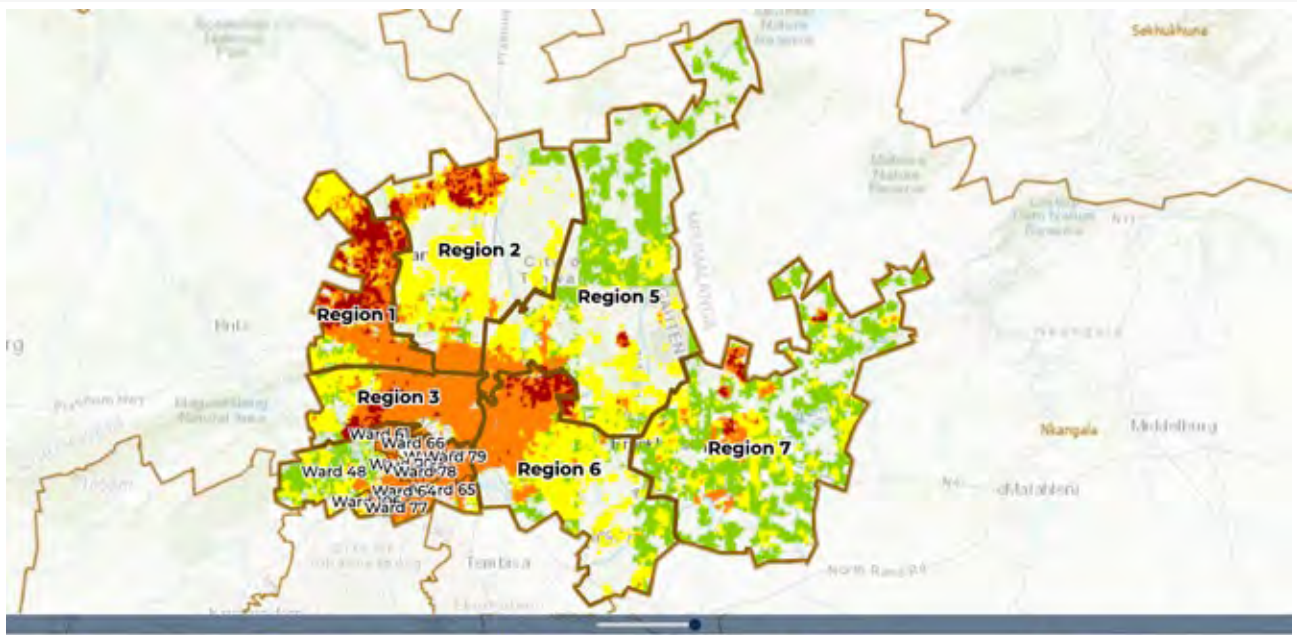
the Department of Water and Sanitation and Walter Sisulu University – has developed a framework to assist South Africa's custodians of SDG 6, SDG 13 and the Paris Agreement – which includes the two funding national departments – to monitor and report optimally on climate change adaptation in the water sector.

The framework is anchored in the eight SDG 6 targets, ranking them in order of their potential to meaningfully demonstrate progress towards adaptation. The study highlights the importance of institutional ownership of the treaties, as well as intra- and interdepartmental cooperation.



Flooding in the town of Bushman's River Mouth in the Eastern Cape.

SUPPORTING SOUTH AFRICAN METROS TO DEVELOP CLIMATE-RESILIENT CITIES



The map shows the 2050 projected increase in flooding pressure areas in the City of Tshwane under the RCP 8.5 low mitigation scenario. When projecting the future increase in flooding pressure for the city, four elements were considered, namely, the current observed flood risk, the projected shifts in extreme rainfall days, the historical growth and location of informal settlements, and the population growth and densification of the city (as future exposure).

The Cities of Tshwane and eThekweni are the first two South African metropolitan municipalities benefitting from the GreenBook MetroView. The GreenBook MetroView is an online planning tool developed specifically to support local government to adapt to climate change, by providing evidence around climate change, population growth, risk and vulnerability for metropolitan municipalities.

The GreenBook was first launched in 2019, offering planning support and evidence around climate change, risk and vulnerability to all local municipalities in South Africa. The GreenBook MetroView provides a more detailed view for metropolitan cities.

It aims to create a shared understanding, across different sectors, departments and other stakeholders, of the possible impacts of climate change and the decisions that need to be made to respond to it and prepare for a future (2050) in which climate impacts will be felt more intensively and frequently.

The GreenBook MetroView edition comprises two tools: The Climate Risk and Vulnerability Profile tool and the Climate Action tool. The Climate Risk and Vulnerability Profile tool provides a current and 2050 picture of climate change and its related impacts on three levels, namely, municipal, planning region and ward levels. The Climate Action tool consists of various adaptation actions and includes some greenhouse gas mitigation actions.

The Tshwane Climate Risk and Vulnerability tool is available online at <https://tshwane-riskprofile.greenbook.co.za> and the Tshwane Climate Action tool is available online at <https://tshwane-climateactions.greenbook.co.za>. The eThekweni MetroView is under development, in collaboration with the National Treasury's Cities Support Programme, Absa and the City of eThekweni.

The CSIR plans to develop a MetroView for each of the metropolitan cities in the country.



SUPPORTING EMERGING INNOVATIVE INDUSTRIES WITH IMPACT ASSESSMENT AND DATA COLLECTION



Several innovative new sectors are emerging in South Africa, ranging from telescopes that aim to improve our understanding of the universe, to innovative energy technologies. The CSIR is supporting the planning and sustainable development of these industries through data collection and impact assessment.

The CSIR played a key part in the environmental authorisation for a fibre optic connection for South Africa's Square Kilometre Array (SKA) radio telescope. The SKA fibre optic cable development, led by the CSIR-hosted South African National Research Network (SANReN), required environmental authorisation from the Department of Forestry, Fisheries and the Environment. Researchers conducted an environmental impact assessment in line with environmental legislation and the fibre optic cable was authorised in January 2022, with construction expected to start towards the end of 2022.

In the field of wind energy, the CSIR is playing a key role in establishing a spatial data inventory for a potential future offshore wind energy industry. The World Bank tasked the CSIR with

collating a comprehensive inventory of available spatial data of relevance to develop an offshore wind industry in South Africa, and identify data gaps. The data inventory was completed in March 2022, and the CSIR plans to play a continued role in catalysing this emerging renewable energy industry.

The CSIR has also commenced with research on how systems thinking can improve the theory and practice of impact assessment. The organisation is applying this research through developing and prototyping a systems modelling approach for impact assessment as part of a strategic analysis for South Africa's emerging green hydrogen economy. The work is co-funded through the German Corporation for International Cooperation and the CSIR's Parliamentary Grant.

OPTIMISING ENERGY INFRASTRUCTURE INVESTMENTS FOR INDUSTRIAL PARKS AND SPECIAL ECONOMIC ZONES



An energy master plan provides guidance on the technologies to pursue and the timing of these investments.

The CSIR has developed energy master plans that focus on deploying renewable energy generation, reducing energy costs, improving energy security and becoming carbon neutral for the Atlantis Special Economic Zone, the Garden Route District Municipality and the Richards Bay Industrial Development Zone. An energy master plan provides guidance on the technologies to pursue and the timing of these investments.

A structured energy planning framework is recommended upfront to ensure that industrial parks and special economic zones approach energy infrastructure investments in an optimal manner. Given the significant capital investments involved, the wrong mix of technologies or the use of inappropriate procurement and financing models could result in significant additional costs and possibly failed projects.

Ongoing studies include the East London Industrial Development Zone, the Phuthaditjhaba Industrial Park and Ekandustria. These studies are co-funded by the National Cleaner Production Centre of South Africa.

Long-term capacity expansion planning involves applying least-cost planning principles to find the optimal mix of existing supply resources and new-build supply options to meet expected future demand.

The CSIR deploys sophisticated commercial software to find the least-cost solution, but it is also developing open-source solutions, such as a cloud-based tool for park management. This will enable clients to incorporate newer input data themselves, ensuring an optimal and updated energy master plan.

CSIR PLAYS A KEY ROLE IN SOUTH AFRICA'S ENERGY TRANSITION

The CSIR provided environmental assessment expertise to 11 of the 25 successful preferred bidders announced in October 2021, following the fifth round of the Renewable Energy Independent Power Producer Procurement programme of the Department of Mineral Resources and Energy.

At a national planning scale, the CSIR played a significant role by conducting strategic environmental assessments to improve the environmental planning for national wind and solar photovoltaic development. These assessments incorporated a full range of relevant aspects, such as availability of wind and solar resources, environmental sensitivity, agricultural land use, heritage and landscape features, socioeconomic development

needs, grid connection, and technical and engineering suitability. In addition, the CSIR conducted strategic environmental assessments to support the responsible development of electricity grid infrastructure, such as transmission lines, at a national scale.

The CSIR has been one of the key players involved in a range of future energy-generation scenarios for South Africa and providing an evidence-based view of long-term power system expansion options. Research included the analysis of decarbonisation scenarios to assess the options, costs and impact of the accelerated decommissioning of ageing coal-fired power stations.

SURVEY ON GAUTENG HOUSEHOLD TRAVEL PATTERNS PROVIDES VALUABLE INFORMATION TO DECISION-MAKERS



CSIR Chief Executive Officer Dr Thulani Dlamini at the handing over of the regional Gauteng household travel reports to the Gauteng MEC of Roads and Transport Jacob Mamabolo.

The Gauteng Household Travel Survey for 2019/20 found that about 60% of households spend more than the transport policy maximum of 10% of their income on public transport.

Interpreted together with previous similar surveys, the 2019/20 survey shows that the average home-to-work travel time in the

morning peak period increased by 17%, from 46 minutes in 2014 to 57 minutes in 2019/20, and the average travel time over the past 20 years has almost doubled. Travel times deteriorated markedly for public transport users.

The 2019/20 survey was a collaborative project between the CSIR and the Gauteng Department of Roads and Transport. A probability sample of over 31 000 households in the cities of Ekurhuleni, Johannesburg, Sedibeng, Tshwane and the West Rand participated in the survey.

The quantitative and qualitative data collected on household travel choices and behaviours assist with evidence-led transport planning. Improved transport planning is important because transport continues to contribute significantly to the increased cost of living and, by extension, the cost of doing business in Gauteng Province.

A follow-up survey due for release towards the end of 2022 will provide a more authoritative measurement of the short to long-term impact of Covid-19 on household travel in Gauteng.

FIRST RESEARCH CHAIR IN SMART MOBILITY ESTABLISHED



The first research chair in smart mobility, Prof. Marianne Vanderschuren.

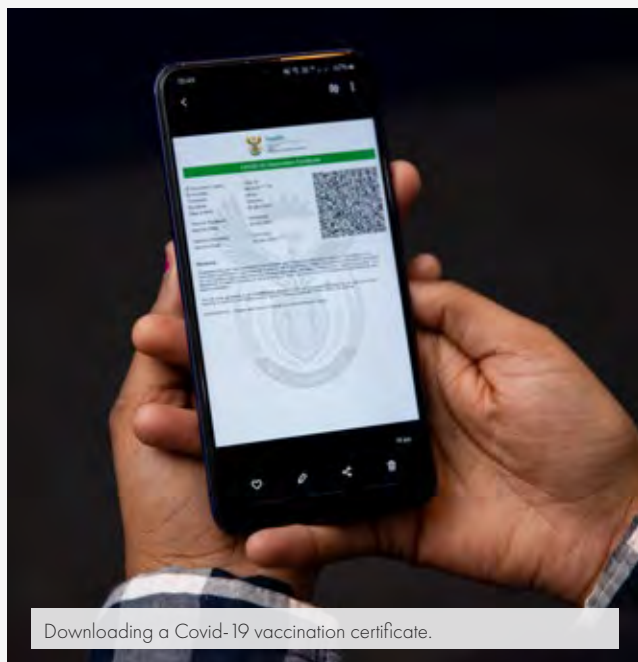
The CSIR, Department of Science and Innovation (DSI) and National Research Foundation (NRF) jointly established a research chair in smart mobility. Prof. Marianne Vanderschuren, an expert in transport planning and engineering at the University of Cape Town, was selected to lead the initiative.

Over the years, the local transport sector has suffered serious losses of skills and capabilities in critical areas of transport planning, pavement engineering, transport modelling, logistics and supply chains, negatively impacting roads and transport infrastructure. The focus of the research chair is on research and postgraduate student development that introduce novel approaches to modern-day challenges locally and on the continent.

Research chairs build on existing research strengths and enhance emerging areas of strategic importance. They provide an enhanced training environment for students and postdoctoral fellows by exposing them to important research challenges and opportunities. The South African Research Chair Initiative was established in 2006 by the DSI (then Department of Science and Technology) and the NRF.

The establishment of the research chair builds on the earlier creation of CSIR Smart Mobility, a cluster to address challenges and opportunities associated with the transport sector. The research chair contributes to human capital development, the advancement of key areas in smart mobility and the development of a plan to translate research into impact.

SUPPORTING NATIONAL GOVERNMENT WITH A WORLD-CLASS VACCINATION CERTIFICATE SYSTEM



Downloading a Covid-19 vaccination certificate.

The Department of Health and the CSIR developed and implemented the country's National Covid-19 Vaccination Certificate System.

The development of a national vaccination system followed the worldwide requirement for countries to provide their citizens with proof of vaccination against Covid-19 for purposes of travel and tourism, as well as large sport and recreation events and gatherings.

Citizens can download their vaccination certificates via a web portal and, once downloaded, the certificates can be printed. By December 2021, approximately 5.2 million vaccine certificates had been successfully downloaded and the system dealt successfully with high volumes of traffic resulting from concurrent requests for vaccine certificates.

The system was developed using a phased approach, with enhancement having been made throughout, heeding international requirements to guarantee the integrity of these certificates.

PORTAL TO PROTECT AND PROMOTE INDIGENOUS KNOWLEDGE LAUNCHED



The CSIR team, from left, Jonathan Killow, Mandlenkosi Ngwanya, Mathlatse Makhutisi, Dr Lulama Wakaba, Melanie van der Westhuizen, Gugu Khalala, Michel Ofori-Appiah, Lindelani Mbedzi, Muzi Matyila and Louis Engelbrecht.

The CSIR has assisted the Department of Science and Innovation (DSI) in developing a first-of-its-kind registration system for indigenous knowledge. The system was launched in March 2022.

Indigenous knowledge is used widely in science and health and by local communities in pursuit of commercial gain, food security and social cohesion. However, its use is threatened by

issues relating to misappropriation and loss. The Indigenous Knowledge Registration System facilitates the capturing, storage, curation, protection, promotion and management of indigenous knowledge. The CSIR drew on its skills in information and communications technology to develop the system, bringing together fragmented databases and systems to empower and encourage local communities to preserve the information for future generations.

The portal provides a gateway to all indigenous knowledge registration and serves as a source of information for research and development communities, as well as the general public. It serves as a platform to capture data from participating communities, and a prior-art database that holds information on the use, quality efficacy and safety of traditional African medicine. The portal facilitates the protection of indigenous knowledge.

The DSI trains regional representatives who interact with community members who hold indigenous knowledge. They record and document this knowledge, in the respective local languages, using video technology and the necessary tools at Indigenous Knowledge System Documentation Centres across the provinces. The knowledge is then uploaded onto the secure system.

UNMANNED AERIAL VEHICLE FLIGHT TESTS FOR FOREST FIRE-DETECTION IMAGING TECHNOLOGY



Testing the K-line imaging technology using an unmanned aerial vehicle.

The CSIR-developed K-line optical imaging technology to detect forest fires continued to prove its potential during flight tests using unmanned aerial vehicles. The technology detects fire flaming and can, therefore, estimate fire dynamics and spreading to better assist firefighting authorities. It complements commercial thermal infrared detectors that detect heat signatures.

The K-line imaging technology is an optical sensing technique for the detection of potassium light energy emitted from fire combustion processes. When plants burn, potassium is released as light energy, which can be identifiable.

The technology has significant implications for the development of sensing systems that can detect burning fires from airborne and spaceborne payloads. It also has a spin-off terrestrial application in gunshot detection, which is useful for shooter location and early warning emergency support.

The CSIR started the development of the space satellite K-line imaging technology in 2016. In December 2018, the ZA-Cube-2 satellite, with the K-line imager onboard, was launched. It was used as a spaceborne laboratory for the experimentation and further development of the K-line sensor for forest fire detection.

The Department of Science and Innovation is funding the continued development of the terrestrial and airborne K-line technologies. The CSIR is partnering with small, medium and micro enterprises during these further development phases.

SA REMOTE SENSING COMMUNITY JOINS FORCES TO GENERATE DATA FROM MULTIPLE SENSORS



CSIR radar technician Siphe Mngomezulu, CSIR chief researcher Willie Nel, CSIR senior engineer Dr Ciara Blaauw, CSIR candidate engineer Hebert Tema and CSIR engineer Katlego Mosito.

The CSIR led a three-month multi-sensor campaign to capture time-series data with a range of locally developed sensors, including, radar, hyperspectral, optical and ground truth sensors, over various areas of interest in Gauteng.

The collaborative campaign included over 20 groups from industry, government, research institutes and councils, the remote sensing community, and 10 universities, all adding either sensors, data, funding, ground truth data or expertise.

The resulting dataset will be made available to the remote sensing community and universities for research purposes in support of application development. It will contribute to expanding the knowledge base and skillset in remote sensing.

Six remote sensing applications were chosen as the initial focus applications for the campaign. They included precision agriculture, disaster management, mining activity and safety monitoring, mapping of wetlands, monitoring of waterbodies and monitoring of urban areas.

The areas covered included mines such as the Cullinan Mine, maize farms in the Bronkhorstspuit area, the Roodeplaat Dam, Colbyn Wetland, the Hennops River, urban areas and areas identified for disaster management, including, Atteridgeville, Centurion and Mamelodi. The data were collected over these areas with multiple sensors, which included a dual-band (C- and L-band) polarimetric airborne synthetic aperture radar (SAR) provided by the CSIR, a spaceborne SAR (X-band), two spaceborne hyperspectral sensors provided by Dragonfly and Astrofica, as well as ground truth and in-situ measurements provided by the CSIR.

The data acquisitions were repeated a few times to form time-series datasets, which is useful to detect changes and monitor areas.

EVALUATING MILITARY VEHICLES ON DEPLOYMENT TO OPTIMISE SA'S GROUND FORCES



The CSIR evaluated military vehicles on deployment along the South Africa-Mozambique border.

The recommendations resulting from field evaluations of military vehicles deployed along the South Africa-Mozambique border will serve as input into future military vehicle configurations and help solve current mobility challenges. The CSIR, along with members of the South African National Defence Force (SANDF) and Armscor, conducted the vehicle mobility performance characterisation and evaluation in a seven-day experiment in the deployment area in KwaZulu-Natal.

The CSIR conducts research and development in tactical vehicle mobility to contribute to the SANDF's capability readiness. Military mobility research includes the study of vehicle-terrain interaction through modelling and simulation, evaluation, verification and validation.

South Africa has a long history of successfully developing and fielding military vehicles. Teams on mission often need to access hostile areas to deliver critically needed food and medical supplies to affected communities, sustain peacekeeping operations and ensure the safety of civilian populations. To do this, protected vehicles that provide high levels of mobility and reliability are needed and they also need to be optimised for terrain negotiability in specific areas of use.

The CSIR also collaborates with the SANDF and local companies to implement and develop locally tailored mobility mapping and prediction solutions.

These research and development efforts are a vital part of supporting the SANDF and ensuring that the latest best practices and leading recommendations for military vehicle mobility requirements are met.

IMPROVED OFFENDER RECOGNITION AT DEPARTMENT OF CORRECTIONAL SERVICES WITH NEW FINGERPRINT DEVICE



Testing of a new contactless fingerprint device.

The CSIR has developed a handheld fingerprint device to assist the Department of Correctional Services with offender recognition.

The fingerprint device is a standalone, handheld, battery-operated computer device that is used to verify the identity of individuals by capturing an individual's fingerprint and comparing it to a fingerprint captured on paper or one stored in the device memory. The department will use the scanner to compare the fingerprints

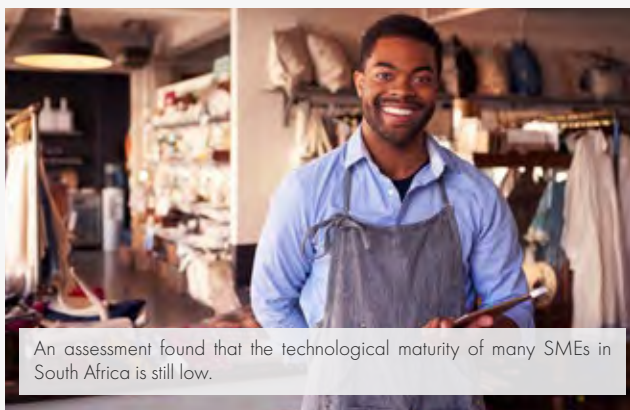
of a person who is brought to a correctional facility for detention from court to the fingerprints on the warrant of detention form. Additionally, the fingerprint device can be used to perform biometric recognition functions, identify and count offenders during rollcall, and verify the identity of an offender during community correctional visits. The device is fitted with a geographic positioning system to record the location at which it is used.

The device uses a standard digital camera to capture an individual's fingerprint. This is done by taking a colour image of the side of a finger with friction ridges and converting it into a conventional fingerprint, using CSIR-developed software. Using this software, the person whose fingerprints are captured need only present their fingerprint in front of the camera – the system is contactless.

The device is in the final stages of development and will be rolled out for further tests at numerous correctional facilities.

Although developed for use by this department, the device can also be used to verify motorists' identities when stopped by traffic officials, by comparing their fingerprints to those on a driver's licence.

C4IR SOUTH AFRICA CONTRIBUTES TO GLOBAL POLICY TOOLS



An assessment found that the technological maturity of many SMEs in South Africa is still low.

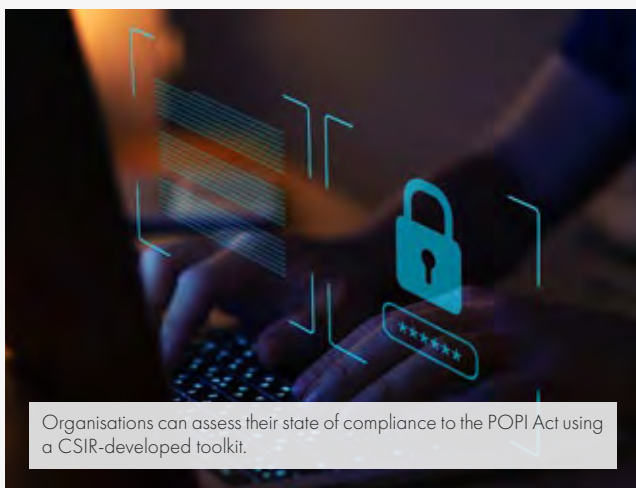
The Centre for the Fourth Industrial Revolution (C4IR) South Africa, in partnership with the World Economic Forum (WEF) and other parties, provided insights into how the Covid-19 pandemic affected small and medium enterprises (SMEs) and their adoption of technology. The centre also played an integral part in piloting an SME policy protocol developed by the WEF.

In collaboration with C4IR centres in Brazil, Colombia, Kazakhstan and Turkey, the partners conducted a survey of the impact of Covid-19 on their countries' technology adoption. A total of 141 SMEs and 34 large enterprises in Azerbaijan, Brazil, Colombia, Kazakhstan, Turkey and South Africa were involved. The 21 industry sectors included the construction, trade, machinery, metallurgy, automotive, food processing, aerospace, textile, agriculture and chemical industries.

A key finding of the study was that most SMEs were unable to adopt 4IR technologies such as the internet of things because of financial constraints, lack of skilled labour and infrastructure barriers.

For the C4IR South Africa to understand the current and future states of SMEs, the centre with experts from the CSIR, developed a 4IR readiness/maturity assessment tool, in collaboration with Deloitte. The tool is tailored to account for the specific conditions, challenges and opportunities in South Africa. The digital maturity assessment revealed that the level of technological maturity of many SMEs is still quite low, with limited integration of digital technologies in their operations.

ASSISTING ORGANISATIONS WITH ASSESSING THEIR COMPLIANCE TO THE PROTECTION OF PERSONAL INFORMATION ACT



Organisations can assess their state of compliance to the POPI Act using a CSIR-developed toolkit.

The CSIR has developed a compliance assessment toolkit to assist organisations with assessing their state of compliance with the Protection of Personal Information Act, 2013 (POPI Act) (Act 4 of 2013). The POPI Act, which came into effect on 1 July 2021, regulates the collection, processing, storage and use of personal information by organisations in South Africa.

Failure to comply with certain provisions of the POPI Act may potentially expose the responsible party and its associated third parties to legal penalties, including possible imprisonment of up to 10 years or a R10 million fine from the Information Regulator of South Africa.

Using the toolkit, organisations will be able to assess their current state of compliance with the POPI Act to minimise chances of receiving legal penalties, especially in an event of a data breach exposing personal identifiable information, while also ensuring that they collect, process, store and use personal information within the ambit of the Act. To develop the toolkit, the organisation drew on a multidisciplinary skillset in software development, cybersecurity and data privacy, while relying on an in-depth legal interpretation of the Act.

The toolkit attempts to assist organisations to assess if they have the correct artifacts in place to comply with the POPI Act towards maintaining the privacy of their clients' and employees' personal identifiable information by preventing loss, damage and unauthorised access to personal data.

The toolkit is being piloted at the CSIR, with plans to pilot it with the City of Johannesburg.

CSIR, ANGLO-AMERICAN AND MINING MUNICIPALITIES COLLABORATE TO ADDRESS SERVICE DELIVERY CHALLENGES



Programme team members exploring evidence of settlement growth and implications for municipal service delivery in Mogalakwena in Limpopo.

The CSIR is working with Anglo American and municipalities to help improve service delivery and find solutions for problems typically experienced by mining towns and regions. Implementation teams, supported by urban and regional planners, civil engineers, water scientists, economists and environmental scientists are focusing on 10 local municipalities in six different provinces.

The Municipal Capability and Partnership Programme supports government and industry partners to improve service delivery and address current and future development challenges unique

to mining towns and regions. The programme's main goals are to assist municipal partners in mitigating critical risks to service delivery related to mine closure, and collaborate with municipal partners to improve service delivery, specifically addressing challenges exacerbated by unique dynamics in mining areas, such as access to water, infrastructure sustainability and service delivery in fast-growing towns. The programme is operational in Gamagara and Tsantsabane (Northern Cape); Blouberg, Fetakgomo-Tubatse, Mogalakwena, Musina and Thabazimbi (Limpopo); Moses Kotane (North West); and Emalahleni and Steve Tshwete (Mpumalanga).

Municipal leaders, teams and relevant industry partners are supported in each municipality to co-create interventions, improve service quality and align investments for increased impact. The initiative takes a problem-solving and outcome-oriented approach.

The programme is spearheaded by Anglo American, in collaboration with the Department of Cooperative Governance and Traditional Affairs. Its implementation is made possible through the commitment from Anglo American, Anglo American Platinum, Kumba Iron Ore, DeBeers, Thungela Resources and their participating mines, as well as the active collaboration of participating municipalities and other partners such as the Provincial Departments of Cooperative Governance, the Development Bank Southern Africa, the Municipal Infrastructure Support Agent, the National Business Institute and the Impact Catalyst.

DEVELOPING TEST KITS TO DETECT FOOD CONTAMINATION



Gold nanoparticles produced by the CSIR for the development of mycotoxin test kits.

The CSIR is developing mycotoxin test kits to detect the presence of mycotoxins, thereby ensuring the safety of food. The organisation has also been key in producing the mycotoxin standards required for mycotoxin testing kits through funding by the Technology Innovation Agency.

Mycotoxins are secondary metabolites that contaminate grain crops. The presence of mycotoxins in food can cause disorders that affect the brain and nerves in the human body. Thus, suspect

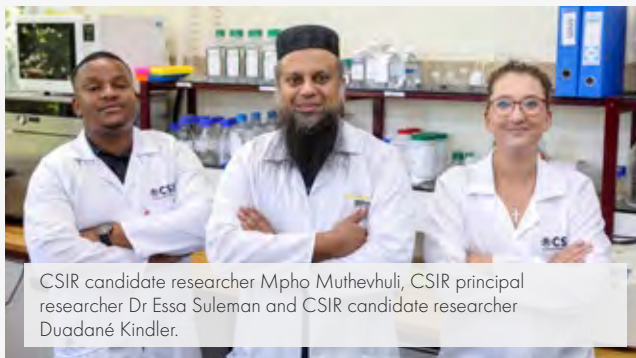
food is inspected, and mycotoxin levels are determined using agreed national standards.

The mycotoxin aflatoxin B1 is one of the most potent mycotoxins, and continued exposure – especially through contaminated food – is associated with liver cancer and can also exacerbate malnutrition in children, leading to impaired growth or stunting. Aflatoxin B1 is produced by *Aspergillus* spp, which is naturally found in soil, from where it contaminates grains and nuts.

Food testing laboratories, chemical companies and the National Metrological Institute of South Africa will benefit from innovation in mycotoxin standards and test kits, as they need high-quality mycotoxin standards that can be used for the accurate measurement of mycotoxins in food products. Researchers produce high-purity mycotoxins that are used to verify the presence and levels of mycotoxins in food.

The CSIR investigates the use of new technologies to help create transparency and trust between consumers and the food industry. The aim is to improve the traceability of food along the food production chain, especially with regard to ensuring safe production and processing practices.

NEW TECHNOLOGY TO DETECT VIRAL DISEASES AFFECTING THE AQUACULTURE INDUSTRY



CSIR candidate researcher Mpho Muthevhuli, CSIR principal researcher Dr Essa Suleman and CSIR candidate researcher Duadané Kindler.

The CSIR has collaborated with African counterparts, including the CSIR Water Research Institute in Ghana, for field trials of diagnostic assays and kits to detect pathogens that affect African aquaculture.

The infectious spleen and kidney necrosis virus and the tilapia lake virus are two pathogens that are threatening the aquaculture industry across the African continent, particularly the freshwater fish farming industry. Fish infected with the infectious spleen and kidney necrosis virus remain at the bottom of their habitat and have a reduced appetite for food – resulting in high morbidity and mortality.

Freshwater fish farming is an affordable and sustainable source of animal protein and a boost for the African economy. However, as production increases, the industry is affected by an escalating rate of diseases that cause economic and feedstock losses.

The Department of Science and Innovation and the CSIR invested in research to develop real-time polymerase chain reaction (PCR) and traditional PCR assays for the detection of the two diseases. PCR detects genetic material from a specific organism, such as a virus. The availability of diagnostic assays will improve the surveillance and detection of the diseases, benefitting African aquaculture by providing freedom from disease and enabling trade and access to export markets.

The next phase of the project involves expanded field trials in several other countries to further demonstrate the technology for licensing and commercialisation.



Field trials of diagnostic assays in Ghana.

CSIR-LED RESEARCH ON ANAEROBIC DIGESTION OF SOLID WASTE IN MAURITIUS

The CSIR and the University of Mauritius investigated anaerobic digestion and the feasibility of a biogas plant to address mounting concerns about waste generation in Mauritius, specifically organic waste from hotels and markets.

Over the past 10 years, solid waste generation in Mauritius has been increasing at an average of 2.8% per year, reaching over 535 000 tonnes in 2017. More than 60% of the solid waste is organic decay, mainly coming from households, hotels, markets and the agricultural sector. Guided by its agreement with the Climate Technology Centre and Network, through the United

Nations Environmental Programme, the CSIR conducted a technical and economic feasibility study for anaerobic digestion of the organic fraction of solid waste from households, hotels and markets in Mauritius. The anaerobic digestion process produces biogas that is combusted to produce electricity.

The CSIR was contracted based on its experience and expertise in climate services research. The research work entailed the quantification of the biogas/energy potential, identification of appropriate technologies and an operational site, as well as a schematic concept and design of the proposed biogas plant.

CSIR LEADS RESEARCH TO IMPROVE WESTERN INDIAN OCEAN MARINE AND COASTAL WATER QUALITY

Coastal and marine experts at the CSIR, in partnership with the Nairobi Convention Secretariat, developed a strategic framework for coastal and marine water quality management in the West Indian Ocean (WIO).

The coastline of the WIO region stretches over 15 000 km with more than 60 million people living within 100 km of the coast. The region's coastal and marine resources have major economic value and investment prospects. Appreciation of the value of the region's coastal and marine resources is shared among the African mainland and island states. Contracting parties to the Nairobi Convention; Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa, Tanzania, and Reunion (France), are allies in their vision for healthier oceans to sustain the economic value derived from them.

CSIR research found that marine and coastal water quality in the WIO is deteriorating. Root causes are population growth,

poverty and inequality, inappropriate governance, inadequate knowledge and awareness, and lack of financial resources. Major sectors that contribute directly to marine pollution are urban development and tourism, agriculture and forestry, fisheries and aquaculture, industry and mining, marine transportation, and energy production.

Based on these findings, the CSIR developed a strategic framework for coastal and marine water quality management and proposed guidelines for setting water and sediment quality targets for the WIO region. Guiding principles for the implementation were provided and the CSIR, through the Nairobi Convention Secretariat, made policy recommendations to assist contracting parties in realising their objective for water quality in the WIO region to meet international standards by 2035. These policy recommendations were adopted at the Tenth Conference of Parties to the Nairobi Convention (COP10) in November 2021.

INVESTIGATING PREMATURE ROAD FAILURE AND BUILDING CAPACITY IN MALAWI



A CSIR team investigates premature road surface disintegration on the M1 in Malawi.

The Malawi Roads Authority appointed the CSIR to conduct an independent investigation into the causes of premature road surface disintegration on the M1 road between Karonga and Songwe. The asphalt surface of the 46 km road started to disintegrate shortly after construction.

Using its expert knowledge in materials design and performance and pavement engineering, the CSIR examined the probable underlying factors causing the premature surfacing disintegration. Detailed visual assessment and field tests were conducted on the road and samples of the road materials were collected and tested at the University of Malawi Polytechnic Civil Engineering Laboratory and at the Central Materials Laboratory of the Ministry of Transport and Public Works in Malawi. Asphalt samples were also tested at the CSIR Advanced Materials Testing Laboratory. The collected data were analysed and the finding was that the main contributing factor causing the disintegration of the asphalt road surfacing was water damage.

The CSIR recommended remedial measures, and that the Malawi Roads Authority enhance and implement quality assurance systems and use the latest materials specifications and design standards to prevent similar occurrences.

In addition, the CSIR conducted a series of project workshops with key industry stakeholders in Malawi, with an emphasis on knowledge transfer. The training guided personnel from the road agency, the University of Malawi and the Central Materials Laboratory on advances in materials testing and all stakeholders on better methods and design standards to improve the quality of road construction and contract management.

AFRICA'S FIRST BIODEGRADATION TESTING FACILITY ESTABLISHED AT THE CSIR



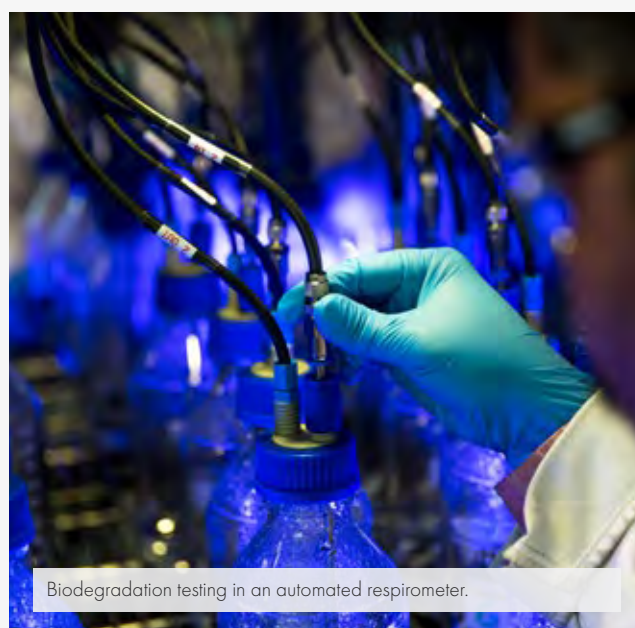
CSIR researcher Nomvuyo Nomadolo conducts an experiment using the automated titrator.

Africa's first biodegradation testing facility has been established at the CSIR. The facility, which is funded by the United Nations Industrial Development Organization (UNIDO) and the Japanese government, will assist the local plastics industry with the verification of imported or locally produced products that are being promoted as biodegradable in various markets.

The facility houses equipment such as an automated respirometer; a carbon, hydrogen, nitrogen and sulphur analyser; and an automated titration system. All the equipment has been commissioned and this has enabled researchers to open the facility's doors to industrial partners for testing. In addition, UNIDO's donation of biopolymers (polyhydroxy butanoate-co-hydroxy hexanoate) will enable researchers to assist industrial partners with the development and testing of compostable prototype demonstrators.

The biodegradation testing facility is capable of establishing the conditions and timeframes of the biodegradation of materials and verifying biodegradable claims on products. Once the facility is fully accredited, the testing reports issued by the facility can be used for certification of biodegradable products.

The facility contributes to Africa's capability in the bio-based materials field and enables a strengthened local bioplastics and sustainable alternative material industry.



Biodegradation testing in an automated respirometer.

LEARNING FACTORY ESTABLISHED AT THE EASTCAPE MIDLANDS TECHNICAL AND VOCATIONAL TRAINING COLLEGE



Experiential exposure to 4IR technologies such as human/computer interfacing forms part of the multi-modal training at the CSIR Learning Factory in Pretoria.

The Eastern Cape became the first provincial site for a pilot learning factory. Established at the Eastcape Midlands Technical and Vocational Education and Training College, the new learning factory is aimed at introducing students to the fourth industrial revolution (4IR) in their ecosystem.

The CSIR has been working closely with the Manufacturing, Engineering and Related Services Sector Education and Training Authority (merSETA), the technical vocational education and training (TVET) college and other provincial stakeholders (including industry, provincial government and academic bodies) to improve the absorption rate of students into the workplace by incorporating industry-led components into the curriculum. Short courses that will supplement the operation of the TVET will be offered to achieve upskilling, reskilling and cross-skilling activities, based on the learning factory's intervention and application areas. It will also create an environment for industry-related research activities.

The CSIR, in partnership with the merSETA, intends to establish more learning factories at TVET institutes around the country, with the target of at least two per province. The learning factory is, in essence, a demonstrator of 4IR technologies to build and

leverage human capital and support research and innovation across the multiple stakeholders in industry, academia and government, as well as to encourage entrepreneurship.

The first physical site of the learning factory was established at the CSIR in 2021 through a partnership between the CSIR and the merSETA. The first virtual training programme was launched in early 2022. This site serves as a reference for the learning factories that will be established around the country.

The CSIR Learning Factory includes demonstrations of technologies such as robotics, the internet of things, cybersecurity, simulation and additive manufacturing. It also covers theoretical training, which introduces candidates to generic 4IR applications from a South African perspective, as well as infrastructure for applications development – such as a modular and flexible configurable manufacturing cell, assembly station using collaborative robots, a smart home and energy optimisation cell, research labs to support design, incubation and prototyping, and experience centres that support experiential learning by exposing students to working environments in which 4IR technologies have been employed.

Visit www.4irsa.co.za for more information.

JOINING FORCES TO DEVELOP SKILLS IN THE TRANSPORT SECTOR



CSIR technologist Phindile Binda facilitating data capture training using the Gauteng Integrated Public Transport Administration System.

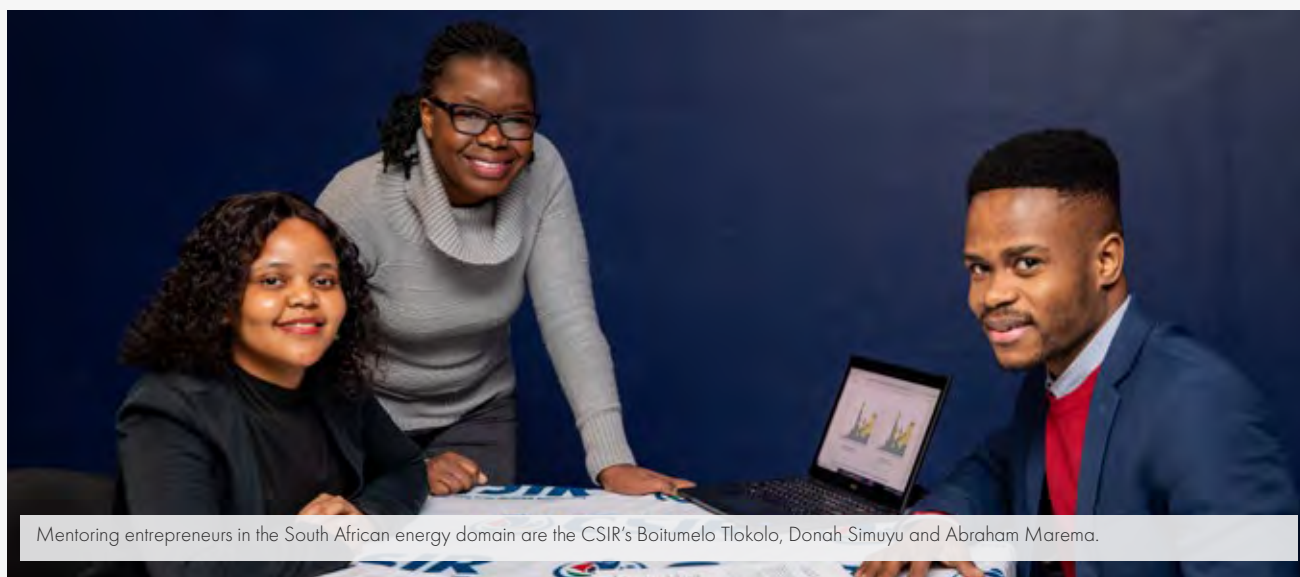
The CSIR has partnered with the Gauteng Department of Roads and Transport to implement a knowledge transfer and skills development programme for young people.

The programme provides mentorship and training in smart mobility, inviting young people with qualifications in engineering, information and communication technology and finance, among others, to develop their skills in the transport sector for a year.

In 2021, 56 data capturers were hosted at the CSIR for mentorship and training on various smart mobility projects that aimed to digitise information in the transport system to contribute to the improvement of infrastructure and transport-related services. The projects included collecting and digitising data on the minibus taxi industry, the impact of Covid-19 on the transport sector, Gauteng household travel patterns and minibus taxi facilities.

The programme aims to take advantage of the emergence of fourth industrial revolution technologies to improve the service offerings of the transport industry in Gauteng.

MASTER CLASSES FOR SMMEs IN THE FIELD OF ENERGY



Mentoring entrepreneurs in the South African energy domain are the CSIR's Boitumelo Tlokolo, Donah Simuyu and Abraham Marema.

In the last year, 15 small, medium and micro enterprises (SMMEs) benefitted from the collaboration between the Enterprise Development Programme of the South African Institute of Chartered Accountants and the CSIR to mentor entrepreneurs in the South African energy space.

As part of the collaboration, each SMME was paired with a CSIR technical expert, and numerous master classes and tailor-made discussions were hosted to support them.

The CSIR has also signed an agreement with the Energy and Water Sector Education Training Authority (EWSETA)

to identify the skills requirement gap in the energy transition to renewable energy and provide specialised technical services to SMMEs in this field. The CSIR has compiled a soon-to-be-published handbook for SMMEs on renewable technology, in collaboration with EWSETA.

Work in this domain continues, with research work having commenced to analyse the value chains of various energy technologies, with a focus on identifying skills and opportunities for enterprise development to contribute to economic growth in South Africa.

ADVOCATING FOR INDUSTRY-PARTNERED LEARNING FACTORIES TO BE ESTABLISHED AT TVETs



The CSIR has developed an initiative to plan for skills for the future. The initiative brings together higher learning institutions across the science, engineering and technology landscape in an effort to establish strategic partnerships to support learning programmes and research, development and innovation projects.

The CSIR's drive to establish partnerships to nurture future skills resulted in the signing of three memorandums of understanding with the Energy and Water Sector Education Training Authority, the Media, Information and Communication Technologies Sector Education and Training Authority and the Safety and Security Sector Education and Training Authority.

In 2021, the CSIR engaged the Department of Science and Innovation, the Department of Higher Education and Training, the National Skills Fund and some Sector Education Training Authorities on fourth industrial revolution (4IR) skills development and innovation. One of the programmes presented was the Industry-partnered Learning Factory, which focuses on 4IR skills development, innovation and entrepreneurship. The programme

comprises the joint CSIR/Manufacturing, Engineering and Related Services Sector Education and Training Authority Master Learning Factory that is currently based at the CSIR, which will also serve as a reference platform for industry-partnered learning factories for technical and vocational education and training (TVET) colleges.

According to the International Association for Learning Factories, a learning factory is a learning environment where processes and technologies are based on a real industrial site, which allows for a direct approach to learning and product creation. These factories are based on a didactical concept, emphasising experimental and problem-based learning.

Industry-partnered learning factories are envisaged to create partnerships between industry and TVET colleges to ensure a collective understanding of industry needs, a curriculum and qualifications that are well aligned with industry needs, training infrastructure that is aligned with emerging industry trends and the economic revitalisation of townships and rural areas through skills development, innovation and entrepreneurship.



The CSIR is building a strong human capital pipeline through, among others, its bursary programme. The programme, which is based on merit, provides full financial support to selected South African students registered, or intending to register full time, with any South African university, in a CSIR-defined priority area. Front left are top-performing students Anika Swanepoel (MEng Industrial Engineering) and Botho Letlotlo Maje (BSc Eng Electrical Engineering) with CSIR human capital development staff members, back, from left, Nokuthula Zama, Babiye Mabasa, Keneilwe Mphago, Ncamisile Masuku and Mmabatho Munyonga.

CSIR VALUES: EMPHASIS ON THE 'P'

Investing in people is one of the pillars of the CSIR's human capital development strategy. This is inspired by the CSIR's people-centred value, which the organisation aspires to live by, along with excellence, integrity and collaboration. The organisation invests in its people through a series of programmes, including grooming a new pipeline of researchers through its bursary programme; supporting employees to upgrade their qualifications and offering e-learning tools to leverage and lead the rapid changes in the technological, scientific and business domains.

BUILDING A CAPABLE STAFF BASE

In response to the unexpected effects on the workforce brought on by the Covid-19 pandemic, the CSIR introduced LinkedIn Learning as a comprehensive digital learning platform to support the upskilling and reskilling of the CSIR workforce. In its first year of implementation, 982 employees completed courses across different disciplines and occupational levels. The LinkedIn Learning tool is one of the key mechanisms implemented to build and transform the critical and core skills that the CSIR requires to fulfil its mandate and strategic objectives. The curated programme is aimed at professional development and addressing the training needs of individuals to create a talent pool that is aligned and able to deliver on the CSIR's strategic goals.

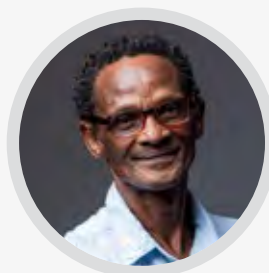
PROVIDING A REAL-LIFE SETTING FOR RECENT GRADUATES

The Graduate-in-Training Programme is aimed at providing newly graduated CSIR bursars with training that is structured and aligned to professional registration bodies' requirements to create a pool of suitably competent scientists and engineers. About 45 graduates were trained and 12 of them have been absorbed in permanent positions at the CSIR.

REACHING THE HIGHEST RUNG ON THE RESEARCH CAREER LADDER

The CSIR regards its cohort of principal and chief researchers as an important indicator of the organisation's capacity to fulfil its mandate and retain its status as a distinguished research organisation on the continent. Attaining these positions requires local and international recognition of a sustained track record and significant outputs in a specialised research field, with proven impact on society and within the research community. In 2021, the organisation welcomed five new chief researchers and 28 principal researchers.

CHIEF RESEARCHERS



Prof. Sisa Pityana

Focuses on research, development and commercialisation of titanium aluminide alloys.



Prof. Moses Cho

Develops remote sensing algorithms for modelling, assessing and mapping vegetation biochemistry and biophysical properties from drone and satellite images.



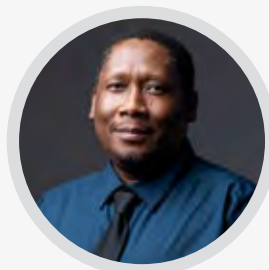
Dr David Reinecke

Works in defence and security, specifically in the fields of blast impact, structural response, trauma biomechanics and military mobility.



Willie Nel

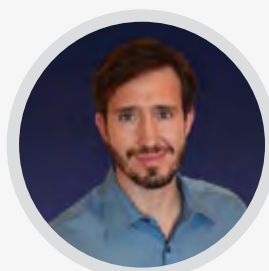
Focuses on new radar system design, radar-based target recognition, imaging radar and radar signal processing.



Dr Tsepo Tsekoa

Works in recombinant production and characterisation of biologics, including vaccine antigens, enzymes and antibodies.

PRINCIPAL RESEARCHERS



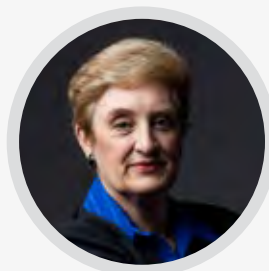
Jaco de Witt

Leads research to develop radar systems for local and international clients, including high-resolution radar systems, synthetic aperture radar and compact airborne radar systems.



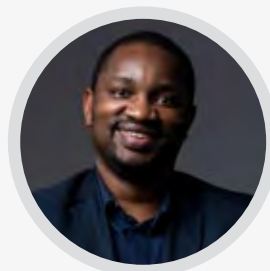
Dr Patience Mthunzi-Kufa

Leads research in biophotonics to develop innovative diagnostic tools.



Lucia Steenkamp

Leads research in biocatalysis and taking technologies in this domain from ideas to piloting.



Luzango Mfupe

Leads research in spectrum-sharing broadband networks to underserved communities using television white space technology.

PRINCIPAL RESEARCHERS



Jacques Cilliers

Leads research in the analysis and design of radar and radio frequency electronic warfare systems, especially digital signal processing and algorithm development.



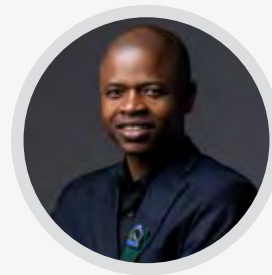
Sandy Thomalla

Leads research in understanding the biological carbon pump through measurements of phytoplankton community structure and primary production in the Southern Ocean.



Santosh Ramchuran

Leads research in bioprocessing with a focus on commercialisation and localisation of bio-based chemicals and products.



Moshe Masonta

Leads research in dynamic radio frequency spectrum management, open radio access networks and network slicing in mobile communications technologies.



Aby Louw

Leads research, development and commercialisation of text-to-speech technologies and the localisation thereof.



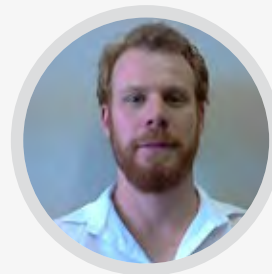
Asmerom Beraki

Leads research on climate modelling at various timescales and the applications of climate models.



Bolelang Sibolla

Leads research and software development to build and deploy operational, standards-compliant, spatiotemporal decision-support tools and systems.



Craig Tong

Leads research to develop and integrate radar and electronic sensing solutions, specialising in signal processing and software-defined radio.



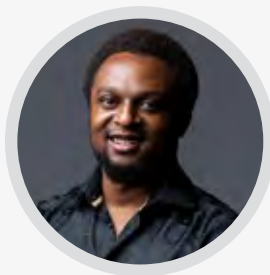
Essa Suleman

Leads research in designing, initiating, effecting and promoting research to better understand the epidemiology of infectious and parasitic diseases.



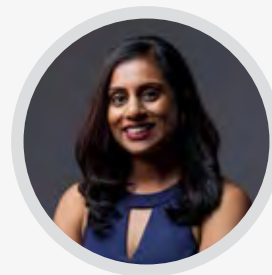
George Sibiya

Leads research in information security focusing on digital forensics and privacy preservation in information systems as well as technology developments.



Georges Mturi

Focuses on research, development and commercialisation of alternative road materials based on advanced characterisation technologies.



Ghaneshree Moonsamy

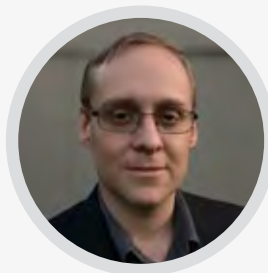
Leads research in biotechnology to develop sustainable technologies for industry.

PRINCIPAL RESEARCHERS



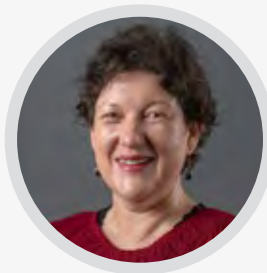
Heidi van Deventer

Leads research in monitoring wetland vegetation using remote sensing.



Kevin Kloke

Leads research in phased array antenna technology for local and international radar applications with a focus on achieving a high performance to price ratio.



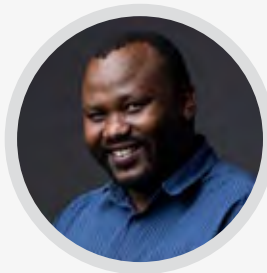
Kobie Smit

Leads research in system dynamics and spatial system dynamics modelling combined with data science and the applications thereof.



Prof. Lara van Niekerk

Leads research in estuary condition and ecosystems, climate change impacts on estuaries, as well as estuarine policy development and management.



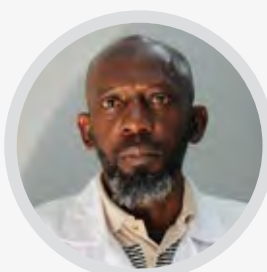
Dr Lusisizwe Kwezi

Leads research on the development of bioprocesses for the production of reagent enzymes and antibodies, as well as plant biotechnology, proteomics, cell signalling and molecular biology.



Mofolo Mofolo

Leads research in technological developments and innovation in wireless communications and networks.



Mohammed Balogun

Leads research in design and synthesis of polymer therapeutics for infectious diseases, nanomedicines and biopolymer modification.



Thanyani Pandelani

Leads research in vehicle blast testing and regulations, post-mortem human surrogate and anthropomorphic test device testing and finite element modelling.



Tirusha Thambiran

Leads research in understanding the causes and drivers of air pollution and the means to mitigate and adapt to the negative effects of climate change.

EMPOWERING SOUTH AFRICAN GRADUATES FOR THE SCIENTIFIC WORKPLACE

Teaming up interns with experts is a proven mechanism of transferring knowledge and contributing to a pipeline of young, talented researchers and engineers. Amidst the high unemployment rate of young people in South Africa, the CSIR welcomed 54 graduates from its partnership with the Youth Employment Service (YES). YES prepares young people for employment by providing them with technical skills and relevant work opportunities. Some of the youths were placed in CSIR research groups, some in support units, while others were placed at small, medium and micro enterprises affiliated to the organisation.

MEET SOME OF THE INTERNS



Mhlali Gotyana

Qualification: BA (Communication Science) from North-West University

Based: CSIR Strategic Communications

Helps the organisation achieve its communications goals through traditional, social and digital communication platforms.



Wandisa Chesane

Qualification: BTech (Chemical Engineering) from Vaal University of Technology, currently working on her Master of Technology (Chemical Engineering)

Based: CSIR Water Research Centre

Assists in driving strategic research and development activities by using software for process design and modelling.



Lesego Hlongwane

Qualification: NDip (Human Resource Management) from Denver Technical College, currently studying BA (Industrial and Organisational Psychology) at the University of South Africa

Based: CSIR Human Capital

Supports human capital practitioners in offering solutions and services related to finance, procurement and information and communications technology.



Luvhani Mudau

Qualification: BSc Honours (Chemistry) from Sefako Makgatho Health Science University

Based: CSIR Smart Places

Assists in designing chemistry-related experimental plans to conduct research on wastewater treatment and resource recovery.

MEET SOME OF THE INTERNS



Bakae Kgolofelo Magdeline Rasebotsa

Qualification: BAgric Honours (Agricultural Management) from the University of Limpopo

Based: I-CAT, an environmental management company

Assists with market research, in-field trials, trial data capturing, report writing and ISO 9001.

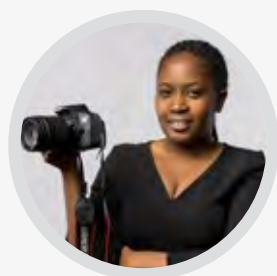


Princes Shanond Sambu

Qualification: Diploma (Operations Management) from Vaal University of Technology

Based: CSIR Smart Mobility

Monitors the value and supply chains of the cannabis industry by tracking products or raw materials from point of cultivation and addresses safety tips in response to human consumption concerns.

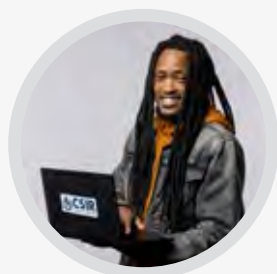


Portia Tshifhiwa Mudau

Qualification: BA (Communication Science) from the University of South Africa

Based: CSIR Strategic Communications

Creates content for CSIR internal website, profiles researchers and projects and assists with events planning.



Karabo Samuel Lekalakala

Qualification: BAdmin from the University of the Witwatersrand

Based: CSIR Future Production: Mining

Provides business administration services.



Morebodi Motaung

Qualification: BEng Technology (Electric and Electronics) from the University of Johannesburg

Based: CSIR Human Capital

Works on a research project about 5G Open Radio Access Network (O-RAN) and O-RAN technology.



This section provides an overview of the organisation's performance against the set objectives and targets for the 2021/22 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.

PART C

PERFORMANCE

INFORMATION

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AUDITOR'S REPORT: PREDETERMINED OBJECTIVES

The Auditor-General of South Africa (AGSA) (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 114 in PART F.

SITUATIONAL ANALYSIS

Service Delivery Environment

Several external and internal environmental factors influence the strategic direction of the CSIR. Our research programmes address national priorities and, as such, our RD&I activities are developed in response to national strategies such as the NDP and its derivative strategies and policies through various government departments, especially the 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 emergence of Covid-19 in South Africa in March 2020, continued to have a significant negative impact on the country during the 2021/22 fiscal year, impacting business continuity and service delivery. The 2021/22 fiscal year was characterised by a massive vaccination rollout, which started in February 2021. This meant that some economic sectors could eventually reopen, fully.

According to Deloitte, South Africa's real GDP growth bounced back to 4.9% in 2021/22 from a contraction of approximately 6.4% since the pandemic emerged. This growth was driven primarily by a combination of base effects, strong commodity prices, and the gradual reopening of the economy after strict Covid-19 regulations and mobility restrictions. The South African economy is the only one among the G20 group of countries that did not achieve pre-Covid-19 levels of growth, according to the Economist Intelligence Unit of The Economist Group. The South African economy is 1.8% smaller than it was before Covid-19.

The low growth was attributed to policy uncertainty, ongoing energy constraints, the unrest in KwaZulu-Natal and Gauteng during July 2021 and the impact that these have had on the rollout of the vaccine programme, in addition to an extended lockdown period.

The CSIR was not spared from the impacts of low growth in the economy. The organisation could not earn as much revenue as was anticipated due to the following factors:

- Reduction in contract R&D income because of adverse economic conditions due to the ongoing Covid-19 pandemic, resulting in parts of the business not being fully operational, for example, the CSIR International Convention Centre.
- Reduced level of productivity due to the ongoing Covid-19 pandemic earlier in the financial year.
- Key contracts with the public sector not secured, for example, contracts with Armscor/Department of Defence and Department of Correctional Services in the Defence and Security cluster. Delays in securing large-value contracts, such as a contract for the Titanium Centre of Competence and the National Foundry Technology Network.
- Lease agreements with proposed tenants for vacant space not secured as planned due to working from home arrangements because of the Covid-19 pandemic and diminishing need for office space.
- Delays in the acquisition of equipment funded by public sector funding (this also results in lower than planned depreciation expenses).
- Electricity crisis impacting wind tunnel testing and the ability to earn revenue from this facility during periods of constrained energy supply.

The 13th edition of the South Africa Economic Update, *Building Back Better from Covid-19*, states that medium-term prospects for higher and more inclusive growth remain constrained. Growth is expected to slow down to 2.1% in 2022 and to 1.5% in 2023. Deloitte also noted that the real GDP growth is forecast to remain below 2% in 2023 and 2024, a rate that is not sufficient to address the country's growing socioeconomic needs.

With regard to South Africa's socioeconomic needs, the job market was negatively impacted by the pandemic. The 13th edition of the South Africa Economic Update, *building back better from Covid-19*, states that, by the end of 2020, the number of employed people had fallen by nearly 1.5 million, and the wages of workers who still had jobs had fallen by 10% to 15%. At the time of releasing its report in July 2021, only 40% of employment losses has been recovered. The report found that South Africa entered the Covid-19 pandemic with low levels of employment and a decade of weak job creation, far below the standards of most upper middle-income countries.

It also found that job losses in Covid-19 times are disproportionately concentrated among low-income earners, worsening already severe inequalities, despite the government's decisive and pro-poor response with transfer programmes that partially cushioned the negative impacts of the pandemic. Low-wage workers suffered almost four times more job losses than high-wage earners.

The report suggests that entrepreneurship and self-employment offer the biggest opportunity to create jobs in South Africa, particularly with the increasing number of start-ups, especially in the digital sector, which could become an engine of job growth in the future. Cape Town alone, the 'tech capital of Africa', has over 450 tech firms that employ more than 40 000 people. In 2020, a total of US \$88 million (R1.2 billion) disclosed investments went into its tech start-ups.

One of the SOs of the CSIR is to provide technology support to SMMEs as its contribution towards reindustrialisation. In 2021/22 alone, the CSIR has supported 99 SMMEs in areas of agriculture, health, ICT, aerospace and defence.

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 investment in scientific and industrial research remain a concern for the National System of Innovation, and particularly for the CSIR. The GERD remains well below the target of 1.5% of GDP, set by the then Department of Science and Technology. GERD, as a percentage of GDP, dropped from 0.76% in 2017/18 to 0.62% in the 2019/20 financial year. As a result, science councils like the CSIR have become more dependent on contract R&D income instead of grant funding.

In its Medium-Term Expenditure Framework technical guidelines June 2019, NT imposed compulsory budget baseline reductions of 5% in 2020/21; 6% in 2021/22 and 7% in 2022/23. Budget Vote allocations from NT have not translated into growth in investments on scientific and industrial research that are in par with inflation. This is, of course, concerning as the lack of sufficient investment on science impacts capability development in the fields that are critical for supporting the economy and a capable state.

Moreover, the NT Regulations make it increasingly difficult for public entities to contract directly with government and state-owned enterprises for mandated work. Public institutions require the CSIR to compete for R&D activities in open tenders, which, as a public entity mandated to perform this type of work, should not be the case. This practice leads to the loss of revenue opportunities to the tune of approximately R450 million, every year.

Our response in addressing funding constraints and achieving growth through our 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 SOs.

The CSIR has increased performance in joint technology development activities with industry sectors and in revenue-generation from international sources.

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 2019 White Paper on Science, Technology and Innovation. The DSI engaged extensively across government and with various of its entities on the Decadal Plan, which is the implementation plan of the 2019 White Paper. A workshop was held with the CSIR to ensure that the CSIR's planning processes are aligned with the plan.

In addition to existing strategies, plans, policies and frameworks, the CSIR also responds and contributes to the implementation of national priorities of the sixth democratic government. These include the ERRP, the dtic's 'Re-imagining Industrialisation Strategy for South Africa' and its sector master plans, and the District Development Model.

The ERRP identifies the defence and aerospace industry as key to economic growth, particularly in localisation and exports. The Defence and Aerospace Masterplan was finalised in 2020. The CSIR plays a significant role in the defence and aerospace industry through the hosting of the AISI, a South African government initiative with the specific aim of improving the competitiveness of the local aeronautics, space, defence and marine advanced manufacturing sectors.

The AISI takes its strategic direction from government's objectives with a specific emphasis on the industrialisation of technology and technology-based supplier development. The **dtic** utilises the CSIR and its position in the National System of Innovation as an independent, strategic directed R&D entity to give industry access to national expertise and infrastructure to improve its capabilities and offerings.

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 defence and aerospace and mining, among others, can only be transformed through technological innovations and strong partnership between government and the private sector.

The Covid-19 pandemic has accelerated existing trends in remote working. The physical dimension of work is a new factor shaping the future of work, brought to the fore by health and safety considerations. To determine how extensively remote work might persist after the pandemic, McKinsey & Company analysed its potential in more than 2 000 tasks used in some 800 occupations across the eight focus countries. The pandemic demonstrated that much more work could be done remotely than previously thought, including business sales calls, legal arbitration and trials, doctor consultations classroom learning, real estate tours, and even expert repairs of the world's most sophisticated machinery done with the help of virtual reality headsets.

The CSIR successfully adopted "Work from Home" at the onset of the Covid-19 pandemic and continues with "Work from Home" arrangements for all staff who can effectively work from home. Operational efficiency has been maintained since the onset of the pandemic.

Even with the adoption of the Flexible Working from Home Policy, safety and good governance remained priorities for the CSIR as all organisations are still grappling with the effects of the pandemic. Already, South Africa is currently dealing with a fifth wave, with the number of new infections increasing.

In line with the changes to the last Covid-19 workplace regulations, as published by the Department of Employment and Labour on 15 March 2022, the CSIR Covid-19 incident response team has reviewed the current precautionary measures. The CSIR strongly urges all staff to obtain a Covid-19 vaccination. Currently, there are several private and government sites where a vaccine can be obtained using a booking system.

To make it easier for staff to vaccinate, the CSIR has partnered with a recognised organisation to provide onsite vaccinations for staff who have not already been vaccinated. As of 31 March 2022, a total of 312 vaccines had been administered onsite. The service will continue as per need and has been expanded to include flu vaccinations as well.

In the safety area, we have maintained a good safety record for the year.

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.

The CSIR achieved or exceeded 81% of the key performance indicators for the 2021/22 financial year. This represents an overall improvement compared to the performance of the previous financial year. Compared to the previous financial year, some of the highlights from these results include:

- An increase of 16 in the number of publication equivalents;
- A 40% increase in priority patent applications;

- A 15% increase in the number of technology demonstrators;
- A 300% increase in the number of technology licence agreements;
- A 180% increase in the number of localised technologies; and
- A 3% increase in the number of SMMEs supported.

The CSIR continues to demonstrate its relevance in supporting the state. The number of projects that contributed to increasing the capability of the state increased by 95%

With regard to human capital, the following is worth noting:

- Our set base increased by 5.2%;
- The transformation of the SET base, in terms of race and gender, also improved;
- The CSIR managed to retain its total number of chief researchers, despite the resignation of three chief researchers during the reporting period; and
- The number of exchange programmes with industry increased by 287.5%, in line with our intention to work more closely with industry.

Financially, the CSIR is in a strong position. Even though we did not achieve our turnover target, we have managed to exceed our margin target and continue to drive the diversification of our income streams. Our current and liquidity ratios have improved compared to 2020/21 financial year, and so has our overall cash position.

Contract income amounted to R1 917 million, which exceeds the prior year's comparative amount by 1%, but it is 10% behind budget for the 2021/22 financial year.

Baseline PG income of R726 million is 8% better than the prior year's comparative amount of R670 million.

The variance in the contract income is due to income not being earned as planned because of issues mentioned in section 5.1 above.

Operating expenses of R1 043 million were the same as the prior year's comparative amount and 15% less than the budget, driven mainly by direct running expenses on projects that were lower due to lower contract income.

Employees' remuneration of R1 476 million was 2.8% higher than the prior year's and 12% less than the budget.

Our B-BBEE rating is currently at Level 1, the best among public sector entities. Our RIR stands at 0.14 from 0.54 in the previous year.

Despite these huge gains and achievements, we have identified the following areas of improvement, which will receive focused attention in the current financial year:

- We need to ensure that we have a strong pipeline of priority patent applications to support the growth in patents granted. More importantly, is to ensure that we monetise this intellectual property through licensing and other means of commercialisation.

- The growth and transformation of our principal and chief researcher pools remain a challenge. Despite the various initiatives that we have put in place, progress is slow. As such, we have created a strategic fund to attract chief and principal researchers to the CSIR.
- We are seeing improvements in terms of private sector contract R&D; however, the pace at which this is growing remains slow. The external economic environment is a major contributing factor to this performance.

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 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 regarding 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 to also 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.

SO1

CONDUCT RESEARCH, DEVELOPMENT AND INNOVATION OF TRANSFORMATIVE TECHNOLOGIES AND ACCELERATE THEIR DIFFUSION.

This SO 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.

SO2

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

This SO 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.

SO3

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

This SO 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 RD&I.

SO4

BUILD AND TRANSFORM HUMAN CAPITAL AND INFRASTRUCTURE.

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

SO5

DIVERSIFY INCOME, AND MAINTAIN FINANCIAL SUSTAINABILITY AND GOOD GOVERNANCE.

This SO 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

SO1

CONDUCT RESEARCH, DEVELOPMENT AND INNOVATION OF TRANSFORMATIVE TECHNOLOGIES AND ACCELERATE THEIR DIFFUSION.

In this SO, the CSIR has put in place KPIs that measure the organisation's ambitions to translate knowledge generated into innovations.

SO1 KPIs: Planned targets and actual achievements

SO1: Conduct research, development and innovation of transformative technologies and accelerate their diffusion.						
Performance Indicator	Actual Achievement 2020/21	Planned Target 2021/22	Actual Achievement 2021/22	Deviation from Planned Target to Actual Achievement for 2021/22	Comment on Deviations	Threshold/ Number
KPI 01: Publication equivalents	406.5	300	422.5	40,8%	Target exceeded	>95%/>285
KPI 02: New priority patent applications filed	5	9	7	-22.2%	Target unachieved due to pipeline issues	>75%/>7
KPI 03: New patents granted	26	8	16	100%	Target exceeded	>80%/>6
KPI 04: New technology demonstrators	48	46	55	19,6%	Target exceeded	>85%/>39
KPI 05: Number of technology licence agreements signed	3	19	12	-36,8%	Target unachieved due the pervasive uncondusive economic environment for the uptake of early stage technologies	>75%/>14

Exceptional performance was realised for the 2021/22 financial year in the number of publication equivalents, the number of new patents granted and the number of new technology demonstrators.

Areas that need attention in the 2022/23 financial year include the number of new priority patent applications filed and the number of new licence agreements signed.

During quarters 1, 2 and 3 of the 2021/22 financial year, there were several administrative delays in negotiating new licence agreements between the CSIR and partners. The CSIR realised only 68% achievement in the number of new licence agreements signed. This result is better than the projections made in the quarter 3 report. Tremendous work was undertaken to conclude outstanding licence agreements.

The CSIR realised only 78% achievement in the number of new priority patent applications filed.

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

List of new priority patents filed

No	Patent title	Filing date	Application number	Country
1	Portable fluorescence detector	20/05/2021	2021/03411	South Africa
2	Antiviral lotion	20/05/2021	2021/03412	South Africa
3	Hemicellulose extraction method and use	27/08/2021	2021/06326	South Africa
4	Plant-based recombinant protein expression system	09/09/2021	2021/06641	South Africa
5	Vertical shaft kiln	30/09/2021	2021/07350	South Africa
6	Alcohol-free antimicrobial hand sanitiser	18/11/2021	2021/09136	South Africa
7	Modified waste plastic bitumen mixture for asphalt and process for production thereof	19/01/2022	2022/00850	South Africa

New patents granted

No	Patent Title	Patent Number	Issue Date	Country
1	A coupling device, a drive assembly for a coupling device and a method of supplying a substance	CN 110168271	02/03/2021	China
2	Treatment of erectile dysfunction and libido enhancement	PI0712478-3	23/03/2021	Brazil
3	A field effect transistor and a gas detector including a plurality of field effect transistors	10-2234452	25/03/2021	Korea
4	Liquid flame retardant composition	365445	27/04/2021	India
5	Plant-produced chimaeric orbivirus VLPs	11,053,509	06/07/2021	USA
6	Doped spinel cathode material having improved cycling performance	AR 107112	31/03/2021	Argentina
7	Pathogenic control of apoptosis	3180017	22/09/2021	EPO
8	Membrane and method for preservation of produce	CN10896639	30/03/2021	China
9	Dual active cathode materials	3649688	20/10/2021	EPO
10	Membrane and method for preservation of produce	11,154,067	26/10/2021	USA
11	A coupling device, a drive assembly for a coupling device and a method of supplying a substance	3433526	17/11/2021	EPO
12	Isotactic polypropylene-based composite	377825	24/09/2021	India
13	A coupling device, a drive assembly for a coupling device and a method of supplying a substance	11,221,096	11/01/2022	USA
14	Spinel material	ZL 201680079751.4	08/02/2022	China
15	Production of a layered lithium-manganese-nickel-cobalt oxide material	11,183,692	23/11/2021	USA
16	Electronically deriving a conclusion of the condition of slurry flow in a non-vertical conduit	11,268,842	08/03/2022	USA

Technology licence agreements signed

No.	Licensee	Technology	Date signed
1	Readspeaker BV	Qfreny text-to-speech system	29/07/2021
2	NLT Media	Qfreny text-to-speech system	02/09/2021
3	LODOX Systems	Umbiflow	27/10/2021
4	Polyfitero (Pty) Ltd	Keratin extraction from chicken feathers	02/03/2022
5	Sabinano (Pty) Ltd	Carbon nanotube related composites	18/02/2022
6	ICAT Environmental Solutions (Pty) Ltd	BioTab, BioTab A, BioTab B, Biogel, Biogel A and Biogel B	02/03/2022
7	Uvirco Technologies (Pty) Ltd	Quvir radiometric camera system for power line inspection	15/02/2022
8	Ecoinvader Solutions (Pty) Ltd	Biodegradable polymer formulations	25/02/2022
9	VEISA Trading Enterprise (Pty) Ltd	Vitamin fortified Okra beverage	24/02/2022
10	3Sixty Biopharmaceuticals (Pty) Ltd	Water-based antimicrobial hand sanitiser	31/03/2022
11	3Sixty Biopharmaceuticals (Pty) Ltd	Advanced antiviral personal protective equipment coating	31/03/2022
12	Hannover Engineering	Self-contained self-rescuers	30/03/2022

SO2

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

In this SO, the CSIR has identified high-impact sectors in which South Africa could carve out a competitive advantage to the specific sectors of the economy, stimulating overall socioeconomic growth.

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 2020/21	Planned Target 2021/22	Actual Achievement 2021/22	Deviation from Planned Target to Actual Achievement for 2021/22	Comment on Deviations	Threshold/Number
KPI 06: Number of localised technologies	5	11	14	27,2%	Target exceeded	>75%/>8
KPI 07: Number of joint technology development agreements being implemented for industry	25	22	25	13,6%	Target exceeded	>75%/>17
KPI 08: Number of SMMEs supported	96	75	99	32%	Target exceeded	>75%/>56

Exceptional performance was realised for the 2021/22 financial year in the three KPIs under this SO.

The CSIR realised 127% achievement (27% above set target) in the number of new localised technologies, 114% achievement (14% above set target) in the number of joint technology agreements being implemented for industry and 132% achievement (32% above set target) in the number of SMMEs supported. This performance demonstrates the CSIR's commitment to support re-industrialisation in the country through technology support. In this SO, there is a strong focus on serving the needs and requirements of the public sector and generating knowledge for the public good.

SO3

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

SO3 KPIs: Planned targets and actual achievements

SO3: Drive socioeconomic transformation through research, development and innovation that supports the development of a capable state.						
Performance Indicator	Actual Achievement 2020/21	Planned Target 2021/22	Actual Achievement 2021/22	Deviation from Planned Target to Actual Achievement for 2021/22	Comment on Deviations	Threshold/Number
KPI 09: Number of reports contributing to national policy development	21	17	22	29,4%	Target exceeded	>75%/>13
KPI 10: Number of standards delivered or contributed in support of the state	11	9	8	-11,1%	Target achieved	>75%/>7
KPI 11: Number of projects implemented to increase the capability of the state	44	40	86	115%	Target exceeded	>75%/>30

Exceptional performance was realised for the 2021/22 financial year in two of the three KPIs under this SO.

The CSIR realised 129% achievement (29% above set target) in the number of reports contributing to national policy development, 215% achievement (115% above set target) in the number of projects implemented to increase the capability of the state. This exceptional performance in supporting a capable state resonates very well with the mandate of the CSIR in that the organisation acts in the national interest.

Only 89% achievement (11% below set target) was realised in the number of standards delivered or contributed in support of the state. This achievement was satisfactory as it was within the threshold set in the 2021/22 Shareholder's Compact.

SO4

BUILD AND TRANSFORM HUMAN CAPITAL AND INFRASTRUCTURE.

This SO is concerned with building a transformed SET base and research infrastructure that will deliver high-quality scientific and industrial research capabilities that support the economy and a capable state.

Over the 2021/22 financial year, the total headcount of the CSIR increased to 2 209 employees. The size of the SET base is at 1 551 (70% of total) and the support base is at 658 (30% of total). We continue to closely monitor the ratio of SET to support and the total headcount to ensure that we maintain sustainability in the core mandated scientific and industrial R&D activities of the organisation. Our 2021/22 financial year turnover rate stands at 8.6% for permanent employees.

SO4 KPIs: Planned targets and actual achievements

SO4: Build and transform human capital and infrastructure.						
Performance Indicator	Actual Achievement 2020/21	Planned Target 2021/22	Actual Achievement 2021/22	Deviation from Planned Target to Actual Achievement for 2021/22	Comment on Deviations	Threshold/ Number
KPI 12: Total SET staff	1 474	1 497	1 551	3,6%	Target exceeded	>95%/>1442
KPI 13: Percentage of SET staff who are black	66.5%	66%	67.8%	1,8%	Target exceeded	Within 2%pts/ ≥64%
KPI 14: Percentage of SET staff who are female	36.4%	37%	39.1%	2,1%	Target exceeded	Within 2%pts ≥35%
KPI 15: Percentage of SET staff with PhDs	20.9%	23%	20.5%	-2,5%	Target unachieved; however, there was an increased recruitment effort of senior executives and researchers towards the end of the FY	Within 1%pt ≥22%
KPI 16: Total chief researchers	15	17	15	-11,8%	Target unachieved; a career ladder process has been initiated to curb the regression	>90%/>15
KPI 17: Percentage of chief researchers who are black	20.0%	17%	13.3%	-3,7%	Target achieved	Within 5%pts ≥12%
KPI 18: Percentage of chief researchers who are female	20.0%	24%	13.3%	-10.7%	Target unachieved; a career ladder process has been concluded in Q4 to curb the regression	5%pts/ ≥19%
KPI 19: Total principal researchers	179	193	188	-2,6%	Target achieved	>95%/>183
KPI 20: Percentage of principal researchers who are black	30.7%	35%	34%	-1%	Target achieved	Within 3%pts ≥32%
KPI 21: Percentage of principal researchers who are female	19.0%	22%	19%	-3%	Target achieved	Within 3%pts ≥19%
KPI 22: Number of exchange programmes with industry	8	13	31	138%	Target exceeded	8
KPI 23: PPE investment (Rm)*	89.4	100	104	4%	Target exceeded	>95%/>95%

The CSIR realised achievement greater than 100% in five KPIs under this SO.

The CSIR realised 104% achievement (4% above the set target) in the total number of SET staff, 103% achievement (3% above set target) in the percentage of SET staff who are black, 106% achievement (6% above the set target) in the percentage of SET staff who are female, 238% achievement (138% above the set target) in the number of staff involved in exchange programmes with industry and 104% achievement (4% above the set target) in the amount of money invested in PPE.

In four KPIs, the organisation realised satisfactory achievement (within the thresholds set in the 2021/22 Shareholder's Compact).

The CSIR realised 78% achievement (22% below the set target) in the percentage of chief researchers who are black, 97% achievement (3% below the set target) in the total number of principal researchers, 97% achievement (3% below the set target) in the percentage of principal researchers who are black, and 86% achievement (14% below the set target) in the percentage of principal researchers who are female.

The CSIR's performance in three KPIs under this SO was not satisfactory – the percentage of SET staff who hold a PhD degree, the total number of chief researchers and the percentage of chief researchers who are female.

The CSIR realised 89% achievement (11% below the set target) in the percentage of SET staff who hold a PhD degree, 88% achievement (12% below the set target) in the total number of chief researchers and only 55% achievement (45% below the set target) the percentage of chief researchers who are female.

SO5

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 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.

The CSIR exceeded performance in four of the KPIs under this SO – the net profit, percentage contract R&D income from international sources, the B-BBEE rating and the RIR.

The CSIR realised a 343% achievement (243% above the set target) in the net profit, 133% achievement (33% above the set target) in percentage contract R&D income from international sources, a rating of 1 against a target of 2 for the B-BBEE rating and an RIR of 0.14 (three recordable incidents/cases) against a target of 1.8 (37 incidents/cases).

Three KPIs were achieved – percentage contract R&D income from public sector sources, percentage of contract R&D income from local private sector sources, and the audit outcome from the review of CSIR annual financial statements and annual performance report.

The CSIR realised a 92% achievement (8% below the set target) in the total income for the 2021/22 financial year. The CSIR holds an unqualified audit record from the previous financial year; the external audit of the 2021/22 results is currently underway.

SO5 KPIs: Planned targets and actual achievements

SO5: Diversify income, maintain financial sustainability and good governance.						
Performance Indicator	Actual Achievement 2020/21	Planned Target 2021/22	Actual Achievement 2021/22	Deviation from Planned Target to Actual Achievement for 2021/22	Comment on Deviations	Threshold/ Number
KPI 24: Total income (Rm)	2 569	2 869	2 654	-7,6%	Target unachieved due to adverse economic conditions due to ongoing Covid-19 pandemic	>95%/>2726
KPI 25: Net profit (Rm)	96	-96,1	137	+R233m	Target exceeded	>95%/> -101
KPI 26: South African public sector income (% total income)	56%	56%	56%	0%	Target achieved	>95%/>53.2%
KPI 27: South African private sector income (% total income)	13%	9%	9%	0%	Target achieved	>95%/>8.5%
KPI 28: International contract income (% total income)	5.0%	6%	8%	2%	Target exceeded	>95%/>5.7%
KPI 29: B-BBEE rating*	2	2	1	Improved	Target exceeded	2
KPI 30: RIR*	0,53	1,8	0,14	Improved	Target exceeded	1.8
KPI 31: Audit opinion	Unqualified audit opinion	Unqualified audit opinion	Unqualified audit opinion	Unqualified audit opinion	Unqualified audit opinion	Unqualified audit opinion

REVENUE COLLECTION

Sources of revenue	2021/2022			2020/2021		
	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	725 537	730 274	4 737	703 100	657 846	-45 254
Contract income	2 140 288	1 916 674	-223 614	2 005 400	1 907 110	-98 290
Royalty income	2 000	7 395	5 395	0	3 691	3 691
Total	2 867 825	2 654 343	-213 482	2 708 500	2 568 647	-139 853

The CSIR received all the PG that was budgeted for in the current year, the difference is due to PG for projects that commenced during the previous financial year but were only completed in the current financial year. 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 achieving the objectives of the CSIR Strategy and, in particular, SO4. On Thursday, 3 June 2021, the CIP for 2021/22 was presented and approved by EXCO. The CIP 2021/22 performance is reported on capital investment planning and the execution of capital projects, which is consolidated from reports provided by the different areas – facilities management, ICT and RD&I, which have funding approved by EXCO. The CAPEX investment per allocation area, which was approved in the FY, is shown in Figure 1.

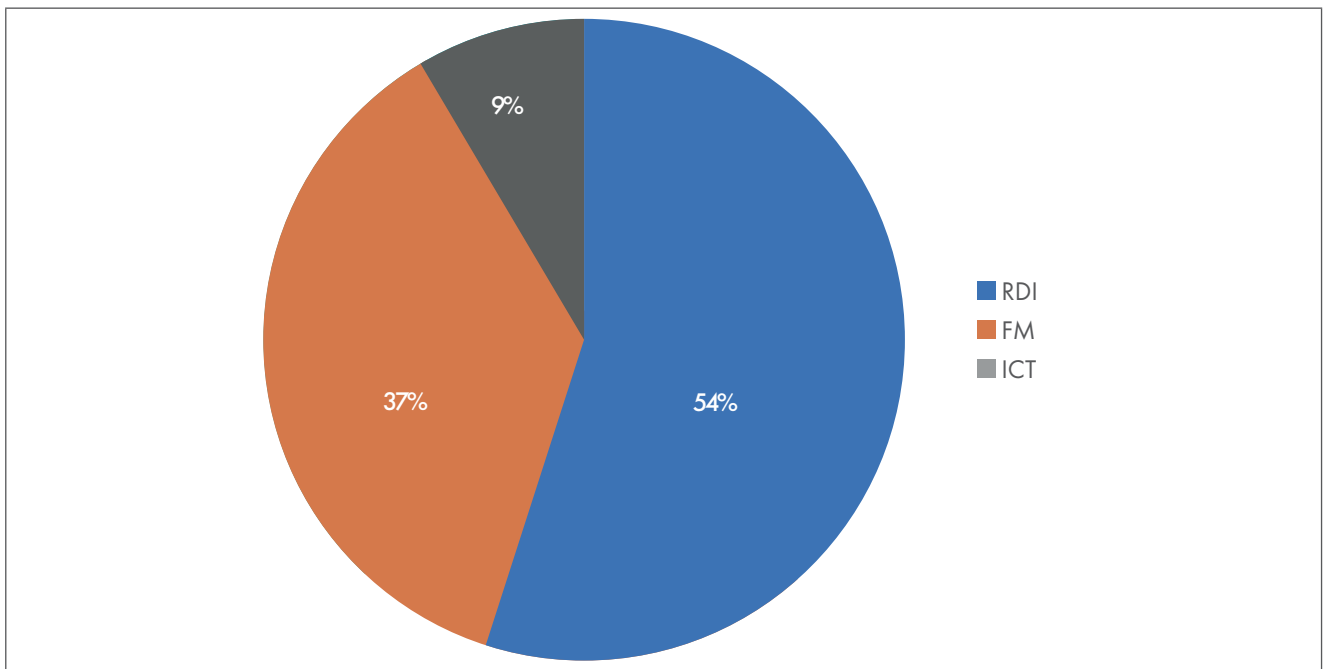


Figure 1: CSIR funds budget allocation per area

The total funding of projects amounts to about R262 million, including the allocation of NT funds and the DSI funds for FY 2021/22. Figure 2 shows the initial percentage split, per source of the total funding of projects on the CIP list as it was initially allocated.

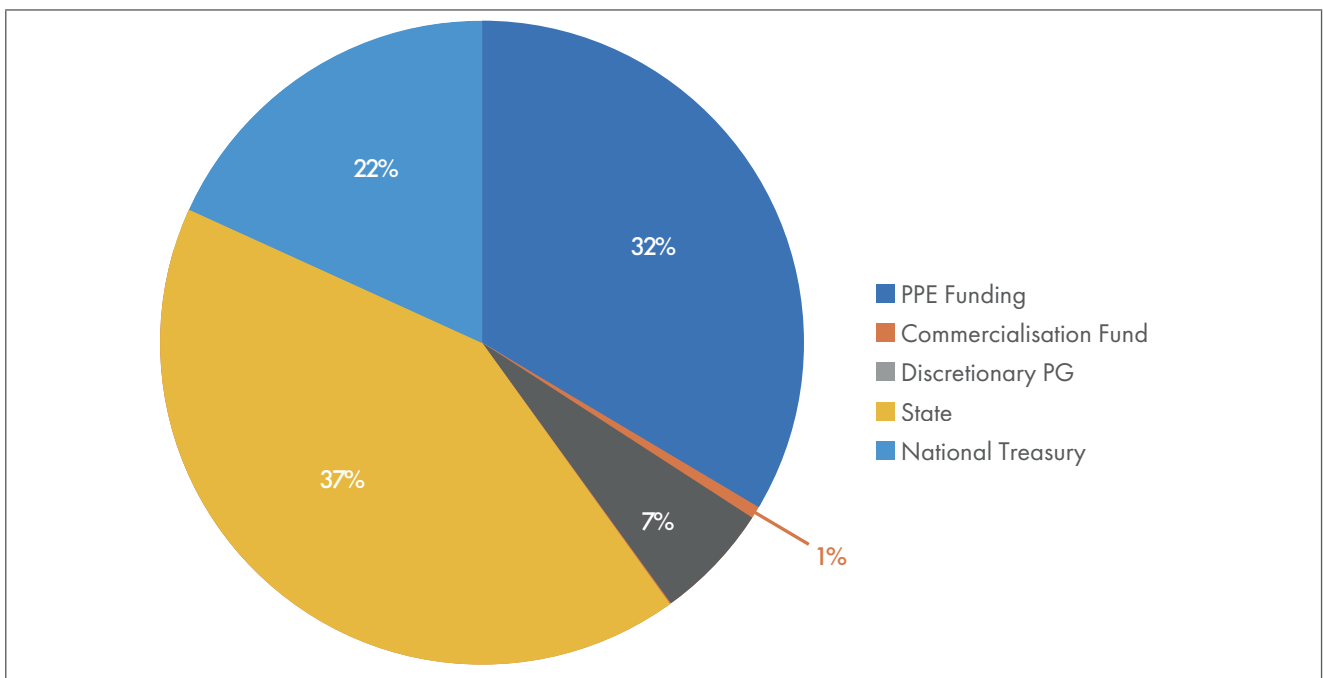


Figure 2: Total budget breakdown per source

TOTAL BUDGET BREAKDOWN PER FUNDING SOURCE

On average, only 30% of the allocated PPE funds for the 2021/22 FY have been spent. From the allocated infrastructure funds, the RD&I office, excluding NT projects, 49% and FM 29.5%. The ICT department had not spent any of the funds and focused mostly on ensuring that projects reach the procurement phase in the 2021/22 financial year. The budget versus expenditure is shown in Figure 3.

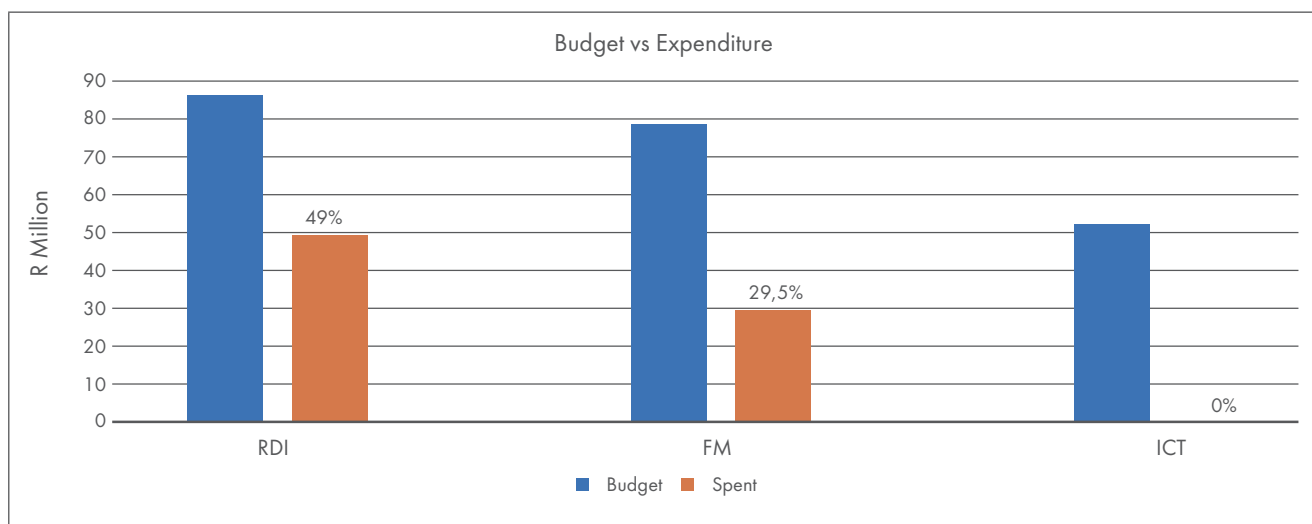


Figure 3: Infrastructure project allocation versus expenditure

RD&I infrastructure projects

The RD&I portfolio covers 13 projects of which two are externally funded by the state, one is funded through the commercialisation fund and nine are funded through PG discretionary. Approximately 49% of the budget has been spent, however, some delays have been experienced due to the moratorium on tenders.

NT-funded group of projects

NT is currently funding four capital infrastructure projects. Approximately 92% of the budget allocation has been committed. This is ringfenced funding allocated to the CSIR and the projects will be completed in three years. As per the contract with the DSI, when the projects are committed up to 90% of the funding, new funding will be allocated to the projects. These projects are currently on track.

Facilities and general infrastructure

The facilities projects focus largely on addressing the deferred maintenance priorities related to building systems and infrastructure. The approved budget includes funding for projects that were not completed in the previous FY. There is currently a mix of projects, with most projects either complete or nearing completion. Of the 19 planned projects for the FY, six are complete, five are in the construction stage, four are in the procurement stage, four are in the planning stage and one has been cancelled. 29.5% of the allocated funds have been spent in this FY.

Information and communications technology

The ICT area has not spent any of its allocated funds and all projects are currently in the procurement phase. All projects in this space are in the initial phase and getting ready for procurement as a result most of the projects will be carried over to the next financial year.

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.

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 Premanufacturing 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.



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.

PART D

GOVERNANCE

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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 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 CEO and delegated executives) of the public entity are responsible for corporate governance.

CSIR/PARLIAMENT ENGAGEMENTS

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

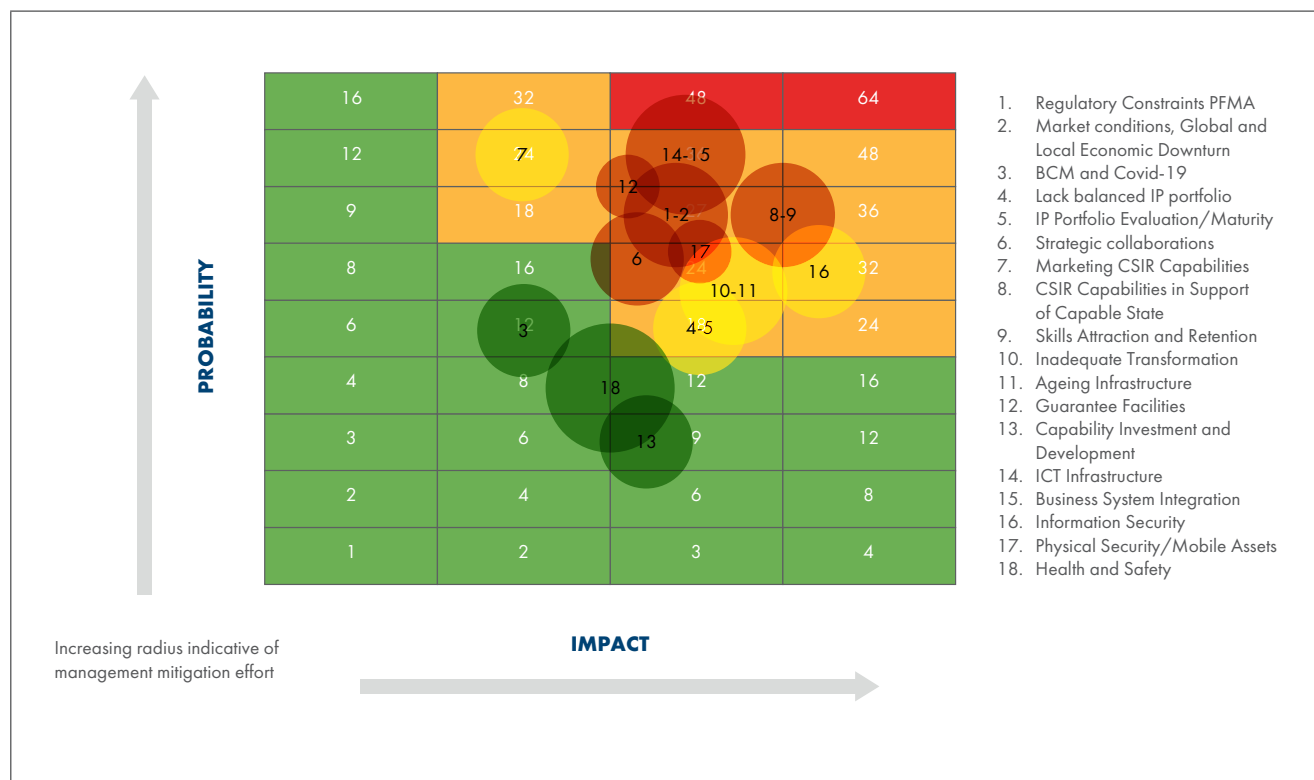
The table below details the engagement activities.

SUMMARY OF ENGAGEMENTS 2021/22				
Date	Activity	Details	Type of Engagement	Responsible Person/ Party
7 May 2021	Presentation on the 2021/22 CSIR Shareholder's Compact	PC on Higher Education, Science and Innovation	Accountability	Board/EXCO
25 May 2021	Round table discussion on the impact of digital media in misinformation and content moderation, especially to ensure election integrity	PC on Communications	Scientific Advisory	Jabu Mtsweni; Dr Vukosi Marivate and Noluntu Mpekoa
30 September 2021	Tabling of the 2020/21 CSIR Annual Report in ATC 133 of 2021	Minister of Higher Education, Science and Innovation	Accountability	Board/EXCO
12 November 2021	Presentation on the 2020/21 CSIR Annual Report	PC on Higher Education, Science and Innovation	Accountability	Board/EXCO
9 December 2021	Launch of the South African Parliamentary Institute	Ms Khungeka Njobe represented the CSIR on a panel at an event on opportunities for strengthening partnerships for the capacitation of the State	Networking	Khungeka Njobe
10 December 2021	Parliament on 4IR	Meeting with the Deputy Speaker, Dr Ntsibane Ntlatlapa and Ms Khungeka Njobe. The meeting focused on various 4IR-related work streams that the two entities could collaborate on	Science Advisory	Khungeka Njobe and Ntsibane Ntlatlapa
15 March 2022	Briefing by the Department of Mineral Resources and Energy, Central Energy Fund, National Treasury and the CSIR, respectively, on the impact of the increasing fuel prices on the economy and possible alternatives and/or considerations	PC on Mineral Resources and Energy	Science Advisory	Thulani Dlamini; Clinton Carter Brown and Mathetha Mokonyama
22 March 2022	Tabling of the CSIR Shareholder's Compact in ATC 42 of 2022	Minister of Higher Education, Science and Innovation	Accountability	Board/EXCO

Areas of risk and what implementation plans/actions the public entity undertook

The graph below presents the top risks mapped for the organisation during the last year and reflects the risk profile that we closed the year with.

For each of these risks, the organisation has a defined risk mitigation strategy and risk owner from the executive to monitor mitigation progress and risk movement. It is presented to EXCO 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:

- Five-year Strategic Plan
- Annual Performance Plan
- Governance Structures
- Risk Plan
- Fraud Plan
- Financial Plan
- Materiality/Significance Framework

The Executive Authority requires quarterly reporting from the CSIR on prescribed dates. For the 2021/22 financial year, the following reports were submitted.

- Quarter 1 Report – 20 July 2021
 - Quarter 2 Report – 20 October 2021
 - Quarter 3 Report – 20 January 2022
 - Quarter 4 Report – 20 April 2022
- No issues were raised by the Executive Authority on reports submitted.

THE ACCOUNTING AUTHORITY/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 and gives input on policies that ultimately influence the way governance is conducted. It further 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 of the organisation and monitors compliance with policies, applicable legislation and achievement against objectives. All members of the Board, except the CEO, 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 21 May 2021, 29 July 2021, 28 October 2021 and 17 February 2022. Board strategic sessions were held on 26 and 27 August 2021. The annual financial statements for the 2021/22 financial year were approved on 29 July 2021.

The Board further engaged in various ad hoc meetings to be advised and provide 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 88). 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 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 the following:

- 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 complying with the Charter in that it:

- Has guided the continued integration of the CSIR's values and standards of conduct, 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; and
- 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
CSIR Chairperson of the Board



Dr Thulani Dlamini
CSIR CEO



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/APAC, 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

Ms Phindile Baleni resigned from the CSIR Board in June 2021.

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)	Director – A1 Consulting Engineers CC		8
Dr Amber-Robyn Potts (Childs)	2019	Active	Rhodes University PhD (Ichthyology) MSc (Cum Laude) (Ichthyology)	None	RDI Committee	8
Dr Ramatsemela Masango	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)	Executive Director Mzansi Energy Solutions and Innovations (Pty) Ltd (Mzesi) Mzesi Energy Mzesi Academy Mzesi Holdings Non-Executive Director ArioGenix Face to Face Foundation Redhorn Holdings Mzesi Water and Construction Yonga Energy Tingo Technologies Amanzi Technologies Africa Energy Wise Solutions Zondibex Miyazi Investments Vito	RDI Committee HRSEC Committee	7
Dr Thulani Dlamini	2017	Active	University of Witwatersrand PhD Chemistry, Catalysis BSc (Hons) Chemistry BSc Chemistry University of South Africa Master's in Business Leadership	Council Member National Advisory Council on Innovation Director Vumelana Trade 120 Kusile Invest 125 Mavela Consulting Services		8
Dr Christine Render	2019	Active	Leeds University PhD (Chemical Engineering) BSc Hons. (Chemical Engineering)	Partner/Shareholder Owner – Team Consultation Pty (Ltd);	ARC RDI Committee	8
Dr Vuyo Mthethwa	2019	Active	University of KwaZulu-Natal PhD (Higher Education Governance)	Employee; Senior Director Durban University of Technology	ARC HRSEC	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
Phindile Baleni	2015	Resigned June 2021	University of the Witwatersrand BProc LLB	Member Wits University Council: (non-remunerative) Board Member IIASA NMO (RSA): (non-remunerative) Employee: (Director General) Gauteng Provincial Government Shares First Rand Black Directors BEE Scheme/Trust New Shelf (Pty) Ltd First Shelf (Pty) Ltd Trustee Rev LW Mbethe Education Trust (Non remunerative)	HRSEC ARC	0
Cassim Shariff	2019	Active	Leicester Business School, DeMontfort University Master's in Business Administration	Executive Director Aquaworx Remediator and Infrastructure Solutions Southern Cross Diamonds Director Lirazest Greenstone Energy Non-Executive Director Silver Crown Trading	HRSEC RDI	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
Stafford Masie	2019	Active		Non-Executive Director and Shareholder Thumbzup South Africa Thumbzup Australia/ AsiaPac Thumbzup International (London) Thumbzup USA Executive Director and Shareholder/Funder Green Moon Transact GATTACA SnapTutor LRXYM Fitness Non-Executive Director and Board Member Advtech – Sauronai Holdings LLC (USA): (South Africa) Discovery Bank	ARC RDI	8
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)	Director Business Entrepreneur Community - (Dormant, deregistration process) Equota Mokhabuki Building and Construction Sphimokha Digiten Employee MICT SETA	ARC	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
Joel Netshitenzhe	2015	Active	University of London MSc (Financial Economics) Postgraduate Diploma (Economic Principles) Institute of Social Sciences, Moscow Diploma (Political Science)	Executive Director Mapungubwe Institute of Strategic Reflection Director Life Healthcare Group Lushote Trading (Fledgling) Topaz Sky Trading 316 (Fledgling) Betascape (Dormant) Member Camel Rock Trading 434 (Dormant) NEC Member African National Congress Patron Oliver and Adelaide Tambo Foundation Visiting Professor Wits School of Governance	RDI	7

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. 18 May 2021 20 July 2021 26 July 2021 (Special) 19 October 2021 8 February 2022	4	Tiny Mokhabuki – Chairperson Stafford Masie Dr Christine Render Dr Vuyo Mthethwa
Human Resources, Social and Ethics Committee	Four meetings were held. 19 May 2021 21 July 2021 18 October 2021 9 February 2022	3	Dr Vuyo Mthethwa – Chairperson Cassim Shariff Dr Ramatsemela Masango
Research, Development and Industrialisation Committee	Four meetings were held. 20 May 2021 22 July 2021 21 October 2021 10 February 2022	5	Dr Christine Render Dr Ramatsemela Masango Dr Amber-Robyn Potts (Childs) Cassim Shariff Joel Netshitenzhe

Remuneration of board members

Name	Remuneration per meeting	Other allowance	Other re-imbursements	Total
Prof. Thokozani Majozi	R 15 696	None	None	R363 000.00
Dr Amber-Robyn Potts (Childs)	R11 664	None	None	R118 098.00
Dr Ramatsemela Masango	R11 664	None	None	R153 090.00
Stafford Masie	R11 664	None	None	R166 698.00
Dr Vuyo Mthethwa	R11 664	None	None	R166 698.00
Dr Christine Render	R11 664	None	None	R166 698.00
Cassim Ebrahim Shariff	R11 664	None	None	R164 754.00
Tiny Mokhabuki	R11 664	None	None	None
Joel Netshitendzhe	R11 664	None	None	R102 271.31

RISK MANAGEMENT

The Board is responsible for ensuring that there is a comprehensive and effective risk management system 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.

The CSIR has a Board-approved Risk Management Policy and a supporting framework. The policy and framework are 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 EXCO 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. 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 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 or initiatives. The outcomes of the

various risk assessments are 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 the following three key categories:

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 function 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:

- Performance reporting;
- Human capital management and development;
- Contract income and project management;
- Financial management;
- Property plant and equipment;
- Supply chain management and accounts payable;
- Billing and accounts receivable;
- Customer contract management;
- Royalty income;
- Health and safety;
- Information, Communication and Technology;

- Records management;
- Board of Directors and Executives remuneration and expenses; and
- Follow-up of previous audit findings.

Key activities and objectives of the Audit and Risk Committee

The Audit and Risk Committee enhances the independence of the Internal Audit function 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 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 do the following:

- Create and maintain an effective internal control environment – financial controls, accounting systems and reporting;
- Deal with all matters prescribed by the regulations issued in terms of 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 can prevent, detect, and respond to fraud and allegations of fraud; and
- Discharge its responsibility relating to:
 - the safeguarding of assets,
 - operation of adequate procedures and controls,
 - reviewing of 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 about the Audit and Risk Committee members.

Table 3: Relevant information about 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
Tiny Mokhabuki	External		2019	Active	4
Dr Thulani Dlamini	Internal	CEO	2015	Active	5
Phindile Baleni	External		2015	Resigned	0
Dr Christine Render	External		2019	Active	5
Stafford Massie	External		2019	Active	5
Dr Vuyo Mthethwa	External		2019	Active	5

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; and
- 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 aims to develop a well-defined regulatory and compliance universe for the CSIR and ensure 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 and Management Policy (FPMP) and Fraud Prevention Plan (FPP) have 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 and corrupt 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; and interactions with upstream and downstream stakeholders in its value chain and overall value proposition, including public and private sector customers, members of the public, suppliers and service providers, employees and its shareholder.

In alignment with the CSIR's core organisational values of excellence, being people-centred, integrity and collaboration, 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 the following 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 were approved by the Board on 16 October 2021. A supplementary FPMP 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 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 and service providers who have been found to be 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 and fraud to the police.

The CSIR's Audit and Risk Committee significantly influences the fraud control environment, particularly by setting the tone at the top of the organisation. This is achieved through 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 and CSIR employees (internal stakeholders) 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 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 items of business to be transacted at a meeting. Equally, CSIR employees are required to disclose any interest they may hold in any organisation, whether it does business with the CSIR or not. This requirement and duty to disclose are enforced when internal stakeholders join the CSIR, and at any stage thereafter as necessitated by changed circumstances or position that may pose a potential conflict of interest.

For the CSIR Board, the declarations are managed by the Company Secretariat function and for CSIR employees, by the Human Capital Development function.

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 above 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 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 EXCO 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 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 and Safety Health Environment Leadership 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 the CSIR's re-positioning of its support services, the SHEQ structure has also now been 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 1.8, by achieving an RIR of 0.14. Despite this achievement, the CSIR is continuously monitoring its SHE risks and implementing appropriate response measures to address undesirable trends as and when identified. This includes numerous management safety walkabouts, SHE articles published on the IntraWeb and safety tips communicated in SHE committees in the clusters, centres, portfolios and regional sites. This is done to raise awareness on the number of recordable incidents and environmental issues that occurred during the year, the lessons learned from such incidents and near misses.

CSI AND OUTREACH ACTIVITIES

CSI

As per the requirements of the Corporate Social Investment Policy, a CSI committee was established to oversee the implementation of the CSI programme. The CSI framework document has been approved by EXCO. For Mandela Day, the CSIR donated office furniture to Sikhululekile High School in Hammanskraal, the school that was identified as a strategic partner to the CSIR based on its focus on science, maths and technology. Three top-performing underprivileged (quintile 1 to 3) schools in rural KZN were identified and engaged to ensure continued support of students and seamless assimilation into tertiary institutions.

CSIR Youth Outreach

The National Science Week Roadshow that was held in August 2021 in KZN and the Free State was a huge success. The CSIR reached students and schools, who without our visit would not have had any information about the CSIR or the available career and bursary opportunities. The number of engagements and radio interviews leading to the National Science Week boosted appeal, which saw a huge interest from the schools and students to engage with the CSIR team. Team CSIR engaged about 3 500 students from grades 10 to 12 at 17 schools in both provinces.

There was a follow-up visit to rural KZN from 27 to 29 September 2021, which the Group Executive: Human Capital and Strategic Communications also participated in, to hold initial engagements with the three schools that the CSIR intends to adopt. The criteria that the CSIR used to select the schools were as follows:

- A top-performing underprivileged science, engineering and technology school in rural KZN;
- A school with a pass rate of 90% to 100% in the last three years; and
- A quintile 1 to 3 school.

The selected schools are Fundukhaliphe High School in Nongoma, Phumanyova High School in Nongoma and Ukuphumula Secondary School in Nquthu. During these engagements, the CSIR was able to further engage 500 maths and science learners in grades 10 to 12. As part of the concerted effort to increase the CSIR's footprint in the KZN rural and underprivileged areas, outreach visits were planned as part of this follow-up visit, which included Bizimali High School in Nkandla, where the CSIR engaged 1 200 maths and science learners in grades 10 to 12 and Tshelimnyama Primary School in Mariannhill, where the CSIR further engaged 210 learners in grades 6 and 7. To expand the outreach programme and ensure diversity, two high schools of learners living with disabilities and some coloured schools were also identified in Pretoria and the Northern Cape, respectively.

BOARD SECRETARY

The Board Secretary's responsibilities include the following:

- 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 interest 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 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; and
- 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.

AUDIT COMMITTEE REPORT

We are pleased to present our report for the financial year ended 31 March 2022.

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 90 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 92 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 2022. Based on the information provided, the Committee considers that it complies, in all material respects 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 2022

B-BBEE COMPLIANCE PERFORMANCE INFORMATION

The following table has been completed in accordance with 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, Industry and Competition.

Has the department/public entity applied any relevant Code of Good Practice (B-BBEE Certificate Levels 1 – 8) with regard 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 and concessions or authorisations to allow economic activity in terms of any law. This would likely only apply to entities that are responsible for issuing trade licences or mining and 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, and so forth 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 or technology on sale and 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 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 small, medium and micro-enterprises, criteria such as B-BBEE levels, status or black and 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 awarding 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 Youth Employment Service 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, and so forth).



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

PART E

HUMAN CAPITAL

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INTRODUCTION

The CSIR plays an instrumental role in supporting national strategic objectives through investment in and the development of skilled human capital that is capable of contributing towards the achievement of the national imperatives through the scientific research, innovation and technology development that is required to address the socioeconomic challenges of the country.

The role and contribution of science councils in South Africa as instruments to enhance the country's scientific and innovation capabilities towards economic advancement and the implementation of national strategic objectives in the National Development Plan were emphasised by President Ramaphosa in the 2019 State of the Nation Address. The development of technology and people that is required to achieve these objectives is imperative to advance society, create employment opportunities and address poverty and inequality. Research and innovation are key drivers for the implementation of initiatives to transform the economy towards industrialisation and create opportunities for local industries and manufacturing, develop skills and address high levels of unemployment. The CSIR implemented a new strategy, operating model and programmes to enhance scientific research and innovation capabilities and the 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, stimulation of economic growth and creation of new job opportunities.

The contribution of the CSIR towards challenges of the country requires a highly skilled, diverse, developed and capable workforce that is able to deliver on the CSIR's mandate and national strategic objectives. The continuous development of human capital is imperative to build a sustainable supply of SET staff.

Transformation of the CSIR staff, particularly the SET base, remains a priority and progress has been made in the last few years in terms of demographic diversity and strengthening the SET base.

With regard to talent management, the organisation has experienced a turnover of key staff such as chief, principal and senior researchers (especially black and female SET staff), which has an impact on the researcher profile, project delivery and mentorship of young and emerging researchers. The CSIR is responding to this turnover challenge by entrenching performance and talent management processes to effect career development and a performance management culture, which is crucial in developing, rewarding and retaining different segments of talent. The enhancement of the career ladder process, supported by the business strategy, which is directed at making an impact on industrialisation and commercialisation, has also ensured that the organisation meets staff expectation.

The organisation has several vacancies in critical positions, which are being prioritised while taking affordability of the organisation into account. The organisation is using a per-needs-basis recruitment strategy, which ensures that the business needs are realised in an affordable and responsible manner when considering PG funding cuts. HC has commenced a process of workforce and recruitment planning to ensure a clear and consistent approach to the current and future resourcing needs to guarantee that the organisation is properly capacitated. The organisation has implemented a new operating model, which provides the roadmap for future organisational growth aligned to the organisational and human capital strategy to ensure that the CSIR has a healthy workforce to support its core business. The processes mentioned above will be augmented by a climate survey and the CSIR's people's strategy, supported by a strong employee value proposition.

Human capital development remains a priority to ensure that the organisation is adequately equipped with the right skills for it to meet its strategic objectives. There are several pipeline development programmes that aim to improve the attraction and retention of critical skills. The pipeline programmes provide the organisation with access to PhD graduates to address the percentage of staff qualified with doctoral qualifications.

The CSIR is now gearing itself to focus on leadership and management development programmes to equip all levels of management (from supervisory to executive) with critical management competencies. Leadership and management development programmes, formalised coaching and mentorship programmes have been introduced to support the efforts in talent management and succession planning rollouts.

Provision of reliable people data to the organisation to assist with decision-making and protection of such data is critical. The importance of HC systems as enablers cannot be overemphasised. Through efficient systems, management responsibilities such as recruitment, performance reviews and similar administrative responsibilities are made easier for managers to spare more time for other equally important operational matters. HC systems must also be efficient in tracking important organisational metrics and simplifying reporting in a continuously reliable manner, as well as supporting faster decision-making.

The CSIR recognises that, from a business and moral perspective, it is important to entrench employment equity and diversity in the workplace and to comply with legislative requirements. One such requirement is that all designated employers are required to take steps to consult and attempt to reach agreement with employees on matters of employment equity and skills development.

To further this end, the CSIR has recently established the Employment Equity and Skills Development Committee (the committee) and Consultative Forums (the forums). The committee and the forums shall represent CSIR employees with the view of effectively addressing 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 interfered with the provisions of educational employment opportunities in the past and have created barriers to full and equal participation of most of the population in economic life, both outside and within the CSIR.

As part of the retention strategy and ensuring that the CSIR is still regarded as the Top Employer to work for, the organisation continues to strengthen its rewards system and EVP. As such, the annual bonus incentive scheme was reviewed and a new short-term incentive scheme has been developed for the CSIR

reward system. The Board approved the proposed scheme in the third quarter of 2021. In addition, an EVP has been designed and developed to be attractive to the type of people that the organisation wishes to attract and retain.

Engagement activities are key to the CSIR and several initiatives, such as the Women's and Youth Forums, have been introduced in the organisation. The Women's Forum was launched in October 2021 and is intended to be a gateway to addressing challenges faced by women in the workplace. The forum emphasises the importance of empowering women in some male-dominated industries and aims to find solutions with women leading and championing the women's development agenda. The Youth Forum initiative further emphasises the role that the youth play in contributing and influencing the strategic future of the CSIR. The forum creates space for networking and collaboration among young professionals, while also contributing towards building a vibrant and inclusive organisational culture withing the CSIR.

STAFF AND TRANSFORMATION PROFILE

Staff profile

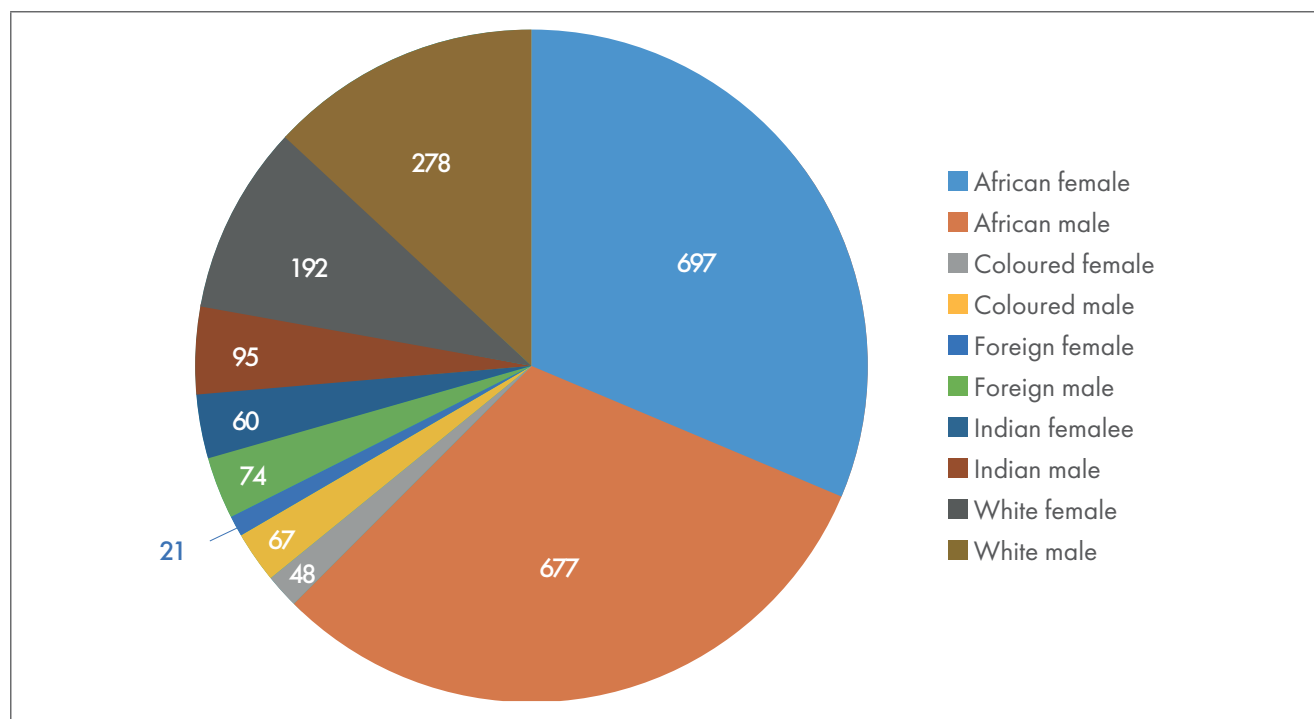


Figure 1: Staff profile

The CSIR total staff headcount at the end of 2021/22 was 2 209, compared to 2 143 as at 31 March 2021, an increase of 66 for this financial year. The CSIR headcount at the end of quarter 4 includes 1 551 (70.2%) SET staff and 658 (29.8%) support staff. Even though most of the CSIR staff was working from home due to the Covid-19 national disaster restrictions, the CSIR still managed to increase the total number of staff and number of SET staff.

Table 1: CSIR staff profile as at 31 March 2021/22

Staff Category	SET Staff	%	Support Staff	%	Total	%
PERMANENT	1 309	59.3%	547	24.8%	1 856	84.0%
TEMPORARY	82	3.7%	45	2.0%	127	5.7%
STUDENTSHIPS	26	1.2%	0	0.0%	26	1.2%
GITs	44	2.0%	3	0.1%	47	2.1%
INTERNS	38	1.7%	12	0.5%	50	2.3%
IN-SERVICE TRAINEES	0	0.0%	0	0.0%	0	0.0%
YES PROGRAMME	28	1.3%	28	1.3%	56	2.5%
WIL STUDENTS	24	1.1%	23	1.0%	47	2.1%
GRAND TOTAL	1 551	70.2%	658	29.8%	2 209	100.00%

Staff Transformation Profile

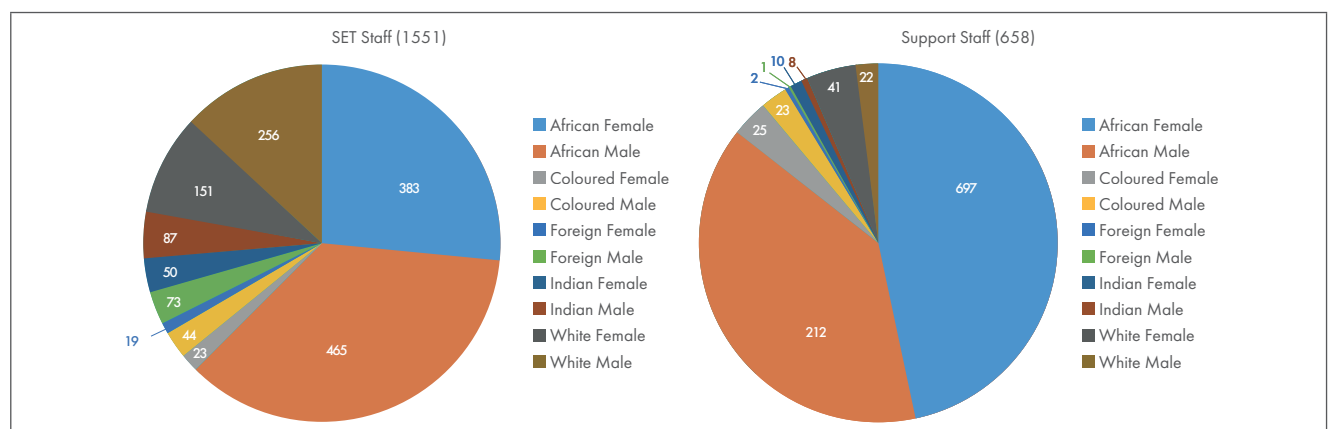


Figure 2: SET and support staff profile

CSIR Employment Equity Performance against NEAP Targets

The table below reflects the transformation profile against National Economically Active Population (NEAP) targets as at 31 March 2022. We saw a growth of designated groups by 4.1% from 70.4% to 74.5% and, in the same period, saw a decrease in non-designated groups by 4.1% from 29.6% to 25.5%.

Table 2: 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
FY19/20 Average %	27.6	28.5	2.7	2.6	4.6	2.8	15.8	10.4	95	3.9	1.1	5	100
FY20/21 Average %	29	28.7	2.9	2.4	4.5	2.9	14.5	10.2	95.1	3.9	1	4.9	100
FY21/22 Average %	30.7	31.6	3	2.2	4.3	2.7	12.5	8.7	95.7	3.4	0.9	4.3	100
GAP % (FY21/22 Ave Vs Target %)	-12	-4.2	-2.2	-2.2	2.6	1.6	7.4	4.7	-4.3	3.4	0.9	4.3	0

Number of Staff with Disabilities

Table 3: Staff with Disability by Occupational level

Occupational Category	AM	CM	IM	WM	AF	CF	IF	WF	Total	Total Staff	%
TOP MANAGEMENT	0	0	0	0	0	0	0	0	0	17	0.0%
SENIOR MANAGEMENT	0	0	0	0	0	0	0	0	0	92	0.0%
MIDDLE MANAGEMENT	3	0	0	6	0	0	1	2	12	854	1.4%
SKILLED	3	0	0	4	0	0	1	1	9	869	1.0%
SEMI-SKILLED	1	0	0	0	0	0	0	0	1	250	0.4%
UNSKILLED	9	1	0	0	7	0	0	0	17	127	13.4%
TOTAL	16	1	0	10	7	0	2	3	39	2 209	1.8%

STAFF MOVEMENTS

Appointments by Occupational Level

A total of 396 employees (including 278 temporary employees), comprising 363 (91.9%) black South Africans and 197 (49.6%) female South Africans were appointed from 1 April 2021 to 31 March 2022 as seen in the following table. This total number of appointments includes 118 permanent staff, of which 108 (91.5%) were black South Africans and 45 (38.1%) were female South Africans. There were 78 (66.1%) and 40 (33.9%) permanent SET staff and support staff, respectively, for the 2021/22 FY.

Table 4: Appointments by Occupational level

Category	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
TOP MANAGEMENT	1	0	0	0	0	0	0	0	1	0	0	0	1
SENIOR MANAGEMENT	2	2	0	0	0	0	0	0	4	0	0	0	4
MIDDLE MANAGEMENT	23	16	4	2	2	4	3	2	56	1	0	1	57
SKILLED	26	15	1	0	2	3	3	0	50	0	1	1	51
SEMI-SKILLED	3	0	1	1	0	0	0	0	5	0	0	0	5
TOTAL PERMANENT	55	33	6	3	4	7	6	2	116	1	1	2	118
TEMPORARY	27	40	0	0	1	1	7	5	81	1	0	1	82
STUDENTSHIP	5	4	0	1	0	2	2	0	14	0	1	1	15
PIPELINE	47	52	0	2	0	1	1	0	102	0	1	1	103
GRADUATES IN TRAINING	6	6	1	0	2	2	1	3	21	0	0	0	21
YES PROGRAMME	22	33	1	0	0	0	0	0	56	0	0	0	56
GRAND-TOTAL	162	168	8	6	7	13	17	10	391	2	3	5	396

The total number of employees, including temporary employees of 175, who exited the CSIR in the 2021/22 FY is 332, which includes 271 (81.6%) black South Africans and 152 (45.8%) female South Africans. There were 222 (66.9%) SET staff, while support staff accounted for 110 (33.1%) of the total for the year.

Table 5: Total Staff Exits

Occupational Category	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
PERMANENT	55	40	4	3	9	7	25	9	152	0	3	3	155
TEMPORARY	59	77	10	3	0	2	8	10	171	4	2	6	177
GRAND TOTAL	114	117	14	6	9	9	33	19	321	4	5	9	330

A total of 155 permanent staff exited the CSIR since the beginning of the FY to the end of March 2022. This brings the attrition rate of permanent staff for the 2021/22 FY to 7%. The permanent staff exits for the year include 118 (76.1%) black South Africans and 59 (38.1%) female South Africans. SET permanent employees accounted for 115 (74.2%) out of the 155 permanent employees, while permanent support staff accounted for 40 (25.8%) for the year.

Table 6: Permanent Staff Exits by Occupational category

Occupational Category	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
TOP MANAGEMENT	0	1	0	0	0	0	0	0	1	0	0	0	1
SENIOR MANAGEMENT	1	2	0	0	1	0	4	0	8	0	0	0	8
MIDDLE MANAGEMENT	19	8	1	2	5	5	17	6	63	0	3	3	66
SKILLED	28	26	2	1	3	2	4	3	69	0	0	0	69
SEMI-SKILLED	5	3	1	0	0	0	0	0	9	0	0	0	9
UNSKILLED	2	0	0	0	0	0	0	0	2	0	0	0	2
GRAND TOTAL	55	40	4	3	9	7	25	9	152	0	3	3	155

Table 7: 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	2	1	0	0	0	0	2	0	5	0	0	0	5
DISMISSAL	1	1	0	0	0	0	0	0	2	0	0	0	2
TERMINATION OF CONTRACT	0	0	0	0	0	0	0	0	0	0	0	0	0
NO-FAULT DISMISSAL: INCAPACITY	0	3	0	1	0	1	0	1	6	0	0	0	6
NO-FAULT DISMISSAL: RETRENCHMENT	0	0	0	0	0	0	0	0	0	0	0	0	0
RESIGNATION	51	35	4	2	9	6	19	7	133	0	3	3	136
RETIREMENT	1	0	0	0	0	0	4	1	6	0	0	0	6
GRAND TOTAL	55	40	4	3	9	7	25	9	152	0	3	3	155

Table 8: Temporary Staff Exits

Temporary Staff Exits	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
DISCIPLINARY	0	1	0	0	0	0	0	0	1	0	0	0	1
END OF CONTRACT / TERMINATION BY AGREEMENT	59	76	10	3	0	2	8	10	170	4	2	6	176
DECEASED	0	0	0	0	0	0	0	0	0	0	0	0	0
GRAND TOTAL	59	77	10	3	0	2	8	10	169	4	2	6	175

HC DEVELOPMENT

Student Pipeline Development

The number of students in the student pipeline programmes as at 31 March 2022 is illustrated in the following table, showing the demographics for the pipeline.

Table 9: Student Pipeline Programmes

Programme	AM	AF	CM	CF	IM	IF	WM	WF	Total SA	FM	FF	Total Foreign	Grand Total
BURSARY STUDENTS	37	43	2	1	3	0	5	3	94	0	0	0	94
IBS STUDENTS	68	183	2	6	4	8	17	15	303	5	4	9	312
STUDENTSHIPS	13	10	0	3	0	3	4	0	33	0	0	0	33
MERSETA BURSARIES	29	18	0	0	0	0	1	1	49	0	0	0	49
INTERNS	35	43	0	2	0	2	2	2	86	0	0	0	86
TOTAL	182	297	4	12	7	13	29	21	565	5	4	9	574
PERCENTAGE	31.7%	51.7%	0.7%	2%	1.2%	2.7%	5%	3.7%	98%	0.9%	0.7%	1.6%	100%

Inter-Bursary Support (IBS) Programme

An allocation of 106 new bursaries was made for the 2022 academic year for the IBS programme, 55 at Honours level, 25 at Master's level and 26 at Doctoral level. This brings the total number of students in the programme to 280 (174 are continuing with their studies).

Studentships

The number of studentships has been decreasing, in line with the plan to initiate a postgraduate bursary programme at Master's and PhD levels. In quarter 4 of 2020/21, the total number of studentships was 41, with 17 doctoral students and 24 Master's students. The number of studentships decreased to 33 as at 31 March 2022.

Bursary Programme

A total of 86 students were funded under the bursary programme. Of these, 45 students were due to complete their studies in the 2021 academic year, and 44 completed (98% success rate). Of those who graduated, two were absorbed into permanent positions within the CSIR, 21 joined the GIT programme, five took up employment with other organisations and four were released from their obligations to the CSIR due to lack of opportunities in the support space. Twelve graduates are furthering their studies at local universities.

The recruitment for the bursary programme for the 2022 academic year was concluded in 2021.

A total of 86 senior students across CSIR bursary programmes, including IBS and merSETA, indicated an interest in mentoring new bursary students through the new student 'buddy' programme. However, 40 suitable mentors were selected based on alignment of study area and university, academic performance and brand ambassadorship. Mentorship training took place for the pairs, mentees and mentors in January 2022.

A total of 22 students were hosted for vacation work from November 2021 to January 2022.

YES Programme

The YES programme continues to contribute to alleviating youth unemployment and to youth skills development, with the programme appointing 55 unemployed youths for 2022/23. The youths were placed at both the CSIR and its partnering SMMEs that are aligned with the organisation's research and innovation outputs.

GIT Programme

The GIT programme had 17 new candidates appointed in March 2022, bringing the total number of graduates supported in the programme to 80 since its inception in 2019/20. A total of 28 graduates has since been appointed permanently in various clusters within the organisation.

Universum Results

Universum recently published its results on ranking of companies in terms of their attractiveness. The CSIR has been ranked at number 2 in the science category, as voted for by university students and professionals in 2021.

Alumni Programme

An Alumni Programme concept and guideline document was approved in December 2021. An alumni webpage has been developed and a database is continuously being updated with new membership.

Learning Factories

The CSIR, DHET and DSI agreed to co-host a workshop on 21 April 2022, with a focus on the development of a national framework for 4IR skills development and innovation for TVET colleges. This workshop would include industry, relevant government departments, SETAs, TVET colleges, national and international funders, etc. A visit by DSI and DHET to the CSIR's Learning Factory was also arranged as a build up to this workshop.

Work Integrated Learning (WIL)

The partnership with merSETA resulted in funding for 50 students, and 35 WIL engineering students have been appointed in different clusters. Three MoUs were entered into with EWSETA, MICT SETA and SASSETA.

Staff Training

The organisation continues to invest in the training of staff through different modes of delivery. The total investment in training of staff at the end of March 2022 amounted to R9 044 217. It is noted that the decrease in training cost has continued since November 2021. Some of this decrease can be attributed to employees taking up to the LinkedIn e-Learning platform, which was launched in November 2021, as an option for their learning. Overleaf is a figure and tables depicting training at the CSIR:

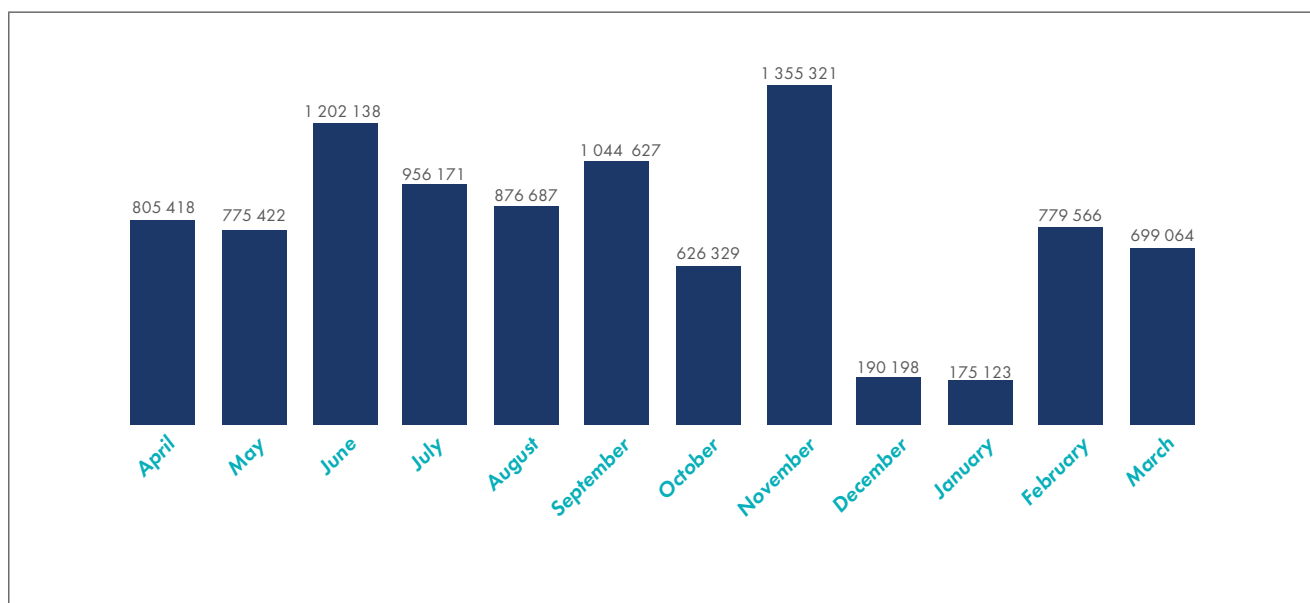


Figure 3: Summary of training costs by month

Table 10: Training Costs by Occupational Category

Category	Number of Staff	Rand	% Of Total Training Cost
TOP MANAGEMENT	11	47 725	0.53%
SENIOR MANAGEMENT	71	485 082	5.36%
MIDDLE MANAGEMENT	702	4 391 532	48.56%
SKILLED	721	3 473 440	38.41%
SEMI-SKILLED	173	554 568	6.13%
UNSKILLED	84	91 870	1.02%
GRAND TOTAL	1 762	9 044 217	100.00%

Table 11: Training Costs by Event Type

Training Event	Number of Staff	Amount
COMPUTER-BASED TRAINING	432	3 181 192
CONFERENCES	286	1 148 328
SEMINARS	1 044	4 714 698
TOTAL	1 762	9 044 217

Table 12: Training Provided by Occupational Categories, Race and Gender

Occupational Category	AM	AF	CM	CF	IM	IF	WM	WF	Total (SA)	FM	FF	Total (Foreign)	Grand Total
TOP MANAGEMENT	4	1	0	0	5	0	1	0	11	0	0	0	11
SENIOR MANAGEMENT	16	8	6	1	7	0	19	14	71	0	0	0	71
MIDDLE MANAGEMENT	197	131	21	9	49	30	165	90	692	9	1	10	702
SKILLED	253	286	19	13	22	12	49	65	719	0	0	0	719
SEMI-SKILLED	79	47	22	17	1	0	0	8	172	1	0	1	173
UNSKILLED	25	59	0	0	0	0	0	0	84	0	0	0	84
GRAND TOTAL	574	532	68	40	84	42	234	177	1 749	10	1	11	1 762

E-Learning Platform

The aim of the e-learning platform is to develop capabilities of CSIR employees and students through behavioural, business, technical and leadership online short courses in support of the organisational performance. The CSIR has a contract with LinkedIn Learning for 1 500 licences per year. This platform was launched at the beginning of November 2021 and licences have been assigned to permanent employees as part of the first phase.

Enhancing CSIR Skills Development Strategy

HC is engaging relevant external stakeholders as part of a collaboration drive to establish strategic partnerships with key stakeholders in the National System of Innovation to support skills development, innovation and CSI. The update on the engagements is presented in the table below.

Table 13: External Stakeholders Engaged in 2021/22 FY

SETAs	Update on SETA engagements
Signed MoUs	MoUs were signed with the following SETAs: MICT, EWSETA and SASSETA
Agriculture Sector Education and Training Authority	The SETA is currently reviewing a draft MoU for approval.
CHIETA	We are awaiting CHIETA to make inputs and approve the draft MoU.
FASSET	The CSIR engaged the FASSET EXCO and sent a draft MoU to its CEO for inputs and signature.
TETA	We are awaiting TETA to finalise the draft MoU between the CSIR and TETA.
MQA	We are awaiting MQA to make inputs on the shared draft MoU.
Other Stakeholders	Update on other engagements
NSF	The CSIR met with the NSF EXCO on 20 October 2021.
DHET, TVET Directorate	The CSIR met with the DHET team from the office of the Chief Director for TVET Directorate to present the Industry-Partnered Learning Factories for TVET colleges. The DHET will co-host a workshop with the CSIR and DSI on the National Framework for Industry-Partnered Learning Factories.

TALENT MANAGEMENT

Talent reviews and succession planning were conducted to support the development of candidates identified in the succession plans. Leadership and management development programmes have been approved by EXCO for implementation. Executive coaching will also be covered in these programmes.

The career paths project for support staff has progressed well, and it aims to allow staff to understand the required experience, qualifications and competence levels to further their careers in the portfolios.

REWARDS AND RECOGNITION

Top Employer Certification

The Top Employers Institute is the global authority on recognising excellence in people practices. Being certified as a Top Employer showcases an organisation's dedication to a better world of work and exhibits this through excellent HC policies and people practices. During May 2021, the CSIR participated in the survey to be re-certified as a Top Employer for 2022. The results of the survey were announced on 24 November 2021 and the CSIR was, once again, successfully certified as a Top employer for 2022. The CSIR will participate again from April 2022 for 2023 certification.

Employee Value Proposition

The CSIR has developed the EVP that is aligned to its vision, mission, strategy and values to create a positive candidate

and employee experience. Following consultations with various stakeholders, the EVP was approved by EXCO in December 2021.

CSIR Recognition Programme and Total Reward Statements

The recognition programme and total rewards statements are in support of the EVP. The recognition programme and total reward statements concept were approved by EXCO. As part of the implementation phase, the HC team investigated online portals and functionalities to host the recognition programme and total reward statements. RFP will be issued to acquire web technology for both the recognition programme and total rewards statements. To attract and retain talent and improve our reputation as an 'employer of choice', it is important that employees discover the full value of being part of the CSIR – what they receive in return for contributing their time, talent and effort to the success of the CSIR. Through the CSIR Total Rewards Statements, employees will be made fully aware of their total rewards and will appreciate the sizable investment that the CSIR makes in them. Furthermore, the implementation of a web-based solution for Total Rewards Statements should improve the quality of Total Rewards communication – make it more transparent, consistent and meaningful.

The CSIR Bonus Incentive Scheme Review

The annual bonus incentive scheme was reviewed and approved by the CSIR Board in October 2021.

EMPLOYEE RELATIONS AND TRANSFORMATION

Internal and External Employee Relations Matters

Table 14: Summary of Internal and External Employee Relations Matters

Matters	Investigations	Disciplinary	Grievances	Incapacity	CCMA	Labour Court
OPEN	3	3	2	8	1	2
CLOSED	13	12	8	10	0	0
TOTAL	16	15	10	18	1	2

The CSIR has seen a sharp decline in several pending employee relations cases. This is because of the investment made in capability development of line managers and HC professionals. The speed of attending to and closing matters without compromising rigour and quality has also contributed to the decline.

Employment Equity Report

The CSIR Employment Equity Plan was presented and approved by EXCO. The Employment Equity Report was submitted to the Department of Employment and Labour on 21 December 2021.

Employment Equity and Skills Development

The Employment Equity and Skills Development Consultative forums and committee held their ground-breaking meetings during March and April 2021.

The process of consulting the employees, through the consultative forums, took place between May and July 2021, and culminated in the production of draft Division and Portfolio Employment Equity Plans, which were later consolidated into a draft CSIR Employment Equity Plan.

The draft CSIR Employment Equity Plan was approved by EXCO on 16 November 2021.

The Employment Equity Report for 2021 was submitted to the Department of Employment and Labour on 21 December 2021.

EMPLOYEE WELLNESS

Psychosocial Intervention

A successful psychosocial intervention designed to create awareness about the impact of Covid-19 on employees' well-being, destigmatise mental health, and empower employees with an understanding of how they can enhance their resilience was rolled-out and completed in Q4. A series of targeted interventions is planned for FY22/23, which will include psychosocial webinars, resilience training, and psychological safety.

Climate Survey

The climate survey, which was concluded in Q3, was followed by divisional and portfolio workshops in Q4, which were designed

to allow employees to reflect on the survey results, share lived experiences, and propose response actions to address identified gaps. The outcome of this process, which was completed in Q4, will be followed by the development of divisional/portfolio response plans, which will be consolidated into a group response plan that will be signed off by the executive in Q2 of FY22/23.

Values-based Leadership Development Intervention

A Values-based Leadership Development Intervention was approved by EXCO for implementation in FY22/23. This evidence-based intervention is designed to empower individuals and leadership teams to enhance their leadership capabilities and lead the cultural transformation agenda of the organisation. The impact of this intervention will be tracked for the next five years, using future climate survey results as a measurement criterion.

Epic Values-based 360° Assessments

An online Epic values-based 360° assessment survey, which includes questions on the CSIR EPIC values was introduced at the CSIR. The 360° assessment reports will be used for performance and personal development purposes.

Health Risk Assessments

Since the adoption of the flexi working from home and the Covid-19-related movement restriction, the need for a service provider that would allow for employees to easily access health risk assessment centres without having to travel to the CSIR campus was identified. The Clicks Group has since been appointed to provide the employee health risk assessments from the middle of April 2022.

CSIR Sports Club

The development and approval of the new sports club operating model, governance principles, structure and branding were completed in Q4 of FY21/22.

HC BUSINESS ENABLEMENT AND EFFICIENCIES

Table 15: Human Capital Efficiency Improvements

Initiative	Status
KPI system changes (no. of SET staff now based on qualifications profile)	Work on the changes in PeopleSoft and APEX BIS systems has been completed.
360° performance assessment tool	The development of the tool was completed and introduced within the business.
PeopleSoft HCM upgrade	A purchase order was issued, and work is in progress to grant access to contracted developers and the relevant systems platforms required for the upgrade were created.

HC POLICIES AND PROCEDURES

Part of the HC portfolio's role is to ensure regulatory compliance and that policies are reviewed periodically. The policies, procedures and guidelines listed below were reviewed during 2021/22.

Table 16: Summary Policies, Procedures And Guideline Approved or in Progress during 2021/22

Policy, Procedure and Guideline	Progress
Recruitment and Selection Policy	Organisational and OPCO reviews completed, EXCO and the Board to approve in May 2022.
Employee Wellness Guideline	Approved and published
Incapacity due to ill-health or injury procedure	Approved and published
Performance moderation procedure	Approved and published
Performance management procedure	Approved and published
Multi-rater 360 procedure	Approved and published
Recruitment and selection procedure	Approved and published
Pipeline development procedure	Approved and published
Professional development procedure	Approved and published
Professional registration procedure	Development in progress
Job evaluation guidelines	Development in progress

HC SYSTEM IMPROVEMENTS

Performance Management System

The upgrade of the e-performance management system into a one-pager has been completed and was well received by the business. The use of the e-performance system is very high, and the mid-year review completion statistics were at 96% as at end March 2022. The system development for the capturing of moderated scores was implemented and will be used as part of the year-end performance evaluation processes.

PeopleSoft HCM Upgrade

The PeopleSoft HCM upgrade to version 9.2 has been approved and will commence in the new FY.

Bursary Management System (includes all pipeline programmes)

The MILA bursary management system was successfully implemented, and the current students' information loaded onto the platform. The tool has proven to be a success in assisting HCD to pick up on student well-being issues and provide support.

The AURA advertising and applications portal was implemented and both the CSIR and IBS bursary calls management are on this platform. The system has improved the efficiency of the different processes.

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 HC personnel with how to navigate the system. Ongoing system improvements have ensured improved user experience.

HC OVERSIGHT STATISTICS

Table 17: 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)
CSIR Advanced Chemistry and Life Sciences	295 548	155 577	53%	230	676.42
CSIR Advanced Production and Security	831 842	460 064	55%	619	743.24
CSIR Smart Society	893 064	475 749	53%	732	649.93
Business Excellence and Integration	199 659	57 380	29%	80	717.25
Chief Financial Officer	35 332	106 483	301%	164	649.28
Human Capital and Communications	132 074	72 481	55%	126	575.25
Legal Compliance and Business Enablement	129 901	107 442	83%	233	461.12
CSIR Leadership and Governance	57 611	39 875	69%	25	1 595.01
Total	2 575 032	1 475 051	57%	2 209	667.75

Table 18: Personnel cost by salary band

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	52 854	3.58%	17	3 109
SENIOR MANAGEMENT	165 694	11.23%	92	1 801
PROFESSIONAL QUALIFIED	815 142	55.26%	854	954
SKILLED	378 318	25.65%	869	435
SEMI-SKILLED	60 024	4.07%	250	240
UNSKILLED	3 019	0.20%	127	24
TOTAL	1 475 051	100.00%	2 209	668

Table 19: Performance rewards

Programme/activity/objective	Performance rewards	Personnel expenditure (R'000)	Percentage of performance rewards to total personnel cost (R'000)
TOP MANAGEMENT	5 604	52 854	11%
SENIOR MANAGEMENT	11 426	165 694	7%
PROFESSIONAL QUALIFIED	34 852	815 142	4%
SKILLED	10 846	378 318	3%
SEMI-SKILLED	1 307	60 024	2%
UNSKILLED	0	3 019	0%
TOTAL	64 034	1 475 051	4%

Table 20: Employment and vacancies as at 31 March

Programme/activity/objective	2020/2021 No. of employees	2021/2022 Approved posts	2021/2022 No. of employees	2021/2022 Vacancies	Percentage of vacancies
CSIR Advanced Chemistry and Life Sciences Division	234	244	230	14	6.09%
CSIR Advanced Production and Security Division	606	669	619	50	8.08%
CSIR Smart Society Division	656	847	732	115	15.71%
Business Excellence and Integration Portfolio	70	94	80	14	17.50%
Chief Financial Officer Portfolio	166	189	164	25	15.24%
Human Capital and Communications Portfolio	157	132	126	6	4.76%
Legal Compliance and Business Enablement Portfolio	225	254	233	21	9.01%
CSIR Leadership and Governance	29	31	25	6	24.00%
Total	2 143	2 460	2 209	251	11.36%

Table 21: Overview of staff complement, including vacancies

Programme/activity/objective	2020/21 No. of employees	2021/22 Approved posts	2021/22 No. of employees	2021/22 Vacancies	Percentage of vacancies
TOP MANAGEMENT	16	20	17	3	17.65%
SENIOR MANAGEMENT	92	101	92	9	9.78%
PROFESSIONAL QUALIFIED	795	970	854	116	13.58%
SKILLED	910	954	869	85	9.78%
SEMI-SKILLED	221	261	250	11	4.40%
UNSKILLED	109	154	127	27	21.26%
TOTAL	2 143	2460	2209	251	11.36%

Table 22: Overview of staff complement, including appointments and terminations

Programme/activity/objective	Employment at beginning of period	Appointments	Internal appointments, promotions and position changes	Terminations	Employment at end of the period
Top management	16	1	1	-1	17
Senior management	92	4	6	-10	92
Professional qualified	795	78	64	-83	854
Skilled	910	163	-71	-133	869
Semi-skilled	221	42	1	-14	250
Unskilled	109	108	-1	-89	127
Total	2 143	396	0	-330	2 209

Table 23: Reasons for staff leaving

Reason	Number	% of total no. of staff leaving
Death	5	1.51%
Resignation	136	40.96%
Dismissal	3	0.90%
Retirement	6	1.81%
Ill health	6	1.81%
End of contract / Termination by agreement	176	53.01%
Retrenchments	0	0.00%
Total	330	100.00%

Table 24: Employee relations matters statistics

Matters	Investigations	Disciplinary	Grievances	Incapacity	CCMA	Labour Court
OPEN	3	3	2	8	1	2
CLOSED	13	12	8	10	0	0
TOTAL	16	15	10	18	1	2

Table 25: Equity target and employment equity status

Occupational Levels	Male							
	African		Coloured		Indian		White	
	Current	Target	Current	Target	Current	Target	Current	Target
TOP MANAGEMENT	7	7	0	0	3	2	3	2
SENIOR MANAGEMENT	36	30	3	3	10	8	21	18
PROFESSIONAL QUALIFIED	234	180	26	27	62	52	216	199
SKILLED	290	311	25	24	29	30	50	50
SEMI-SKILLED	105	98	13	15	1	1	0	1
UNSKILLED	56	56	1	1	0	0	0	0
TOTAL	728	682	68	70	105	93	290	270

Table 26: Female employees across occupational levels

Occupational Levels	Female							
	African		Coloured		Indian		White	
	Current	Target	Current	Target	Current	Target	Current	Target
TOP MANAGEMENT	3	4	0	0	0	0	1	1
SENIOR MANAGEMENT	12	20	1	3	0	1	9	9
PROFESSIONAL QUALIFIED	159	131	11	17	32	27	114	108
SKILLED	354	371	25	26	31	26	65	73
SEMI-SKILLED	112	88	12	11	1	1	6	6
UNSKILLED	70	70	0	0	0	0	0	0
TOTAL	710	684	49	57	64	55	195	197

Table 27: Disabled employees across occupational levels

Occupational Levels	Disabled Staff			
	Male		Female	
	Current	Target	Current	Target
TOP MANAGEMENT	0	0	0	0
SENIOR MANAGEMENT	0	1	0	0
PROFESSIONAL QUALIFIED	10	5	3	4
SKILLED	7	7	2	8
SEMI-SKILLED	0	2	1	2
UNSKILLED	8	1	9	1
TOTAL	25	17	15	16



The consolidated financial statements set out on pages 117 to 159, have been prepared on the going concern basis and were approved by the CSIR board on 29 July 2022.

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REPORT OF THE AUDITOR-GENERAL

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 117 to 159, which comprise the consolidated and separate statement of financial position as at 31 March 2022, the 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 group as at 31 March 2022, and their financial performance and cash flows for the year then ended in accordance with 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 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 objective presented in the entity's annual performance report for the year ended 31 March 2022:

Objective	Pages in the annual performance report
SO1 – conduct research, development and innovation of transformative technologies and accelerate their diffusion	72 – 73

13. 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.
14. I did not identify any material findings on the usefulness and reliability of the reported performance information for this objective:
- SO 1 – conduct research, development and innovation of transformative technologies and accelerate their diffusion.

Other matter

15. I draw attention to the matter below.

Achievement of planned targets

16. Refer to the annual performance report on pages 68 to 79 for information on the achievement of planned targets for the year.

REPORT ON THE AUDIT OF COMPLIANCE WITH LEGISLATION

Introduction and scope

17. 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.
18. 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

19. 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 those selected objective presented in the annual performance report that have been specifically reported in this auditor's report.
20. 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.
21. 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 objective presented in the annual performance report, or my knowledge obtained in the audit, or otherwise appears to be materially misstated.
22. I did not receive the other information prior to the date of this auditor's report. When I do receive and read this information and 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

23. 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.
24. I did not identify any significant deficiencies in internal control.

Auditor - General

**Pretoria
30 July 2022**



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 objective 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.

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

STATEMENT OF PROFIT OR LOSS AND OTHER COMPREHENSIVE INCOME

	Note(s)	Group		CSIR	
		2022 R'000	2021 R'000	2022 R'000	2021 R'000
Revenue	2	2 654 343	2 568 647	2 654 343	2 568 647
Other income		2 907	733	2 895	724
Total operating income		2 657 250	2 569 380	2 657 238	2 569 371
Expenses					
Employees' remuneration		(1 475 969)	(1 435 595)	(1 475 969)	(1 435 595)
Depreciation		(49 763)	(52 489)	(49 763)	(52 489)
Operating expenses		(1 046 057)	(1 024 887)	(1 043 940)	(1 025 105)
Operating profit		85 461	56 409	87 566	56 182
Finance income	3	53 178	41 255	52 966	40 980
Finance expense	4	(1 069)	(1 119)	(1 069)	(1 119)
Share of (loss)/ of joint ventures and associates		2 138	(252)	-	-
Profit for the year		139 708	96 293	139 463	96 043
Other comprehensive income:					
Items that will not be reclassified to profit or loss:					
Remeasurement of post-retirement medical benefit obligation		1 595	(22)	1 595	(22)
Other comprehensive income for the year net of taxation		1 595	(22)	1 595	(22)
Total comprehensive income for the year		141 303	96 271	141 058	96 021

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

STATEMENT OF FINANCIAL POSITION AS AT 31 MARCH 2022

		Group		CSIR	
	Note(s)	2022 R'000	2021 R'000	2022 R'000	2021 R'000
Assets					
Non-current assets					
Property, plant and equipment	5	737 633	744 117	737 633	744 117
Right-of-use assets	6	7 598	9 580	7 598	9 580
Investments in subsidiaries	8	-	-	4 650	4 650
Investments in joint venture and associate	7	2 443	2 394	2 443	2 394
		747 674	756 091	752 324	760 741
Current assets					
Inventories	20	605	956	605	956
Other receivables from contracts with customers	21	181 803	134 341	181 803	134 341
Trade and other receivables	9	307 945	293 534	307 912	293 518
Contract assets	22	4 315	7 931	4 315	7 931
Cash and cash equivalents	16	1 432 077	1 435 133	1 423 772	1 427 019
		1 926 745	1 871 895	1 918 407	1 863 765
Total Assets		2 674 419	2 627 986	2 670 731	2 624 506
Equity and Liabilities					
Equity					
Reserves		133 571	133 602	133 571	133 602
Retained income		1 175 341	1 034 036	1 171 597	1 030 537
		1 308 912	1 167 638	1 305 168	1 164 139
Liabilities					
Non-current liabilities					
Lease liabilities	6	7 561	8 845	7 561	8 845
Retirement benefit obligation	11	10 402	12 881	10 402	12 881
		17 963	21 726	17 963	21 726
Current liabilities					
Trade and other payables	10	373 675	440 178	373 731	440 197
Lease liabilities	6	3 765	3 196	3 765	3 196
Retirement benefit obligation	11	1 802	-	1 802	-
Advances from customers	24	968 302	995 248	968 302	995 248
		1 347 544	1 438 622	1 347 600	1 438 641
Total Liabilities		1 365 507	1 460 348	1 365 563	1 460 367
Total Equity and Liabilities		2 674 419	2 627 986	2 670 731	2 624 506

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

STATEMENT OF CHANGES IN EQUITY

	Revaluation reserve R'000	Retained income R'000	Total equity R'000
Group			
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
Opening balance as previously reported	133 602	1 034 037	1 167 639
Adjustments			
Prior year adjustments	(31)	-	(31)
Balance at 01 April 2021 as restated	133 571	1 034 037	1 167 608
Profit for the year	-	139 708	139 708
Other comprehensive income	-	1 596	1 596
Total comprehensive income for the year	-	141 304	141 304
Balance at 31 March 2022	133 571	1 175 341	1 308 912
Company			
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
Opening balance as previously reported	133 602	1 030 537	1 164 139
Adjustments			
Prior year adjustments	(31)	-	(31)
Balance at 01 April 2021 as restated	133 571	1 030 537	1 164 108
Profit for the year	-	139 463	139 463
Other comprehensive income	-	1 597	1 597
Total comprehensive income for the year	-	141 060	141 060
Balance at 31 March 2022	133 571	1 171 597	1 305 168

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

STATEMENT OF CASH FLOWS

	Note(s)	Group		CSIR	
		2022 R'000	2021 R'000	2022 R'000	2021 R'000
Cash flows from operating activities					
Cash receipts from external customers		1 930 649	1 903 510	1 930 638	1 903 511
Parliamentary Grant received		725 537	670 045	725 537	670 045
Cash paid to suppliers and employees		(2 659 231)	(2 393 409)	(2 659 199)	(2 393 403)
Cash generated from operations	15	(3 045)	180 146	(3 024)	180 153
Finance income received		54 510	42 217	54 298	41 942
Finance expense		(803)	(894)	(803)	(894)
Net cash from operating activities		50 662	221 469	50 471	221 201
Cash flows from investing activities					
Purchase of property, plant and equipment	5	(50 972)	(36 193)	(50 972)	(36 193)
Sale of property, plant and equipment		1 436	-	1 436	-
Net cash from investing activities		(49 536)	(36 193)	(49 536)	(36 193)
Cash flows from financing activities					
Payment on lease liabilities		(1 626)	(2 745)	(1 626)	(2 745)
Net cash from financing activities		(1 626)	(2 745)	(1 626)	(2 745)
Unrealised exchange gains/(losses) on foreign cash		(2 556)	(1 235)	(2 556)	(1 235)
Total cash movement for the year		(3 056)	181 296	(3 247)	181 028
Cash at the beginning of the year		1 435 133	1 253 837	1 427 019	1 245 991
Total cash at end of the year	16	1 432 077	1 435 133	1 423 772	1 427 019

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

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 Naudé 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 2022 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 financial statements incorporate the financial statements of the CSIR and all subsidiaries. Subsidiaries are entities (including structured 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.

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

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 arrangement and determined it to be a joint venture.

Joint venture

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.

Investment in joint venture in the separate financial statements

In the company's separate financial statements, investment in joint venture is carried at cost less any accumulated impairment losses.

1.4 Investment in associate

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.

Investment in associate is accounted for using the equity method. Under the equity method, investment in associate is 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.

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

ACCOUNTING POLICIES

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 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 which give rise to single performance obligations, and others which give rise to multiple performance obligations. Judgement is applied in the determination of distinct performance obligations, as well as to 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 2022, the Group had R38 million (2021: R38 million) in allowance for doubtful accounts for trade and other receivables. The allowance for doubtful accounts is based on assumptions about risk of default and expected loss rates. 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.

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1.5 Significant judgements and sources of estimation uncertainty (continued)

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.

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 amount 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.

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1.6 Property, plant and equipment (continued)

The useful lives of items of property, plant and equipment have been assessed as follows:

Item	Depreciation method	Average useful life
Buildings	Straightline	90 years
Furniture and fixtures	Straightline	3 to 20 years
Motor vehicles	Straightline	10 years
Office equipment	Straightline	3 to 20 years
IT equipment	Straightline	3 to 5 years
Land	Straightline	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.

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:

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1.7 Financial instruments (continued)

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 transaction price.

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:

- It rebuts the more than 30 days past due presumption, instead the CSIR 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 CSIR's 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. an 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.

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1.7 Financial instruments (continued)

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.

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 IFRS9; and
- The amount initially recognised less, where appropriate, cumulative amount of income recognised in accordance with the revenue recognition policies.

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1.7 Financial instruments (continued)

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.

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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.

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ACCOUNTING POLICIES

1.9 Leases (continued)

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;
- 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 headlease 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.

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1.10 Inventories

Inventories are measured at the lower of cost and net realisable value on the weighted average 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 of 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.

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.

Irrespective of whether there is any indication of impairment, the Group also:

- tests intangible assets with an indefinite useful life or intangible assets not yet available for use for impairment annually by comparing its carrying amount with its recoverable amount. This impairment test is performed during the annual period and at the same time every period.
- tests goodwill acquired in a business combination for impairment annually.

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.

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ACCOUNTING POLICIES

1.12 Impairment of assets (continued)

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.

Defined benefit plans

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.

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.

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1.13 Employee benefits (continued)

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. 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.

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ACCOUNTING POLICIES

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).

Derives revenue from contracts with customers for the following:

- Contract income, including 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.

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.

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1.16 Revenue from contracts with customers (continued)

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.

1.16 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 and includes costs such as direct labour, materials, professional/consulting services and allocation of overhead cost which relate directly to satisfy 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 be 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).

1.17 Related parties

A related party is a person or an entity with the ability to control or jointly control the other party, or exercise significant influence over the other party, or vice versa, or an entity that is subject to common control, or joint control.

Control is the power to govern the financial and operating policies of an entity so as to obtain benefits from its activities. A related party transaction is a transfer of resources, services or obligations between the reporting entity and a related party, regardless of whether a price is charged. Significant influence is the power to participate in the financial and operating policy decisions of an entity but is not control over those policies.

Key management are those persons responsible for planning, directing and controlling the activities of the entity, including those charged with the governance of the entity in accordance with legislation, in instances where they are required to perform such functions. All individuals from the level of Corporate Executive up to the Board of Directors are regarded as key management. Close members of the family of a person are those family members who may be expected to influence or be influenced by that person in their dealings with the entity.

The entity is exempt from disclosure requirements in relation to related party transactions if that transaction occurs within normal supplier and/or client/recipient relationships on terms and conditions no more or less favourable than those which it is reasonable to expect the entity to have adopted if dealing with that individual entity or person in the same circumstances and terms and conditions are within the normal operating parameters established by that reporting entity's legal mandate. Where the entity is exempt from the disclosures in accordance with the above, the entity discloses narrative information about the nature of the transactions and the related outstanding balances, to enable users of the entity's financial statements to understand the effect of related party transactions on its annual financial statements.

The entity operates in an economic sector currently dominated by entities directly or indirectly owned by the South African Government. As a consequence of the constitutional independence of the three spheres of government in South Africa, only entities within the national sphere of government are considered to be related parties.

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FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

	Group		CSIR	
	2022 R'000	2021 R'000	2022 R'000	2021 R'000
2. Revenue				
Revenue				
Parliamentary Grant	730 274	657 846	730 274	657 846
Contract income	1 596 368	1 633 293	1 596 368	1 633 293
Royalty income	7 395	3 691	7 395	3 691
Other government grants	320 306	273 817	320 306	273 817
	2 654 343	2 568 647	2 654 343	2 568 647
The group disaggregates revenue from customers as follows:				
Parliamentary Grant				
Parliamentary Grant received	725 537	670 045	725 537	670 045
Less:				
Grant received for projects started before year-end but not completed	(53 505)	(58 242)	(53 505)	(58 242)
Add:				
Grant received in prior year for projects completed in this year	58 242	46 043	58 242	46 043
	730 274	657 846	730 274	657 846
Contract income				
Local private sector	232 116	332 092	232 116	332 092
Local public sector	1 163 501	1 164 879	1 163 501	1 164 879
International sector (including Africa)	200 751	136 322	200 751	136 322
	1 596 368	1 633 293	1 596 368	1 633 293
Royalty income				
Royalty income	7 395	3 691	7 395	3 691
Other government grants				
Other government grants	320 306	273 817	320 306	273 817
Total revenue	2 654 343	2 568 647	2 654 343	2 568 647

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FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

	Group		CSIR	
	2022 R'000	2021 R'000	2022 R'000	2021 R'000

2. Revenue (continued)

Parliamentary Grant				
Parliamentary Grant received	28%	26%	28%	26%
Contract income				
Local private sector	9%	13%	9%	13%
Local public sector	44%	45%	44%	45%
International sector (including Africa)	7%	5%	7%	5%
Other government grants				
Other government grants	12%	11%	12%	11%
	100%	100%	100%	100%

Included in other government grants is R128 million (2021: R104 million) ring-fenced allocation from the Department of Science and Innovation for specific initiatives managed through memorandums of agreement.

Included in contract income is rental income amounting to R57,8 million (2021: R60,7 million) and revenue of R6million (2021: R2,9 million) earned by the CSIR International Convention Centre.

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 .

3. Finance income

Interest income				
Investments in financial assets:				
Finance income	53 178	41 255	52 966	40 980
Finance income				
Interest on bank balances and investments	53 179	41 246	52 966	40 971
Interest on trade and other receivables	-	9	-	9
Total	53 179	41 255	52 966	40 980

4. Finance expense

Finance leases	1 069	1 119	1 069	1 119
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CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

5. Property, plant and equipment

Group	2022			2021		
	Cost or revaluation	Accumulated depreciation	Carrying value	Cost or revaluation	Accumulated depreciation	Carrying value
Land	138 400	-	138 400	138 400	-	138 400
Buildings	537 691	(97 094)	440 597	528 743	(91 280)	437 463
Furniture and fixtures	15 569	(13 409)	2 160	15 794	(13 039)	2 755
Motor vehicles	8 177	(6 795)	1 382	8 405	(6 785)	1 620
Office equipment	531 105	(419 873)	111 232	534 088	(414 231)	119 857
IT equipment	210 610	(166 748)	43 862	212 524	(168 502)	44 022
Total	1 441 552	(703 919)	737 633	1 437 954	(693 837)	744 117

CSIR	2022			2021		
	Cost or revaluation	Accumulated depreciation	Carrying value	Cost or revaluation	Accumulated depreciation	Carrying value
Land	138 400	-	138 400	138 400	-	138 400
Buildings	537 691	(97 094)	440 597	528 743	(91 280)	437 463
Furniture and fixtures	15 569	(13 409)	2 160	15 794	(13 039)	2 755
Motor vehicles	8 177	(6 795)	1 382	8 405	(6 785)	1 620
Office equipment	531 105	(419 873)	111 232	534 083	(414 226)	119 857
IT equipment	210 610	(166 748)	43 862	212 524	(168 502)	44 022
Total	1 441 552	(703 919)	737 633	1 437 949	(693 832)	744 117

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

5. Property, plant and equipment (continued)

Reconciliation of property, plant and equipment - Group - 2022

	Opening balance	Additions	Other changes, movements	Depreciation	Total
Land	138 400	-	-	-	138 400
Buildings	437 463	8 965	7	(5 838)	440 597
Furniture and fixtures	2 755	148	(47)	(696)	2 160
Motor vehicles	1 620	-	-	(238)	1 382
Office equipment	119 857	20 539	(4 731)	(24 433)	111 232
IT equipment	44 022	21 320	(5 550)	(15 930)	43 862
	74 4117	50 972	(10 321)	(47 135)	737 633

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	1005	(49 700)	744 117

Reconciliation of property, plant and equipment - CSIR - 2022

	Opening balance	Additions	Other changes, movements	Depreciation	Total
Land	138 400	-	-	-	138 400
Buildings	437 463	8 965	7	(5 838)	440 597
Furniture and fixtures	2 755	148	(47)	(696)	2 160
Motor vehicles	1 620	-	-	(238)	1 382
Office equipment	119 857	20 539	(4 731)	(24 433)	111 232
IT equipment	44 022	21 320	(5 550)	(15 930)	43 862
	744 117	50 972	(10 321)	(47 135)	737 633

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

5. Property, plant and equipment (continued)

Reconciliation of property, plant and equipment - CSIR - 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

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 5 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 there valued assets under the cost model would have been:

Land	4 829	4 829	4 829	4 829
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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 R3,7million (2021: R7million) decrease in the depreciation amount for the current financial year.

During the current financial year, assets to the value of R66,5 million (2021: R45,6 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 R865,2 million (2021: R881,7 million).

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NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

	Group		CSIR	
	2022 R'000	2021 R'000	2022 R'000	2021 R'000

6. Leases (group as lessee)

The group leases several assets, including buildings, motor vehicles and office equipment. The average lease term is 4 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:

Buildings	7 287	9 262	7 287	9 262
Motor vehicles	274	189	274	189
Office equipment	37	129	37	129
	7 598	9 580	7 598	9 580
Additions to right-of-use assets				
Motor vehicles	360	269	360	269

Depreciation recognised on right-of-use assets

Depreciation recognised on each class of right-of-use assets, is presented below.

Buildings	2 261	2 261	2 261	2 261
Motor vehicles	275	436	275	436
Office equipment	92	92	92	92
	2 628	2 789	2 628	2 789
Other disclosures				
Interest expense on lease liabilities	1 069	1 119	1 069	1 119
Lease liabilities				

The maturity analysis of lease liabilities is as follows:

Within one year	4 062	3 910	4 062	3 910
Two to five years	7 391	10 182	7 391	10 182
	11 453	14 092	11 453	14 092
Non-current liabilities	7 561	8 845	7 561	8 845
Current liabilities	3 765	3 196	3 765	3 196
	11 326	12 041	11 326	12 041

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NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

	Group		CSIR	
	2022 R'000	2021 R'000	2022 R'000	2021 R'000
7. INTEREST IN JOINT VENTURE AND ASSOCIATE				
The following are details of joint venture and associate of 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	(14 890)	(14 903)	-	-
Share of post-acquisition losses of associates	(3 800)	(5 913)	-	-
Subtotal	24 680	22 554	44 441	44 441
Impairment of joint ventures and associates	(22 237)	(20 160)	(41 998)	(42 047)
	2 443	2 394	2 443	2 394

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.

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

7. INTEREST IN JOINT VENTURES AND ASSOCIATES (continued)

Group

Name of company	% ownership interest	% ownership interest	Carrying amount	Carrying amount
	2022	2021	2022	2021
Joint ventures				
Sera (Pty) Ltd - South Africa	50,00%	50,00%	3 226	3 213
Associates				
Persomics AB-South Africa	35,03%	35,03%	21 454	19 341
			24 680	22 554
Impairment of investment in joint venture and associate			(22 237)	(20 160)
			2 443	2 394

The following are details of the significant joint ventures' and associates' assets, liabilities, income and expenses:

	JOINT VENTURES		ASSOCIATES	
	2022 R'000	2021 R'000	2022 R'000	2021 R'000
Current assets	4 808	4 758	62	181
Non Current assets	-	-	7 784	7 511
Current liabilities	35	11	1 321	2 145
Non-current liabilities	36 232	36 232	-	6 282
Income	90	140	6 272	121
Expenses	74	190	239	797

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

	Group		CSIR	
	2022 R'000	2021 R'000	2022 R'000	2021 R'000
8. Interests in subsidiaries				
Shares at cost less impairment losses	-	-	4 650	4 650
Indebtedness				
- by subsidiaries	-	-	-	7 976
- impairment of loans	-	-	-	(7 976)
	-	-	4 650	4 650

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 which 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 2022	%voting power 2021	% holding 2022	% holding 2021	Carrying amount 2022	Carrying amount 2021
Technology Finance Corporation SOC Ltd		100,0 %	100,0 %	100,0 %	100,0 %	4 650	4 650
Technovent SOC Ltd		100,0 %	100,0 %	100,0 %	100,0 %	-	-
						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.

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NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

	Group		CSIR	
	2022 R'000	2021 R'000	2022 R'000	2021 R'000

9. Trade and other receivables

Financial instruments:				
Trade receivables	271 775	273 612	271 743	273 604
Accrued income	1	8	-	-
Loss allowance	(38 565)	(38 180)	(38 565)	(38 180)
Trade receivables at amortised cost	233 211	235 440	233 178	235 424
Other receivables	2 487	2 150	2 487	2 150
Non-financial instruments:				
Prepayments	72 247	55 944	72 247	55 944
Total trade and other receivables	307 945	293 534	307 912	293 518

Trade receivables are shown net of impairment losses. Refer to note 14 for more details on risk management of trade receivables.

The net carrying amounts, in Rand, of trade and other receivables, excluding non-financial instruments, are shown below.

Rand Amount				
Rand	235 698	-	235 665	-

10. Trade and other payables

Financial instruments:				
Trade payables	247 404	234 042	247 460	234 061
Salary related payables	79 430	143 254	79 430	143 254
Non-financial instruments:				
VAT	46 841	62 882	46 841	62 882
	373 675	440 178	373 731	440 197

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

	Group		CSIR	
	2022 R'000	2021 R'000	2022 R'000	2021 R'000

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 R181 million (2021: R174 million) were expensed during the year.

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 (2021: 18 continuation members) was recalculated by the actuaries as at 31 March 2022 and will be funded through cash and cash equivalents. These cash and cash equivalents have not been set aside specifically for this benefit.

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:

Carrying value				
Present value of the defined benefit obligation-wholly unfunded	(12 204)	(12 881)	(12 204)	(12 881)
Non-current liabilities	(10 402)	(12 881)	(10 402)	(12 881)
Current liabilities	(1 802)	-	(1 802)	-
	(12 204)	(12 881)	(12 204)	(12 881)

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	918	1 059	918	1 059
Actuarial (losses) gains	(1 595)	22	(1 595)	22
	(677)	1081	(677)	1 081

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

	Group		CSIR	
	2022 R'000	2021 R'000	2022 R'000	2021 R'000

11. Retirement benefits of employees (continued)

Movements for the year				
Opening balance	12 881	11 800	12 881	11 800
Net expense recognised in profit or loss	(677)	1081	(677)	1 081
Net liability at the end of the year	12 204	12 881	12 204	12 881

Key assumptions used

Principal actuarial assumptions at the reporting date.

Discount rates used	9,01%	7,67%	9,01%	7,67%
Subsidy inflation rate	5,60%	4,03%	5,60%	4,03%

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	664	720	664	720
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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	(609)	(661)	(609)	(661)
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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.

Historical information (R'000):	2022	2021	2020	2019	2018
Present value of the defined benefit obligation	12 204	12 881	11 800	10 906	10 963

The average term (undiscounted) of the defined benefit obligation is 8.6 years (2021: 8.3 years) and the average duration (discounted) of the defined benefit obligation is 5.7 years (2021: 5.8 years).

CONSOLIDATED FINANCIAL STATEMENTS

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NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

12. Board members, directors and executive management's remuneration

2022	Emoluments	Directors' fees	Total
Board members and Executive Directors			
Dr TH Dlamini	6 265	-	6 265
Non-executive Board members			
Prof T Majozi	-	363	363
Dr AR Childs	-	118	118
Dr R Masango	-	153	153
Mr S Masie	-	167	167
Dr Mthethwa	-	167	167
Mr J Netshitenzhe	-	102	102
Dr C Render	-	167	167
Mr CE Shariff	-	165	165
Executive Management			
Mr. MA Dindar	4 104	-	4 104
Dr K Naidoo (Acting executive since 1 January 2022)	664	-	664
Dr RK Chikwamba	4 252	-	4 252
Dr MS Maserumule	4 243	-	4 243
Ms K Njobe (until 31 December 2021)	2 291	-	2 291
Mr MC Mabindisa	3 064	-	3 064
Adv. E Kennedy	3 199	-	3 199
	28 082	1 402	29 484

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NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

12. Board members, directors and executive management's remuneration (continued)

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
Ms T Mokhabuki	-	117	117
Mr S Masie	-	163	163
Dr V Mthethwa	-	175	175
Mr J Netshitenzhe	-	112	112
Dr C Render	-	175	175
Mr CE Shariff	-	175	175
Executive Management			
Mr MA Dindar	2 717	-	2 717
Dr RK Chikwamba	3 379	-	3 379
Ms K Njobe	2 673	-	2 673
Dr Maserumule	3 642	-	3 642
Adv E Kennedy	2 673	-	2 673
Mr MC Mabindisa	2 300	-	2 300
Mrs PN Monama (acting CFO until 30 June 2020)	533	-	533
	23 190	1 757	24 947

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.

CONSOLIDATED FINANCIAL STATEMENTS

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NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

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 Group 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.

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 2022 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 enters into forward exchange contracts to buy specified amounts of foreign currencies in the future at a predetermined exchange rate.

Forward exchange contracts are entered into mainly to cover import orders. The Group has no policy to enter into forward exchange contracts for anticipated foreign receipts. The Group does not use derivative financial instruments for speculative purposes.

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

14. Financial instruments and risk management (continued)

The Group's exposure to foreign currency risk was as follows:

31 March 2022	ZAR R'000	EURO R'000	USD R'000	GBP R'000	OTHER R'000	Total R'000
Trade receivables	251 011	3 089	12 075	271	146	266 592
Bank accounts	31 476	4 237	33 169	2 506	222	71 610
Trade and other payables	(325 667)	(160)	(965)	-	(42)	(326 834)
Gross statement of financial position exposure	(43 180)	7 166	44 279	2 777	326	11 368
Net exposure	(43 180)	7 166	44 279	2 777	326	11 368

31 March 2021	ZAR R'000	EURO R'000	USD R'000	GBP R'000	OTHER R'000	Total 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)
Net exposure	(29 639)	14 632	44 663	6 995	942	37 593

The following closing exchange rates were applied at reporting date:

Rand per unit of foreign currency:

US Dollar	14,567	15,000
Euro	16,309	17,605
GBP	19,148	20,618

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 2021.

Euro	(749)	(1 463)
USD	(4 621)	(4 466)
GBP	(278)	(700)
Other	(41)	(94)

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	1 315 356	1 262 607	-	-
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CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

14. Financial instruments and risk management (continued)

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	45 000	28 000	-	-
Financial assets: Bank balances	71 610	144 415	-	-
	116 610	172 415	-	-

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 2021.

Variable rate instruments	1 166	1 724	-	-
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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.

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.

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.

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NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

14. Financial instruments and risk management (continued)

The maximum exposure to credit risk at the reporting date was:

Current fixed deposits	1 315 356	1 262 607	-	-
Call deposits	45 000	28 000	-	-
Bank balances	71 610	144 415	-	-
Cash on hand and cash deposits	112	112	-	-
Trade and other receivables	307 945	293 534	-	-
Contracts in progress less provision for losses	181 803	134 341	-	-
	1 921 826	1 863 009	-	-

The maximum exposure to credit risk for trade receivables at the reporting date by type of customer was:

Local public sector	157 851	120 974	-	-
Local private sector	51 225	77 682	-	-
International sector	18 950	33 638	-	-
	228 026	232 294	-	-

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:

The aging of the Group's trade receivables at the reporting date was:	2022 R'000 Gross	2022 Impairment R'000	2021 Gross R'000	2021 Impairment R'000
Not past due	16 8320	3 810	160 242	1 143
Past due 0 – 30 days	32 490	1 122	25 390	195
Past due 31 – 120 days	18 546	5 104	35 526	3 210
Past due more than 120 days	47 236	28 530	49 316	33 632
	266 592	38 566	270 474	38 180

The movement in the allowance for impairment in respect of trade receivables during the year was as follows:

	Group 2022 R'000	Group 2021 R'000
Balance at 1 April	38 180	35 207
Movement for the year		
Recoveries	(377)	(219)
Utilisation	(34 327)	(13 402)
New impairment allowances	35 090	16 594
Balance at 31 March	38 566	38 180

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.

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FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

14. Financial instruments and risk management (continued)

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:

	2022 Contractual Cash			2021 Contractual Cash		
	Carrying amount R'000	6 months or less R'000	6 - 12 months R'000	Carrying amount R'000	6 months or less R'000	6 - 12 months R'000
Non-derivative financial liabilities						
Trade and other payables	(326 834)	(326 834)	-	(377 296)	(377 296)	-

14.4 Fair values

As at 31 March 2022 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.

Forward exchange contracts

The fair value of forward exchange contracts is determined using forward exchange rates at the Statement of Financial Position date, with the resulting value discounted back to present value.

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

15. Reconciliation of operating profit to cash generated from operating activities

Profit before taxation	139 708	96 293	139 463	96 043
Adjustments for:				
Depreciation and amortisation	49 763	52 489	49 763	52 489
(Profit)/losses on disposal and write-off of property, plant and equipment	(563)	194	(563)	194
Losses (gains) on foreign exchange	174	(3 211)	174	(3 211)
Bad debt written off	15 846	2 549	15 846	2 549
Interest income	(53 178)	(41 255)	(52 966)	(40 980)
Finance expense	1 069	1 119	1 069	1 119
Impairments (reversal of impairments)	2 463	2 761	386	2 998
Movements in retirement benefit assets and liabilities	918	1 059	918	1 059
Movements in provisions	-	(12 464)	-	(12 464)
Leave and bonus accrual	11 922	93 872	11 922	93 872
Share of (profits) losses from joint venture and associate	(2 138)	252	-	-
Other non-cash items	12 844	6 754	12 800	6 771
Changes in working capital:				
Inventories	351	1 770	351	1 770
Trade and other receivables	(29 972)	(1 770)	(29 972)	(1 790)
Contract assets	3 616	1 996	3 616	1 996
Other receivables from contracts with customers	(49 872)	(21 496)	(49 872)	(21 496)
Trade and other payables	(78 425)	(45 650)	(78 388)	(45 650)
Advances from customers	(27 571)	44 884	(27 571)	44 884
	(3 045)	18 0146	(3 024)	180 153

16. Cash and cash equivalents

Cash and cash equivalents consist of:				
Cash on hand	112	112	112	112
Bank balances	71 609	144 414	70 856	143 662
Short-term deposits	1 360 356	1 290 607	1 352 804	1 283 245
	1 432 077	1 435 133	1 423 772	1 427 019

Cash on hand comprises of petty cash.

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

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 note 7). 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

Constitutional institutions

Services rendered	2 117	2 029	2 117	2 029
Services received	17	-	17	-
Amount due (to) from	348	1 593	348	1 593

Major public entities

Services rendered	230 500	335 783	230 500	335 783
Services received	37 021	45 526	37 021	45 526
Amount due (to) from	49 707	51 181	49 707	51 181

National public entities

Services rendered	103 612	117 260	103 612	117 260
Services received	16 946	16 551	16 946	16 551
Amount due (to) from	26 800	17 717	26 800	17 717

National government business enterprises

Services rendered	4 983	5 056	4 983	5 056
Services received	427	661	427	661
Amount due (to) from	1 673	2 061	1 673	2 061

Government departments

Services rendered	1 795 124	1 569 724	1 795 124	1 569 724
Services received	54 504	8 717	54 504	8 717
Amount due (to) from	66 391	47 282	66 391	47 282

Subsidiaries

Amount due (to) from	-	-	(13)	(13)
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The above is a summary of transactions with related parties during the year and balances due at year-end:

Transactions with key management

Total remuneration of key management is included in employees' remuneration (refer to note 12 for Executive Management's remuneration).

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

18. Irregular and fruitless and wasteful expenditure

Irregular expenditure

Opening balance	8 187	9 888	8 187	9 888
Irregular expenditure relating to the current financial year:				
- Non-compliance to PPPFA and/or PFMA*	3 673	-	3 673	-
Irregular expenditure relating to prior financial years:				
- Non-compliance to PPPFA and/or PFMA*	68	372	68	372
Amounts condoned	(129)	(2 073)	(129)	(2 073)
	11 799	8 187	11 799	8 187

Included in the balance of R11,7 million above is a total of R6,2 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 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 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 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.
- * During the 2021/22 financial year nine transgressions were detected which constitute irregular expenditure. Of the nine transgressions detected three were committed prior to 2021/22. At time of reporting line management were carrying out consequence management against officials who committed the offences. In all instances no loss was suffered by the public entity.

Fruitless and wasteful expenditure

Balance at the beginning of the year	174	174	174	174
Amount incurred in the current year	17	-	17	-
	191	174	191	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

During 2021/22 fruitless and wasteful expenditure of R 17 400 was incurred, being legal costs from late payment of a supplier .

CONSOLIDATED FINANCIAL STATEMENTS

FOR THE YEAR ENDED 31 MARCH 2022

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

19. New Standards and Interpretations

19.1 Standards and interpretations not yet effective

The Group has decided against the early adoption of the following standards and interpretations, which have been published and are mandatory for the Group's accounting periods beginning on or after 1 June 2020 or later periods:

- IFRS 16: COVID-19-Related Rent Concessions: Amendment providing lessees with an exemption from assessing whether a COVID-19-related rent concession (a rent concession that reduces lease payments due on or before 30 June 2021) is a lease modification. Impact of the amendment could not be reliably estimated at the of reporting.

20. Inventories

Finished goods	605	956	605	956
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21. Other receivables from contracts with customers

Contracts in progress at the end of the reporting period

Other receivables from contracts with customers	181 803	134 341	181 803	134 341
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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.

22. Contract assets

Contract assets	4 315	7 931	4 315	7 931
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Summary of contract assets

Contract assets	4 315	7 931	4 315	7 931
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Reconciliation of contract assets

Opening balance	7 931	9 927	7 931	9 927
Transfers of contract assets to receivables	(3 616)	(1 996)	(3 616)	(1 996)
	4 315	7 931	4 315	7 931

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NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

23. Provisions

Reconciliation of provisions - Group - 2021

	Opening balance	Utilised during the year	Total
Restructuring	12 464	(12 464)	-

Reconciliation of provisions - CSIR - 2021

	Opening balance	Utilised during the year	Total
Restructuring	12 464	(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

Property, plant and equipment	105 684	53 594	105 684	53 594
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26. Financial guarantees

Local and foreign payments and performance guarantees issued as at 31 March	38 176	43 979	38 176	43 979
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This section provides a detailed account of the CSIR's publication equivalents. These include accredited journal articles, conference papers, books and book chapters.

PART G

KNOWLEDGE

DISSEMINATION

PART E: KNOWLEDGE DISSEMINATION	160
Journal articles.....	162
Conference papers	180
Books and book chapters.....	189

PUBLICATION EQUIVALENTS – LIST OF 2021 OUTPUTS

The organisation produced 422.5 publication equivalents

JOURNAL ARTICLES

Abu El-Magd, SA, Taha, TH, Pienaar, Harrison H, Breil, P, Amer, RA, Namour, PH. 2021. Assessing heavy metal pollution hazard in sediments of Lake Mariout, Egypt. *Journal of African Earth Sciences*, 176, p.12pp.

Adams, J, Raw, J, Riddin, T, Wasserman, J, Van Niekerk, Lara. 2021. Salt marsh restoration for the provision of multiple ecosystem services. *Diversity-Basel*, 13(12), p.20pp.

Adams, R, Adeleke, F, Anderson, D, Bawa, A, Branson, N, Christoffels, A, De Vries, J, Etheredge, H, Flack-Davison, E, Molefe, Mapitso N. 2021. POPIA code of conduct for research. *South African Journal of Science*, 117(5/6), p.13pp.

Adekoya, Gbolahan J, Adekoya, Oluwasegun C, Sadiku, RE, Ray, Suprakas S. 2021. Structure-property relationship and nascent applications of thermoelectric PEDOT: PSS/carbon composites: A review. *Composites Communications*, 27, p.13pp.

Adeleye, AT, John, KI, Adeleye, PG, Akande, Amos A, Banjoko, OO. 2021. One-dimensional titanate nanotube materials: Heterogeneous solid catalysts for sustainable synthesis of biofuel precursors/value-added chemicals – a review. *Journal of Materials Science*, 228, p.26pp.

Adetunji, KE, Hofsajer, IW, Abu-Mahfouz, Adnan MI, Cheng, L. 2021. A review of metaheuristic techniques for optimal integration of electrical units in distribution networks. *IEEE Access*, 9, p.5046-5068.

Adetunji, KE, Hofsajer, IW, Abu-Mahfouz, Adnan MI, Cheng, L. 2021. Category-based multiobjective approach for optimal integration of distributed generation and energy storage systems in distribution networks. *IEEE Access*, 9, p.28237-28250.

Adeyemi, A, Ramoelo, A, Cho, Moses A, Masemola, C. 2021. Spectral index to improve the extraction of built-up area from WorldView-2 imagery. *Journal of Applied Remote Sensing*, 5(2), p.19pp.

Adeyemi, A, Ramoelo, A, Cho, Moses A, Strydom, J. 2021. Spatio-temporal analysis of built-up impervious surface area and interplay with land surface temperature in Pretoria, South Africa. *Geocarto International*, p.22pp.

Afolabi, OJ, Mabuza-Hocquet, Gugulethu P, Nelwamondo, Fulufhelo V, Paul, BS. 2021. The use of U-Net lite and Extreme Gradient Boost (XGB) for glaucoma detection. *IEEE Access*, 9, p.47411-47424.

Alimi, OA, Ouahada, K, Abu-Mahfouz, Adnan MI, Rimer, S, Alimi, KOA. 2021. A review of research works on supervised learning algorithms for SCADA intrusion detection and classification. *Sustainability*, 13(17), p.19pp.

Alimi, OA, Ouahada, K, Abu-Mahfouz, Adnan MI, Rimer, S. 2021. Power system events classification using genetic algorithm-based feature weighting technique for support vector machine. *Heliyon*, 7(1), p.9pp.

Ameh, AE, Musyoka, Nicholas M, Oyekola, O, Louis, B, Petrik, LF. 2021. Acylation of anisole with benzoyl chloride over rapidly synthesized fly ash-based HBEA zeolite. *Frontiers in Chemistry*, 9, p.16pp.

Aramide, B, Pityana, Sisa L, Jamiru, T, Popoola, P, Sadiku, R. 2021. Influence of vanadium-chromium carbide on the microstructure of reinforced FeCrV15 hardfacing. *Journal of Materials Engineering and Performance*, 31(1), p.514-523.

Aramide, B, Pityana, Sisa L, Sadiku, R, Jamiru, T, Popoola, P. 2021. Improving the durability of tillage tools through surface modification - a review. *The International Journal of Advanced Manufacturing Technology*, 116, p.83-89.

Aramide, B, Popoola, P, Sadiku, R, Jamiru, T, Pityana, Sisa L. 2021. Influence of extra chromium addition on the microstructure, hardness, and corrosion behaviour of high carbon ferrochrome FeCrV15 deposited through laser cladding on steel baseplate for tillage application. *Surface Topography: Metrology and Properties*, 9, p.11pp.

- Archer, E, Dziba, LE, Mulongoy, KJ, Maoela, Malebajoa A, Walters, Michele, Biggs, R, Cormier Salem, M-C, DeClerck, F, Diaw, MC, Dunham, AE. 2021. Biodiversity and Ecosystem Services on the African continent – what is changing, and what are our options?. *Environmental Development*, 37, p.9pp.
- Arthur, Nana KK, Siyasiya, C, Pityana, Sisa L, Tlotleng, Monnamme. 2021. Microstructural response of Ti6Al4V ELI alloyed with molybdenum by direct energy deposition. *Journal of Materials Engineering and Performance*, p.11 pp.
- Arunachellan, IC, Sypu, VS, Kera, NH, Pillay, K, Maity, Arjun. 2021. Flower-like structures of carbonaceous nanomaterials obtained from biomass for the treatment of copper ion-containing water and their re-use in organic transformations. *Journal of Environmental Chemical Engineering*, 9(4), p.14pp.
- Bandyopadhyay, Jayita, Mekoa, Raphaahle C, Makwakwa, Dimakatso M, Skosana, Sifiso, Ray, Suprakas S. 2021. Influence of nucleation and growth mechanisms on the heat deflection temperature of a reactively processed polypropylene nanocomposite. *Polymer Engineering and Science*, 61 (4), p.1195-1208.
- Banerjee, R, Ray, Suprakas S. 2021. An overview of the recent advances in polylactide-based sustainable nanocomposites. *Polymer Engineering and Science*, 61 (3), p.617-649.
- Berndt, Robert J, Nel, Willem AJ, Abdul Gaffar, MY, O'Hagan, D. 2021. Probability of helicopter blade flash interception in search radar. *IEEE Transactions on Aerospace and Electronic Systems*, p.11 pp.
- Bhaumik, M, Maity, Arjun, Brink, HG. 2021. Zero valent nickel nanoparticles decorated polyaniline nanotubes for the efficient removal of Pb(II) from aqueous solution: Synthesis, characterization and mechanism investigation. *Chemical Engineering Journal*, 417, p.11 pp.
- Bhuyar, P, Sundararaju, S, Xuan Feng, H, Rahim, MHA, Muniyasamy, Sudhakar, Maniam, GP, Govindan, N. 2021. Evaluation of microalgae's plastic biodeterioration property by a consortium of *Chlorella* sp. and *Cyanobacteria* sp. *Journal of Environmental Research, Engineering and Management*, 77(3), p.86-98.
- Boitsov, S, Newman, Brent K, Muiambo, HF, Chaúque, EFC, Serigstad, B, Malauene, BS. 2021. Distribution and possible sources of polycyclic aromatic hydrocarbons (PAHs) and metals in marine surface sediments off northern Mozambique. *Marine Pollution Bulletin*, 163, p.9pp.
- Bopape, MM, Cardoso, H, Plant, RS, Phaduli, E, Chikoore, H, Ndarana, T, Khalau, L, Rakate, Edward M. 2021. Sensitivity of tropical cyclone Idai simulations to cumulus parametrization schemes. *Atmosphere*, 12(8), p.22pp.
- Botha, Natasha, Inglis, HM, Coetzer, R, Labuschagne, FJWJ. 2021. Statistical design of experiments: An introductory case study for polymer composites manufacturing applications. *MATEC Web of Conferences*, 347, p.12pp.
- Bredenkamp, IE, Kritzing, E, Herselman, Martha E. 2021. A conceptual framework for consumer IS compliance awareness: South African government context. *Lecture Notes in Networks and Systems*, 228, p.682-701.
- Burman, RJ, Watson, IM, Smith, DC, Raimondo, JV, Ballo, R, Scholefield, Janine, Cowley, S, Wood, MJA, Kidson, SH, Greenberg, UJ. 2021. Molecular and electrophysiological features of spinocerebellar ataxia type seven in induced pluripotent stem cells. *PLoS ONE*, 16(2), p.20pp.
- Bvumbi, Mpelegeng V, Van der Westhuyzen, Christiaan W, Mmutlane, EM, Ngwane, A. 2021. Riminophenazine derivatives as potential antituberculosis agents: Synthesis, biological, and electrochemical evaluations. *Molecules*, 26(14), p.14pp.
- Calitz, Joanne R, Bansa, RC. 2021. The system value of optimized battery electric vehicle charging: a case study in South Africa. *Electrical Engineering*, p.11 pp.
- Celliers, Louis, Scott, D, Ngcoya, M, Taljaard, Susan. 2021. Negotiation of knowledge for coastal management? Reflections from a transdisciplinary experiment in South Africa. *Humanities and Social Sciences Communications*, 8(207), p.11 pp.
- Chen, G, Guo, Y, Yue, X, Tong, S, Gasparrini, A, Bell, ML, Armstrong, B, Schwartz, J, Jaakkola, JJK, Garland, Rebecca M. 2021. Mortality risk attributable to wildfire-related PM_{2.5} pollution: A global time series study in 749 locations. *Lancet Planetary Health*, 5(9), p.e579-e587.

- Chikosha, Silethelwe, Tshabalala, Lerato C, Bissett, H, Lesufi, M, Mnguni, Khulekani N, Motsai, Tebogo M, Manama, T, Hoosain, S. 2021. Spheroidisation of stainless steel powder for additive manufacturing. *Metals*, 11(7), p.15pp.
- Cilliers, P, Van Vuuren, JH, Van Heerden, Quintin. 2021. A framework for modelling spatio-temporal informal settlement growth prediction. *Computers, Environment and Urban Systems*, 90, p.15pp.
- Cloete, R, Look, JC, Van Horsten, Natasha R, Fietz, S, Mtshali, TN, Planquette, H, Roychoudhury, AN. 2021. Winter Biogeochemical Cycling of Dissolved and Particulate Cadmium in the Indian Sector of the Southern Ocean (GEOTRACES G1pr07 Transect). *Frontiers in Marine Science*, 8, p.18pp.
- Cloete, R, Look, JC, Van Horsten, Natasha R, Menzel Barraqueta, J-L, Fietz, S, Mtshali, TN, Planquette, H, Garcia-Ibanez, MI, Roychoudhury, AN. 2021. Winter dissolved and particulate zinc in the Indian Sector of the Southern Ocean: Distribution and relation to major nutrients (GEOTRACES G1pr07 transect). *Marine Chemistry*, 236, p.13pp.
- Cobbinah, PV, Matizamhuka, W, Machaka, Ronald, Shongwe, MB, Yanabe-Mitaria, Y. 2021. The high-temperature performance of Ti-46.5Al-%xTa (x = 0.8, 4 and 8 at.%) alloys produced using SPS. *Materials Today: Proceedings*, 38(2), p.528-535.
- Crouch, NR, Styles, DG, Walters, Michele. 2021. *Cotyledon nielsii* (Crassulaceae), a new cremophyte from KwaZulu-Natal, South Africa. *Bradleya*, 39, p.131-137.
- Dada, A, Popoola, P, Mathe, Ntombizodwa R, Adeosun, S, Aramide, O. 2021. 2D numerical model for heat transfer on a laser deposited high entropy alloy baseplate using Comsol Multiphysics. *Materials Today: Proceedings*, p.2541-2546.
- Dada, M, Popoola, P, Mathe, Ntombizodwa R, Adeosun, S, Pityana, Sisa L. 2021. Investigating the elastic modulus and hardness properties of a high entropy alloy coating using nanoindentation. *International Journal of Lightweight Materials and Manufacture*, 4(3), p.339-345.
- Dada, M, Popoola, P, Mathe, Ntombizodwa R, Pityana, Sisa L, Adeosun, S, Aramide, O. 2021. The comparative study of the microstructural and corrosion behaviour of laser-deposited high entropy alloys. *Journal of Alloys and Compounds*, 866, p.8pp.
- Dada, M, Popoola, P, Mathe, Ntombizodwa R. 2021. Recent advances of high entropy alloys for aerospace applications: A review. *World Journal of Engineering*, p.32pp.
- Dada, M, Popoola, P, Mathe, Ntombizodwa, Pityana, Sisa L, Adeosun, S. 2021. Effect of laser parameters on the properties of high entropy alloys: A preliminary study. *Materials Today: Proceedings*, 38 (Part 2), p.756-761.
- Daniels, AJ, Poblete-Echeverría, C, Nieuwoudt, HH, Botha, Gerda N, Opara, UL. 2021. Classification of browning on intact table grape bunches using near-infrared spectroscopy coupled with partial least squares-discriminant analysis and artificial neural networks. *Frontiers in Plant Science*, 12(768046), p.10pp.
- Daswa, Pfarelo, Chikosha, Silethelwe, Siyasiya, CW. 2021. Shape memory properties and transformation temperature of Ti50-XVXPt50 alloy. *Intermetallics*, 133, p.6pp.
- Davoren, B, Sacks, N, Theron, Maritha. 2021. Microstructure characterization of WC-9.2wt%Monel 400 fabricated using laser engineered net shaping using laser engineered net shaping. *Progress in Additive Manufacturing*, 6, p.431-443.
- De Beer, M, Van Rensburg, Yvette, Maina, JW. 2021. Three-dimensional contact stresses of a slick solid rubber tyre on a rigid surface. *Journal of the South African Engineering Institution of Civil Engineering*, 63(3), p.2-13.
- De Canha, MN, Thipe, VC, Katti, KV, Mandiwana, Vusani, Kalombo, Lonji, Ray, Suprakas S, Rikhotso, Rirhandzu S, Van Vuuren, J, Lall, N. 2021. The activity of gold nanoparticles synthesized using *helichrysum odoratissimum* against *cutibacterium acnes* biofilms. *Frontiers in Cell and Developmental Biology*, p.16pp.
- De Lange, A, Naidoo, Mogesh, Garland, Rebecca M, Dyson, LL. 2021. The sensitivity of simulated surface-level pollution concentrations to WRF-ARW-model PBL parameterisation schemes over the Highveld of South Africa. *Atmospheric Research*, 254, p.38pp.

De Lange, A, Naidoo, Mogesh, Garland, Rebecca M, Dyson, LL. 2021. Sensitivity of meteorological variables on planetary boundary layer parameterization schemes in the WRF-ARW model. *Atmospheric Research*, 247, p.19pp.

Diale, RG, Modiba, Rosinah, Ngoepe, PE, Chauke, HR. 2021. Phase stability of TiPd_{1-x}Rux and Ti_{1-x}Pd_x shape memory alloys. *Materials Today: Proceedings*, 38(part 2), p.1071-1076.

Dileepkumar, VG, Pratapkumar, C, Viswanatha, R, Basavaraja, BM, Maphanga, Rapela R, Chennabasappa, M, Srinivasa, N, Ashoka, S, Chen, Z, Rtimi, S. 2021. Nanostructured NaFeS₂ as a cost-effective and robust electrocatalyst for hydrogen and oxygen evolution with reduced overpotentials. *Chemical Engineering Journal*, 426, p.10pp.

Dima, Ratshilumela S, Phuthu, L, Maluta, NE, Kirui, JK, Maphanga, Rapela R. 2021. Electronic, Structural, and Optical Properties of Mono-Doped and Co-Doped (210) TiO₂ Brookite Surfaces for Application in Dye-Sensitized Solar Cells-A First Principles Study. *Materials*, 14(14), p.10pp.

Dlamini, ML, Bhaumik, M, Pillay, K, Maity, Arjun. 2021. Polyaniline nanofibers, a nanostructured conducting polymer for the remediation of Methyl orange dye from aqueous solutions in fixed-bed column studies. *Heliyon*, 7(10), p.13pp.

Dlamini, Moses T, Elo, JHP, Venter, HS, Elo, MM. 2021. CBAC4C: Conflict-based VM isolation control for cloud computing. *International Transactions in Operational Research*, p.24pp.

Eccles, R, Van der Linde, J, Le Roux, M, Holloway Jennifer P, MacCutcheon, D, Ljung, R, Swanepoel, D. 2021. Is phonological awareness related to pitch, rhythm, and speech-in-noise discrimination in young children?. *Language, Speech, and Hearing Services in Schools*, 52(1), p.383-395.

Effossou, KA, Cho, Moses A. 2021. Land tenure conflict and agribusiness development in sub-Saharan Africa. *South African Geographical Journal*, p.23pp.

Elayaperumal, M, Gnanasekaran, K, Moodley, MK, Mwakikunga, Bonex W, Gaur, R, Umapathy, S, Ladchumananandasivam, R, Maaza, M. 2021. Ultrananocrystalline diamond-like carbon (UN-DLC) assembled on epitaxial ZnO film by PLD technique and SIMS Raman Rutherford spectroscopic fingerprint investigation. *Journal of Raman Spectroscopy*, 52(11), p.1838–1846.

Elegbeleye, IF, Maluta, NE, Maphanga, Rapela R. 2021. Density functional theory study of optical and electronic properties of (TiO₂)_{n=5,8,68} clusters for application in solar cells. *Molecules*, 26(4), p.19pp.

Ellero, AA, Van den Bout, I, Vlok, M, Cromarty, AD, Hurrell, Tracey. 2021. Continual proteomic divergence of HepG2 cells as a consequence of long-term spheroid culture. *Scientific Reports*, 11(1), p.14pp.

Emej, IC, Ama, OM, Khoele, K, Osifo, PO, Ray, Suprakash S. 2021. Electro fenton degradation of selected antiretroviral drugs using a low-cost iron-modified carbon cloth electrode. *Electrocatalysis*, 128, p.327-339.

Engelbrecht, FA, Monteiro, Pedro MS. 2021. The IPCC assessment report six working group 1 report and southern Africa: Reasons to take action. *South African Journal of Science*, 117(11/12), p.7pp.

Ezika, AC, Sadiku, ER, Idumah, CI, Ray, Suprakash S, Hamam, Y. 2021. On energy storage capacity of conductive MXene hybrid nanoarchitectures. *Journal of Energy Storage*, 45, p.20pp.

Fagbemi, Olajumoke D, Andrew, Jerome E, Sithole, Bishop B. 2021. Beneficiation of wood sawdust into cellulose nanocrystals for application as a bio-binder in the manufacture of particleboard. *Biomass Conversion and Biorefinery*, p.12pp.

Fagbemi, Olajumoke D, Sithole, Bishop B. 2021. Evaluation of waste chicken feather protein hydrolysate as a bio-based binder for particleboard production. *Current Research in Green and Sustainable Chemistry*, 4, p.12pp.

Fanta, GB, Pretorius, L, Erasmus, Louwrence D. 2021. Techno-organisational factors of eHealth acceptance: a system dynamics model. *International Journal of Learning and Change*, 1(1), p.40pp.

Fashedemi, OO, Mwonga, PV, Miller, HA, Maphanga, Rapela R, Vizza, F, Ozoemena, KI. 2021. Performance of Pd@FeCo catalyst in anion exchange membrane alcohol fuel cells. *Electrocatalysis*, 12, p.295-309.

Fikeni, Lusanda, Annan, KA, Mutombo, Kalenda, Machaka, R. 2021. Effect of Nb content on the microstructure and mechanical properties of binary Ti-Nb alloys. *Materials Today: Proceedings*, 38(2), p.913-917.

- Folorunso, O, Hamam, Y, Sadiku, R, Ray, Suprakas S, Adekoya, GJ. 2021. Electrical resistance control model for polypyrrole-graphene nanocomposite: Energy storage applications. *Materials Today Communications*, 26, p.8pp.
- Folorunso, O, Hamam, Y, Sadiku, R, Ray, Suprakash S, Adekoya, GJ. 2021. Investigation of graphene loaded polypyrrole for lithium-ion battery. *Materials Today: Proceedings*, 38 (part 2), p.635-638.
- Folorunso, Oladipo, Hamam, Y, Sadiku, R, Ray, Suprakas S, Adekoya, GJ. 2021. Comparative study of graphene-polypyrrole and borophene-polypyrrole composites: Molecular dynamics modeling approach. *Engineering Solid Mechanics*, 9(3), p.311-322.
- Folorunso, Oladipo, Hamam, Y, Sadiku, R, Ray, Suprakas S, Kumar, Neeraj. 2021. Investigation and modeling of the electrical conductivity of graphene nanoplatelets-loaded doped-polypyrrole. *Polymers*, 13(7), p.18pp.
- Folorunso, Oladipo, Hamam, Y, Sadiku, R, Ray, Suprakas S. 2021. Computational study of graphene-polypyrrole composite electrical conductivity. *Nanomaterials*, 11(4), p.15pp.
- Folorunso, Oladipo, Sadiku, R, Hamam, Y, Ray, Suprakas S. 2021. An investigation of copper oxide-loaded reduced graphene oxide nanocomposite for energy storage applications. *Applied Physics A: Materials Science and Processing*, 54, p.12pp.
- Fosu, EA, Obuah, C, Hamenu, L, Aniagyei, A, Ainooson, MK, Govender, Krishna K. 2021. Quantum mechanistic studies of the oxidation of ethylene by rhenium oxo complexes. *Journal of Chemistry*, p.11pp.
- Fuku, Xolile G, Modibedi, Remegia M, Mkhohlakali, Andile, Mathe, Mahlanyane K. 2021. Co-existence of Pd, Bi₂O₃ and CuO supported on porous activated biocarbon for electrochemical conversion and energy storage. *New Journal of Chemistry*, 45(37), p.17603-17616.
- Furnival-Adams, J, Olanga, EA, Napier, Mark, Garner, P. 2021. House modifications for preventing malaria (Review). *Cochrane Database of Systematic Reviews*, 10, p.60pp.
- Gangire, Y, Da Veiga, A, Herselman, Martha E. 2021. Assessing information security behaviour: A self-determination theory perspective. *Information and Computer Security*, 29(4), p.22pp.
- Garland, Rebecca G, Wernecke, B, Feig, G, Langerman, K. 2021. The new WHO Global Air Quality Guidelines: What do they mean for South Africa. *Clean Air Journal*, 31(2), p.2pp.
- Gbadeyan, OJ, Adali, BJ, Bright, G, Sithole, Bishop B. 2021. The investigation of reinforcement properties of nano- CaCO₃ synthesized from Achatina fulica snail shell through mechanochemical methods on epoxy nanocomposites. *Nanocomposites*, 7(1), p.15pp.
- Gbadeyan, OJ, Adali, S, Bright, G, Sithole, Bishop B, Lekha, Prabashni S. 2021. Mechanical, microstructure, and dynamic mechanical analysis of nano-shell and plant fiber hybrid biocomposite. *Journal of Composite Materials*, p.14pp.
- Giddy, Isabelle, Swart, S, Du Plessis, Marcel, Thompson, AF, Nicholson, Sarah-Anne. 2021. Stirring of sea-ice meltwater enhances submesoscale fronts in the Southern Ocean. *Journal of Geophysical Research: Oceans*, 126(4), p.24pp.
- Godfrey, Linda K. 2021. Quantifying economic activity in the informal recycling sector in South Africa. *South African Journal of Science*, 117(9/10), p.7pp.
- Govender, A, Bemont, C, Chikosha, Silethelwe. 2021. Sintering high green density direct powder rolled titanium strips, in argon atmosphere. *Metals*, 11(6), 936, p.21pp.
- Grobler, J, Harding, KG, Smit, Monique, Ramchuran, Santosh O, Durand, P, Low, M. 2021. Biodiesel production potential of an indigenous South African microalga, *Acutodesmus bajacalifornicus*. *Scientific African*, 13, p.9pp.
- Grobler, Lichelle R, Suleman, Essa, Thimiri Govindaraj, Deepak B. 2021. Patents and technology transfer in CRISPR technology. *Progress in Molecular Biology and Translational Science*, 180, p.153-182.

- Grundling, P-L, Grundling, AT, Van Deventer, Heidi, Le Roux, JP. 2021. Current state, pressures and protection of South African peatlands. *Mires and Peat*, 27(26), p.25pp.
- Gumbo, AD, Kapangaziwiri, Evison, Chikoore, H, Pienaar, Harrison H. 2021. Assessing water resources availability in headwater sub-catchments of Pungwe River Basin in a changing climate. *Journal of Hydrology: Regional Studies*, 35, p.13pp.
- Gumbo, AD, Kapangaziwiri, Evison. 2021. The fate of the City of Mutare's urban water supply as changing climate impacts on its source in the Pungwe sub-catchment. *River Research and Applications*, p.11pp.
- Gusain, Rashi, Kumar, Neeraj, Opoku, F, Govender, PP, Ray, Suprakas S. 2021. MoS₂ nanosheet/ZnS composites for the visible-light-assisted photocatalytic degradation of oxytetracycline. *ACS Applied Nano Materials*, 4, p.4721-4734.
- Harikrishnan, D, Kumar, NS, Joseph, RS, Nair, Kishor K, Nishanth, R, Joseph, AJ. 2021. FPGA implementation of fast & secure fingerprint authentication using trsg (true random and timestamp generator). *Microprocessors and Microsystems*, 82, p.8pp.
- Haywood, Lorren K, De Lange, Willem J, Musvoto, Constansia D, De Wet, Benita. 2021. What do South African supermarket retailers disclose about the sustainability of suppliers?. *Journal of Contemporary Management*, 18(1), p.173-193.
- Haywood, Lorren K, Kapwata, T, Oelofse, Suzanna H, Breetzke, G, Wright, CY. 2021. Waste disposal practices in low-income settlements of South Africa. *International Journal of Environmental Research and Public Health*, 18(15), p.12pp.
- Haywood, Lorren K. 2021. Putting risk management into the corporate sustainability context. *Social Responsibility Journal*, p.20pp.
- Hemmati, F, Hemmati-Dinarvand, M, Karimzade, M, Rutkowska, Daria A, Eskandari, MH, Khanizadeh, S, Afsharifar, A. 2021. Plant-derived VLP: A worthy platform to produce vaccine against SARS-CoV-2. *Biotechnology Letters*, 44(1), p.13pp.
- Henrico, S, Coetzee, S, Cooper, Antony K. 2021. The role of age, gender, experience, education and professional registration in acceptance of QGIS in South Africa. *Transactions in GIS*, p.16pp.
- Hoosain, SE, Tshabalala, Lerato C, Skhosana, Besabakhe S, Freemantle, C, Mndebele, N. 2021. Investigation of the properties of direct energy deposition additive manufactured 304 stainless steel. *South African Journal of Industrial Engineering*, 32(3), p.258-263.
- Iroegbu, Austine OC, Ray, Suprakas S. 2021. Bamboos: From bioresource to sustainable materials and chemicals. *Sustainability*, 13(21), p.25pp.
- Jele, TB, Lekha, Prabashni, Sithole, Bishop B. 2021. Role of cellulose nanofibrils in improving the strength properties of paper: A review. *Cellulose*, 29, p.55-81.
- Jin, S, Yang, SY, Lee, JM, Kang, MS, Choi, SM, Ahn, W, Fuku, Xolile G, Modibedi, Mmalewane R, Han, B, Seo, MH. 2021. Fluorine-decorated graphene nanoribbons for an anticorrosive polymer electrolyte membrane fuel cell. *ACS Applied Materials & Interfaces*, 13(23), p.26936-26947.
- Johakimu, Jonas K, Sithole, Bishop, B. 2021. Woodchip impregnation with weak white liquor and its effect in mitigating operational costs and environmental impacts in Kraft pulp mills. *Biofuels Bioproducts & Biorefining-Biofpr*, 15(5), p.12pp.
- Josiah, Andrea J, Pillai, Sreejarani K, Cordier, W, Nell, M, Twilley, D, Lall, N, Sinha Ray, Suprakas. 2021. Cannabidiol-mediated green synthesis, characterization, and cytotoxicity of metal nanoparticles in human keratinocyte cells. *ACS Omega*, 6(43), p.29078-29090.
- Josiah, Andrea J, Twilley, D, Kesavan Pillai, Sreejarani, Ray, Suprakas S, Lall, N. 2021. Pathogenesis of keratinocyte carcinomas and the therapeutic potential of medicinal plants and phytochemicals. *Molecules*, 26(7), p.29pp.
- Kabongo, GL, Mhlongo, Gugu H, Dhlamini, MS. 2021. Unveiling semiconductor nanostructured based holmium-doped ZnO: Structural, luminescent and room temperature ferromagnetic properties. *Nanomaterials*, 11, p.15pp.

- Kabwe, KP, Nsibande, SA, Lemmer, Yolandy, Pilcher, LA, Forbes, PB. 2021. Synthesis and characterisation of quantum dots coupled to mycolic acids as a water-soluble fluorescent probe for potential lateral flow detection of antibodies and diagnosis of tuberculosis. *Luminescence*, 37(2), p.278-289.
- Kakonke, Grace, Tesfaye, Tamrat, Sithole, Bishop B, Ntunka, M. 2021. A novel method for rapid extraction of biofibres from waste chicken feathers. *Journal of Solid Waste Technology and Management*, 47(1), p.31-45.
- Kalombo, Lonji, Adeniyi, A, Nomadolo, Elizabeth N, Setshedi, Katlego Z, Madito, MJ, Manyala, N, Mbaya, K. 2021. Preparation and characterisation of polypyrrole nanoparticles for enhancement of granular activated carbon (GAC) as adsorbent. *Journal of the Taiwan Institute of Chemical Engineers*, 129, p.264-272.
- Karunaratna, B, Jayakody, RS, Karunanayake, L, Govender, Krishna K. 2021. Computational development and validation of a representative MDI-BDO-based polyurethane hard segment model. *Journal of Molecular Modeling*, 27(37), p.20pp.
- Kauko, HM, Hattermann, T, Ryan-Keogh, Thomas J, Singh, Asmita, De Steur, L, Fransson, A, Chierici, M, Falkenhaus, T, Hallfredsson, EH, Bratbak, G. 2021. Phenology and Environmental Control of Phytoplankton Blooms in the Kong Håkon VII Hav in the Southern Ocean. *Frontiers in Marine Science*, 8, p.24pp.
- Khomenko, MD, Makoana, Nkutuane W, Mirzade, FKH, Pityana, Sisa L. 2021. Coupled heat transfer, fluid flow and solidification kinetics for laser additive manufacturing applications. *Journal of Manufacturing Processes*, 67, p.611-618.
- Khosa, MC, Dube, Z, Tselanyane, Malefa, Senabe, Jeremiah V, Fouche, G, De Waele, D, Daneel, MS. 2021. Effect of *maerua angolensis* and *tabernaemontana elegans* leaf meal extracts on *meloidogyne incognita* second-stage juvenile hatch and viability. *Russian Journal of Nematology*, 29(1), p.1-9.
- Khumalo, Nosipho N, Oyerinde, OO, Mfupe, Luzango. 2021. Reinforcement learning-based resource management model for fog radio access network architectures in 5G. *IEEE Access*, 9, p.12706-12716.
- Kirui, JK, Olaleru, Solomon A, Jhamba, L, Wamwangi, D, Roro, Kittessa T, Shnier, A, Erasmus, R, Mwakikunga, Bonex W. 2021. Elucidating the trajectory of the charge transfer mechanism and recombination process of hybrid perovskite solar cells. *Materials*, 14(11), p.18pp.
- Kravitz, J, Matthews, M, Lain, L, Fawcett, S, Bernard, Stewart. 2021. Potential for high fidelity global mapping of common inland water quality products at high spatial and temporal resolutions based on a synthetic data and machine learning approach. *Frontiers in Environmental Science*, 9, p.23pp.
- Kumar, Neeraj, Salehiyan, Reza, Chauke, V, Botlhoko, OJ, Setshedi, K, Scriba, M, Masukume, M, Ray, Suprakash S. 2021. Top-down synthesis of graphene: A comprehensive review. *FlatChem*, 27, p.40pp.
- Lain, Elisabeth J, Smith, Marie E. 2021. The future of aquaculture is now. *Water Wheel*, 20(6), p.38-41.
- Latha, S, Selvamani, P, Suganya, G, Thimiri Govindaraj, Deepak B, Pal, TK. 2021. Preparation and in-vitro evaluation of pantoprazole sodium magnetic microspheres by emulsion solvent evaporation method. *BioNanoScience*, 11, p.643-647.
- Ledwaba, Lehlogonolo PI, Hancke, GP, Isaac, Sherrin J, Venter, HS. 2021. Smart microgrid energy market: Evaluating distributed ledger technologies for remote and constrained microgrid deployments. *Electronics*, 10(6), p.9pp.
- Lehong, C, Isong, B, Lugayizi, F, Abu-Mahfouz, Adnan MI. 2021. A spreading factor congestion status-aware adaptive data rate algorithm. *Journal of Sensor and Actuator Networks*, 10(4), p.12pp.
- Lehutso, Raisibe F, Tancu, Yolanda, Maity, Arjun, Thwala, Melusi. 2021. Characterisation of engineered nanomaterials in nano-enabled products exhibiting priority environmental exposure. *Molecules*, 26(5), p.21pp.
- Lehutso, Raisibe F, Thwala, Melusi. 2021. Assessment of nanopollution in water environments from commercial products. *Nanomaterials*, 11(10), p.21pp.

- Lehutso, Raisibe F, Wesley-Smith, J, Thwala, Melusi. 2021. Aquatic toxicity effects and risk assessment of 'Form Specific' product-released engineered nanomaterials. *International Journal of Molecular Sciences*, 22(22), p.25pp.
- Lekoadi, Paul M, Tlotleng, Monnamme, Annan, K, Maledi, N, Masina, Bathusile N. 2021. Evaluation of heat treatment parameters on microstructure and hardness properties of high-speed selective laser melted Ti6Al4V. *Metals*, 11(2), p.15pp.
- Lekoadi, Paul M, Tlotleng, Monnamme, Masina, Bathusile N. 2021. Effects of substrate heating on the microstructure and hardness of TiB/Ti6Al4V-ELI during laser in-situ metal deposition. *South African Journal for Science and Technology / Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie*, 40(1), p.6pp.
- Lemley, DA, Lamberth, SJ, Manuel, W, Nunes, M, Rishworth, GM, Van Niekerk, Lara, Adams, JB. 2021. Effective management of closed hypereutrophic estuaries requires catchment-scale interventions. *Frontiers in Marine Science*, 8, p.17pp.
- Letwaba, U, Tlhabadira, I, Daniyan, IA, Seerane, Mandy. 2021. Development and microstructural analysis of beta-SiAlONs produced by spark plasma sintering. *Materials Today: Proceedings*, 38(part2), p.590-594.
- Lloyd, CD, Bhatti, S, McLennan, D, Noble, M, Mans, Gerbrand G. 2021. Neighbourhood change and spatial inequalities in Cape Town. *Geographical Journal*, p.16pp.
- Maarsingh, B, Grobbelaar, SS, Uriona-Maldonado, M, Herselman, Martha E. 2021. Exploring functional dynamics of innovation for inclusive development: Event history analysis of an ICT4D project. *Innovation and Development*, p.32pp.
- Machabaphala, KM, Hlekelele, Lerato, Dlamini, LN. 2021. The photoreduction of selenite and selenate on the surface of few layer black phosphorus and a UiO-66 p-n junction heterostructure. *New Journal of Chemistry*, 45(19), p.8467-8478.
- Machaka, Ronald, Motsi, Glenda T, Raganya, Mampai L, Radingoana, Precious M, Chikosha, Silethelwe. 2021. Machine learning-based prediction of phases in high-entropy alloys: A data article. *Data in Brief*, 38, p.7pp.
- Machaka, Ronald. 2021. Machine learning-based prediction of phases in high-entropy alloys. *Computational Materials Science*, 188, p.9pp.
- Madigoe, Mandy N, Modiba, Rosinah, Cornish, LA. 2021. Use of first principles and Thermo-Calc to identify potential low elastic modulus titanium-based alloys for biomedical applications. *South African Journal for Science and Technology*, 40(1), p.228-233.
- Madonsela, Sabelo, Cho, Moses A, Naidoo, Laven, Main, Russell S, Majozi, Nobuhle P. 2021. Exploring the utility of Sentinel-2 for estimating maize chlorophyll content and leaf area index across different growth stages. *Journal of Spatial Science*, p.13pp.
- Madonsela, Sabelo, Cho, Moses A, Ramoelo, A, Mutanga, O. 2021. Investigating the relationship between tree species diversity and landsat-8 spectral heterogeneity across multiple phenological stages. *Remote Sensing*, 13(13), p.17pp.
- Mahaye, N, Thwala, Melusi, Musee, N. 2021. Interactions of coated-gold engineered nanoparticles with aquatic higher plant *Salvinia minima* Baker. *Nanomaterials*, 11(12), p.16pp.
- Majozi, Nobuhle P, Mannaerts, CM, Ramoelo, A, Mathieu, R, Verhoef, W. 2021. Uncertainty and sensitivity analysis of a remote-sensing-based Penman-Monteith model to meteorological and land surface input variables. *Remote Sensing*, 13(5), p.18pp.
- Makatsa, TJ, Baloyi, Siwela J, Masuku, CM. 2021. Computational Fluid Dynamics Modelling of Phenol Oxidation in a Trickle-Bed Reactor using 3D Eulerian Model. *Computer Aided Chemical Engineering*, 50, p.825-831.
- Makhanya, N, Oboirien, B, Ren, J, Musyoka, Nicholas M, Sciacovelli, A. 2021. Recent advances on thermal energy storage using metal-organic frameworks (MOFs). *Journal of Energy Storage*, 34, p.18pp.
- Malatji, N, Lengopeng, T, Pityana, Sisa L, Popoola, AP. 2021. Microstructural, mechanical and electrochemical properties of AlCrFeCuNiWx high entropy alloys. *Journal of Materials Research and Technology*, 11, p.1594-1603.
- Malatija, N, Popoola, API, Pityana, Sisa L, Lengopeng, T. 2021. Fabrication of Ti10Fe5Si5Cr3Nb composite coatings on Ti-6Al-4V alloy using laser cladding technique. *Materials Research*, 24(5), p.8pp.

Malibo, Pretrus M, Makgwane, Peter R, Baker, PGL. 2021. Hetero-mixed TiO₂-SnO₂ interfaced nano-oxide catalyst with enhanced activity for selective oxidation of furfural to maleic acid. *Inorganic Chemistry Communications*, 129, p.6pp.

Malley, CS, Hicks, WK, Kulyenstierna, JCI, Michalopoulou, E, Molotoks, A, Slater, J, Heaps, CG, Ulloa, S, Veysey, J, Mantlana, Khanyisa B. 2021. Integrated assessment of global climate, air pollution, and dietary, malnutrition and obesity health impacts of food production and consumption between 2014 and 2018. *Environmental Research Communications*, 3(7), p.29pp.

Malunga, MM, Cho, Moses A, Chirwa, PW, Yerokun, OA. 2021. Land use induced land cover changes and future scenarios in extent of Miombo woodland and Dambo ecosystems in the Copperbelt province of Zambia. *African Journal of Ecology*, p.15pp.

Mamushiane, Lusani, Mwangama, J, Lysko, Albert A. 2021. Controller placement optimization for Software Defined Wide Area Networks (SDWAN). *ITU Journal on Future and Evolving Technologies*, 2(1), p.21pp.

Mandiwana, Vusani, Kalombo, Lonji, Hayeshi, R, Zeevaart, JR, Ebenhan, T. 2021. Preclinical assessment addressing intravenous administration of a [⁶⁸Ga]Ga-PSMA-617 microemulsion: Acute in vivo toxicity, tolerability, PET imaging, and biodistribution. *Molecules*, 26(9), p.16pp.

Mandree, Prisha, Masika, Wendy S, Naicker, Justin, Moonsamy, Ghaneshree, Ramchuran, Santosh O, Laloo, Rajesh. 2021. Bioremediation of polycyclic aromatic hydrocarbons from industry contaminated soil using indigenous bacillus spp. *Processes*, 9(9), p.15pp.

Mangisa, Mandisa, Peter, Xolani K, Khosa, Mbokota, Fouche, Gerda, Nthambeleni, Rudzani, Senabe, Jeremiah V, Tarirai, C, Tembu, VJ. 2021. Ethnomedicinal and phytochemical properties of sesquiterpene lactones from *Dicoma* (Asteraceae) and their anticancer pharmacological activities: A review. *Scientific African*, 13, p.13pp.

Maphanga, Rapela R, Mokoena, T, Ratsoma, Mahlatse. 2021. Estimating DFT calculated voltage using machine learning regression models. *Materials Today: Proceedings*, 38(part 2), p.773-778.

Marumbwa, FM, Cho, Moses A, Chirwa, PW. 2021. Geospatial analysis of meteorological drought impact on Southern Africa biomes. *International Journal of Remote Sensing*, 42(6), p.2155-2173.

Maswanganyi, S, Gusain, Rashi, Kumar, Neeraj, Fosso-Kankeu, E, Waanders, FB, Ray, Suprakash S. 2021. Bismuth molybdate nanoplates supported on reduced graphene Oxide: An effective nanocomposite for the removal of naphthalene via adsorption-photodegradation. *ACS Omega*, 6, p.16783-16794.

Mathabathe, Maria N, Modiba, Rosinah, Bolokang, Amogelang S. 2021. The effects of quaternary alloying additions on the TiAl alloy: Preferential site occupancy, interfacial energetics to physical parameters. *Surfaces and Interfaces*, 25, p.13pp.

Mathe, Ntombizodwa R, Tshabalala, Lerato C, Hoosain, Shaik, Motibane, Londiwe P, Du Plessis, A. 2021. The effect of porosity on the mechanical properties of Ti-6Al-4V components manufactured by high-power selective laser melting. *International Journal of Advanced Manufacturing Technology*, 115, p.3589-3597.

Mathe, Ntombizodwa R. 2021. Development of ideal processing parameters for powder bed fusion system processing of AlSi10Mg using design of experiments. *Journal of Physics: Conference Series*, 2045, p.8pp.

Mathew, Maya J, Dyanti, Nokuzola, Mokhena, Teboho C, Agbakoba, Victor, Sithole, Bishop B. 2021. Design and development of cellulosic bionanocomposites from forestry waste residues for 3D printing applications. *Materials*, 14(13), p.13pp.

Matseke, Maphoma S, Zheng, Haitao, Mathe, Mahlanyane K, Carleschi, E, Doyle, B. 2021. Influence of Co doping on physiochemical properties of MnFe₂O₄/C nano compounds toward oxygen reduction reaction. *Journal of Alloys and Compounds*, 888, p.8pp.

Mbatha, Siphesihle, Everson, RC, Musyoka, Nicholas M, Langmi, HW, Lanzini, A, Brilman, W. 2021. Power-to-methanol process: A review of electrolysis, methanol catalysts, kinetics, reactor designs and modelling, process integration, optimisation, and techno-economics. *Sustainable Energy and Fuels*, 14(5), p.3490-3569.

- McDonald, Andre M, Van Wyk, M, Chen, G. 2021. The inverse Frobenius-Perron problem: A survey of solutions to the original problem formulation. *AIMS Mathematics*, 6(10), p.11200-11232.
- Mdlalose, Lindani M, Balogun, Mohammed O, Setshedi, Katlego Z, Klavins, M, Chimuka, L, Chetty, Avashnee. 2021. Ligand-based poly(phenylenediamine) adsorbents for enhanced removal of phosphate from water. *Polymer Bulletin*, 57, p.21 pp.
- Mehlhorn, P, Viehberg, F, Kirsten, K, Newman, Brent K, Frenzel, P, Gildeeva, O, Green, A, Hahn, A, Haberzettl, T. 2021. Spatial distribution and consequences of contaminants in harbour sediments – A case study from Richards Bay Harbour, South Africa. *Marine Pollution Bulletin*, 172, p.17pp.
- Merckel, RD, Heydenrych, MD, Sithole, Bishop B. 2021. Pyrolysis oil composition and catalytic activity estimated by cumulative mass analysis using Py-GC/MS EGA-MS. *Energy*, 219, p.15pp.
- Merryfield, WJ, Baehr, J, Batte, L, Becker, E, Butler, AH, Coelho, CA, Danabasoglu, G, Dirmeyer, PA, Doblas-Reyes, FJ, Beraki, Asmerom F. 2021. Subseasonal to decadal prediction filling the weather–climate gap. *Bulletin of the American Meteorological Society*, 101(9), p.767-770.
- Miya, LE, Sithole, ME, Modiba, Rosinah. 2021. Investigating the electronic and magnetic properties of Dy, Y and La by site substitution on Nd₂Fe₁₄B permanent magnet employing the first-principle approach. *South African Journal for Science and Technology*, 40 (1), p.224-227.
- Mkhohlakali, AC, Fuku, X, Modibedi, Remegia M, Khotseng, LE, Mathe, Mkhulu K. 2021. Electroformation of Pd-modified thin film electrocatalysts using E-ALD technique. *Electroanalysis*, 33, p.1746-1760.
- Mnisi, VC, Sithole, ME, Modiba, Rosinah. 2021. First principles study of phase stability and elastic properties of Ti₉₄Mo₆-xZrx (where x: 2 = x = 5) for biomaterials. *South African Journal for Science and Technology*, 40(1), p.150-153.
- Mobe, Nompumelelo T, Dzikit, S, Dube, T, Mazvimavi, D, Ntshidi, Zanele. 2021. Modelling water utilization patterns in apple orchards with varying canopy sizes and different growth stages in semi-arid environments. *Scientia Horticulturae*, 283 (110051), p.10pp.
- Mogale, N, Matizamhuka, W, Machaka, Ronald, Shongwe, M, Yamabe-Mitarai, Y. 2021. The effect of Cr additions and oxidation on densification, microstructure, phase constituents and mechanical properties of TiAlCr alloys produced by SPS. *Materials Today: Proceedings*, 38(2), p.621-627.
- Mohanrasu, K, Rao, GJ, Dinesh, GH, Zhang, H, Muniyasamy, Sudhakar, Pugazhendhi, A, Jeyakanthan, J, Ponnuchamy, K, Govarthanan, M, Arun, A. 2021. Production and characterization of biodegradable polyhydroxybutyrate by micrococcus luteus isolated from marine environment. *International Journal of Biological Macromolecules*, 186, p.125-134.
- Mokhena, TC, Sadiku, ER, Mochane, MJ, Ray, Suprakas S, John, Maya J, Mtibe, Asanda. 2021. Mechanical properties of cellulose nanofibril papers and their bionanocomposites: A review. *Carbohydrate Polymers*, 273, p.30pp.
- Mokhena, TC, Sadiku, ER, Ray, Suprakas S, Mochane, MJ, Motaung, TE. 2021. The effect of expanded graphite/clay nanoparticles on thermal, rheological, and fire-retardant properties of poly(butylene succinate). *Polymer Composites*, 42(12), p.6370-6382.
- Mokoena, Refiloe, Motau, T, Mturi, George AJ. 2021. Investigating the use of isothermal calorimetry for predicting physical properties of cements. *ConcreteBeton*, 166, p.8-14.
- Mokoena, Teboho P, Swart, HC, Hillie, Kenneth T, Motaung, DE. 2021. Colour tuning from violet to blue emission stimulated by various nickel oxide nanostructures: Influence of bias voltage towards volatile organic compounds vapours. *Applied Surface Science*, 542, p.15pp.
- Molatlhegi, G, Hoosain, Shaik, Popoola, API, Malatji, N, Pityana, Sisa L. 2021. The effect of laser surface re-melting on the surface roughness and micro-hardness of selective laser melting (SLM) fabricated Ti-6Al-4V samples. *South African Journal for Science and Technology / Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie*, 40(1), p.186-189.

- Moloi, MS, Lehutso, Raisibe F, Erasmus, M, Oberholster, PJ, Thwala, Melusi. 2021. Aquatic environment exposure and toxicity of engineered nanomaterials released from nano-enabled products: Current status and data needs. *Nanomaterials*, 11 (11), p.22pp.
- Moncrieff, GR, Slingsby, JA, Le Maitre, David C. 2021. Propagating uncertainty from catchment experiments to estimates of streamflow reduction by invasive alien plants in southwestern South Africa. *Hydrological Processes*, 35(4), p.13pp.
- Moolla, Yaseen, De Kock, Antonie J, Mabuza-Hocquet, Gugulethu P, Ntshangase, Cynthia S, Nelufule, Nthatheni, Khanyile, Nontokozo P. 2021. Biometric recognition of infants using fingerprint, iris and ear biometrics. *IEEE Access*, 9, p.38269-38286.
- Moshokoa, Nthabisen A, Raganya, Mampai L, Machaka, Ronald, Makhathan, ME, Obadele, BA. 2021. The effect of molybdenum content on the microstructural evolution and tensile properties of as-cast Ti-Mo alloys. *Materials Today Communications*, 27, p.10pp.
- Motlatle, Abesach M, Mofokeng, Tladi G, Scriba, Manfred R, Ojijo, Vincent O, Ray, Suprakash S. 2021. The effect of electrically conducting carbon materials on the conductivity and morphology of poly(vinyl butyral) and chitosan blend composite for application in anti-corrosive coatings. *Synthetic Metals*, 281, p.19pp.
- Motloun, Mpho P, Mofokeng, Tladi G, Ojijo, Vincent O, Ray, Suprakash S. 2021. A review on the processing–morphology–property relationship in biodegradable polymer composites containing carbon nanotubes and nanofibers. *Polymer Engineering and Science*, 61 (11), p.2719-2756.
- Motloun, Mpho P, Mofokeng, Tladi G, Ray, Suprakash S. 2021. Viscoelastic, thermal, and mechanical properties of melt-processed poly (ε-caprolactone) (PCL)/hydroxyapatite (HAP) composites. *Materials*, 15(1), p.15pp.
- Mpofu, Mvikel, Ngobese, Sibusiso SG, Maphalala, B, Roberts, David P, Khan, Sumaya. 2021. The influence of stemming practice on ground vibration and airblast. *Journal of the Southern African Institute of Mining and Metallurgy*, 121, p.10pp.
- Mthethwa, Sthembile N, Dlamini, Nelisiwe P, Mkuzangwe, Nenekazi NP, Shibambu, Ncedisa AM, Boateng, Thato G, Mantsi, Andile M. 2021. Understanding the Impact of and Analysing Fake News About COVID-19 in SA. *Lecture Notes in Computer Science*, 12887, p.66-84.
- Mtibe, Asanda, Motloun, Mpho P, Bandyopadhyay, Jayita, Ray, Suprakash S. 2021. Synthetic biopolymers and their composites: Advantages and limitations – An overview. *Macromolecular Rapid Communications*, 42, p.28pp.
- Mudzanani, Khuthadzo, Van Heerden, E, Mbhele, Nkhangweleni R, Daramola, MO. 2021. Enhancement of biogas production via co-digestion of wastewater treatment sewage sludge and brewery spent grain: Physicochemical characterization and microbial community. *Sustainability*, 13(15), p.16pp.
- Mulovhedzi, PT, Rambuwani, GT, Bopape, M-J, Maisha, R, Monama, Nkwe O. 2021. Model inter-comparison for short-range forecasts over the southern African domain. *South African Journal of Science*, 117(9/10), p.12pp.
- Muniyasamy, Sudhakar, Patnaik, Asis. 2021. Biodegradable behaviour of waste wool and their recycled polyester preforms in aqueous and soil conditions. *Journal of Renewable Materials*, 9(10), p.1661-1671.
- Munonde, Tshimangadzo S, Zheng, Haitao. 2021. The impact of ultrasonic parameters on the exfoliation of NiFe LDH nanosheets as electrocatalysts for the oxygen evolution reaction in alkaline media. *Ultrasonics Sonochemistry*, 76, p.10pp.
- Musvoto, Constansia D, Kgaphola, Motsoko J, Mwenge Kahinda, Jean-Marc. 2021. Assessment of homegarden agroforestry for sustainable land management intervention in a degraded landscape in South Africa. *Land Degradation & Development*, p.17pp.
- Mutanga, Shingirirai S, Ngungu, M, Tshililo, FP, Kaggwa, M. 2021. Systems dynamics approach for modelling South Africa's response to COVID-19: A "what if" scenario. *Journal of Public Health Research*, 10(1), p.8pp.
- Muzata, Tanyaradzwa S, Gebrekstos, Amanuel, Ray, Suprakash S. 2021. Recent progress in modified polymer-based PPE in fight against COVID-19 and beyond. *ACS Omega*, 6 (43), p.28463-28470.
- Mwandila, G, Mwanza, M, Sikhivhilu, K, Siame J, Mutanga, Shingirirai S, Simposya, A. 2021. Modeling energy requirements for a biogas-supported decentralized Water treatment systems for communities in chambishi (Zambia) and diepsloot (South Africa) townships. *Renewable Energy Focus*, 37(1), p.20-26.

- Mzondo, Buntubonke, Dlamini, Nomusa, Malan, FP, Labuschagne, Philip W, Bovilla, VR, Madhunapantula, SV, Maharaj, V. 2021. Dammarane-type triterpenoids with anti-cancer activity from the leaves of *Cleome gynandra*. *Phytochemistry Letters*, 43, p.16-22.
- Naidu, Darrel S, John, Maya J. 2021. Cellulose nanofibrils reinforced xylan-alginate composites: Mechanical, thermal and barrier properties. *International Journal of Biological Macromolecules*, 179, p.448-456.
- Nape, I, Mashaba, Nikiwe P, Mphuthi, N, Jayakumar, S, Bhattacharya, S, Forbes, Andrew. 2021. Vector-mode decay in atmospheric turbulence: An analysis inspired by quantum mechanics. *Physical Review Applied*, 15(3), p.9pp.
- Ncube, EN, Mathiba, Kgama, Steenkamp, Lucia H, Dubery, IA. 2021. Gas chromatographic profiling of the biocatalytic conversion of sclareol to ambradiol by *Hypophyza roseoniger*. *Biocatalysis and Biotransformation*, p.6pp.
- Ndiaye, M, Hancke, GP, Abu-Mahfouz, Adnan MI, Zhang, H. 2021. Software-defined power grids: A survey on opportunities and taxonomy for microgrids. *IEEE Access*, 9, p.98973-98991.
- Nemufulwi, Murendeni I, Swart, HC, Mhlono, Gugu H. 2021. A comprehensive comparison study on magnetic behaviour, defects-related emission and Ni substitution to clarify the origin of enhanced acetone detection capabilities. *Sensors and Actuators: B. Chemical*, 339, p.15pp.
- Nemufulwi, Murendeni I, Swart, HC, Mhlono, Gugu H. 2021. Enhanced propanol response behavior of ZnFe₂O₄ NP-based active sensing layer induced by film thickness optimization. *Processes*, 9(10), p.15pp.
- Nemufulwi, Murendeni I, Swart, HC, Mhlono, Gugu H. 2021. Evaluation of the effects of Au addition into ZnFe₂O₄ nanostructures on acetone detection capabilities. *Materials Research Bulletin*, 142, p.9pp.
- Ngejane, Hombakazi C, Eloff, JHP, Sefara, Tshephisho J, Marivate, VN. 2021. Digital forensics supported by machine learning for the detection of online sexual predatory chats. *Forensic Science International: Digital Investigation*, 36, p.11 pp.
- Nofara, M, Salehiyan, Reza, Ray, Suprakas S. 2021. Influence of nanoparticles and their selective localization on the structure and properties of polylactide-based blend nanocomposites. *Composites Part B: Engineering*, 215, p.29pp.
- Nondlazi, Basanda X, Cho, Moses A, Van Deventer, Heidi, Sieben, EJ. 2021. Determining the wetland-dryland boundary of depressions using littoral gradient analysis of soil edaphic factors. *Wetlands*, 41(81), p.14pp.
- Ntshidi, Zanele, Dzikiti, S, Mazvimavi, D, Mobe, Nompumelelo, Mkunanya, YP. 2021. Water use of selected cover crop species commonly grown in South African fruit orchards and their response to drought stress. *Physics and Chemistry of the Earth*, 124(Part2), p.10pp.
- Ntshidi, Zanele, Dzikiti, S, Mazvimavi, D, Mobe, NT. 2021. Contribution of understorey vegetation to evapotranspiration partitioning in apple orchards under Mediterranean climatic conditions in South Africa. *Agricultural Water Management*, 245, p.11pp.
- Nweke, EE, Thimiri Govindaraj, Deepak B. 2021. Development of insect cell line using CRISPR technology. *Progress in Molecular Biology and Translational Science*, 180, p.1-20.
- Nxumalo, Precious Z, Takundwa, MM, Thimiri Govindaraj, Deepak B. 2021. Chapter 14 - Patents, ethics, biosafety and regulation using CRISPR technology. *Progress in Molecular Biology and Translational Science*, 181, p.345-365.
- Nyadongo, ST, Olakanmi, EO, Pityana, Sisa L. 2021. Experimental and numerical analyses of geometrical and microstructural features of Tribaloy T-800 composite coating deposited via laser cladding-assisted with pre-heat (LCAP) process. *Journal of Manufacturing Processes*, 69, p.84-111.
- Nyadongo, ST, Pityana, Sisa L, Olakanmi, EO. 2021. Isothermal oxidation performance of laser cladding assisted with preheat (LCAP) Tribaloy T-800 composite coatings deposited on EN8. *Coatings*, 11(7), p.17pp.
- Nyembe, S, Ntho, T, Ndlovu, G, Shumbula, P, Moloto, N, Mwakikunga, Bonex W, Sikhivhilu, L. 2021. Indium phosphide nanowires: Synthesis and integration into a gas sensing device. *Sensors and Actuators B- Chemical*, 333, p.8pp.

Nzuza, P, Ramoelo, A, Odindi, J, Mwenge Kahinda, Jean-Marc, Lindeque, L. 2021. A triangulation approach for assessing and mapping land degradation in the Lepellane catchment of the greater Sekhukhune District, South Africa. *South African Geographical Journal*, p.25pp.

Nzuza, P, Ramoelo, A, Odindi, J, Mwenge Kahinda, Jean-marc, Madonsela, Sabelo. 2021. Predicting land degradation using Sentinel-2 and environmental variables in the Lepellane catchment of the Greater Sekhukhune District, South Africa. *Physics and Chemistry of the Earth, Parts A/B/C*, 124(1), p.12pp.

Oberholster, PJ, Steyn, Maronel, Botha, A. 2021. A comparative study of improvement of phycoremediation using a consortium of microalgae in municipal wastewater treatment pond systems as an alternative solution to Africa's sanitation challenges. *Processes*, 9(9), p.16pp.

Ogbodo, E, Dorrell, D, Abu-Mahfouz, Adnan MI. 2021. Energy-efficient distributed heterogeneous clustered spectrum-aware cognitive radio sensor network for guaranteed quality of service in smart grid. *International Journal of Distributed Sensor Networks*, 17(7), p.19pp.

Ogbodo, EU, Dorrell, DG, Abu-Mahfouz, Adnan MI. 2021. Radio resource allocation improvements in cognitive radio sensor network for smart grid: Investigative study and solutions. *International Journal of Sensors, Wireless Communications and Control*, 11, p.23pp.

Okoro, OM, Machaka, Ronald, Lephuthing, SS, Awotunde, MA, Olubambi, PA. 2021. Microstructural evolution and mechanical properties of multiwall carbon nanotubes reinforced titanium-based nanocomposites developed by spark plasma sintering. *Metals and Materials International*, 11, p.17pp.

Oladele, DA, Markus, ED, Abu-Mahfouz, Adnan MI. 2021. Adaptability of assistive mobility devices and the role of the internet of medical things: Comprehensive review. *JMIR Rehabilitation and Assistive Technologies*, 8(4), p.20pp.

Oladipo, Folorunso, Hamam, Y, Sadiku, R, Ray, Suprakas S, Adekoya, GJ. 2021. Synthesis methods of borophene, graphene-loaded polypyrrole nanocomposites and their benefits for energy storage applications: A brief overview. *FlatChem*, 26, p.13pp.

Olaleru, SA, Kirui, JK, Wamwangi, D, Jhamba, L, Erasmus, R, Mwakikunga, Bonex W, Roro, Kittessa T. 2021. Enhanced optical properties of perovskite thin film through material optimization for photovoltaic application. *E3S Web of Conferences*, 239(14), p.14pp.

Olatinwo, DD, Abu-Mahfouz, Adnan MI, Hancke, GP. 2021. A hybrid multi-class MAC protocol for IoT-enabled WBAN systems. *IEEE Sensors*, 21(5), p.6761-6774.

Olatinwo, DD, Abu-Mahfouz, Adnan MI, Hancke, GP. 2021. Towards achieving efficient MAC protocols for WBAN-enabled IoT technology: A review. *EURASIP Journal on Wireless Communications and Networking*, 60, p.47pp.

Omarjee, Aadila, Taljaard, Susan, Ramjukadh, Carla-Louise, van Niekerk, Lara. 2021. pH variability in catchment flows to estuaries – A South African perspective. *Estuarine, Coastal and Shelf Science*, 262, p.11pp.

Omoniyi, P, Mahamood, R, Arthur, Nana KK, Pityana, Sisa L, Skhosane, Besabakhe S, Okamoto, Y, Shinonaga, T, Maina, M, Jen, T-C, Akinlabi, E. 2021. Laser butt welding of thin Ti6Al4V sheets: Effects of welding parameters. *Journal of Composites Science*, 5(9), p.9pp.

Omoniyi, PO, Mahamood, RM, Arthur, Nana KK, Pityana, Sisa L, Akinlabi, SA, Hassan, S, Okamoto, Y, Maina, MR, Akinlabi, ET. 2021. Investigation of the mechanical and microstructural properties of TiG welded Ti6Al4V alloy. *Lecture Notes in Mechanical Engineering*, p.111-118.

Omoniyi, PO, Mahamood, RM, Arthur, Nana KK, Pityana, Sisa L, Akinlabi, SA, Okamoto, Y, Maina, MR, Akinlabi, ET. 2021. Investigation and optimization of heat treatment process on tensile behaviour of Ti6Al4V alloy. *Materialwissenschaft und Werkstofftechnik*, 52(10), p.1057-1063.

Onumanyi, Adeiza J, Isaac, Sherrin J, Kruger, Carel P, Abu-Mahfouz, Adnan MI. 2021. Transactive energy: State-of-the-art in control strategies, architectures, and simulators. *IEEE Access*, 9, p.131552-131573.

- Onumanyi, AJ, Abu-Mahfouz, Adnan M, Hancke, GP. 2021. Generalized self-tuning system for adaptive threshold estimators in cognitive radio systems using swarm and evolutionary-based approaches. *Transactions on Emerging Telecommunications Technologies*, 32(1), p.18pp.
- Onumanyi, AJ, Abu-Mahfouz, Adnan MI, Hancke, G. 2021. Amplitude quantization method for autonomous threshold estimation in self-reconfigurable cognitive radio systems. *Physical Communication*, 44, p.18pp.
- Osifeko, MO, Hancke, GP, Abu-Mahfouz, Adnan MI. 2021. SurveilNet: A lightweight anomaly detection system for cooperative IoT surveillance networks. *IEEE Sensors Journal*, 21(22), p.25293-25306.
- Pelders, Jodi L, Magweregwe, Fleckson, Rupprecht, SM. 2021. Optimization of shift cycles in the South African mining sector. *Journal of the Southern African Institute of Mining and Metallurgy*, 121(8), p.427-435.
- Pelders, Jodi, Schutte, S. 2021. Worker inclusion in equipment development processes in the modernizing minerals sector in South Africa. *Journal of the Southern African Institute of Mining and Metallurgy*, 121(2), p.63-70.
- Phasha, MJ, Bolokang, Amogelang S, Kebede, Mesfin A. 2021. First-principles investigation of W single bond V and W single bond Mo alloys as potential plasma facing materials (PFMs) for nuclear application. *International Journal of Refractory Metals and Hard Materials*, 95, p.6pp.
- Pienaar, Harrison H, Xu, Y, Braune, E, Cao, J, Dziki, S, Jovanovic, NZ. 2021. Implementation of groundwater protection measures, particularly resource-directed measures in South Africa: A review paper. *Water Policy*, 23(4), p.819-837.
- Pieterse, Heloise. 2021. The cyber threat landscape in South Africa: A 10-year review. *The African Journal of Information Communication*, 28, p.21pp.
- Potgieter, A, Fabris-Rotelli, IN, Kimmie, Z, Dudeni-Tlhone, Nontembeko, Holloway, Jennifer P, Janse van Rensburg, C, Thiede, R, Debba, Pravesh, Manjoo-Docrat, R, Abdelatif, N, Makhanya, S. 2021. Modelling representative population mobility for COVID-19 spatial transmission in South Africa. *Frontiers in Big Data*, 4, p.22pp.
- Potgieter, M, Pauck, WJ, Johakimu, Jonas K, Sithole, Bishop B. 2021. Using hydrocyclone fractionation to improve chemical pulp quality. *South African Journal of Chemical Engineering*, 36, p.74-79.
- Pratt, Lawrence E, Govender, Devashen, Klein, R. 2021. Defect detection and quantification in electroluminescence images of solar PV modules using U-net semantic segmentation. *Renewable Energy*, 178, p.1211-1222.
- Raganya, Mampai L, Moshokoa, N, Obadele, B, Makhatha, E, Machaka, Ronald. 2021. Effect of Nb glue atom in the cluster formula on the microstructure and mechanical properties of Ti-Mo alloy. *South African Journal of Science and Technology*, 40(1), p.239-243.
- Raganya, Mampai L, Moshokoa, Nthabiseng A, Obadele, B, Makhatha, E, Machaka, Ronald. 2021. Microstructure and mechanical properties of Ti-Mo-Nb alloys designed using the cluster-plus-glue-atom model for orthopedic applications. *The International Journal of Advanced Manufacturing Technology*, 115, p.3053-3064.
- Raji, SA, Popoola, API, Pityana, Sisa L, Monnamme, Tlotleng. 2021. Microstructure and mechanical properties of heat-treated Ti-Al-Si alloy produced via laser in situ alloying. *Journal of Materials Engineering and Performance*, 30, p.3321-3332.
- Raji, SA, Popoola, API, Pityana, Sisa L, Popoola, OM, Arthur, Nana K, Tlotleng, Monnamme. 2021. Influence of Mo on microstructure and nanoindentation hardness of Ti-Al-Si-xMo alloy processed by Laser Engineered Net Shaping (LENS). *South African Journal for Science and Technology*, 40(1), p.7pp.
- Raji, SA, Popoola, API, Pityana, Sisa L, Popoola, OM, Arthur, NKK, Tlotleng, Monnamme. 2021. Modelling and simulation of the fatigue usage factor of -TiAl alloy fabricated through Laser Additive Manufacturing (LAM). *South African Journal for Science and Technology*, 40(1), p.8pp.
- Ramasobane, P, Mashinini, PM, Masina, Bathusile N. 2021. In-situ synthesis of TiC/Ti-6Al-4V-ELI composite by laser. *South African Journal for Science and Technology/ Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie*, 40(1), p.70-74.

- Ramatlo, D, Loveday, P, Long, Craig S, Wilke, D. 2021. Modelling and simulation of ultrasonic inspections in welded rails subjected to practical environmental conditions. MATEC Web of Conferences, 347, p.9pp.
- Rambau, Khavharendwe MA, Musyoka, Nicholas M, Palaniyandy, Nithyadharseni, Manyala, N. 2021. Manganese-based metal organic framework from spent Li-Ion batteries and its electrochemical performance as anode material in Li-ion battery. Journal of The Electrochemical Society, 168(1), p.10pp.
- Ramdas, Veshara M, Laloo, Rajesh, Lekha, Prabashni S, Mgangira, Martin B, Muniyasamy, Sudhakar, Mukaratirwa, S, Ramchuran, Santosh O. 2021. Understanding the mechanism of interaction of candidate soil stabilizing prototypes by using microscopy and spectroscopy techniques. Microscopy Research and Technique, p.14pp.
- Ramdas, Veshara M, Mandree, Prisha, Mgangira, Martin B, Mukaratirwa, S, Laloo, Rajesh, Ramchuran, Santosh O. 2021. Review of current and future bio-based stabilisation products (enzymatic and polymeric) for road construction materials (article). Transportation Geotechnics, 27, p.54pp.
- Ramlucken, Uraisha, Ramchuran, Santosh O, Moonsamy, Ghaneshree, Jansen van Rensburg, C, Thantsha, MS, Laloo, Rajesh. 2021. Production and stability of a multi-strain Bacillus based probiotic product for commercial use in poultry. Biotechnology Reports, 29, p.8pp.
- Ray, Suprakas S, Irougbu, AOC. 2021. Nanocellulosics: Benign, sustainable, and ubiquitous biomaterials for water remediation. ACS Omega, 6(7), p.4511-4526.
- Reddy, T, Shkedy, Z, Janse van Rensburg, C, Mwambi, H, Debba, Pravesh, Zuma, K, Manda, S. 2021. Short-term real-time prediction of total number of reported COVID-19 cases and deaths in South Africa: A data driven approach. BMC Medical Research Methodology, 21, p.11pp.
- Robinson, CM, Huot, Y, Schuback, N, Ryan-Keogh, Thomas J, Thomalla, Sandy J, Antoine, D. 2021. High latitude Southern Ocean phytoplankton have distinctive bio-optical properties. Optics Express, 14(5), p.29pp.
- Roos, Thomas H. 2021. The cost of production and storage of renewable hydrogen in South Africa and transport to Japan and EU up to 2050 under different scenarios. International Journal of Hydrogen Energy, 46(72), p.35814-35830.
- Rorke, DCS, Lekha, Prabashni S, Kana, GEB, Sithole, Bishop B. 2021. Surfactant-assisted green liquor dregs pretreatment to enhance the digestibility of paper mill sludge. International Journal of Hydrogen Energy, 46(41), p.21359-21371.
- Russo, Valentina, Strever, AE, Ponstein, HJ. 2021. Exploring sustainability potentials in vineyards through LCA? Evidence from farming practices in South Africa. The International Journal of Life Cycle Assessment, 225, p.17pp.
- Rust, FC, Sono, P, Van Dijk, G, Fourie, HS, Smit, Michelle A. 2021. Conceptualising a benefit assessment framework for the South African National Roads Agency Ltd SOC research and development programme. Administratio Publica, 29(3), p.19-43.
- Rust, FC, Van Dijk, G, Fourie, HS, Smit, Michelle A. 2021. Validating a balanced score card benefit assessment framework indicator set: The case of the South African National Roads Agency Ltd SOC research and development programme. Administratio Publica, 29(4), p.33-54.
- Rust, FC, Wall, K, Smit, Michelle A, Amod, S. 2021. South African infrastructure condition - an opinion survey for the SAICE Infrastructure Report Card. Journal of the South African Institution of Civil Engineering, 63(2), p.35-46.
- Ryan-Keogh, Thomas J, Robinson, CM. 2021. Phytoplankton photophysiology utilities: A python toolbox for the standardization of processing active chlorophyll-a fluorescence data. Frontiers in Marine Science, 8, p.20pp.
- Ryan-Keogh, Thomas J, Smith Jr, WO. 2021. Temporal patterns of iron limitation in the Ross Sea as determined from chlorophyll fluorescence. Journal of Marine Systems, 215, p.8pp.
- Scholefield, Janine, Harrison, PT. 2021. Prime editing – an update on the field. Gene Therapy, 28, p.396-401.
- Schuback, N, Tortell, PD, Berman-Frank, I, Campbell, DA, Ciotti, A, Courtecuisse, E, Erickson, ZK, Fujiki, T, Ryan-Keogh, Thomas J, Thomalla, Sandy J. 2021. Single-turnover variable chlorophyll fluorescence as a tool for assessing phytoplankton photosynthesis and primary productivity: Opportunities, caveats and recommendations. Frontiers in Marine Science, 8, p.24pp.

- Sebogodi, Keolebogile R, Johakimu, Jonas K, Sithole, Bishop B. 2021. A review of technologies used in handling the acid mine drainage challenge: Perspectives on using green liquor dregs as a sustainable option for treatment of acid mine drainage. *The Journal of Solid Waste Technology and Management*, 47(1), p.18pp.
- Semelane, Maphumzane S, Nwulu, N, Kambule, N, Tazvinga, H. 2021. Economic feasibility assessment of manufacturing solar panels in South Africa – A case study of Steve Tshwete Local Municipality. *Sustainable Energy Technologies and Assessments*, 43, p.9pp.
- Semelane, Maphumzane S, Nwulu, N, Kambule, N, Tazvinga, H. 2021. Evaluating economic impacts of utility scale solar photovoltaic localisation in South Africa. *Energy Sources, Part B: Economics, Planning, and Policy*, 16(4), p.22pp.
- Semelane, Maphumzane S, Nwulu, N, Kambule, N, Tazvinga, H. 2021. Evaluating available solar photovoltaic business opportunities in coal phase-out regions – An energy transition case of Steve Tshwete Local Municipality in South Africa. *Energy Policy*, 115, p.8pp.
- Senekane, MF, Makhene, Agnes, Oelofse, Suzanna HH. 2021. Methodology to investigate indigenous solid waste systems and practices in the rural areas surrounding Maseru (Kingdom of Lesotho). *International Journal of Environmental Research and Public Health*, 18, p.18pp.
- Sharma, S, Kumar, N, Makgwane, Peter R, Singh Chauhan, N, Kumari, K, Rani, M, Maken, S. 2021. TiO₂/SnO₂ nano-composite: New insights in synthetic, structural, optical and photocatalytic aspects. *Inorganica Chimica Acta*, p.13pp.
- Sharma, S, Mittal, A, Singh Chauhan, N, Makgwane, Peter R, Kumari, K, Maken, S, Kumar, N. 2021. Developments in visible-light active TiO₂/SnX (X = S and Se) and their environmental photocatalytic applications – A mini-review. *Inorganic Chemistry Communications*, 133, p.12pp.
- Shen, Y, Nape, I, Yang, X, Fu, X, Gong, M, Naidoo, Darryl, Forbes, A. 2021. Creation and control of high-dimensional multi-partite classically entangled light. *Light: Science & Applications*, 10(50), p.10pp.
- Shingwenyana, Rhulani K, Shabalala, AN, Mbhele, Nkhangweleni R, Masindi, Vhangwele. 2021. Techno-economic analysis of the reclamation of drinking water and valuable minerals from acid mine drainage. *Minerals*, 11 (12), p.17pp.
- Sieben, EJJ, Glen, RP, Van Deventer, Heidi, Dayaram, A. 2021. The contribution of wetland flora to regional floristic diversity across a wide range of climatic conditions in southern Africa. *Biodiversity and Conservation*, 30, p.575-596.
- Siebritz, LA, Desai, A, Coetzee, S, Cooper, Antony K. 2021. Capacitating local governments for the digital earth vision: Lessons learnt from the role of municipalities in the South African spatial data infrastructure. *International Journal of Digital Earth*, p.22p.
- Singh, Advaita A, Pillay, Priyen, Kwezi, Lusisizwe, Tsekoa, Tsepo L. 2021. A plant-biotechnology approach for producing highly potent anti-HIV antibodies for antiretroviral therapy consideration. *Journal of Genetic Engineering and Biotechnology*, 19(1), p.5pp.
- Singh, Advaita A, Pillay, Priyen, Tsekoa, Tsepo L. 2021. Engineering approaches in plant molecular farming for global health. *Vaccines*, 9(11), p.11pp.
- Singh, S, Sithole, Bishop B, Lekha, Prabashni S, Permaul, K, Govinden, R. 2021. Pretreatment and enzymatic saccharification of sludge from a prehydrolysis kraft and kraft pulping mill. *Journal of Wood Chemistry and Technology*, 41(1), p.16pp.
- Slingsby, JA, De Buys, A, Simmers, ADA, Prinsloo, E, Forsyth, Gregory G, Glenday, J, Allsopp, N. 2021. Jonkershoek: Africa's oldest catchment experiment - 80 years and counting. *Hydrological Processes*, 35(4), p.7pp.
- Sokhi, RS, Singh, V, Querol, X, Finardi, S, Crespo Targino, A, De Fatima Andrade, M, Pavlovic, R, Garland, Rebecca M, Massague, J, Kong, S. 2021. A global observational analysis to understand changes in air quality during exceptionally low anthropogenic emission conditions. *Environment International*, 157, p.25pp.
- Stein, ED, Gee, EM, Adams, JB, Irving, K, Van Niekerk, Lara. 2021. Advancing the science of environmental flow management for protection of temporarily closed estuaries and coastal lagoons. *Water*, 13(5), p.29pp.

- Stoltz, M, Stoltz, George G, Obara, K, Wang, T, Bryant, D. 2021. Acceleration of hidden Markov model fitting using graphical processing units, with application to low-frequency tremor classification. *Computers & Geosciences*, 156, p.8pp.
- Sweijid, Neville, Zaitchik, BF. 2021. The 2020 WMO symposium on climatological, meteorological and environmental factors in the COVID-19 pandemic: A special issue from symposium presentations. *One Health*, 12, p.3pp.
- Sypu, VS, Kera, NH, Bhaumik, M, Raju, Kumar, Maity, Arjun. 2021. Efficient catalytic reduction of nitroaromatics by recyclable 2-naphthalene sulfonic acid doped polyaniline nanotubes decorated with NiFe₂O₄ nanorods. *Materials Today Communications*, 26, p.11pp.
- Taljaard, Susan, Adams, J. 2021. Coastal management – working towards the UN's Decade of Ocean Science for Sustainable Development (2021 –2030). *South African Journal of Science*, 117(9/10), p.7pp.
- Teffo, ML, Nyakane, NE, Seerane, M, Shongwe, MB, Machaka, Ronald. 2021. The effect of alloying elements on densification and mechanical behaviour of titanium-based alloy. *Materials Today: Proceedings*, 38(2), p.1203-1208.
- Thaba, KP, Mphahlele-Makgwane, MM, Kyesmen, PI, Diale, M, Baker, PGL, Makgwane, Peter R. 2021. Composition-dependent structure evolution of FeVO₄ nano-oxide and its visible-light photocatalytic activity for degradation of methylene blue. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 633(Part2), p.13pp.
- Thakur, A, Moyo, P, Van Der Westhuizen, Carl Johan, Yang, HO, Maharaj, V. 2021. A novel cardenolide glycoside isolated from *Xysmalobium undulatum* reduces levels of the Alzheimer's disease-associated β -Amyloid peptides a β 42 in vitro. *Pharmaceuticals (Basel)*, 14(8), p.14pp.
- Thimiri Govindaraj, Deepak B. 2021. Synthetic biology meets precision medicine: Drug repurposing for blood cancer precision medicine. *Hematology, Transfusion and Cell Therapy*, 43(Suppl 3), p.37-38.
- Thoresen, M, Malgas, S, Gandla, ML, Jonsson, LJ, Sithole, Bishop B, Pletschke, BI. 2021. The effects of chemical and structural factors on the enzymatic saccharification of *Eucalyptus* sp. samples pre-treated by various technologies. *Industrial Crops and Products*, 166, p.12pp.
- Thulasinathan, B, Jayabalan, T, Sethupathi, M, Kim, W, Muniyasamy, Sudhakar, Sengottuvelan, N, Nainamohamed, S, Ponnuchamy, K, Alagarsamy, A. 2021. Bioelectricity generation by natural microflora of septic tank wastewater (STWW) and biodegradation of persistent petrogenic pollutants by basidiomycetes fungi: An integrated microbial fuel cell system. *Journal of Hazardous Materials*, 412 (125228), p.15pp.
- Thwala, Melusi, Klaine, S, Musee, N. 2021. Exposure media and nanoparticle size influence on the fate, bioaccumulation, and toxicity of silver nanoparticles to higher plant *salvinia minima*. *Molecules*, 26(8), p.17pp.
- Timothy, A, Akande, Amos A, Odoh, CK, Philip, M, Fidelis, TT, Amos, PI, Banjoko, OO. 2021. Efficient synthesis of bio-based activated carbon (AC) for catalytic systems: A green and sustainable approach. *Journal of Industrial and Engineering Chemistry*, 96, p.59-75.
- Tolufashe, GF, Lawal, MM, Govender, Krishna K, Shode, FO, Singh, T. 2021. Exploring the bioactivity of pentacyclic triterpenoids as potential antimycobacterial nutraceuticals: Insights through comparative biomolecular modelling. *Journal of Molecular Graphics and Modelling*, 105, p.8pp.
- Tshabalala, Zamaswazi P, Mokoena, Teboho P, Hillie, Kenneth T, Swart, Hendrik C, Motaung, DE. 2021. Improved BTEX gas sensing characteristics of thermally treated TiO₂ hierarchical spheres manifested by high-energy {001} crystal facets. *Sensors and Actuators: B. Chemical*, 338, p.16pp.
- Tshwane, David M, Modiba, Rosinah, Govender, Gonasagren, Ngoepe, PE, Chauke, R. 2021. The adsorption of halogen molecules on Ti (110) surface. *Journal of Materials Research*, p.10pp.
- Tshwane, David M, Modiba, Rosinah, Govender, Gonasagren, Ngoepe, PE, Chauke, HR. 2021. Adsorption-desorption of F₂ diatomic molecule on Ti (100) surface at different coverages. *South African Journal for Science and Technology*, 40(1), p.200-204.
- Vahdat, MM, Hemmati, F, Ghorbani, A, Rutkowska, Daria, Afsharifar, A, Eskandari, MH, Rezaei, N, Niazi, A. 2021. Hepatitis B core-based virus-like particles: A platform for vaccine development in plants. *Biotechnology Reports*, 29, p.10pp.

- Van der Westhuizen, D, Slabber, CA, Fernandes, MA, Joubert, DF, Kleinhans, G, Van der Westhuizen, Carl J, Stander, A, Munro, OQ, Bezuidenhout, DI. 2021. A Cytotoxic Bis(1,2,3-triazol-5-ylidene) carbazolid Gold(III) complex targets DNA by partial intercalation. *Chemistry-A European Journal*, 27(32), p.8295-8307.
- Van Deventer, Heidi, Adams, J, Durand, JF, Grobler, R, Grundling, PL, Janse van Rensburg, S, Jewitt, D, Kelbe, B, MacKay, CF, Naidoo, Laven, Van Niekerk, Lara. 2021. South Africa's swamp forests are very likely critically endangered wetland ecosystems. *Water Wheel*, p.33pp.
- Van Deventer, Heidi, Adams, JB, Durand, JF, Grobler, R, Grundling, PL, Janse van Rensburg, S, Jewitt, D, Kelbe, B, Naidoo, Laven, Van Niekerk, Lara. 2021. Conservation conundrum – Red listing of subtropical-temperate coastal forested wetlands of South Africa. *Ecological Indicators*, 130, p.14pp.
- Van Deventer, Heidi. 2021. Monitoring changes in South Africa's surface water extent for reporting Sustainable Development Goal sub-indicator 6.6.1.a. *South African Journal of Science*, 117(5/6), p.5pp.
- Van Reenen, Coralie A, Du Plessis, Chrisna. 2021. Acoustics in South African classrooms: Regulations versus reality. *Building Acoustics*, p.22pp.
- Van Reenen, Coralie, Du Plessis, C. 2021. Traffic noise attenuation solutions for naturally ventilated classrooms in South Africa. *Building Acoustics*, p.22pp.
- Vermeulen, E, Grobbelaar, SS, Botha, Adele, Nolte, K. 2021. Computational modelling in sport: A hybrid simulation of the runner as a complex adaptive system. *Theoretical Issues in Ergonomics Science*, p.25pp.
- Vermeulen, E, Grobbelaar, SS, Botha, Adele. 2021. Conceptualising a systems thinking perspective in sport studies. *Theoretical Issues in Ergonomics Science*, 22(2), p.160-176.
- Walubita, LF, Mahmoud, E, Fuentes, L, Komba, Julius J, Teshale, EZ. 2021. Portable WIM systems: Comparison of sensor installation methods for site-specific traffic data measurements. *Journal of Testing and Evaluation*, 49(3), p.41 pp.
- Wang, H, Ma, J, Zhang, J, Feng, Y, Vijjapu, MT, Yuvaraja, S, Surya, SG, Salama, KN, Tshabalala, ZP, Akande, Amos A. 2021. Gas sensing materials roadmap. *Journal of Physics: Condensed Matter*, 33(30), p.73pp.
- Wang, S, Panayides, Jenny-Lee, Riley, D, Tighe, CJ, Hellgardt, K, Hii, KK, Miller, PW. 2021. Rapid formation of 2-lithio-1-(triphenylmethyl)imidazole and substitution reactions in flow. *Reaction Chemistry and Engineering*, 6(11), p.2018-2023.
- Wang, Z, Shen, Y, Naidoo, Darryl, Fu, X, Forbes, A. 2021. Astigmatic hybrid SU(2) vector vortex beams: Towards versatile structures in longitudinally variant polarized optics. *Optics Express*, 29(1), p.315-329.
- Whitfield, AK, Adams, JB, Harrison, TD, Lamberth, SJ, Lemley, DA, MacKay, F, Van Niekerk, Lara, Weyl, OLF. 2021. Possible impacts of non-native plant, pathogen, invertebrate and fish taxa on the indigenous ichthyofauna in South African estuaries: A preliminary review. *Biological Invasions*, p.19pp.
- Wright, CY, Kapwata, T, Du Preez, DJ, Wernecke, B, Garland, Rebecca M, Nkosi, V, Landman, WA, Dyson, L, Norval, M. 2021. Major climate change-induced risks to human health in South Africa. *Environmental Research*, 196, p.11pp.
- You, C, Sanchez, AG, Leering, M, Glaser, Daniel, Furfari, D, Fitzpatrick, ME, Wharton, J, Reed, PAS. 2021. The effects of surface pits and intermetallics on the competing failure modes in laser shock peened AA7075-T651: Experiments and modelling. *International Journal of Fatigue*, 155, p.11pp.
- Zhang, D, Du, L, Wang, W, Zhu, Q, Bi, J, Scovronick, N, Naidoo, Mogesh, Garland, Rebecca M, Liu, Y. 2021. A machine learning model to estimate ambient PM2.5 concentrations in industrialized highveld region of South Africa. *Remote Sensing of Environment*, 266, p.10pp.
- Zhou, S, Liua, G, Wen, L, Luo, H. 2021. Preparation and electrochemical properties of uniform spherical lithium rich materials xLi2MnO3·(1-x)LiMn1/3Ni1/3Co1/3O2. *Journal of Alloys and Compounds*, 874, p.9pp.

CONFERENCE PAPERS

Adetunji, KE, Hofsajer, IM, Abu-Mahfouz, Adnan MI, Cheng, L. 2021. Miscellaneous energy profile management scheme for optimal integration of electric vehicles in a distribution network considering renewable energy sources. Southern African Universities Power Engineering Conference, Potchefstroom, South Africa, 27-29 January 2021, p.6pp.

Adetunji, RO, Strydom, M, Herselman, Martha E, Botha, Adele. 2021. Scoping review: Adherence in TB journey, its challenges and sustainability. International Conference on Emerging Technology and Interdisciplinary Sciences (ICETIS 2021), India and Universiti Malaysia Kelantan, 4 December 2021, p.82-95.

Alimi, OA, Ouahada, K, Abu-Mahfouz, Adnan MI, Rimer, S, Alimi, KOA. 2021. Intrusion detection for water distribution systems based on a hybrid particle swarm optimization with back propagation neural network. In: Mfupe, L Kaijage, S Mwangama, J Oyerinde, O Katzis, K (eds.). Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.5pp.

Asaka, OT, Adejo, A, Salawu, N, Onumanyi, Adeiza J, Bello-Salau, H, Oluwamotemi, FT. 2021. Load-driven resource allocation for enhanced interference mitigation in cellular networks. 1st International Conference on Multidisciplinary Engineering and Applied Science (ICMEAS), Abuja, Nigeria, 15-16 July 2021, p.6pp.

Badenhorst, Jacob AC, De Wet, Febe. 2021. Investigating the feasibility of harvesting broadcast speech data to develop resources for South African languages. Proceedings of the International Conference of the Digital Humanities Association of Southern Africa. 2nd workshop on Resources for African Indigenous Language (RAIL), Virtual, 29 November - 3 December 2021, p.9pp.

Barbour, Graham D, McDonalds, Andre, Mkuzangwe, Nenekazi N. 2021. Evasion of port scan detection in zeek and snort and its mitigation. 20th European Conference on Cyber Warfare and Security, Chester, UK, 24-25 June 2021, p.12pp.

Basappa Ayanna, Manjunath, Pratt, Lawrence E, Roro, Kittessa K. 2021. Solar PV inverter characterization in indoor laboratory. Southern African Sustainable Energy Conference, Lanzerac, Western Cape, 17-19 November 2021, p.8pp.

Bello-Salau, H, Onumanyi, Adeiza J, Adebiyi, RF, Adedokun, EA, Hancke, GP. 2021. Performance analysis of machine learning classifiers for pothole road anomaly segmentation. IEEE 30th International Symposium on Industrial Electronics (ISIE), Online conference, 20-23 June 2021, p.6pp.

Bester, Duwan C, Tshabalala, Lerato C. 2021. Industry taking up on-demand additive manufacturing of spare parts. The 22nd Annual International RAPDASA-RobMech-PRASA Conference, CSIR International Convention Centre, Pretoria, South Africa, 3-5 November 2021, p.213-215.

Boloka, Tlou J, Crafford, Gerhardus J, Mokuwe, Mamuku W, Van Eden, Beatrice. 2021. Anomaly detection monitoring system for healthcare. SAUPEC/RobMech/PRASA Conference, Potchefstroom, South Africa, 27-29 January 2021, p.6pp.

Boloka, Tlou J, Makondo, N, Rosman, B. 2021. Knowledge transfer using model-based deep reinforcement learning. 2021 Southern African Universities Power Engineering Conference/Robotics and Mechatronics/Pattern Recognition Association of South Africa (SAUPEC/RobMech/PRASA), Potchefstroom, South Africa, 27-29 January 2021, p.6pp.

Botha, Natasha, Marais, Stephen T. 2021. Development of a graphical user interface as a learning tool for artificial intelligence. 22nd Annual International RAPDASA-RobMech-PRASA Conference, CSIR International Convention centre, Pretoria, South Africa, 3-5 November 2021, p.6pp.

Burke, Ivan D, Motlhabi, Michael B, Netshiya, Rofhiwa, Pieterse, Heloise. 2021. Lost packet warehousing service. Proceedings of the 16th International Conference on Cyber Warfare and Security, Tennessee Tech University and Oak Ridge National Laboratory, Cookeville, Tennessee, USA, 25-26 February 2021, p.501-508.

Charles, L, Isong, B, Lugayizi, F, Abu-Mahfouz, Adnan MI. 2021. Empirical analysis of LoRaWAN-based adaptive data rate algorithms. IECON 2021 – 47th Annual Conference of the IEEE Industrial Electronics Society, Toronto, ON, Canada, 13-16 October 2021, p.7pp.

Chauke, Mamello D, Prinsloo, L, Pratt, Lawrence E, Roro, Kittessa K. 2021. Wind speed trend analysis and inter-annual variability in South Africa. Southern African Sustainable Energy Conference, Lanzerac, Western Cape, 17-19 November 2021, p.8pp.

Dada, M, Popoola, P, Mathe, Ntombizodwa R, Pityana, Sisa L, Adeosun, S, Dlamini, Thembisile P, Aramide, O. 2021. Influence of Ti and Cu on the corrosion properties of laser-deposited high entropy alloys. The 22nd Annual International RAPDASA Conference, CSIR International Convention Centre, Pretoria, South Africa, 3-5 November 2021, p.6pp.

Daniel, OA, Markus, ED, Abu-Mahfouz, Adnan MI. 2021. Internet of things based multi-sensor fusion for assistive mobility devices. IEEE Conference on Information Communications Technology and Society, Durban, South Africa, 10-11 March 2021, p.6pp.

Davoren, B, Sacks, N, Theron, Maritha. 2021. Framework for cemented tungsten carbide drill bit prototype fabrication using laser engineered net shaping. 22nd Annual International RAPDASA Conference, CSIR International Convention Centre, Pretoria, 3-5 November 2021, p.6pp.

Dickens, John S, Goorun, Yurisha, De Ronde, Willis. 2021. Development of a multipurpose, outdoor autonomous ground vehicle for agricultural inspection. The 22nd Annual International RAPDASA Conference, CSIR International Convention Centre, Pretoria, 3-5 November 2021, p.5pp.

Dludla, Angeline G, Mekuria, Fisseha. 2021. Dynamic spectrum sharing for future wireless networks: Regulators perspective. 2021 IST-Africa Conference, Virtual Conference, South Africa, 10-14 May 2021, p.7pp.

Erasmus, Louwrence D, Van Schalkwyk, R. 2021. Engineered intelligent system of systems with emotions - example of a smart city with feelings. In: Oosthuizen, R Lalk, J (eds.). Proceedings of the 15th Annual Systems Engineering Conference (INCOSE), Online, 15-16 September 2021, p.14pp.

Gibberd, Jeremy T. 2021. Net-positive water systems for schools in drought-stricken areas. CIB International Conference on Smart Built Environment, Virtual Conference, 14-15 December 2021, 23, p.32-42.

Gibberd, Jeremy T. 2021. Urban sustainability transformation through building adaptive pathways. CIB International Conference on Smart Built Environment, Virtual Online, 14-16 December 2021, p.11pp.

Gonçalves, Duarte PD, Auret, Marius. 2021. Responding to drivers of change: Preparing for the "unthinkable" before it happens – A case study. Proceedings of the 15th SA INCOSE Conference, 15-16 September 2021, p.15pp.

Gonçalves, Duarte PD. 2021. The concept of 'system' in a whole-of society approach. Proceedings of the 15th SA INCOSE Conference, University of Pretoria, Pretoria, South Africa, 15-16 September 2021, p.15pp.

Govender, Devashen, Moodley, Jayandren, Balmahoon, Reevana. 2021. Augmented and mixed reality-based decision support tool for the integrated resource plan. IECON 2021 - 47th Annual Conference of the IEEE Industrial Electronics Society (IES), Toronto, Canada, 13-16 October 2021, p.6pp.

Harrison, Arthur J, Forbes, A, Naidoo, Darryl. 2021. Amplification of a propagation invariant vector flat-top beam. In: Dudley, A Laskin, AV (eds.). Proceedings Volume 11818, Laser Beam Shaping XXI; 118180C (2021), San Diego, California, United States, 1-5 August 2021, p.12pp.

Harrison, Arthur J, Forbes, A, Naidoo, Darryl. 2021. Determination of amplification characteristics in end-pumped solid state amplifiers. In: Dudley, A Laskin, AV (eds.). SPIE Optical Engineering + Applications, San Diego, California, United States, 1 August 2021, p.9pp.

Heyns, R, Ndiaye, M, Abu-Mahfouz, Adnan MI. 2021. Enabling user-oriented features at the edge: A case of an IoT-based smart shopping cart. 2021 IEEE 30th International Symposium on Industrial Electronics (ISIE), Kyoto, Japan, 20-23 June 2021, p.6pp.

Hussien, HM, Katzis, K, Mfupe, Luzango P, Bekele, ET. 2021. A novel resource allocation for HAP wireless networks exploiting TVWS spectrum. Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.292-297.

Hussien, HM, Katzis, K, Mfupe, Luzango P. 2021. Intelligent power allocation for cognitive HAP wireless networks using TVWS spectrum. Proceedings of the International Conference on Electrical, Computer and Energy Technologies (ICECET), Cape Town, South Africa, 9-10 December 2021, p.6pp.

Jamison, Kevin A, Roux, Jeanne M, Zwane, Lindokuhle. 2021. Selecting munition design features and operational concepts using a trade study supported by simulated operational scenarios. Proceedings of the 15th SA INCOSE Conference, Virtual, 15-16 September 2021, p.21pp.

Kekana, MT, Mosuang, TE, Sikhwihlu, L, Mahladisa, A, Saasa, Valentine R, Mwakikunga, Bonex W. 2021. Synthesis and evaluation of the gas sensing properties of 2D h-BNNSs as a semiconductor-based gas sensor on H₂S and CO gases at various temperatures. 6th International Conference on Nanotechnology for Instrumentation and Measurement (NanofIM), Opole, Poland, 25-26 November 2021, p.5pp.

Kemp, Lana, Roux, Michael P, Kemp, Mauritz J, Kock, R. 2021. Application of drones and image processing for bridge inspections in South Africa. The 39th Annual Southern African Transport Conference, South Africa, 5-7 July 2021, p.14pp.

Kgogo, T, Isong, B, Lugayizi, F, Abu-Mahfouz, Adnan MI. 2021. A survey of resource allocation and controller placement problem in SDN-SDWSN. 3rd IEEE International Multidisciplinary Information Technology and Engineering Conference, Windhoek, Namibia, 23-25 November 2021, p.8pp.

Kinabo, AB, Mwangam, JB, Lysko, Albert A. 2021. An overview of time-sensitive communications for the factory floor. IST-Africa Conference, 10-14 May 2021, p.9pp.

Kinabo, ABD, Mwangama, JB, Lysko, Albert A. 2021. An evaluation of broadband technologies from an industrial time sensitive networking perspective. 7th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, Tamil Nadu, India, 19-20 March 2021, p.9pp.

Kinabo, ABD, Mwangama, JB, Lysko, Albert A. 2021. Towards wi-fi-based Time Sensitive Networking using OMNeT++/NeSTiNg simulation models. Proceedings of the International Conference on Electrical, Computer and Energy Technologies (ICECET), Cape Town, South Africa, 9-10 December 2021, p.6pp.

Klein, Peter, Potgieter, M, Ferreira, Bianca A. 2021. Systems based CFD modelling of package steam boilers. ICHMT International Symposium on Advances in Computational Heat Transfer, Rio de Janeiro, Brazil, 15-19 August 2021, p.12pp.

Kolade, O, Abu-Mahfouz, Adnan MI, Cheng, L. 2021. A subcarrier permutation scheme for noise mitigation and multi-Access in powerline channels. IEEE International Symposium on Power Line Communications and its Applications, Aachen, Germany, 26-27 October 2021, p.19-24.

Kufakunesu, R, Hancke, GP, Abu-Mahfouz, Adnan MI. 2021. Towards achieving an efficient ADR scheme for LoRaWAN: A review of the constrained optimisation approach. The Southern Africa Telecommunication Networks and Applications Conference (SATNAC 2021), Spier, Stellenbosch, Western Cape, South Africa, 1-23 November 2021, p.6pp.

Kumpaty, S, Coen, B, Coen, L, Tlotleng, Monnamme, Arthur, Nana KK, Pityana, Sisa L. 2021. Laser metal deposition of functionally graded Ti-6Al-4V + mo samples and characterization studies. Proceedings of the ASME 2021 International Mechanical Engineering Congress & Exposition, IMECE2021, Virtual Online, 1-5 November 2021, p.9pp.

Le Roux, E, Ndiaye, M, Abu-Mahfouz, Adnan MI. 2021. Automatic number plate recognition for remote gate automation: An edge computing approach. 2021 IEEE 30th International Symposium on Industrial Electronics (ISIE), Kyoto, Japan, 20-23 June 2021, p.6pp.

Lebese, J, Olwal, T, Mfupe, Luzango P. 2021. Real-time spectrum occupancy measurements based on the energy detection method in cognitive radios. Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.6pp.

Lugongolo, Masixole Y, Manoto, Sello L, Maphanga, Charles P, Ombinda-Lemboumba, Saturnin, Thobakgale, Setumo L, Mthunzi-Kufa, Patience. 2021. Label-free detection of mutations in the HIV genome using a surface plasmon resonance biosensor. Proceedings of SPIE, Volume 11661, Plasmonics in Biology and Medicine XVIII, San Francisco, United States of America (Online), 6-12 March 2021, p.10pp.

Lugongolo, Masixole Y, Ombinda-Lemboumba, Saturnin, Manoto, Sello L, Mthunzi-Kufa, Patience. 2021. Examining HIV infected cells using optical trapping and Raman spectroscopy. Proc. SPIE 11798, Optical Trapping and Optical Micromanipulation XVII, San Diego, California, United States, 1-5 August 2021, p.8pp.

Magubane, Z, Tarwireyi, P, Abu-Mafouz, Adnan MI, Adigun, M. 2021. Extended context aware and load balancing routing protocol for low power and lossy networks in IoT networks. 3rd International Multidisciplinary Information Technology and Engineering Conference (IMITEC), Windhoek, Namibia, 23-25 November 2021, p.9pp.

Makhari, A, Hawes, Nomashaka BN, Mturi, George AJ, Ojijo, Vincent O. 2021. Analytical techniques to quantify modifiers in bitumen for the South African asphalt pavement industry. Southern Africa Transport Conference, Pretoria, South Africa, 5-7 July 2021, p.15pp.

Makute, T, Mwangama, J, Lysko, Albert A. 2021. Linux networking performance profiling towards network function virtualisation improvements. The 23rd annual Southern Africa Telecommunication Networks and Applications Conference (SATNAC 2021), Champagne Sports Resort, KwaZulu-Natal, South Africa, 21-23 November 2021, p.6pp.

Malinga, Andries L, Oosthuizen, Rudolph. 2021. Technology roadmapping and systems engineering - A symbiotic relationship?. 15th Annual INCOSE South Africa Conference, Pretoria, South Africa, 15-16 September 2021, p.205-217.

Mamushiane, Lusani, Mboweni, Lawrence S, Kobo, Hlabishi I, Mwangama, J, Lysko, Albert A. 2021. Towards cloud-based multi-operator core networks (MOCN) for infrastructure sharing. SATNAC, Central Drakensburg, KwaZulu Natal, 21-23 November 2021, p.7pp.

Mamushiane, Lusani, Mboweni, Lawrence S, Kobo, Hlabishi, Mudumbe, Mduduzi J, Mwangama, J, Lysko, Albert A. 2021. 4G RAN infrastructure sharing by 5G virtualized mobile network operators: A tutorial. Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.424-430.

Mamushiane, Lusani, Shoji, Themba C, Manqele, L. 2021. IPv6 adoption in South Africa: Barriers, benefits and government intervention. In: Cunningham, M Cunningham, P (eds.). IST-Africa 2021 Conference Proceedings, Virtual Conference, 10-14 May 2021, p.10pp.

Mamushiane, Lusani, Shoji, Themba C. 2021. A QoS-based evaluation of SDN controllers: ONOS and OpenDayLight. In: Cunningham, M Cunningham, P (eds.). IST-Africa 2021 Conference Proceedings, Virtual Conference, 10-14 May 2021, p.10pp.

Mangoale, Bokang C, Pantsi, Phumeza N, Mapimele, Fikile. 2021. Cyber protect: A situational awareness platform. ICCWS 2021: Sixteenth International Conference on Cyber Warfare and Security, Tennessee Tech, USA, 25-26 February 2021, p.9pp.

Maphanga, Charles P, Manoto, Sello L, Ombinda-Lemboumba, Saturnin, Mthunzi-Kufa, Patience. 2021. Detection of mycobacterium tuberculosis using gold nanoparticles conjugated to TB antibodies. Proceedings Volume 11651, Optical Diagnostics and Sensing XXI: Toward Point-of-Care Diagnostics, 6-11 March 2021, p.11p.

Maphanga, Charles P, Ombinda-Lemboumba, Saturnin, Manoto, Sello L, Mthunzi-Kufa, Patience. 2021. Surface plasmon resonance (SPR) based biosensor for mycobacterium tuberculosis diagnosis. Proceedings of SPIE, Volume 11651, Optical Diagnostics and Sensing XXI: Toward Point-of-Care Diagnostics, 6-11 March 2021, p.9pp.

Marais, JM, Abu Mahfouz, Adnan MI, Hancke, GP. 2021. The impact of application-based downlink traffic in LoRaWANs. The Southern Africa Telecommunication Networks and Applications Conference, Champagne Sports Resort, KwaZulu-Natal, South Africa, 21-23 November 2021, p.290-294.

Marais, Laurette, Wilken, Ilana. 2021. Morphology-based investigation of differences between spoken and written isiZulu. Proceedings of the International Conference of the Digital Humanities Association of Southern Africa, Virtual Conference, 29 November - 3 December 2021, p.8pp.

Marais, Laurette. 2021. Approximating a Zulu GF concrete syntax with a neural network for natural language understanding. In: Kuhn, T Spreeuwenberg, S Hoppenbrouwers, S Fuchs, NE (eds.). Proceedings of the Seventh International Workshop on Controlled Natural Language, Amsterdam, Netherlands, 8-9 September 2021, p.29-38.

Marais, Mario A, Vannini, S. 2021. Network weaving to foster resilience and sustainability in ICT4D. In: Masiero, S Nielsen, P (eds.). Proceedings of the 1st Virtual Conference on Implications of Information and Digital Technologies for Development (IFIP 9.4), Resilient ICT4D, University of Oslo, Norway, (Virtual), 25-28 May 2021, p.16pp.

Martin, MW, Winberg, SL, Gaffar, MYA, Macleod, David N. 2021. The design and development of a GPU-accelerated radar simulator for space debris monitoring. High Performance Computing and Cluster Technologies Conference, Qingdao, China, 2-4 July 2021, p.14.

Matinise, Sihle N, Oelofse, Suzanna H, Polasi, Letlotlo T. 2021. Reducing food waste across the supply chain. WasteCon 2020, Emperors Place – Johannesburg, Gauteng, South Africa, 9-11 February 2021, p.11 - 14.

Matogoro, J, Mfupe, Luzango P, Mvungi, N, Anatory, J. 2021. Investigation of radio propagation characteristics in UHF band over straight and circular paths in Central Tanzania. Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.6pp.

Maweza, Elijah L, Pratt, Lawrence E, Roro, Kittessa T. 2021. Spectral analysis using a multi-bin method for photovoltaic sites. Proceedings of the Southern African Sustainable Energy Conference (SASEC), Lanzerac, Western Cape, 17-19 November 2021, p.229-235.

May, Siyasanga I, Pratt, Lawrence E, Roro, Kittessa T, Bokoro, P. 2021. Power output predictions of photovoltaic system using machine learning. Southern African Sustainable Energy (SASEC) Conference, Lanzerac Wine Estate, Western Cape, 17-19 November 2021, p.157-162.

Mboweni, IV, Abu-Mahfouz, Adnan MI, Ramotsoela, DT. 2021. A machine learning approach to intrusion detection in water distribution systems – A review. The 47th Annual Conference of the IEEE Industrial Electronics Society (IECON), Toronto, Canada, 13-16 October 2021, p.7pp.

Mekuria, Fisseha, Mzyece, M, Mfupe, Luzango P, Odusola, A. 2021. Affordable connectivity and digital entrepreneurial ecosystem for rural Africa. In: Mfupe, L Kaijage, S Mwangama, J Oyerinde, O Katzis, K (eds.). Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.6pp.

Mkasi, Hlaluku W, Pratt, Lawrence E, Basappa Ayanna, Manjunath, Roro, Kittessa. 2021. Modelling of solar photovoltaic module performance. Proceedings of the Southern African Sustainable Energy Conference (SASEC), Lanzerac, Western Cape, 17-19 November 2021, p.145-149.

Mnguni, S, Mudali, P, Abu-Mahfouz, Adnan MI, Adigun, M. 2021. Impact of the packet delivery ratio (PDR) and network throughput in gateway placement LoRaWAN networks. The 23rd Southern Africa Telecommunication Networks and Applications Conference, Champagne Sports Resort, Kwa-Zulu Natal, South Africa, 21-23 November 2021, p.6pp.

Modungwa, Dithoto M, Mekuria, Fisseha, Kekana, Mzuzwezulu Z. 2021. Conceptual development of an autonomous underwater robot design for monitoring and harvesting invasive weeds. Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.5pp.

Moganedi, Mapoung S, Dlamini, Sifiso B. 2021. Security by design: rethinking resilience of IoT in healthcare. IST-Africa Conference, IST-Africa Institute, 10-14 May 2021, p.9pp.

Mokgeseng, TA, Malik, Humna H, Pretorius, JHC. 2021. The impact of municipal leadership on technology acquisition, transfer process and performance: The case of Gauteng metropolitan municipalities. IEEE Technology & Engineering Management Conference - Europe (TEMSCON-EUR) Conference Proceedings, Croatia (virtual conference), 17-21 May 2021, p.169-174.

Mokgonyane, TB, Sefara, Tshephisho J, Manamela, MJ, Modipa, TI. 2021. A cross-platform interface for automatic speaker identification and verification. 2021 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD), Durban, South Africa, 5-6 August 2021, p.6pp.

Molefi, M, Markus, ED, Abu-Mahfouz, Adnan MI. 2021. Accelerated design of a conformal strongly coupled magnetic resonance wireless power transfer. Proceedings of the 24th International Conference on Information Fusion (FUSION), Sun City Resort, Sun City, North-West, South Africa, 1-4 November 2021, p.5pp.

Molobi, E, Sacks, N, Theron, Maritha. 2021. Directed energy deposition of a cemented tungsten carbide rotary burr prototype. 22nd Annual International RAPDASA Conference, CSIR International Convention Centre, Pretoria, 3-5 November 2021, p.4pp.

Molobi, E, Sacks, N, Theron, Maritha. 2021. Influence of z-increment on the build height, porosity and microstructure of laser deposited WC-10wt%FeCr thin walls. Euro PM2021 Congress held online from 18-22 October 2021, p.6pp.

Molose, RSS, Isong, B, Dladlu, N, Abu-Mahfouz, Adnan MI. 2021. Analysis of hierarchical cluster-based energy-aware routing protocols in WSNs for SDWSN application. International Conference on Electrical, Computer and Energy Technologies (ICECET), Cape Town, South Africa, 9-10 December 2021, p.8pp.

Motlhabi, Michael B, Pantsi, Phumeza N, Netshiya, Rofhiwa. 2021. A Machine Learning deep-dive analysis into network logs. 16th International Conference on Cyber Warfare and Security, Tennessee Tech University, Cookeville, Tennessee, United States, 25-26 February 2021, p.10pp.

Mudau, Unarine B, Senatla, M, Mulaba-Bafubiandi, AF. 2021. Diversification and repositioning as a resilience strategy for sugar cane Industry in South Africa after implementing a tax on sugar-containing beverages. Engineering Institution of Zambia Annual Symposium, Avani Victoria Falls Resort, Livingstone, Zambia, 16 April 2021, p.38-44.

Mudzanani, K, Van Heerden, E, Mbhele, Nkhangweleni R, Daramola, MO. 2021. Towards developing an optimum anaerobic co-digestion from wastewater sewage sludge as biogas production enhancement technique: Physicochemical characteristics & microbial community of methanogens of the feedstock. 29th European Biomass Conference and Exhibition (EUBCE), Online, 26-29 April 2021, p.623-630.

Muswema, Aubrey P, Oelofse, Suzanna HH. 2021. SMMEs and stakeholder contribution to a Green Economy in KZN: Towards a guideline for municipalities. WasteCon 2020, Emperors Place, Gauteng, 9-11 February 2021, p.10pp.

Mutemwa, Muyowa, Masango, Mfundo G, Gcaza, Noluxolo. 2021. Managing the shift in the enterprise perimeter in order to delay a cybersecurity breach. The International Conference on Artificial Intelligence and its Applications, ICARDI 2021, Bagatelle, Mauritius, 9-10 December 2021, p.10pp.

Mwakikunga, Bonex W, Maesela, Maushe E, Lay-Ekuakille, A, Du Toit, Jurie H. 2021. Effects of temperature, humidity and pressure on the nano-based gas/breath analyzer performance on the gate-voltage enabled detection of acetone and ethanol. 6th International Conference on Nanotechnology for Instrumentation and Measurement (NanofIM), Opole, Poland, 25-26 November 2021, p.5pp.

Nahman, Anton, Russo, Valentina, Stafford, William HL. 2021. Informing policy on grocery carrier bags: Evidence from a life cycle sustainability assessment. WasteCon 2020, Emperors Place - Johannesburg, Gauteng, South Africa, 9-11 February 2021, p.14pp.

Naidoo, Darryl, Sroor, H, Huang, Y, Sephton, B, Vallés, A, Ginis, V, Zhan, Q, Qiu, C, Ambrosio, A, Capasso, F, Forbes, A. 2021. High-purity orbital angular momentum states from a visible metasurface laser (conference paper). CLEO: Science and Innovations, San Jose, California United States, 9-14 May 2021, p.2pp.

Naidoo, Laven, Main, Russell S, Cho, Moses A, Madonsela, Sabelo, Majozi, Nobuhle P. 2021. Estimating South African maize biomass using integrated high-resolution UAV and Sentinel-1 and 2 datasets. International Geoscience and Remote Sensing Symposium, Brussels, Virtual Conference, 11-16 July 2021, p.3pp.

Nair, Kishor K, Nair, HD. 2021. Security considerations in the Internet of Things Protocol Stack. In: Pudaruth, S Singh, U (eds.). 4th International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD), Durban, South Africa, 5-6 August 2021, 1(1), p.6pp.

Ngcama, Lwando, Mostert, N. 2021. An evaluation of social media policy awareness and compliance at the Nelson Mandela University. Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.6pp.

Niemann, Hester E, Nicolaides, Kyriacos, Dhuness, Kahesh. 2021. A prototype broadband acoustic underwater data communication system for high data rates. IEEE OCEANS 2021, Virtual, 20-23 September 2021, p.6pp.

Nkosi, Mpho, Kobo, Hlabishi I, Grobbelaar, S. 2021. Techno-economic analysis for 5G network slicing: eMBB slice. In: Cunningham, M Cunningham, P (eds.). IST-Africa 2021 Conference, Virtual, 10-14 May 2021, p.10pp.

- Ntshabele, K, Isong, B, Abu-Mahfouz, Adnan MI. 2021. A mechanism for energy efficiency in cognitive radio sensor networks based on sleep-wake scheduling strategy. Proceedings of the International Conference on Electrical, Computer and Energy Technologies (ICECET), Cape Town, South Africa, 9-10 December 2021, p.7pp.
- Ntshabele, K, Isong, B, Abu-Mahfouz, Adnan MI. 2021. CR-LPWAN: Issues, solutions and research directions. IEEE World AI IoT Congress, Seattle, United States, 10-13 May 2021, p.504-511.
- Oelofse, Suzanna HH. 2021. Reporting on the SDGs - A focus on waste reporting in the 2019 South Africa Country Report. WasteCon 2020, Emperors Place – Johannesburg, Gauteng, South Africa, 9-11 February 2021, p.12pp.
- Olwal, TO, Chuku, PN, Lysko, Albert A. 2021. Antenna research directions for 6G: A brief overview through sampling literature. 7th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, Tamil Nadu, India, 19-20 March 2021, p.6pp.
- Oosthuizen, Rudolph, Grobbelaar, S. 2021. Implementing bibliometric analysis and topic modelling to inform curriculum development for engineering management. American Society for Engineering Management (ASEM) Virtual International Conference, Virtual, 27-30 October 2021, p.10pp.
- Oosthuizen, Rudolph. 2021. A bibliometric approach to support redefining management of technology for the post-digital world. IAMOT 2021 Conference, Cairo, Egypt, 19-23 September 2021, p.12pp.
- Pillay, Kasandra, Erasmus, Louwrence D, Pretorius, JC. 2021. A systems thinking approach to value-added services adoption in national research and education networks. Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.6pp.
- Pratt, Lawrence E, Basappa Ayanna, Manjunath, May, Siyasanga I, Mkasi, Hlaluku W, Maweza, Elijah L, Roro, Kittessa T. 2021. PV module reliability scorecard – round 1. 2021 Southern African Sustainable Energy Conference (SASEC), Lanzerac Wine Estate, Western Cape, South Africa, 17-19 November 2021, p.163-169.
- Pretorius, Morne, Dlamini, Nelisiwe P, Mthethwa, Sthembile N. 2021. Towards academic and skills credentialing standards and distributed ledger technologies. 7th International Conference on Information Systems Security and Privacy (ICISSP), Vienna, Austria, Online Streaming, 11-13 February 2021, 1, p.249-257.
- Purdon, Kyla, Setati, Tiro, Marais, Stephen T. 2021. Manufacturing and evaluation of the open-source AR3 robot arm for educational uses. 22nd Annual International RAPDASA Conference, International Convention Center, CSIR, Pretoria, 3-5 November 2021, p.5pp.
- Rampersad, Ashiel, Mvelase, Gculisile M. 2021. Use of non-potable water in pavement construction: A laboratory study using seawater. International Symposium on Frontiers of Road and Airport Engineering, Delft, Netherlands, 12-14 July 2021, p.6pp.
- Ramruthan, Kshir, Goorun, Yurisha, Dickens, John S, De Ronde, Willis. 2021. Core functional MES with machine monitoring using open-source software. RAPDASA-RobMech-PRASA Conference and Exhibition, CSIR International Convention Centre, Pretoria, 3 November 2021, p.7pp.
- Ramukhwatho, Fhumulani R, Oelofse, Suzanna HH, Musvoto, Constansia D, Polasi, Letlotlo T. 2021. Assessment of food losses and waste at the Tshwane market and small-scale farms. WasteCon 2020, Emperors Place - Johannesburg, Gauteng, South Africa, 9-11 February 2021, p.8pp.
- Reddy, Reeshen. 2021. Strategic considerations of Industry 4.0 on electronic warfare using technology roadmaps. Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.6pp.
- Sebopelo, R, Isong, B, Gasela, N, Abu-Mahfouz, Adnan MI. 2021. A review of intrusion detection techniques in the SDN environment. 3rd International Multidisciplinary Information Technology and Engineering Conference 2021, Windhoek, Namibia, 23-25 November 2021, p.9pp.

- Sebopetse, Nakampe S, Burger, Christiaan R, Mofolo, Raarone OM, Lysko, Albert A. 2021. Measuring with JPerf and PsPing: Throughput and estimated packet delivery delay vs TCP window size & parallel streams. 7th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, Tamil Nadu, India, 19-20 March 2021, p.5pp.
- Sefala, R, Gebru, T, Mfupe, Luzango P, Moorosi, N, Klein, R. 2021. Constructing a visual dataset to study the effects of spatial apartheid in South Africa. In: Ranzato, M Beygelzimer, A Nguyen, K Liang, PS Vaughan, JW Dauphin, Y (eds.). Thirty-Fifth Conference on Neural Information Processing Systems (NeurIPS), Virtual, 6-14 December 2021, p.14pp.
- Sefara, Tshephisho J, Mokgonyane, TB. 2021. Gender identification in Sepedi speech corpus. 2021 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD), Durban, South Africa, 5-6 August 2021, p.6pp.
- Sefara, Tshephisho J, Mokgonyane, TB. 2021. Practical approach on implementation of Wordnets for South African languages. In: Bosch, S Fellbaum, C Griesel, M Rademaker, A Vossen, P (eds.). Proceedings of the 11th Global Wordnet Conference, University of Pretoria, Pretoria, South Africa, 18-22 January 2021, p.6pp.
- Sefara, Tshephisho J, Zwane, SG, Gama, N, Sibisi, H, Senoamadi, PN, Marivate, V. 2021. Transformer-based machine translation for low-resourced languages embedded with language identification. 5th Conference on Information Communications Technology and Society, Durban, South Africa, 10-11 March 2021, p.6pp.
- Sheik, Muhammed, Klein, Peter, Segakweng, Tshiamo. 2021. Experimental analysis of a zeolite heat storage system. Southern African Sustainable Energy Conference, Lanzerac Wine Estate, Western Cape, South Africa, 17-19 November 2021, p.43-49.
- Shen, Y, Wang, Z, Nape, I, Naidoo, Darryl, Fu, X, Forbes, A. 2021. Classically entangled vectorial structured light towards multiple degrees of freedom and higher dimensions. CLEO: Science and Innovations, San Jose, California United States, 9-14 May 2021, p.2pp.
- Skosana, V, Abu-Mahfouz, Adnan MI. 2021. Performance comparison of video encoding at low sampling rates. International Symposium on Networks, Computers and Communications (ISNCC), Dubai, United Arab Emirates, 31 October - 2 November 2021, p.7pp.
- Smit, Michelle A, Akhalwaya, Imraan, Rust, FC. 2021. Laboratory evaluation of alternative cost-effective pavement materials. Southern African Transport Conference (SATC 2021), CSIR International Convention Centre, Pretoria, South Africa, 5-7 July 2021, p.12pp.
- Smith, Andrew C, Mkhize, Cyprian B, Mahlobo, Boitumelo T, Isaac, Sherrin J. 2021. A micro grid information architecture with open source components. 2021 Sixth International Conference on Fog and Mobile Edge Computing (FMEC), Gandia, Spain, 6-9 December 2021, p.4pp.
- Smith, Andrew C. 2021. Familiar household items as program objects. 15th International Conferences on Interfaces and Human Computer Interaction; and Game and Entertainment Technologies 2021, Online, 21-23 July 2021, p.4pp.
- Steenkamp, Anton J, De Saxe, CC, Kienhöfer, F, Kemp, Lana. 2021. Comparing dynamic road wear of a performance- based standards and baseline vehicle. Southern African Transport Conference (SATC) 39, Online (South Africa-based), 5-8 July 2021, p.12pp.
- Steenkamp, Anton J, Kienhofer, F, De Saxe, CC. 2021. Heavy vehicle dynamic road wear from a rigid heavy vehicle when including road crossfall. 16th Heavy Vehicle Technology and Transport (HVTT) Conference, Online (China-based), 7-9 September 2021, p.12pp.
- Steenkamp, Anton J, Venter, Karien, De Saxe, Christopher, Kemp, Lana. 2021. Operating costs: PBS vs conventional heavy vehicles in South Africa. 39th Annual Southern African Transport Conference (SATC), Online (South Africa-based), 6-9 July 2021, p.11pp.
- Steyn, Maronel, Walters, Chavon R, Mathye, Salamina M, Thwala, Melusi, Banoo, Ismail, Ndlela, Luyanda L, Tancu, Yolanda, Genthe, Bettina. 2021. Bulk scale industrial effluent reuse potential in South Africa. 84th IMESA and IAWQES Joint International Conference, Cape Town, Virtual, 17-19 November 2021, p.18pp.

Thamoethata, K, Isong, B, Abu-Mahfouz, Adnan MI. 2021. Analysis of IoT-based Vehicle Anti-Theft Security. 3rd International Multidisciplinary Information Technology and Engineering Conference (IMITEC), Windhoek, Namibia, 23-25 November 2021, p.6pp.

Tlake, LC, Markus, ED, Abu-Mahfouz, Adnan M. 2021. A review of interference challenges on integrated 5GNR and NB-IoT networks. In: Mfupe, L Kaijage, S Mwangama, J Oyerinde, O Katzis, K (eds.). Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.6pp.

Van Eden, Beatrice, Wessels, Gert JC, Botha, Nicolene, Botha, Natasha, Du Toit, Jurie H. 2021. A comparative study towards particle identification employing semi-automated image processing in experimental SEM images. 22nd Annual International RAPDASA Conference, CSIR International Convention Centre, Pretoria, 3-5 November 2021, p.7pp.

Veerasamy, Namosha. 2021. Cyber threats focusing on Covid-19 outbreak. In: Lopez, J Jr Siraj, A Perumalla, K (eds.). 16th International Conference on Cyber Warfare and Security (ICCWS 2021), Tennessee, USA, 25-26 February 2021, p.391-400.

Veerasamy, Namosha. 2021. The threat of juice jacking. In: Eze, T (eds.). Proceedings of the 20th European Conference on Cyber Warfare and Security (ECCWS 2021), University of Chester, United Kingdom, 24-25 June 2021, p.6pp.

Vilakazi, Mlamuli C, Burger, Christiaan R, Lysko, Albert A, Mboweni, Lawrence S, Mamushiane, Lusani. 2021. Evaluating an evolving OAI testbed: Overview of options, building tips, and current performance. 7th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, Tamil Nadu, India, 19-20 March 2021, p.818-827.

Vilakazi, Mlamuli C, Sebopetse, Nakampe, Khutsoane, Oratile O. 2021. LCSM node based on geo location spectrum database for cooperative dynamic spectrum access. Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, p.443-448.

Young, Gertruida M. 2021. Commercialisation planning for "sell-ability". INCOSE SA 15th Annual Systems Engineering Conference Proceedings, Online, 15-16 September 2021, p.27-39.

Zandamela, Frank, Ratshidaho, Thikhathali T, Kunene, Dumisani C, Nana, Muhammad A. 2021. Comprehensive evaluation of blind single image deblurring algorithms on real-world blurs. Institute of Electrical and Electronics Engineers (IEEE) AFRICON, Arusha, Tanzania, 13-15 September 2021, 1(1), p.6pp.

Zhu, H, Ouahada, K, Abu-Mahfouz, Adnan MI. 2021. A Lyapunov-based real time energy management system for smart IoT homes. The 47th Annual Conference of the IEEE Industrial Electronics Society, Toronto, ON, Canada, 13-16 October 2021, p.7pp.

Zlobinsky, N, Johnson, D, Mishra, AK, Lysko, Albert A. 2021. Metaheuristic optimisation for radio interface-constrained channel assignment in a hybrid Wi-Fi-Dynamic Spectrum Access wireless mesh network. 16th EAI International Conference on Cognitive Radio Oriented Wireless Networks, Shijiazhuang, Hebei, People's Republic of China, 10-12 December 2021, p.20pp.

Zlobinsky, N, Johnson, DL, Mishra, AK, Lysko, Albert A. 2021. Simulation and improved channel assignment by simulated annealing of a wireless mesh network using Dynamic Spectrum Access. MobiWac '21: Proceedings of the 19th ACM International Symposium on Mobility Management and Wireless Access, Alicante, Spain, 22-26 November 2021, p.157-166.

BOOKS AND BOOK CHAPTERS

Adekoya, GJ, Olajide, JL, Ray, Suprakash S, Hamam, Y, Mwakikunga, Bonex W, Folorunso, O, Adekoya, AC, Biotidara, OF, Sadiku, RE. 2021. Rheological characterisation of cellulose nanocrystal stabilised emulsions. In: Thakur, VK Frollini, E Scott, J (eds.). *Cellulose Nanoparticles: Volume 1: Chemistry and Fundamentals*, p.317-353.

Aramide, BP, Popoola, API, Sadiku, ER, Aramide, FO, Pityana, Sisa L. 2021. Wear-resistant metals and composites. In: Kharissova, OV Torres-Martinez, LM Kharisov, BI (eds.). *Handbook of Nanomaterials and Nanocomposites for Energy and Environmental Applications*, p.1-25.

Bolokang, Amogelang S, Mathabathe, Maria N. 2021. Laser cladding - a modern joining technique. In: Gupta, K Davim, P (eds.). *Advanced Welding and Deforming*, p.291-319.

Chinecherem Nkele, A, Ezema, FI, Kebede, Mesfin A. 2021. Dual performance of fuel cells as efficient energy harvesting and storage systems. In: Kebede, Mesfin A Ezema, FI (eds.). *Electrode Materials for Energy Storage and Conversion*. First edition, p.279-288.

Crocker, H, Gorda, B, Pelosse, M, Thimiri Govindaraj, Deepak, Berger, I. 2021. SynBac: Enhanced baculovirus genomes by iterative recombineering. In: Owens, RJ (eds.). *Structural Proteomics*, p.141-152.

Dada, M, Popoola, P, Adeosun, S, Pityana, Sisa L, Mathe, Ntombizodwa, Aramide, O, Malatji, N, Lengopeng, T, Ayodeji, A. 2021. Recent advances of high entropy alloys: High entropy superalloys. In: Kitagawa, J (eds.). *Advances in High-Entropy Alloys - Materials Research, Exotic Properties and Applications*, p.95-112.

Dlamini, ZI, Phahlamohlaka, Letlibe J. 2021. Building a cyber smart community. In: Phahlamohlaka, J (eds.). *Approaches to Building a Smart Community: An Exploration Through the Digital Village Concept*, p.119-139.

Dube, A, Semete-Makokotlela, Boitumelo, Ramalapa, Bathabile E, Reynolds, J, Boury, F. 2021. Nanomedicines for the treatment of infectious diseases: Formulation, delivery and commercialization aspects. In: Glover, RL Nyanganyura, D Mufamadi, MS Mulaudzi, RB (eds.). *Green Synthesis in Nanomedicine and Human Health*. 1st Edition, p.35pp.

Eze, CN, Obodo, RM, Kebede, Mesfin A, Ezema, FI. 2021. Stannate materials for solar energy applications. In: Kebede, Mesfin A Ezema, FI (eds.). *Electrode Materials for Energy Storage and Conversion*. First edition, p.473-489.

Gibberd, Jeremy T. 2021. Transforming urban residential sites for improved sustainability, developing and assessing alternative configurations. In: De Jager, Peta (eds.). *The Sustainability handbook: Volume 2*, p.46-57.

Godfrey, Linda K, Nahman, Anton, Oelofse, Suzanna HH, Trotter, Douglas, Khan, Sumaya, Nontso, Zintle, Magweregwede, Fleckson, Sereme, Busisiwe V, Okole, Blessed N, Gordon, Gregory ER, Brown, Bernadette, Pillay, Boyse, Schoeman, Chanel, Fazluddin, Shahed, Ojijo, Vincent O, Cooper, Antony K, Kruger, Daniel M, Napier, Mark, Mokoena, Refiloe, Steenkamp, Anton J, Msimanga, Xolile P, North, Brian C, Seetal, Ashwin R, Mathye, Salamina M. 2021. The Circular Economy as Development Opportunity: Exploring Circular Economy Opportunities across South Africa's Economic Sectors. In: Godfrey, Linda (eds.). p.61 pp.

Godfrey, Linda K, Roman, H, Smout, S, Maserumule, R, Mpofu, A, Ryan, G, Mokoena, K. 2021. Unlocking the opportunities of a circular economy in South Africa. In: Ghosh, SK Kumar Ghosh, SK (eds.). *Circular Economy: Recent Trends in Global Perspective*, p.145-180.

John, Maya J, Molaba, Tshepiso P. 2021. Mechanical properties and water sorption of chemically modified natural fibre-based composites. In: Brabazon, D (eds.). *Encyclopedia of Materials: Composites*, 3, p.159-167.

Kebede, Mesfin A, Palaniyandy, Nithyadharseni, Koao, LF, Ezema, FI, Mhlango, MR. 2021. Current status and trends in spinel cathode materials for lithium-ion battery. In: Kebede, Mesfin A Ezema, FI (eds.). *Electrode Materials for Energy Storage and Conversion*. First edition, p.35-46.

Komba, Julius J, Langa, R, Paige-Green, P, Verhaeghe, Benoit MJ, Mokoena, Refiloe. 2021. Design and construction of sustainable climate resilient rural access road infrastructures. In: De Jager, Peta (eds.). *The Sustainability Handbook: Volume 3*, p.38-44.

- Latha, S, Selvamani, P, Palanisamy, SB, Thimiri Govindaraj, Deepak B, Thangavelu, P. 2021. Magnetic nanoparticles: Role in next generation nanomedicine. In: Saravanan, M Gopinath, V Deekonda, K (eds.). Handbook of Research on Nano-Strategies for Combatting Antimicrobial Resistance and Cancer, p.337-369.
- Latha, S, Selvamani, P, Prabu, C, Harini, R, Babu, PS, Thimiri Govindaraj, Deepak B. 2021. Polyelectrolyte multifaceted magnetic microcapsules for magnetic drug targeting at rheumatoid arthritic joints. In: Anand, K Chandrasekaran, B Kanchi, S Chen, Q Saravanan, M Panchu, S (eds.). Handbook on Nanobiomaterials for Therapeutics and Diagnostic Applications, p.545-581.
- Le Roux, Alize, Cooper, Antony K, Ludick, Chantel J, Arnold, Kathryn A, Mans, Gerbrand G. 2021. Stirring of sea-ice meltwater enhances submesoscale fronts in the Southern Ocean. In: Rajabifard, A Paez, D Foliente, G (eds.). COVID-19 Pandemic, Geospatial Information, and Community Resilience Global Applications and Lessons, p.291-301.
- Le Roux, Willem H. 2021. Digital ecosystems. In: Phahlamohlaka, J (eds.). Approaches to Building a Smart Community: An Exploration Through the Digital Village Concept, p.75-103.
- Malinga, Linda, Phahlamohlaka, Jackie. 2021. Why a smart community?. In: Phahlamohlaka, Jackie (eds.). Approaches to Building a Smart Community: An Exploration through the Concept of the Digital Village, p.19-33.
- Mansor, MH, Garcion, E, Ramalapa, Bathabile E, Buchtova, N, Toullec, C, Aucamp, M, Le Bideau, J, Hindré, F, Dube, A, Alvarez-Lorenzo, C. 2021. Polymer-based protein delivery systems for loco-regional administration. In: Glover, RLK Nyanganyura, D Mufamadi, MS Mulaudzi, RB (eds.). Green Synthesis in Nanomedicine and Human Health. 1st Edition, p.33pp.
- Maritz, Johan, Oranje, Mark, Van Huyssteen, Elsona, Nel, Verna. 2021. Planning for a post-mining future in the Rustenburg region and the transition towards it?. In: Marias, L Campbell, M Denoon-Stevens, S Van Rooyen, D (eds.). Mining and Community in the South African Platinum Belt: A Decade after Marikana, p.65-84.
- Mnguni, S, Pragasen, M, Abu-Mahfouz, Adnan MI, Adigun, M. 2021. Performance evaluation of Spreading Factors in LoRa networks. In: Zitouni, R Phokeer, A Chavula, J Elmokashfi, A Gueye, A Benamar, N (eds.). Towards new e-Infrastructure and e-Services for Developing Countries: Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, p.14pp.
- Mtshweni, Jabu, Modiba, FS. 2021. A microtasking approach for building smart communities in digital villages. In: Phahlamohlaka, Jackie (eds.). Approaches to Building a Smart Community: An Exploration through the Concept of the Digital Village, p.53-74.
- Mturi, George AJ, O'Connell, Johannes S, Akhalwaya, Imraan, Ojijo, Vincent O, Mofokeng, Tladi G, Ncolosi, Nonzwakazi, Smit, Michelle A. 2021. The use of plastic waste in road construction. In: De Jager, Peta (eds.). The Sustainability Handbook: Volume 3, 3, p.98-107.
- Mugwagwa, L, Yadroitsava, I, Makoana, Nkutwane W, Yadroitsev, I. 2021. Residual stress in laser powder bed fusion. In: Igor Yadroitsev, I Ina Yadroitsava, I Du Plessis, A MacDonald, E (eds.). Fundamentals of Laser Powder Bed Fusion of Metals. 1st Edition, p.37pp.
- Muniasamy, Sudhakar, Dada, OS. 2021. Recycling of plastics and composites materials and degradation technologies for bioplastics and biocomposites. In: Nayak, R Patnaik, A (eds.). Waste Management in the Fashion and Textile Industries: The Textile Institute Book Series, p.311-333.
- Muniasamy, Sudhakar, Noore, S. 2021. Cellulose-based bionanocomposites: Structure and chemistry. In: Thakur, VK Frollini, E Scott, J (eds.). Cellulose Nanoparticles: Volume 1: Chemistry and Fundamentals, p.424-449.
- Mutanga, Shingirirai S, Lunga, W. 2021. Uncertainty in disaster risk management: A reflection on cyclone idai using the systems thinking approach. In: Nhamo, G Dube, K (eds.). Cyclones in Southern Africa, Volume 2: Foundational and Fundamental Topics, p.179-192.
- Nweke, EE, Suleman, Essa, Du Plessis, M, Thimiri Govindaraj, Deepak B. 2021. Bioinformatics tools for gene and genome annotation analysis of microbes for synthetic biology and cancer biology applications. In: Singh, V Kumar, A (eds.). Advances in Bioinformatics, p.317-332.

- Nweke, EE, Thimiri Govindaraj, Deepak B. 2021. Drug sensitivity and drug repurposing platform for cancer precision medicine. In: Turksen, Kursad (eds.). *Cell Biology and Translational Medicine*, Volume 12, p.47-53.
- Obodo, RM, Nwanya, AC, Ahmad, I, Kebede, Mesfin A, Ezema, FI. 2021. Carbon derivatives in performance improvement of lithium-ion battery electrodes. In: Kebede, Mesfin A Ezema, FI (eds.). *Electrode Materials for Energy Storage and Conversion*. First edition, p.23-33.
- Oranje, M, Nel, V, Van Huyssteen, Elsona, Maritz, Johan. 2021. A brief history of platinum mining with a focus on the Rustenburg region. In: Marias, L Campbell, M Denoon-Stevens, S Van Rooyen, D (eds.). *Mining and Community in the South African Platinum Belt: A Decade after Marikana*, p.13-37.
- Phahlamohlaka, Letlibe J, De Villiers, C. 2021. A research-anchored e-entrepreneurship empowerment approach to building a smart community. In: Phahlamohlaka, J (eds.). *Approaches to Building a Smart Community: An Exploration Through the Digital Village Concept*, p.34-50.
- Pratt, Lawrence E, Ayanna, Manjunath Basappa, Wright, Jarrad G, Fourie, Ruan. 2021. A solar PV procurement method for self-consumption: Lessons learned from a commercial installation at the CSIR.... In: De Jager, Peta (eds.). *The Sustainability Handbook: Volume 2*, p.98-109.
- Rampersad, Ashiel, Mvelase, Gculisile M. 2021. Sustainable pavement construction: Use of non-potable water and smart techniques for compaction. In: De Jager, Peta (eds.). *The Sustainability Handbook: Volume 3*, p.86-97.
- Ray, Suprakash S, Banerjee, R. 2021. Foamability of thermoplastic polymeric materials. In: Ray, Suprakash S Banerjee, Ritima (eds.). p.278pp.
- Sadiki, Vhonani P. 2021. Does non-motorised transport and EV culture reduce carbon footprint?. *The Sustainability Handbook: Volume 2*, p.35-41.
- Singh, Keval. 2021. Relevance of geotechnical considerations in the development of renewable energy projects. In: De Jager, Peta (eds.). *The Sustainability Handbook: Volume 2*, p.10pp.
- Smith, Simone. 2021. Moving to a smart blue economy. In: Onditi, F Yates, D (eds.). *Illusions of Location Theory: Consequences for Blue Economy in Africa*, p.27pp.
- Steyn, Maronel, Oberholster, PJ. 2021. Barriers to closing the loop on nutrient recycling - a case study on phycoremediation of domestic wastewater in South Africa. In: De Jager, P (eds.). *The Sustainability Handbook: Volume 3*, p.140-153.
- Van Heerden, Renier P, Leenen, L, Irwin, B. 2021. Description of a network attack ontology presented formally. In: Misra, S Tyagi, AK (eds.). *Artificial Intelligence for Cyber Security: Methods, Issues and Possible Horizons or Opportunities*, p.343-368.

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PO Box 395, Pretoria, 0001, South Africa
Published by: CSIR Communication
Enquiries: Tel +27 12 841 2911
Email: Enquiries@csir.co.za
ISBN: 978-0-7988-5668-3

