National Research Foundation

NRF DATA INSIGHTS

Unveiling the trends to shape tomorrow

ANALYSIS OF RESEARCH OUTPUT

Supported or Performed by the NRF

science, technology & innovation
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Introduction

In this edition of NRF Data Insights, we continue to explore and analyse research with impact produced with the National Research Foundation's (NRF) support. Building on the insights from the previous edition of *NRF Data Insights volume 2* (2024), this edition delves deeper into the trends and achievements that are shaping the future of research in South Africa.

First, we highlight the significant contributions of NRF-funded researchers to the global body of knowledge, with a particular focus on the advancements made in the past five years.[1] We examine their productivity as well as the strategic alignment of the research with national and international priorities and the societal impact of these research endeavours. The focus is on analysing the number of Web of Science (WoS) publications produced by NRF-funded researchers, compared to national and global benchmarks,[2] and on the strategic research areas highlighting research that addresses critical challenges aligned to United Nations (UN) Sustainable Development Goals (SDGs), including health, climate change, and poverty alleviation.

Second, we consider the research produced by the NRF's National Research Facilities. Five National Facilities (NFs) form part of the NRF, namely the South African Radio Astronomy Observatory (NRF-SARAO), South African Astronomical Observatory (NRF-SAAO), iThemba Laboratory for Accelerator Based Sciences (NRF-iThemba LABS), South African Institute for Aquatic Biodiversity (NRF-SAIAB) and South African Environmental Observation Network (NRF-SAEON). The NFs produced 721 research publications published in WoS journals in 2024, an increase of 4% since 2020. The discussion highlights the groundbreaking work conducted at the NFs, their contributions to scientific innovation, and their role in addressing societal needs and contributing to policy development through research development.

Key findings noted in this edition of *NRF Data Insights* are:

- NRF-funded researchers contributed 35% of South Africa's total WoS publications in 2024, up from 30% in 2020, despite support for a smaller proportion of the entire research cohort.
- Publications by researchers receiving NRF supported increased by 11% from 2020 to 2024, outperforming global growth (4%).
- 74% of NRF-funded publications in 2024 were linked to one or more SDGs, slightly exceeding the national average of 72%.
- 721 WoS publications were produced by the five NRF National Facilities in 2024, a 4% increase since 2020.
- Investment in research infrastructure grew from R1.3 billion (2019/20) to R2.7 billion (2024/25).

Research Output Supported or Performed by the NRF

Research productivity (with quality assessment) is a recognised measure of researcher performance and the efficiency of a research system. Various journal indices can be used for the assessment of research performance, and the Department of Higher Education and Training (DHET) uses seven indices for research subsidy purposes.[3] The NRF uses the Clarivate (previously called Thomson Reuters) Web of Science (WoS) index for its analysis as it provides deep coverage and comprehensive indexing of journals in the Natural Sciences, Social Sciences, Arts and Humanities. More than half (58%) of all DHET subsidised journal articles published in 2023 appeared in WoS indexed journals.[4]

To gauge the productivity of NRF-funded researchers, a comparative analysis of the WoS publications by each NRF-funded authors, all South African authors, and all global authors is shown in Figure 1. From 2020 to 2024, publications by NRF-supported researchers increased by a significant 11% while global publications increased by 4%. During the same period, the number of WoS publications by all South African authors decreased slightly by 4%. During the five-year period, it is evident that there was a slight decline in

1. The data in this edition of *NRF Data Insights* covers calendar years, not financial years.
2. The data is drawn from Clarivate Web of Science (WoS) and reflects numbers on that specific day. Slight variations are evident depending on the day drawn. The number refers to WoS documents and not only research articles.
3. Scopus, the Scientific Electronic Library Online South Africa (SciELO SA), the Norwegian Register for Scientific Journals, the Clarivate (previously Thomson Reuters) Web of Science (WoS), the ProQuest International Bibliography of the Social Sciences (IBSS), the Directory of Open Access Journals (DOAJ), and the SA DHET index.
4. Department of Higher Education and Training (DHET). 2025. The Report on the Evaluation of 2023 Universities' Research Output available from www.dhet.gov.za/Policy%20and%20Development%20Support/The%20Report%20on%20the%20Evaluation%20of%202023%20Universities%27%20Research%20Output.pdf accessed 2 Sept 2025.

publications output in 2022, possibly influenced by a return to normal after the Covid-19 pandemic. Publications by NRF-funded researchers recovered in 2023, while global publications only recovered in 2024, and publications by all South African authors show some recovery but have not yet reached 2020 levels.

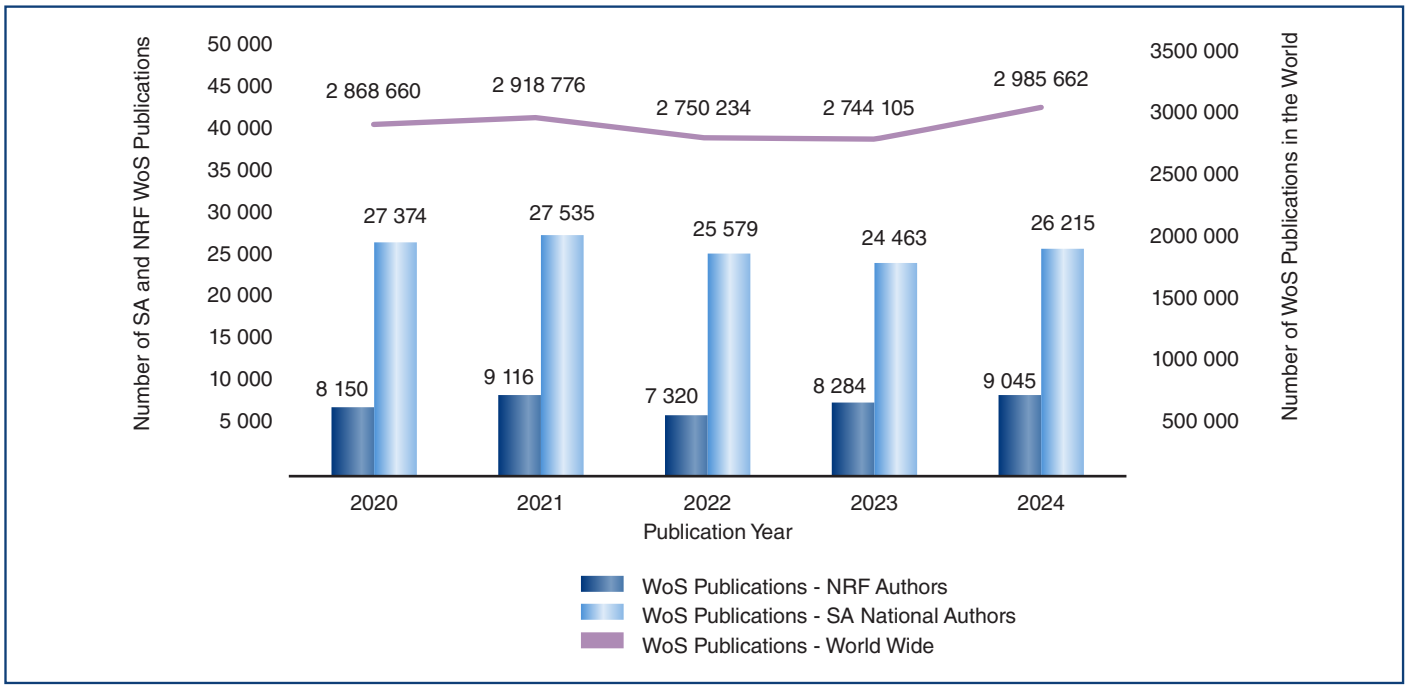


Figure 1: Number of Web of Science Publications, 2020 to 2024

NRF-funded researchers contributed 35% (9 045) of the total South African publications (26 215) in 2024, compared to 30% in 2020. When compared to the proportion of public university permanent research and instruction staff with a Doctorate who are funded by the NRF, it is again evident that output by NRF-funded researchers is growing. Using 2023 data, the latest DHET data available, the NRF funded 16% (3 261 researchers) of the entire permanent research and instruction staff cohort (20 946) and 29% of those with a Doctorate (11 264). In 2020, the NRF funded 2 972 researchers, 15% of the staff cohort or 30% of those with a Doctorate.[5]

Publications fields and priorities

Along with assessing the number of South African and NRF-funded publications, it is also important to consider the research area in which these are published, and the potential for societal impact. Globally, a key assessment tool is to map publications responding to specific UN SDGs. Research responding to SDG challenge areas highlights potential for societal benefit. Given the wide range of SDGs, this includes research in areas such as health, climate change, poverty, education, gender and more. Some SDGs are more aligned to South African developmental challenges than others, but all highlight the need to collaborate internationally to respond to global challenges. The NRF first mapped NRF-funded WoS published research to SDGs in 2021, and added global SDG analysis to *NRF Data Insights Volume 1* in 2025. In 2024, Clarivate added analysis for SDG 17: Partnerships for the Goals, for the first time. The South African analysis is shown in Figures 2 and 3.

5. Analysis is done for 2023 as HEMIS data are not available for 2024. The researcher cohort refers to the headcount of all Permanent Instruction and Research Staff at public universities, while the second cohort is only those with a Doctoral degree.

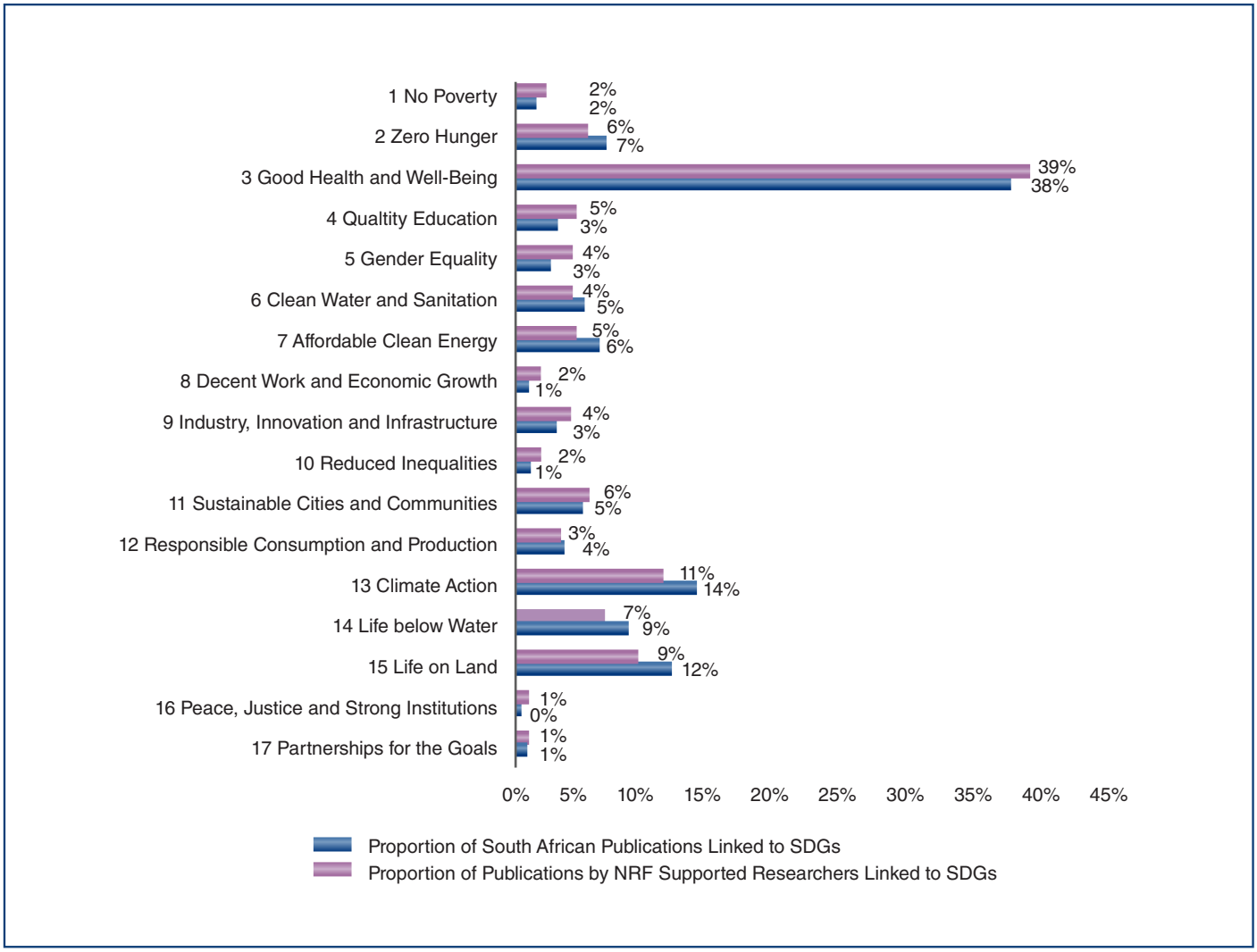


Figure 2: WoS Analysis of South African and NRF-funded Research Output Linked to SDGs, 2024

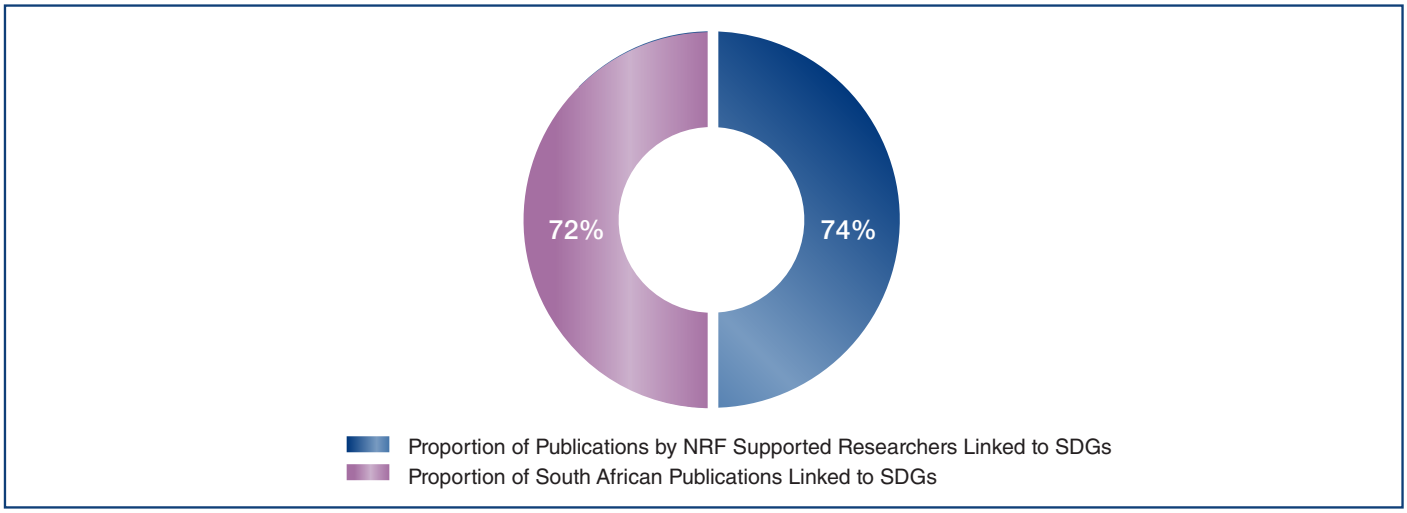


Figure 3: WoS Analysis of South African and NRF-funded Research Output Linked to One or More to SDGs, 2024

In 2024, 74% of NRF-funded research publications were linked to one or more SDG, compared to 79% in 2023. This aligns closely to all South African research, where the proportion was 72% in 2024 and 77% in 2023. Analysis over a longer period is required to establish trends, and the variations are not sufficiently significant to indicate a shift in research focus.

In both 2023 and 2024, the highest proportion of publications for both NRF and South African researchers were linked to *SDG 3: Good Health and Well-Being*. This indicates a strong and consistent research focus on health, which is an area of particular concern in South Africa. The societal impact of some of the research is already evident, but more needs to be done to ensure that this health research translates into innovations that positively impact society. An example of health research that addresses societal health challenges is the *DSI-NRF Centre of Excellence for Biomedical Tuberculosis Research (CBTBR)*, which led research with clear *societal impact* to address the societal burden of tuberculosis (TB), HIV/AIDS, and other diseases in South Africa. The key innovation was the development of biomimetic diagnostic controls which mimic TB bacteria and are used to validate diagnostic instruments without using infectious material. This breakthrough enabled the mass rollout of TB testing. CBTBR's technologies have been adapted for other diseases, including HIV testing, improving early detection and care. During the Covid-19 pandemic, the CBTBR applied its biomimetic technology to support national testing efforts. Research institutions are also working to improve access to health facilities and address health inequalities. This includes innovative approaches by the *University of Cape Town (UCT) researchers, under South African Research Chairs Initiative (SARChI)*, who developed advanced infrastructure and technologies to tackle urgent health challenges in Africa. Their work includes the creation of machine learning tools for early disease detection and personalised treatment, particularly for cancers. This initiative is part of UCT's broader 'Building a Healthy Africa' research focus.

Other areas with concentrated research, evident in both 2023 and 2024, are *SDG 13: Climate Action, SDG 15: Life on Land and SDG 14: Life below Water*. The proportion of research aligned to each of these SDGs has increased. This reflects a significant emphasis on environmental sustainability and climate-related research, and highlights the current challenges being faced in terms of a changing climate and adapting to minimise its negative impact on South Africans. Climate action has also been integrated into national policies focused on both mitigation and adaptation strategies. *The Adaptation Network*, a multi-stakeholder initiative connects researchers, policymakers, civil society, and private sector actors to strengthen climate adaptation efforts. It highlights the importance of knowledge sharing and policy engagement to improve institutional coordination and reduce vulnerability, especially among marginalised communities. Two of the NRF's NFs, NRF-SAIAB and NRF-SAEON, focus their research in these areas, and this is discussed in more detail in the next section. Despite significant advances, research in this area has highlighted that, while South Africa has developed robust national adaptation strategies and a climate change bill, resilience-building has lagged due to institutional implementation and coordination. The research also emphasises the need to align energy policies with climate mitigation goals.[6]

Given South Africa's developmental challenges, there are SDG areas where more research is needed to address persistent developmental challenges. For instance, the *National Development Plan (NDP) Assessment Report by Stellenbosch University* [7] and the *National Planning Commission* [8] noted that, while South Africa has made strides in aligning national priorities with the SDGs, implementation and evidence-based policy development remain weak in areas such as *SDG 1: No Poverty, SDG 5: Gender Equality* and *SDG 16: Peace, Justice and Strong Institutions*. Research in areas aligned to decent work, economic growth and reduced inequality is also too low. All of these are areas where research could play a significant role in improving the lives of ordinary South Africans.

In 2024, Universities South Africa (USAf) commissioned the University of the Free State to conduct a *comprehensive SDG mapping* of South African public universities. The aims of the study were to identify strengths, gaps, and opportunities for contributing to the SDGs; collect examples of initiatives and partnerships advancing SDGs; and identify overlapping and complementary strengths to inform possible partnerships to accelerate solutions to South Africa's developmental challenges. The report highlights how institutions align their research outputs, annual reports, and strategic goals, and includes data on SDG-related publications, the South African Research Chairs Initiative (SARChI), and Centres of Excellence (CoE).[9]

6. Ziervogel, G., Lennard, C., Midgley, G., New, M., Simpson, N.P., Trisos, C.H. and Zvobgo, L. 2022. 'Climate change in South Africa: Risks and opportunities for climate-resilient development in the IPCC Sixth Assessment WGII Report'. *South African Journal of Science*, 118(9-10) available from https://scielo.org.za/pdf/sajs/v118n9-10/08.pdf accessed 18 Aug 2025.
7. Fourie, H. 2020. South Africa's progress towards its development objectives: 2020 assessment report. Bureau for Economic Research, Stellenbosch University available from https://resep.sun.ac.za/wp-content/uploads/2021/02/NDP-Assessment-Report_FINAL.pdf accessed 18 Aug 2025.
8. National Planning Commission. 2022. Report on monitoring National Development Plan (NDP) indicators and targets: December 2022 available from www.nationalplanningcommission.org.za/assets/Documents/Report%20on%20Monitoring%20National%20Development%20Plan%20Indicators%20and%20Targets_December%202022.pdf accessed 18 Aug 2025.
9. Witthuhn, C., van Niekerk, J. and Vermeulen, M. 2024. 'South African Universities. Mapping the Sustainable Development Goals'. University of the Free State in collaboration with Universities South Africa available from https://usaf.ac.za/wp-content/uploads/Mapping-the-Sustainable-Development-Goals-Report.pdf accessed 18 Aug 2025.

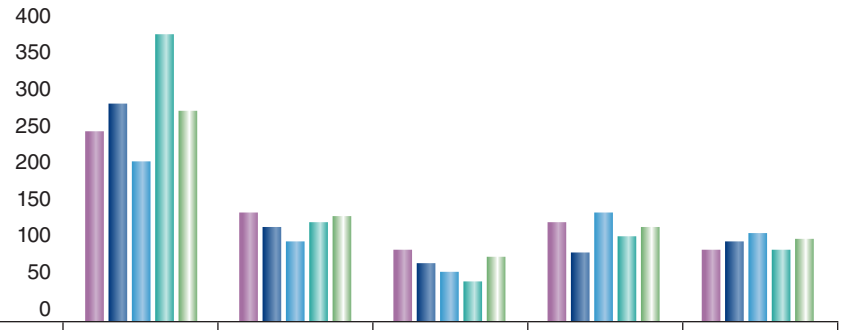
The SDG mapping exercises are important for the NRF to identify developmental areas where more funding is required, and the analysis may inform future funding priorities to ensure a greater focus on research with potential for societal benefit. Universities and research centres are also integrating SDGs into their curricula and research agendas. This helps raise awareness and equip future leaders with the knowledge to tackle global challenges.[10]

NRF National Research Facility publications

The NRF's National Facilities (NFs) produce a considerable amount of research across their various specialised fields and disciplines, with some focused more on academic WoS publications, and others, given their research areas, more on local journals, policy briefings, or similar publications to ensure local societal impact. Given their different knowledge domains, sizes, and budgets, it is important to consider each facility's research individually.

Overall, investment in National Research Infrastructure Platforms has grown from R1.3 billion in 2019/20 to R2.7 billion in 2024/25. A significant proportion of this was directed towards capital expenditure, the majority of which was spent on major infrastructure projects. Some of the highest expenditure in 2024 was on the three Research Infrastructures hosted by NRF-SAEON as part of the South African Research Infrastructure Roadmap (SARIR). These were launched in 2016 and are the Expanded Freshwater and Terrestrial Environmental Observation Network (EFTEON); the Shallow Marine and Coastal Research Infrastructure (SMCRI); and the South African Polar Research Infrastructure (SAPRI). There was also high expenditure on the various NRF-SARAO projects, including the Square Kilometre Array (SKA) Engineering Operations Centre (EOC) and the NRF-SARAO MeerKAT Extension project. Investment in upgrading the NFs helps to ensure the availability of platforms for local and international researchers and students. It has led to increased impact, growth in publication output, and the development of postgraduate students, particularly from designated groups.

Over the period 2020 to 2024, the number of WoS publications by the NFs has grown by 4%, exceeding initial NRF targets. This demonstrates the value of cutting-edge research infrastructure platforms for national research output. Despite these achievements, challenges have been experienced, and stable and sufficient funding is required to maintain and further develop research infrastructures. Achievements and challenges for each NF are explored below.



	NRF-iThemba LABS	NRF-SAIAB	NRF-SAEON	NRF-SAAO	NRF-SARAO
2020	250	142	96	130	94
2021	287	124	78	93	107
2022	210	105	64	143	116
2023	380	132	55	114	95
2024	277	137	84	128	110

Figure 4: WoS Publications Emanating from the National Research Facilities, 2020 to 2024

10. Nhamo, G. and Chapungu, L. 2024. 'Seven years of embracing the sustainable development goals: perspectives from University of South Africa's academic staff'. Frontiers in Education. 9(1354916) available from https://www.frontiersin.org/journals/education/articles/10.3389/feduc.2024.1354916/full accessed 18 Aug 2025.

South African Radio Astronomy Observatory (NRF-SARAO)

NRF-SARAO produced 110 WoS publications in 2024, an increase from 94 in 2020. Most radio astronomy research papers are produced by scientists who use the research platforms (mainly the MeerKAT telescope[11]) for scientific research. The National Facilities' scientists are primarily enablers of research through the provision of cutting-edge research platforms for the global research community. Key facility highlights are discussed below.

In 2024, two seminal sets of results were published. The first publication highlight formed part of *the MeerKAT Pulsar Timing Array* project, which focuses on pulsars, the ultra-dense rotating neutron star remnants of some supernova explosions that end the lives of massive stars. Pulsar timing arrays monitor sets of ultra-stable radio emitting millisecond pulsars in our galaxy, each spinning hundreds of times per second, with the primary, long-sought, aim of detecting ultra-low frequency gravitational waves expected to permeate the Universe. In 2023, evidence for this signature was announced by astronomers using radio telescopes in Australia, China, Europe, India, and North America. However, a confident detection eluded them. One way to make such a detection is to observe a larger number of pulsars to higher precision. Since 2019, the MeerKAT Pulsar Timing Array, has been monitoring the largest sample of pulsars to the highest precision of any existing array. MeerKAT results, showing compelling evidence for spatial correlations consistent with gravitational waves, have been published in three papers:

- ***The MeerKAT Pulsar Timing Array: The 4.5-year data release and the noise and stochastic signals of the millisecond pulsar population***
- ***The MeerKAT Pulsar Timing Array: The first search for gravitational waves with the MeerKAT radio telescope***
- ***The MeerKAT Pulsar Timing Array: Maps of the gravitational-wave sky with the 4.5 year data release.***

These results are, after only four and a half years of data, comparable or superior to those obtained with other telescopes around the world over a period of more than 15 years. The MeerKAT opens up this new window to view the Universe.

The second set of results highlight NRF-SARAO's significant progress in understanding gas accretion in galaxies. This process is crucial because galaxies need to replenish their gas from intergalactic space to continue forming stars. Using the MeerKAT radio telescope, *the MHONGOOSE survey* conducted ultra-sensitive observations of nearby galaxies. These observations are up to a hundred times deeper than previous studies. One of the first results to come out of the survey (*Healy et al., 2024*) shows the distribution of the neutral hydrogen gas as observed with MeerKAT surrounding the galaxy NGC 5068.[12] A faint outer disk is probably the diffuse gas that is falling into the galaxy and fuelling the star formation. This would be one of the first times this process is directly observed. No other telescope in the world has the ability to make these studies.

South African Astronomical Observatory (NRF-SAAO)

Publication output at NRF-SAAO has fluctuated annually, with 128 publications in 2024. Publications are produced using the NRF-SAAO telescopes, including the Southern African Large Telescope (SALT) and the Lesedi telescope. NRF-SAAO has made substantial strides in astronomical research, contributing significantly to our understanding of the Universe. Groundbreaking research, that has captivated the interest of both the scientific community and the public, is evident over the past five years, with key highlights discussed below.

- **Asteroid deflection test:** In 2022, the National Aeronautics and Space Administration's (NASA) Double Asteroid Redirection Test (DART) spacecraft intentionally crashed into an asteroid's moon (Dimorphos) to alter its orbit, marking the first time humanity deliberately changed the course of a celestial body. NRF-SAAO astronomers supported this mission through observation of the impact live from Sutherland, using the 1-metre Lesedi telescope which captured a bright ejecta plume and helped confirm that DART successfully deflected the asteroid's orbit. This participation highlights the societal impact of NRF-SAAO, with the potential to deflect asteroids heading towards Earth.

11. The South African MeerKAT radio telescope is a precursor to the Square Kilometer Array (SKA) telescope and will be integrated into the mid-frequency component of SKA, for more information see: *https://www.sarao.ac.za/science/meerkat/about-meerkat/*.
12. Healy, J., De Blok, W.J.G., Maccagni, et al. 2024. 'Possible origins of anomalous H I gas around MHONGOOSE galaxy, NGC 5068'. Astronomy & Astrophysics, 687, A254 available from *www.aanda.org/articles/aa/pdf/2024/07/aa47475-23.pdf* accessed 20 Aug 2025.

- **Groundbreaking occultation result:** In late 2023, a 1.9-metre NRF-SAAO telescope observation of the distant minor planet *Chiron (a 'Centaur' object)* revealed unexpected behaviour in its surrounding material. As *Dynamic Rings Around Chiron* passed in front of a star, NRF-SAAO astronomers observed varying dips in the starlight, indicating clumps of debris orbiting Chiron rather than the two neat, stable rings that had been hypothesised. This groundbreaking occultation result showed that Chiron does not have a large global atmosphere and instead is surrounded by a dynamic, ever-changing dust environment—a finding that overturns previous theories about its ring system.

- **X-ray transient event:** In 2024, the NRF-SAAO successfully studied an X-ray transient event, demonstrating significant advancements in observational capabilities. *Prof Stephen B. Potter's* paper highlighted the collaborative efforts and technological innovations of the Intelligent Observatory and instrumentation team.[13] He used both the Lesedi telescope and 1.9m telescope to obtain photometric and spectroscopic data following an X-ray transient alert. This was the first use of both the new 1.9m instrument selector port, which allows for seamless switching between instruments, and the innovative Mookodi, a multi-purpose low-resolution spectrograph and multi-filter photometric imager detailed in *Nicolas Erasmus's recent publication*.[14] The study focused on the X-ray transient EP240309a (EP J115415.8-501810), classifying it as an intermediate polar. These new instruments highlight the exceptional capabilities developed for the quick follow-up of transient astronomical sources.

iThemba Laboratory for Accelerator Based Sciences (NRF-iThemba LABS)

NRF-iThemba LABS has consistently produced the highest proportion of NF WoS publications. Over the five-year period, publication output has increased by 11%, with a peak in 2023 of 380 publications. Since its inception in the early 1980s, NRF-iThemba LABS has distinguished itself by producing world-class research and development in accelerator-based sciences and technologies. It has become a hub of vibrant research and human capacity development, with a network of national and international partners. Major experimental highlights during the period under review are outlined below.

- In September 2024, a significant development was the dispatch of the *first irradiated Rb-target* to an external partner for validation testing. This marked the beginning of a transformative journey for the NRF-iThemba LABS's Nuclear Medicine Department of testing the full cycle from irradiation to packaging and transport. The research facility has positioned itself to make an even greater impact on the health sector through the supply of life-saving medical and research radioisotopes.

- The inauguration of the South African Isotope Facility (SAIF) on Friday, 9 June 2023 forms part of the collective efforts to enhance scientific infrastructure and technology development for the benefit of society. Its establishment signals the start of a strong research and development prospect for the future through the production of alpha-particle-emitting radioisotopes, and other ground-breaking theranostic isotopes, in collaboration with local and international partners. These novel radioisotopes have the potential capability to target and destroy cancer cells while simultaneously providing diagnostic imagery of the tumour.

- An NRF-iThemba LABS scientist's study showed that elephants' resistance to cancer, due to multiple copies of the TP53 gene, is a remarkable example of how nature has evolved mechanisms to combat diseases. Peto's paradox highlights how these large mammals, despite having more cells and a longer lifespan, have lower cancer rates than humans. Jansen van Vuuren's work on the Tumour Suppression and Subdual of Cancer (TUSSC) project is a significant contribution to understanding these mechanisms. While simply increasing TP53 copies in humans would have potential side effects such as accelerated aging, studying these natural defences can inspire new approaches to cancer prevention and treatment.

- NRF-iThemba LABS has developed the capability to use accelerator beams for proton beam writing, a technique with potential applications in the fabrication of electronic devices at the sub-micron scale. The project was developed with the University of Singapore. *The research* [15] demonstrates how precise beam tuning and quadrupole lens performance analysis have achieved spot sizes as small as 3.2 µm × 580 nm. This positions NRF-iThemba LABS as a leader in proton beam writing in Africa, with significant implications for nanofabrication and ion beam techniques globally.

13. Stephen. B. Potter, David A. H. Buckley, S. Scaringi, et al. 2024. 'Optical spectroscopic and photometric classification of the X-ray transient EP240309a (EP J115415.8-501810) as an intermediate polar'. High Energy Astrophysical Phenomena available from https://arxiv.org/abs/2405.01996v1 accessed 20 Aug 2025.
14. Nicolas Erasmus, Iain A. Steele, Andrzej S. Piascik, et al. 2024. 'Mookodi: multi-purpose low-resolution spectrograph and multi-filter photometric imager for rapid follow-up observations of astronomical transient events'. Journal of Astronomical Telescopes, Instruments, and Systems. Vol. 10, Issue 2, 025005 available from www.spiedigitallibrary.org/journals/Journal-of-Astronomical-Telescopes-Instruments-and-Systems/volume-10/issue-2/025005/Mookodi--multi-purpose-low-resolution-spectrograph-and-multi-filter/10.1117/1.JATIS.10.2.025005.short# = accessed 20 Aug 2025.
15. Mongwaketsi, N., Khumalo, Z., Mtshali, C., Machethe, K., Mokoena, T. and Barnard, H., 2024. Exploring the focusing system and evaluating structures through proton beam writing. Journal of Micromechanics and Microengineering, 35(1), p.015007. available form https://iopscience.iop.org/article/10.1088/1361-6439/ad9f75 accessed 20 Aug 2025.

- The H-line at the 3-MeV Tandetron accelerator facility in Cape Town allows researchers to study nuclear radiative capture reactions, providing insights into stellar nucleosynthesis, the process of forming heavier elements. Dr Jongile and her team conducted the first experiment in September 2024, focusing on low-energy γ-decay at high excitation energies. They bombarded an Fe-56 target with protons to extract the photon strength function (PSF) of Co-57, which describes the interaction of photons with atomic nuclei. This research is crucial for understanding nuclear reactions and nucleosynthesis.

- NRF-iThemba LABS has expertise in radiation detection and safety, data-analysis, and the utilisation of technology for the betterment of society. The spillage of polluted process water from the Bosveld Phosphates mine adjacent to the Kruger National Park in 2013, led to the *investigation of possible radiation pollution in the Olifants River using a mobile detection system*. The Portable African Neutron-Gamma Laboratory for Innovative Nuclear Science (PANGoLINS) project is the brainchild of Dr Jones, a senior research scientist at NRF-iThemba. The mobile radiation detection unit (MRDU), pioneered by NRF-iThemba LABS in 2022, allows a user to operate in the field and chart the location, strength and energy of gamma radiation. The PANGoLINS, which is an upgrade to the mobile radiation detection unit in 2022, will be used for *in situ* measurements of naturally occurring or technologically enhanced radiation fields that are essential for investigation, monitoring, prospecting and future projecting. The development has led to collaboration with the United Kingdom's Science and *Technology Facilities Council (STFC)* to find solutions to challenges in the fields of radiation detection and in the creation of beam line targets.

- Air pollution is a significant issue in Africa, causing around seven million deaths annually according to the World Health Organization's (WHO) estimate in 2016. It results from harmful particulates and gases that damage human health, animals, crops, and ecosystems. One challenge in combating pollution is the identification of hotspots due to the high costs of monitoring systems. Leveraging expertise from high energy physics, a team led by Professor Mellado developed a cost-effective air quality monitoring device which uses sensors and Artificial Intelligence. An article entitled *Air Pollution in South Africa: Affordable new devices use Artificial Intelligence to monitor hotspots in real time*, was published in *The Conversation Africa on 14 August 2024*. This device helps identify pollution hotspots more affordably. A public *dashboard* was also launched, where you can see all the data that is gathered, along with a website with *more information*.

Another area of impact is the hosting of key international conferences, which allows for collaboration and networking. NRF-iThemba LABS hosted the 28th *International Nuclear Physics Conference* in Cape Town in 2022; the *African Nuclear Physics Conference (ANPC)* in Mpumalanga, in 2023; and the *2nd South Africa-Joint Institute for Nuclear Research (SA-JINR) Workshop* on Theory and Computation in the Eastern Cape in 2023. In 2024, NRF-iThemba LABS became the twelfth institution globally and the first in the Southern Hemisphere to host an *Information Centre of the Russian Federation's Joint Institute for Nuclear Research (JINR)*. The centre aims to enhance public awareness of nuclear research in South Africa, foster international collaboration, and develop the next generation of scientists, engineers, and technicians. The initiative will enable students to engage in joint research projects with the JINR, offering valuable international exposure and practical experience in high-energy physics and related fields.

South African Institute for Aquatic Biodiversity (NRF-SAIAB)

Publication output at NRF-SAIAB has been relatively consistent throughout the five-year period, with a dip in 2022 and a slight decline over the period (4%), with 2020 as a high point. This may relate to Covid-19 and having more time to write during lockdowns when acquisition of new data was constrained. Despite these challenges, NRF-SAIAB has maintained a strong research record, which is particularly significant given the loss of a SARChI Chairholder and a Principal Scientist during the review period. In this context, the ability to sustain and even raise publication numbers is commendable. NRF-SAIAB serves as a hub of scientific innovation and ecosystem-based research to support the sustainability of Africa's aquatic environments. It delivers high-impact, interdisciplinary work that addresses national and global challenges, with a growing focus on research with societal impact. NRF-SAIAB has demonstrated a consistent commitment to Open Science and Responsible Research principles, further enhanced by the integration of science communication specialists into transdisciplinary projects. NRF-SAIAB's work is driven by a combination of advanced research platforms, a dynamic team of scientists, and a strong institutional culture of inclusion, transformation, and collaboration.

One of the inspiring programmes during this period has been the *Indigenous Marine Innovations for Sustainable Environments and Economies (IMIsEE)* project. It demonstrates NRF-SAIAB's leadership in blending science with Indigenous Knowledge Systems to tackle complex coastal challenges. The project integrates ecological-engineering approaches with cultural heritage, and places women knowledge holders and traditional weavers at the centre of innovation. Key contributions include a peer-reviewed, and open-access case study by Porri *et al., (2023)* [16], which reimagines coastal infrastructure as inclusive, resilient, and ecologically functional. McConnachie *et al., (2025)* [17] elevated traditional music and storytelling as decolonial tools for knowledge transmission, while Ndaba *et al., (2025)* [18] provided ecological evidence for the use of Cyperus textilis in marine infrastructure retrofitting. These outputs demonstrate the power of community-rooted, African-led science that is both locally transformative and globally relevant. This recent (2023-2025) leadership by the Coastal and Ocean Sciences Team (COST) at NRF-SAIAB in ecological engineering of the coast builds on a decade of pioneering engagement in this field of research, underscored by the NRF-SAIAB's role as African partner for the World Harbour Project Strain *et al., (2021)*.[19]

NRF-SAIAB's seascape ecology group focuses on fish habitat ecology (how fish interact with their environment) and the effects of global and climate change on coastal and estuarine habitats and associated fauna. Habitat loss and disturbance not only affect population abundances but also make these populations less resilient to climate stress. The identification of important fish nursery habitats and prevention of habitat loss and disturbance can be used as fisheries management tools to ensure resilient fish stocks for communities' dependent on marine resources. NRF-SAIAB plays a leading role in the research fields of climate change and seascape ecology, with 15 papers, two book chapters, and four policy and briefing notes published on climate change and 17 papers and one briefing note published on seascape ecology during this period. NRF-SAIAB also co-led the estuarine fish component of a Department of Water and Sanitation (DWS) programme setting resource quality objectives (defining the quantity and quality of water ecosystems need to function optimally) and ecological reserves for Eastern Cape catchments.

Marine biodiversity monitoring remains a pillar of NRF-SAIAB's research infrastructure. The *Acoustic Tracking Array Platform (ATAP)* enabled a range of studies on the movement patterns of multiple fishes, sharks and rays along South Africa's coastline, and provided crucial information that can be incorporated in the development and/or adjustment of management regulations and spatial planning initiatives. In parallel, the *Marine Remote Imagery Platform (MaRIP)* and the *Geophysics and Mapping Platform (GeMaP)* contributed essential seafloor and biodiversity data through Remotely Operated Vehicles (ROV), Baited Remote Underwater Videos (BRUV), and multibeam bathymetric surveys in a majority of the coastal Marine Protected Areas along South Africa's south and east coasts. These marine platforms have also been instrumental in driving the development of South Africa's deep sea research capacity, enabling marine spatial planning and biodiversity conservation through the generation of high-resolution, spatially explicit, data for ecosystem management. These data are used in the National Marine Biodiversity Assessment and for Marine Ecosystem Classification and Marine Protected Area expansion and management, and to support fisheries management. Platforms have also enabled marine research by neighbouring African countries, especially within the Western Indian Ocean, and contributed to continental development objectives. At a global scale, MaRIP participated in the *FinPrint project* that resulted in high impact publications in Nature MacNeil *et al., (2020)* [20] and *Science Simpfendorfer et al., (2023)* [21] which documented dramatic declines in reef shark populations and identified effective conservation measures. Through representation on various panels and working groups, the marine platforms have been key players in driving regional and global research standards and supporting the development of Findable, Accessible, Interoperable, and Reusable (FAIR) data management for the *Global Ocean*

16. Porri, F., McConnachie, B., van der Walt, K.A., Wynberg, R. and Pattrick, P., 2023. 'Eco-creative nature-based solutions to transform urban coastlines, local coastal communities and enhance biodiversity through the lens of scientific and Indigenous knowledge'. Cambridge Prisms: Coastal Futures, 1, p.e17 available from *www.cambridge.org/core/services/aop-cambridge-core/content/view/E407B01EA62656B73F4419CE4520D179/S2754720522000105a.pdf/eco-creative-nature-based-solutions-to-transform-urban-coastlines-local-coastal-communities-and-enhance-biodiversity-through-the-lens-of-scientific-and-indigenous-knowledge.pdf* accessed 20 Aug 2025.
17. McConnachie, B., Porri, F. and Wynberg, R., 2025. 'Shifting from Development to Empowerment Through Eco-Creative Knowledge Transmission.' Routledge Handbook of Arts and Global Development. pp. 477-492. Routledge available from *https://vital.seals.ac.za/vital/access/manager/Repository/vital:78410?site_name=GlobalView&view=grid&f0=sm_publisher%3A%22Taylor+and+Francis%22&sort=sort_ss_title%5C* accessed 20 Aug 2025.
18. Ndaba, J., Cotiyane-Pondo, P., Human, L., Puccinelli, E., Pieterse, P., Pattrick, P. and Porri, F., 2025. 'Diatom colonisation and biofilm metal bioaccumulation: Can Indigenous Knowledge Systems aid the ecological engineering of urban coastlines?'. Ecological Engineering, 219, p.107696 available from *http://www.researchgate.net/publication/392433971_Diatom_colonisation_and_biofilm_metal_bioaccumulation_Can_Indigenous_Knowledge_Systems_aid_the_ecological_engineering_of_urban_coastlines* accessed 05 Sept 2025.
19. Strain, E.M., Steinberg, P.D., Vozzo, M., Johnston, E.L., Abbiati, M., Aguilera, M.A., Airoldi, L., Aguirre, J.D., Ashton, G., Bernardi, M. and Brooks, P., 2021. 'A global analysis of complexity–biodiversity relationships on marine artificial structures'. Global Ecology and Biogeography, 30(1), pp.140-153 available from *https://onlinelibrary.wiley.com/doi/abs/10.1111/geb.13202* accessed 05 Sept 2025.
20. MacNeil, M.A., Chapman, D.D., Heupel, M., Simpfendorfer, C.A., Heithaus, M., Meekan, M., Harvey, E., Goetze, J., Kiszka, J., Bond, M.E. and Currey-Randall, L.M., 2020. Global status and conservation potential of reef sharks. Nature, 583(7818), pp.801-806 available from *https://doi.org/10.1038/s41586-020-2519-y* accessed 16 Sept 2025.
21. Simpfendorfer, C.A., Heithaus, M.R., Heupel, M.R., MacNeil, M.A., Meekan, M., Harvey, E., Sherman, C.S., Currey-Randall, L.M., Goetze, J.S., Kiszka, J.J. and Rees, M.J., 2023. Widespread diversity deficits of coral reef sharks and rays. Science, 380(6650), pp.1155-1160 available from *https://doi.org/10.1126/science.ade4884* accessed 16 Sept 2025.

Observing System (GOOS). The Aquatic Ecophysiology Research Platform explores the effects of climate change, emerging pollutants, water quality and biological invasions on the physiology, metabolic and behavioural response of aquatic organisms in freshwater and marine ecosystems. Physiology research serves as a sustainable tool to gain understanding of the organismal level response to environmental stressors. The platform is equipped with a variety of systems such as static systems to measure oxygen consumption for short term and this is mainly used on larvae and/or eggs. In addition, the platform has flexible systems used to monitor the flow of oxygen. Work conducted by Edworthy *et al., (2024)* [22], Muller *et al., (2020)* [23] and Van der Walt *et al., (2021)* [24] through the platform has contributed significantly to our knowledge on the impact of catch-and-release angling on the physiology of fish, thermal tolerance, impacts of climate change on marine ectotherms, and ocean acidification on aquatic organisms.

Inland fisheries and freshwater biodiversity research continued to evolve, even after the untimely death of Prof Olaf Weyl, the DSI/NRF Research Chair in Inland Fisheries and Freshwater Ecology. Noteworthy contributions include the publication of a foundational policy-oriented paper by Weyl *et al., (2021)*, [25] which identified ten research priorities for supporting inland fisheries governance. The NRF-SAIAB Freshwater Field Unit collaborated with the Department of Forestry, Fisheries and the Environment (DFFE) and other stakeholders on a project to establish the potential for small-scale inland fisheries in public dams in the Limpopo Province. The development of inland fisheries capacity on a national level will help achieve some of the objectives outlined in the NDP 2030, such as adequate nutrition. Research conducted to date shows that there is a need for a cautious, small-scale approach towards the sustainable development of the inland fisheries sector in South Africa. [26] The tilapia project, focused on assessing the current distribution of alien invasive Nile tilapia, *O. niloticus*, and native Mozambique tilapia, *O. mossambicus*, across the Limpopo, Mpumalanga and KwaZulu-Natal provinces, is another collaborative project with the DFFE and the South African National Biodiversity institute (SANBI). This project provided comprehensive scientific information on the current distribution of these species, which could be used to guide the DFFE on the potential future aquaculture developments within the three provinces. Overall, the mapping exercise and associated data represent a tool for the sustainable development of the tilapia aquaculture sector. The data from this project can be used to help guide permitting of aquaculture activities by feeding into an Integrated Environmental Management (IEM) decision-making process that drive sustainable development.

Taxonomy and Biodiscovery contribute directly to the description and quantification of global biodiversity assets. During this period, through the application of integrative taxonomic approaches that combined morphological and molecular data, research by NRF-SAIAB researchers resulted in the description of 28 new fish species, revalidated 11 previously synonymised species and uncovered multiple cryptic lineages requiring further taxonomic resolution from Southern Africa.[27] Significant highlights include the description of eight new species previously included under a single species, *Parauchenoglanis ngamensis*, from the region[28], as well as comprehensive revisions of the genera *Pseudobarbus, Galaxias, Enteromius* which increased the number of endemic freshwater fish species in South Africa from 105 (in 2020) to 139 recognised endemic species for the country.[29] Regional projects such as the Waterberg Biodiversity Project and the *REFRESH* [30] initiative have expanded freshwater data coverage and supported species conservation planning. NRF-SAIAB acquired funding through the Water Research Commission (WRC) for a project on optimising environmental DNA (eDNA) application for biodiversity assessment and ecological monitoring of freshwater ecosystems. Information from this project will facilitate monitoring of fishes of socio-economic importance, which will in turn support sustainable fisheries, job creation and food and nutrition security.

22. Edworthy, C., James, N.C., Potts, W.M., Duncan, M.I. and Dupont, S., 2024. Temperate coastal fish shows resilience to extreme low pH in early larval stages. Journal of Experimental Marine Biology and Ecology, 578, p.152037 available from https://www.sciencedirect.com/science/article/pii/S0022098124000522 accessed 16 Sept 2025
23. Muller, C., Childs, A.R., James, N.C. and Potts, W.M., 2020, December. Effects of experimental ocean acidification on the larval morphology and metabolism of a temperate sparid, Chrysoblephus laticeps. In Oceans (Vol. 2, No. 1, pp. 26-40). MDPI available from https://www.mdpi.com/2673-1924/2/1/2 accessed 16 Sept 2025
24. Van der Walt, K.A., Porri, F., Potts, W.M., Duncan, M.I. and James, N.C., 2021. Thermal tolerance, safety margins and vulnerability of coastal species: Projected impact of climate change induced cold water variability in a temperate African region. Marine Environmental Research, 169, p.105346 available from https://doi.org/10.1016/j.marenvres.2021.105346 accessed 16 Sept 2025
25. Weyl, O.L.F., Barkhuizen, L., Christison, K., Dalu, T., Hlungwani, H.A., Impson, D., Sankar, K., Mandrak, N.E., Marr, S.M., Sara, J.R. and Smit, N.J., 2021. 'Ten research questions to support South Africa's inland fisheries policy'. African Journal of Aquatic Science, 46(1), pp.1-10 available from https://www.researchgate.net/profile/Tatenda-Dalu/publication/346053116_Ten_research_questions_to_support_South_Africa%27s_Inland_Fisheries_Policy/links/5fb8c1a492851c933f49532c/Ten-research-questions-to-support-South-Africas-Inland-Fisheries-Policy.pdf accessed 05 Sept 2025.
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28. Sithole, Y., Vreven, E. J. W. M. N., Bragança, P. H. N., Musschoot, T., and Chakona, A. 2024. Nine in one: integrative taxonomic evidence of hidden species diversity in the widespread Zambezi grunter, Parauchenoglanis ngamensis (Siluriformes: Auchenoglanididae), from southern and south-central Africa. Zoological Journal of the Linnean Society, 202: p.1-33.
29. Skelton, P. H. 2024. Freshwater Fishes of Southern Africa: A complete guide. Struik Nature, Cape Town, South Africa p.1 – 481.
30. REFRESH is a multi-institutional research project that aims to update and generate comprehensive data on species diversity and distribution, as well as provide scientific knowledge to guide policy development and inform conservation strategies to halt biodiversity loss and preserve ecosystem services.

A significant area of societal impact has been the inclusion of the biological control of invasive aquatic weeds into NRF-SAIAB's core research focus. As a partner in the Centre for Biological Control (CBC) at Rhodes University, NRF-SAIAB has led national-scale interventions that target invasive species such as water hyacinth, water lettuce, and giant salvinia. The programme has successfully deployed and monitored host-specific biocontrol agents in several heavily infested water bodies, including the Hartbeespoort Dam and the Vaal River Barrage. Innovations such as climate-matching, molecular barcoding, and local stakeholder co-development have enhanced the precision and sustainability of control efforts. The work contributes directly to national priorities around invasive species, climate adaptation, and water security, while restoring ecosystem function and community access to aquatic resources.

The institute continues to provide strategic leadership in national and regional science networks. Its platforms serve as essential infrastructure for evidence-based decision-making in fisheries, biodiversity conservation, climate adaptation, and water security. Partnerships with national departments, universities, and African institutions ensure that research outputs feed directly into policy processes and capacity development efforts for societal impact.

South African Environmental Observation Network (NRF-SAEON)

As with NRF-SAIAB, NRF-SAEON's publications peaked in 2020 (96 publications), possibly due to the Covid-19 related lockdowns. The decline from 2021 was also due to a focus on the implementation and deployment of instruments in different sites of the three research infrastructures hosted by NRF-SAEON. This trend shifted in 2024, with publications increasing from 55 in 2023 to 88, and output is expected to increase further as the research infrastructures mature, and scientists have more time to focus on research and work with collaborators.

NRF-SAEON's research publications reflect its depth and breadth of scientific inquiry across terrestrial, marine, and atmospheric domains. Several publications have made significant global impact, including a highly cited study published in *Science* on grazing and ecosystem service delivery in global drylands.[31] Highly cited research on the marine domain included *Microfibers in oceanic surface waters: A global characterisation* [32] published in Science Advances and *A global analysis of complexity–biodiversity relationships on marine artificial structures* [33], highlighting NRF-SAEON's contribution to the advancement of global understanding of marine pollution as well as biodiversity and ecosystem dynamics and its role as a leading research infrastructure in support of high-impact science.

NRF-SAEON has expanded its infrastructure and research footprint to support evidence-based policy, cutting-edge science, and public engagement. These initiatives have not only contributed to scientific knowledge but have also delivered tangible societal impact, particularly in the areas of climate resilience, environmental management, and data accessibility. Highlights of work conducted include:

- **Building Climate Resilience Through Long-Term Terrestrial Observations:** NRF-SAEON's terrestrial nodes and EFTEON have deployed a network of hydrology, meteorology and micrometeorology stations across South Africa. These stations have produced continuous, high-quality data, which is critical for understanding the effects of land use and climate variability on water resources. These data have underpinned collaborations with universities to develop models for improving sustainable agricultural practices in semi-arid regions. Data also supported the first assessment of the hydrological impacts of woody vegetation and informed inputs to the DWS's National State of Water report.
- **Empowering Ocean and Climate Science with Mobile Polar Labs:** Under SAPRI, NRF-SAEON's mobile polar container labs will revolutionise access to real-time data in the Antarctic and sub-Antarctic regions. These labs will facilitate critical research on ocean biogeochemistry, sea-ice dynamics, and atmospheric observations, and contribute to the global understanding of climate tipping points. The infrastructure supports expeditions and contributes to South Africa's involvement in the Southern Ocean Observing System (SOOS).

31. Maestre, F.T., Le Bagousse-Pinguet, Y., Delgado-Baquerizo, et al. 2022. 'Grazing and ecosystem service delivery in global drylands'. *Science, 378*(6622), pp.915-920 available from https://www.science.org/doi/10.1126/science.abq4062 accessed 05 Sept 2025.
32. Suaria, G., Achtypi, A., Perold, V., Lee J.R., Pierucci, A., Bornman, T., Aliani, S., Ryan, P.G. 2020. Microfibers in oceanic surface waters: a global characterization. *Science Advances*, 6 (23), eaay8493. available from https://www.science.org/doi/10.1126/sciadv.aay8493 accessed 16 Sept 2025.
33. Strain, E.M., Steinberg, P.D., Vozzo, M., Johnston, E.L., Abbiati, M., Aguilera, M.A., Airoldi, L., Aguirre, J.D., Ashton, G., Bernardi, M. and Brooks, P., 2021. 'A global analysis of complexity–biodiversity relationships on marine artificial structures'. *Global Ecology and Biogeography*, 30(1), pp.140-153 available from https://onlinelibrary.wiley.com/doi/abs/10.1111/geb.13202 accessed 05 Sept 2025.

- **Enhancing Climate Risk Monitoring with the Airborne Remote Sensing Platform:** The SMCRI Airborne Remote Sensing Platform, based at the David Stuurman International Airport in Gqeberha, has enabled high-resolution spatial mapping of coastal, terrestrial, and marine environments. Over the past five years, the platform has supported ecological change detection, disaster risk monitoring, e.g. post-fire and flood assessments, and vegetation structure analysis, all crucial for climate adaptation planning. The airborne LiDAR data collected have been used by researchers and government agencies to support conservation and land-use decisions, including mapping of invasive alien species and wetland degradation, as well as the establishment of set-back lines for extreme events.
- **Expanding Digital Access to Environmental Knowledge through Open Data and Online Education:** NRF-SAEON has developed two powerful tools to support Open Science and public engagement. The first is the NRF-SAEON Open Data Platform, hosted at the uLwazi Node in Cape Town, which integrates observational, model simulations, and remotely sensed data, to enable transparent access for researchers, decision-makers, and the public. The platform has grown significantly since 2020 in both data volume and user base and serves as a foundation for collaborations with universities, municipalities, and international networks. The second is an Online Education Platform developed by NRF-SAEON in response to Covid-19 disruptions. It has reached thousands of high school learners and educators across South Africa. The platform includes interactive modules, virtual field trips, and citizen science projects aimed at improving environmental literacy and inspiring the next generation of scientists.

Conclusion

Journal publications are a recognised format for research dissemination and publications in quality journals highlight the productivity of the researcher cohort. In the South African context, growing our knowledge impact along with our societal impact is critical. NRF-funded researchers have demonstrated remarkable growth in productivity, contributing significantly to national and global knowledge systems. The research not only aligns with international benchmarks but also addresses pressing societal challenges, particularly those outlined in the UN SDGs. Despite these achievements, the above analysis also reveals areas that require greater attention, such as research on poverty, gender equality, and economic growth. Strengthening institutional coordination, enhancing policy engagement, and ensuring inclusive research agendas will be key to maximising societal impact.

The strategic investments in National Facilities have yielded tangible outcomes, with ground-breaking research across diverse domains, from astronomy and accelerator-based sciences to aquatic biodiversity and environmental observation. The NFs have become hubs of innovation, collaboration, research impact, and capacity development, which enable South Africa to remain competitive in global research while responding to local developmental needs. Overall, the NRF's contributions have not only advanced research output but also fostered the development of postgraduate students and ensured the availability of essential research platforms. Continued support and sufficient funding are crucial to maintaining and furthering these achievements. By fostering a research ecosystem that is both globally relevant and locally transformative, the NRF not only advances scientific knowledge but also contributes meaningfully to South Africa's developmental trajectory.