



SOUTH AFRICAN OPEN SCIENCE POLICY

2026

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Department:
Science, Technology and Innovation
REPUBLIC OF SOUTH AFRICA



Contents

Acronyms	3
Terminology	5
1. Foreword	6
2. Executive Summary	7
3. Introduction.....	8
3.1. Open Science Practice.....	11
4. Background	12
4.1. Applicability	13
5. Open Science for South Africa.....	13
5.1. Vision.....	13
5.2. Objectives and Outcomes	14
5.3. Guiding Principles	15
6. Policy Linkages	16
7. Problem Statement	18
8. Accelerating Progress toward Open Science: Seven Policy Intents of Open Science	19
8.1. Introduction.....	19
8.2. Seven Policy Intents for Open Science.....	19
8.2.1. Policy and Regulatory Changes.....	20
8.2.1.1. Copyright and Intellectual Property	20
8.2.2. Open Access	21
8.2.3. Open Data	22
8.2.4. Education and Skills	24
8.2.5. Rewards and Incentives.....	26
8.2.6. Open Science Infrastructure	28
8.2.7. Citizen Science.....	29
9. Implementation: Resources, Roles, Responsibilities and Governance	31
9.1. Critical Success Factors.....	31
9.2. Governance.....	34
9.3. Resources, Stakeholders and Responsibilities	34
10. Monitoring and Evaluation.....	35
11. Conclusion.....	37

Acronyms

AmeliCA	Open Knowledge for Latin America and the Global South
AOSP	African Open Science Platform
APC	Article Processing Charge
ARC	Agricultural Research Council
ASSAf	Academy of Science of South Africa
CARE	Collective Benefit, Authority to Control, Responsibility and Ethics
CODATA	ISC Committee on Data
CSIR	Council for Scientific and Industrial Research
DHET	Department of Higher Education and Training
DIRISA	Data Intensive Research Initiative of South Africa
DOI	Digital Object Identifier
DORA	San Francisco Declaration on Research Assessment
DSI	Department of Science and Innovation
EU	European Union
FAIR	Findable, Accessible, Interoperable, Reusable Data Principles
HSRC	Human Sciences Research Council
ICT	Information and communications Technology
IP	Intellectual Property
IPR	Intellectual Property Rights
iThemba LABS	iThemba Laboratory for Accelerator Based Sciences
MRC	Medical Research Council
NACI	National Advisory Council on Innovation
NDP	National Development Plan
NECSA	South African Nuclear Energy Corporation
NICIS	National Integrated Cyber-Infrastructure System
NIPMO	National Intellectual Property Management Office
NPO	Non-Profit Organisation
NRF	National Research Foundation
NSI	National System of Innovation
OA	Open Access
OA2020	Open Access Initiative OA2020
OS	Open Science
OSAB	Open Science Advisory Board
POPIA	Protection of Personal Information Act
SA	South Africa
SACNASP	South African Council for Natural Scientific Professions
SA-EU	South Africa – European Union
SAAO	South African Astronomical Observatory
SAIAB	South African Institute for Biodiversity
SANAP	South African National Antarctic Programme
SANBI	South African National Biodiversity Institute

SANEDI	South African National Energy Development Institute
SANSA	South African National Space Agency
SARAO	South African Radio Astronomy Observatory
SAWS	South African Weather Service
SciELO	Scientific Electronic Library Online
STM	International Association of Scientific, Technical and Medical Publishers
TIA	Technology Innovation Agency
TRUST	Transparency, Responsibility, User Community, Sustainability and Technology
USAf	Universities South Africa

Terminology

'Open Science' is defined as research and development that is collaborative, transparent and reproducible and whose outputs are publicly available¹.

'Open Access' is a set of principles and a range of practices through which research outputs are distributed online, free of cost or other access barriers².

'Open Data' refers to data that anyone can freely access, use and share, subject, at most, to requirements that preserve provenance and openness³.

Further definitions will be found in the text.

¹ European Commission, "EC Open Science Policy Platform," [Online]. Available: <https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-policy-platform>

² P. Suber, "Overview of Open Access," [Online]. Available: <https://web.archive.org/web/20070519103647/http://www.earlham.edu/~peters/fos/overview.htm>

³ Opendefinition.org

1. Foreword

The National Open Science Policy is set within a broader government policy context of socio-economic development that takes cognisance of global issues codified within the Sustainable Development Goals (SDGs)⁴. Its implementation presents opportunities for South Africa to drive socio-economic development in a responsible and ethical manner - meeting human development goals whilst, at the same time, sustaining the ability of natural systems to provide natural resources and an ecosystem upon which the economy and society depend.

Taking into consideration the various fiscal, developmental and ecological challenges that South Africa may face, not only now but in the future, it is therefore incumbent upon us to ensure that the implementation of this policy is undertaken in a manner that sustains social, economic and ecological capital and growth for future generations. Such an approach is not only necessary, but critical to ensure a prosperous South Africa that is part of a worldwide community facing challenges at a global scale.

⁴ <https://sdgs.un.org/goals>

2. Executive Summary

Scientific research seeks to meet human development goals, while sustaining the ability of natural systems to provide both resources and the ecosystem on which our socio-economic conditions depend. Faster, less costly access to scientific results, data, and methods can accelerate the pace of scientific discovery and the uptake of the results.

Global inter-connectedness supports the rapid exchange of these outputs. Open Science is defined as research and development that is collaborative, transparent, and reproducible, and whose outputs are made publicly available.

The benefits of using the Open Science paradigm are broadening the benefits of science across society, recognition that reproducibility and validation are required for science to remain credible, and the enabling of new mechanisms for technological changes. An outstanding example has been seen with the high-speed development of a global scientific response to COVID-19, where barriers to exchanging the results of scientific discoveries were lowered or removed – supporting the often held view that Open Science is effectively a vehicle for “the democratisation of knowledge”.

Open Science can only be successful with the mindful application of the cardinal guiding principle “As Open As Possible, As Closed As Necessary”. This principle recognises both the legislative environment, and the critical socio-economic role of intellectual property rights.

South Africa's competitiveness depends on understanding and embracing this new paradigm. There is also an urgent need for change in access to research publications in terms of the present cost.

This Open Science policy sets out guiding principles, objectives, and policy linkages. The seven policy intents concern (1) the policy and regulatory environment, (2) Open Access to the scientific literature, (3) access to valuable Open Data, (4) the required supporting education and skills, (5) the potential incentives, (6) the required Infrastructure, and (7) the relationship to Citizen Science. Among the critical success factors are trusted security, and financial sustainability in implementation. The move to Open Science supports the need for district and local internet access. Since Open Science is a global movement generated by researchers themselves, engagement of stakeholders is a critical element. Transition towards an open research culture requires an enabling environment with appropriate support mechanisms in place.

Open practices result in a transformation in the way in which science is done. An Open Science Observatory is proposed, which will continuously monitor the efficiency and relevance of the system, and will provide feedback on implementation.

Through the adoption of an Open Science Policy, South Africa will facilitate equality of opportunity within the National System of Innovation, as well as benefiting from a global and African trend.

3. Introduction

Society is rapidly advancing towards a state of increased global inter-connectedness - often described as the Fourth Industrial Revolution – and is characterised by exponentially increasing data generation, distribution and analysis capacity across broad segments of society not traditionally involved in the research endeavor. Global experience has demonstrated that open access to data and publications can lead to an acceleration in scientific breakthroughs and act as a catalyst for the research and innovation enterprise. The societal benefits are quite marked – dependent on the scope and breadth of data availability, this can extend from research and innovation to drivers of socio-economic development, social welfare and public perception of transparency^{5,6,7,8}.

On the back of this global transformation, Open Science is a rapidly growing global field of practice that, in its most aspirational form, seeks to improve the practice and return on investment in science, and deepen the positive socio-economic benefits across all sectors of society. Open Science has a significant role to play in countering the emergence of popular pseudo-scientific agenda. It is viewed as a critical mode of reach in the 21st century, and is driven by three key inter-related drivers:

- Broadening of the benefits of science, both to research and to society at large;
- Recognition that reproducibility and validation of scientific results are required for science to remain credible; and
- Technology changes that both enable, and require, new mechanisms for scientific endeavor.

Inclusive growth and sustainable development are central to the African Union's Agenda 2063⁹. The role of open, collaborative science, technology and innovation (STI), central to Open Science policy, is critical - from disaster preparedness and prevention, to biodiversity, conservation management and climate resilience. Developing the potential offered by African people, with goals of full gender equality¹⁰ and

⁵ UNESCO (16 November 2021). "UNESCO Recommendation on Open Science". [Online]. Available: <https://www.unesco.org/en/natural-sciences/open-science>

⁶ <http://opendatatoolkit.worldbank.org/en/starting.html>

⁷ <https://journals.sagepub.com/doi/10.1177/2053951717718853>

⁸ <https://publicadministration.un.org/en/ogd>

⁹ African Union Agenda2063, 2015 <https://au.int/en/agenda2063/overview>

¹⁰ In the South African community of practice, the goal is gender equity.

engaged and empowered youth, needs an enabling environment for STI (STISA-2024¹¹), a strong science culture, and well-educated citizens.

Alignment by South Africa with this growing trend will facilitate adoption of emerging research methodologies that will strengthen the South African research and innovation enterprise, enable broader and more equitable societal access to the scientific endeavor, and give rise to new opportunities for the delivery of direct and indirect socio-economic benefits to society. As a driver for the democratization of knowledge, the establishment of an Open Science system on the back of technological change and increased internet accessibility by the population is a policy intervention well suited for the strengthening of the South African research enterprise¹², particularly in Historically Disadvantaged Institutions. It also becomes a key enabler of the objectives of the South Africa Indigenous Knowledge System¹³ - to stimulate and strengthen contribution of indigenous knowledge to social and economic development in South Africa.

The growing, global adoption of Open Science as a systemic approach towards the democratization of knowledge is establishing a global commons for science and innovation. Not only does this enable active participation by South Africa within a global knowledge enterprise and knowledge economy, but it is critical in addressing global challenges that face humanity today. These challenges, codified as the Sustainable Development Goals¹⁴, represent an existential crisis for humanity that requires a common, unified approach

¹¹ African Union STI Strategy for Africa STISA-2024, <https://au.int/en/documents/20200625/science-technology-and-innovation-strategy-africa-2024>

¹² Additional consequences are expected to arise from accelerated societal change – some of which were observed in 2020 due to the COVID-19 pandemic. Increased remote working will rely on enhanced, and remote, accessibility to research outputs and infrastructure. A natural benefit of this is increased participation of women, youth, disabled individuals and previously disadvantaged individuals in the research endeavor.

¹³ https://www.dst.gov.za/images/pdfs/IKS_Policy%20PDF.pdf

¹⁴ <https://sdgs.un.org/goals>

These goals include:

- No poverty – End poverty in all its forms everywhere
- Zero hunger – End hunger, achieve food security and improved nutrition and promote sustainable agriculture
- Good health and well-being – Ensure healthy lives and promote well-being for all at all ages
- Quality education – Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
- Gender equality – Achieve gender equality and empower all women and girls
- Clean water and sanitation – Ensure availability and sustainable management of water and sanitation for all
- Affordable and clean energy – Ensure access to affordable, reliable, sustainable and modern energy for all
- Decent work and economic growth – Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
- Industry, innovation and infrastructure – Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation

to address. Many initiatives were drawn together in the construction of the UNESCO Recommendations on Open Science¹⁵. South Africa has been actively represented and engaged in many international Open Science initiatives since 2006 and landscape studies, with detailed recommendations, have been published at intervals¹⁶. Among the most important and most influential international initiatives are the UNESCO Open Science Partnership¹⁷; OA2020¹⁸; ISC¹⁹, CODATA²⁰, and WDS²¹; RDA²²; and cOAlition S, which includes funders²³. International organisations such as the OECD, IAP, GRC, and SCGI²⁴ include Open Science in action plans. National and multilateral policies have provided useful background.

The voice of the global south in scholarly-led, non-profit business models is consolidated in AmeliCA²⁵. SciELO, the Scientific Library Online, was created to meet the scientific communication needs of developing countries. SciELO-SA²⁶ is South Africa's premier open-access database. In the pan-African context, the

-
- Reduced inequalities – Reduce inequality within and among countries
 - Sustainable cities and communities – Make cities and human settlements inclusive, safe, resilient and sustainable
 - Responsible consumption and production – Ensure sustainable consumption and production patterns
 - Climate action – Take urgent action to combat climate change and its impacts
 - Life below water – Conserve and sustainable use the oceans, seas and marine resources for sustainable development
 - Life on land – Protect, restore and promote sustainable use of terrestrial ecosystems, sustainable manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
 - Peace, justice and strong institutions – Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
 - Partnerships for the goals – Strengthen the means of implementation and revitalise the global partnership for sustainable development

¹⁵ UNESCO (16 November 2021). "UNESCO Recommendation on Open Science". [Online]. Available: <https://www.unesco.org/en/natural-sciences/open-science>

¹⁶ ASSAf, 2019. "Twelve Years Later: Second ASSAf Report on Research Publishing In and From South Africa (2018)". [Online] Available at: DOI:10.17159/assaf.2018/0030

¹⁷ UNESCO Global Science Partnership <https://en.unesco.org/science-sustainable-future/open-science/partnership>

¹⁸ Open Access Initiative OA2020, <https://oa2020.org/>

¹⁹ International Science Council, "Open Science", <https://council.science/actionplan/open-science/> ; <https://council.science/publications/sci-pub-report1/>

²⁰ International Data Policy Committee CODATA <https://www.codata.org/>

²¹ World Data System WDS <https://www.worlddatasystem.org/>

²² Research Data Alliance RDA <https://www.rd-alliance.org/>

²³ cOAlition S <https://www.coalition-s.org/>

²⁴ The Organisation for Economic Co-operation and Development, InterAcademy Partnership Global Research Council, Science Councils Granting Initiative respectively.

²⁵ AmeliCA <http://amelica.org/>

²⁶ SciELO-SA <http://www.scielo.org.za/>

African OS Platform AOSP^{27,28} aims to put African scientists at the cutting edge of contemporary, data-intensive science as a fundamental resource for a modern society. South Africa has a stake in the success of AOSP and this policy recommends close cooperation with AOSP.

In global trends, alternative models have emerged. One example is that of pre-print servers, such as the arXiv^{29,30} and AfricarXiv³¹, which are unreviewed. A second example is that of sponsoring consortia such as SCOAP³ in particle physics³².

3.1. Open Science Practice

Using definitions drawn from international policies¹⁵ and the SA-EU Dialogue Framework^{33,34}, we define Open Science for the South African publicly funded context as follows: enabling appropriate access, utilization and sharing of publicly funded research outputs and data to all levels of society. The concept of 'appropriately accessible' shall be guided by the principles in Section 5.3 of this document.

It is intended that Open Science shall facilitate the production of knowledge that is transparent, accessible, shared and developed largely through collaborative networks utilizing appropriate technology tools. In its implementation, Open Science should not, however, be to the disadvantage of credible, single author research. The guiding principle of "As Open As Possible, As Closed As Necessary" (see Section 5.3) shall apply to all Open Science practices.

Depending on the scope of the system-wide implementation, a number of facets of Open Science are likely to have extensive impact on the science and innovation system. It is recognised that the term 'open' can be applied to each facet of a science system separately and independently³⁵. The term 'open', when applied

²⁷ AOSP Project, "The Future of Science and Science of the Future: Vision and Strategy for the African Open Science Platform v02," 2018.

²⁸ Academy of Science of South Africa, "African Open Science Platform - Landscape Study", SA Dept. of Science and Technology, National Research Foundation, Academy of Science of South Africa, 2019.

²⁹ arXiv <https://arxiv.org/> ;

³⁰ arXiv is financially supported by about 100 members

³¹ "Achieving full Open Access in Africa," AfricarXiv, 2019. [Online]. Available: <https://medium.com/@africarxiv/achieving-open-access-1063053d8ac0>. [Accessed 12 July 2020].

³² The Sponsoring Consortium for Open Access Publishing in Particle Physics SCOAP³ <https://scoap3.org/> ; converted key journals in the field of High-Energy Physics to Open Access at no cost for authors, by central payment of publishers Open Access Article Publishing Charges

³³ <https://zenodo.org/record/2559469#.YJPnobUzY2w>

³⁴ https://www.dialoguefacility.org/joint_sa_eu_dialogue_on_open_source_science.pdf

³⁵ For example, Open Big Data, Open Government Data, Open Source, Open Notebooks etc.

within this context, is defined to mean the following: to establish the necessary transparency and non-proprietary approach in order to support an Open Science system.

In broad terms, Open Science in South Africa shall achieve six inter-related outcomes, subject to the guiding principles referenced above:

- Facilitating **Open Access** to scholarly publications and research outputs, as well as educational resources for teaching, learning and assessing³⁶
- Ensuring **Open Data** that facilitates equal opportunity of access to research data to enable re-production of published results, and re-use of publicly funded data to enhance discovery potential and opportunity
- Supporting **Open Source** by providing access, discoverability and re-use³⁷ of software code and algorithms used in the processing and analysis of research data
- Providing **Open Resources** through enabling responsible access and use of scientific data, research infrastructure, and computing infrastructure beyond hosting institutions to a wider research community³⁸
- Facilitating **Open Methods** that place no unwarranted restriction on, and encourage, the publication and re-use of methodologies, techniques and protocols (both after, and during the course of³⁹, the primary research)
- Enabling **Open Review** as a departure from current practice, whereby the peer review process becomes transparent and publicly visible.

4. Background

Open Science has been championed in South Africa by various actors within the National System of Innovation (NSI)⁴⁰, including the Academy of Science of South Africa (ASSAf), the scholarly publishing communities, universities and libraries, various coalitions, public funding agencies and academic authors. One of the repositories that has been a product of this engagement is SciELO (Scientific Electronic Library Online) – South Africa's premier open access, searchable full-text journal database established by ASSAf in 2009.

³⁶ Often referred to as 'Open Educational Resources'

³⁷ Under appropriate licences such as, for example GNU, <https://www.gnu.org/licenses/licenses.en.html>

³⁸ This may include citizen scientists, or other members of the research community

³⁹ Commonly referred to as 'open notebooks'

⁴⁰ White Paper on Science and Technology, 1996,

https://www.gov.za/sites/default/files/gcis_document/201409/sciencetechnologywhitepaper.pdf

Recognising the progress of the Open Science global trend, the SA-EU Open Science Dialogue Process assisted the development of the present policy as follows. An Expert Task Group was appointed to support the establishment of a multi-stakeholder Open Science Steering committee to facilitate an initial consultative workshop, which discussed key issues and engaged key stakeholders. The report arising was reviewed at a second workshop attended by the stakeholder community. A draft document was submitted to the Open Science Steering committee and finalized³³, providing the framework on which this policy is based. The Open Science Advisory Board was appointed in 2020, with an Expert Task Team to assist it in drafting the policy.

4.1. Applicability

This policy shall be applicable to:

- all publicly funded research processes and outputs⁴¹; and
- data⁴² acquired or generated utilising public funds that may have broader research use.

For clarity, publicly funded research outputs shall be interpreted to mean outputs from ‘research and development undertaken by individuals, teams or publicly funded research performing organisations using any funds allocated by a state funding agency’.

Research may be co-created with, or funded by, the private sector, philanthropic organisations, or other organisations. Collaboration and co-creation are encouraged and it is advised that Intellectual Property Rights, and the extent to which Open Science principles can be used, must be discussed and agreed upon in the initial project negotiations. Where research is made subject to contractual conditions requiring Open Science or otherwise, this policy shall be applied on a best-effort basis and within limitations that respect the relevant contractual funding conditions.

5. Open Science for South Africa

5.1. Vision

⁴¹ Research processes and outputs are defined to include: Scholarly publications and supplementary data; data generated by publicly funded research and infrastructure; associated code, algorithms, systems, and applications; vocabularies, services, and registries; methodologies and protocols; and peer review tasks and contributions.

⁴² This data includes data acquired, or generated, through government departments and agencies.

Through the adoption of a National Open Science policy, South Africa will facilitate equality of opportunity within its NSI⁴³, and through the democratisation of knowledge, enhance opportunities for environmentally sustainable and inclusive socio-economic development through the scientific research endeavour.

5.2. Objectives and Outcomes

Successful implementation of this National Open Science policy is reliant on achieving key goals, set out as follows:

- Facilitation of a change in the research endeavor that supports the principles of open science in terms by supporting the principles of Open Methods and the use of consistent and transparent tools and methodologies;
- Deposition and publication of publicly funded research outputs in accordance with best practice that is applicable to the relevant discipline and nature of the output, whilst adhering to the principle of 'as open as possible, as closed as necessary', defined in Section 5.3;
- Rewards and incentives framework for researchers embracing the principles of Open Science;
- Accessibility of infrastructure, at an institutional and national scale, that supports the deposit, discovery and dissemination of data and metadata in a manner consistent with the principles of FAIR, TRUST and CARE, defined below;
- Accessibility of designated national Open Science infrastructure that is inter-operable and supports a range of use cases, making it possible for service-based, automated integration between this infrastructure, institutional and disciplinary repositories, global services and the publication industry;
- Accessibility of research outputs that can be re-used with confidence, based on proper re-usable metadata, standardised and machine-readable licenses, ensuring appropriate provenance and enabling the reproducibility of scientific findings;
- Increased scientific, inter-disciplinary and inter-institutional collaboration, both national and international, delivering direct and indirect societal benefit through improved, evidence-based decision making and policy formulation, economic and ecological benefit, and an informed society;
- Increased participation of society in the national system of innovation and scientific enquiry; enabling greater translation of scientific outputs and enabling broader societal engagement, thereby delivering increased transdisciplinary innovation;

⁴³ Department of Arts, Culture, Science and Technology, White Paper on Science and Technology, 4 September 1996

- An appropriate monitoring and evaluation system that takes direct and indirect impact into account, and acknowledges contributions in data gathering and processing, methodological development, and other actions supporting the production, review and publication of research output.

5.3. Guiding Principles

Adoption of best practice principles, based on an underlying core value system, is critical in the successful implementation of an Open Science policy for South Africa. Internationally, broad consensus has developed around the adoption of key guiding principles, which shall be entrenched within the implementation of the Open Science policy. Implementation of these guiding principles shall be founded on the following core values:

- Quality and integrity – the Open Science system shall enable the entrenchment of high-quality research through facilitating transparency, scrutiny, critique and reproducibility, whilst maintaining the highest standards of integrity amongst its actors;
- Equity, fairness and collective benefit – all stakeholders shall have equitable opportunity to access, contribute to, and benefit from Open Science;
- Diversity and inclusiveness – the Open Science system shall promote the principles of collaboration, participation and inclusion across participants in the South African research enterprise.

The following guiding principles shall inform the adoption and implementation of Open Science in South Africa:

- FAIR – concerning the characteristics of datasets, publicly funded data and outputs shall be Findable, Accessible (discoverable), Inter-operable and Re-usable. Implementation of FAIR principles shall give consideration to an underlying principle of data being ‘as open as possible, as closed as necessary’;
- CARE – the CARE principles (Collective Benefit, Authority to Control, Responsibility, and Ethics) complement and extend the more data-centric approach of the FAIR principles. They concern the ethical and non-exploitative framing of research, where data ecosystems are designed to ensure benefit can be derived by indigenous peoples⁴⁴;

⁴⁴ Indigenous peoples shall be interpreted to mean indigenous communities, as defined in the Protection, Promotion, Development and Management of Indigenous Knowledge Act No. 6 of 2019, https://www.gov.za/sites/default/files/gcis_document/201908/4264719-8act6of2019protectpromodevelopmanagementindigenouknowledgeact.pdf

- iii. TRUST – concerning the trustworthiness of repositories, ensuring that repositories are transparent in their service and data holdings, responsible for ensuring integrity and authenticity, ensuring user expectations are met, curation and preservation of data holdings is sustainable, and ensuring the appropriate technological domain expertise and infrastructure is in place to secure persistent and reliable data services. The principles consider Transparency, Responsibility, User Community, and Sustainability, and Technology (TRUST) as the essential components for assessing, developing, and sustaining the trustworthiness of data repositories, and thus supporting the scientist and other actors;
- iv. Flexibility – recognising the need to implement a flexible approach for the implementation of Open Science that is context driven;
- v. Operational and Financial Sustainability – ensuring the implementation model is sustainable in respect of long-term practices, services, infrastructures and funding models;
- vi. ‘As open as possible, as closed as necessary’⁴⁵ - means that research output shall be open and consistent with the objectives of this Open Science Policy, unless statutory⁴⁶, ethical⁴⁷, intellectual property⁴⁸, contractual or commercial⁴⁹, environmental⁵⁰ or research credibility⁵¹ considerations would result in untenable risk to the key research subject(s) or stakeholders.

6. Policy Linkages

The implementation of a National Open Science Policy sits within a broader national and international policy framework¹⁵. South Africa is represented within the Open Access Initiative OA2020⁵², and is a party to the

⁴⁵ Anecdotally, the implementation of this principle is suggested to have resulted in approximately 70% of publicly funded research outputs in Europe being classified as ‘open’

⁴⁶ Including but not restricted to legislation or policy, legal process and public order; protection of personal information; national security

⁴⁷ Including but not restricted to protection of human rights; right to privacy and respect for human subjects of study; protection of sacred or secret indigenous knowledge; protection of vulnerable populations

⁴⁸ Including protection of Intellectual Property Rights and copyright

⁴⁹ Including confidentiality, contractual agreements, and research agreements

⁵⁰ Including, but not limited to, protection of rare, threatened or endangered species and preservation of the natural environment

⁵¹ Compromise of the scientific credibility of the researcher or research output due to publication context (examples: journals in the correct research scope are not open, relevant open journals have been identified as predatory); transitional impediments (examples: inadequate funding sources for Article Processing Charges, relevant journal does not offer Open Access)

⁵² Open Access Initiative OA2020, <https://oa2020.org/progress-report>

São Paulo Statement⁵³. The country is a stakeholder in the African Open Science Platform (AOSP)^{54,55}, and supports the mission of a network of excellence in Open Science.

In the national context, facilitation of Open Science is supported by the National Development Plan (NDP)⁵⁶, and is explicitly mandated by the 2019 White Paper on Science, Technology, and Innovation⁵⁷ where the pivotal role of Information and Communications Technology (ICT) is recognised, along with Open Science, Open Access, and Open Innovation. Open Science is enabled by the National Cyberinfrastructure Framework⁵⁸, and is closely aligned to the long-term objectives of the National Research Big Data Strategy for South Africa that exploit the opportunities brought about by the 4th Industrial Revolution⁵⁹.

The National Research Foundation (NRF) Statement on Open Access⁶⁰ recognises the need to harmonise policies supporting Open Access. The Scholarly Publishing Programme within the Academy of Science of South Africa (ASSAf), mandated by the Department of Science and Innovation, has contributed extensively to the policy background^{61,62}. Considerable dialogue has taken place through the OS initiatives with the European Union (EU)⁶³, and the policy framework has been developed through this interaction⁶⁴. In formulating this policy, the Science Engagement Strategy⁶⁵, and the Department of Higher Education (DHET) Ministerial Task Team Report on Black Academics⁶⁶, provide valuable guidance.

⁵³ AOSP, AmeliCA, cOAlition S, OA2020 and SciELO, "São Paulo Statement on Open Access: Joint Declaration", 2019, <https://www.nrf.ac.za/media-room/news/s%C3%A3o-paulo-statement-open-access>

⁵⁴ AOSP Project Advisory Council, "The Future of Science and Science of the Future: Vision and Strategy for the African Open Science Platform v02," 2018, <https://zenodo.org/record/2222418#.YGdTBK8zY2w>

⁵⁵ ASSAf, 2019, <http://dx.doi.org/10.17159/assaf.2019/0047>

⁵⁶ National Development Plan, 2011, <https://www.gov.za/documents/national-development-plan-vision-2030>

⁵⁷ White Paper on STI, 2019, <https://www.gov.za/documents/white-paper-science-technology-and-innovation-1-mar-2019-0000>

⁵⁸ NICIS Framework, 2014, https://www.dst.gov.za/images/NICIS_Framework_Report_December_2013_26_May_2014.pdf

⁵⁹ Parliament note on 4IR Opportunities and Threats, 2019, https://cdn.lqseta.co.za/resources/research_and_reports/4IR%20Resources/4IR_Opportunities%20and%20Threats_Parliament%20of%20South%20Africa.pdf

⁶⁰ NRF Statement on Open Access to Research Publications, 2015, <https://www.nrf.ac.za/sites/default/files/documents/NRF%20Open%20Access%20Statement.pdf>

⁶¹ ASSAf, <https://www.assaf.org.za/index.php/programmes/scholarly-publishing-programme>

⁶² ASSAf, "Twelve Years Later", 2019, <http://research.assaf.org.za/handle/20.500.11911/114>

⁶³ Joint Final Statement of the SA-EU Dialogue on OS, 2018, https://www.dialoguefacility.org/joint_sa_eu_dialogue_on_open_source_science.pdf

⁶⁴ SA-EU OS Dialogue Report, 2018, <https://zenodo.org/record/2559469#.YGgp068zY2w>

⁶⁵ Science Engagement Strategy, https://www.dst.gov.za/images/Science_Engagement_Strategy_-_SES.pdf

⁶⁶ DHET Report of the Ministerial Task Team on the recruitment, retention and progression of Black South African academics, https://www.dst.gov.za/images/2020/02/Report_MTT_RRP_of_Black_Academics_web_final1.pdf

Legislative provisions, and respective regulators, are relevant. These include, but are not limited to, the Protection of Personal Information Act (POPIA)⁶⁷ (No. 4 of 2013) and the Information Regulator, the Intellectual Property Rights Act (No. 51 of 2008)⁶⁸ and the National Intellectual Property Management Office, and the Copyright Act No. 98 of 1978 as amended⁶⁹. POPIA gives effect to the constitutional right to privacy, balanced with the constitutional values of democracy and openness, and the need for economic and social progress, within the framework of the information society, which require the removal of unnecessary impediments to the free flow of information, including personal information. The Information Regulator (SA) is empowered to monitor and enforce compliance by public and private bodies.

Open Science provides an enabling environment for researchers in Indigenous Knowledge Systems, and the principle of ‘as open as possible, as closed as necessary’ is vital in the prevention of exploitation of indigenous knowledge, as informed by the Indigenous Knowledge Act (No. 6 of 2019)⁷⁰.

The existing policy and legislative framework that informs the implementation of this National Open Science Policy is set out in Annexure A. Through an appropriate stakeholder engagement process, this framework may be extended, whilst certain regulatory and policy provisions may need to be revised due to unforeseen challenges that may arise as a result of implementation of this policy.

7. Problem Statement

Competitiveness of the overall South African science and research system depends on understanding and implementing the new research paradigms. Reviews by the National Advisory Council on Innovation show declining global competitiveness of South Africa in innovation⁷¹. South Africans need science and innovation that lead to a better quality of life and a globally inclusive economy. In parallel, Open Science has become a global movement that is transforming, for the better, the practice of research and

⁶⁷ Protection of Personal Information Act (POPIA) No 4 of 2013, <https://www.gov.za/documents/protection-personal-information-act>

⁶⁸ Intellectual Property Rights from Publicly Financed Research and Development Act No. 51 of 2008, <https://www.gov.za/documents/intellectual-property-rights-publicly-financed-research-and-development-act-regulations-1>

⁶⁹ Copyright Act No. 98 of 1978 as amended, <https://www.gov.za/documents/copyright-act-16-apr-2015-0942>

⁷⁰ Protection, Promotion, Development and Management of Indigenous Knowledge Act No. 6 of 2019, https://www.gov.za/sites/default/files/gcis_document/201908/4264719-8act6of2019protectpromodevelopmanagementindigenouknowledgeact.pdf

⁷¹ From 2018 to 2019, SA moved from rank 48 of 127 countries to 51 of 129 in innovation inputs, from 65 to 68 in innovation outputs, and from 46 of 140 countries in innovation ecosystem to 50 of 141. The number of scientific publications per million of population was 371 in 2017 and 360 in 2018. South African Science Technology and Innovation Indicators Report 2020, <http://www.naci.org.za/index.php/south-african-science-technology-and-innovation-indicators-report-2019-2/>

development, and particularly publicly funded research and development. A coherent national approach will provide a common sense of direction on Open Science.

There is urgent need for change in access to research publications. In a report published by ASSAf on research publishing in, and from, South Africa⁷², key emerging risks were highlighted. Large disparities exist in access to, and usage of, research publications and core databases across higher education institutions and research performing South African organisations. The current cost to South Africa is dependent on factors outside institutions. An increase of over 300% was seen in annual subscription fees over the last two decades⁷³. A well-considered move from an institutional approach towards a national approach, and from pay-to-read to pay-to-publish, is indicated and should be based on an evidence-based projection of new cost structures into the future.

Research cyberinfrastructure for Open Science is in its infancy in South Africa, and significant investment is required in order for its full potential and catalyzing effect to be realised.

Transition towards an open research culture requires an enabling environment with appropriate support mechanisms in place⁷⁴, as this could result in transformation of the way in which science is conducted.

A clear legislative framework is needed, which sets rules for disclosure of data and other research inputs and outputs for public good, ensuring equitable access across the research enterprise (particularly from historically disadvantaged institutions), while protecting personal information, vulnerable people, South African resources, commercial interests, safety, national security and the economy.

8. Accelerating Progress toward Open Science: Seven Policy Intents of Open Science

8.1. Introduction

The National Open Science Policy proposes seven policy intents, set out in the following subsections.

8.2. Seven Policy Intents for Open Science

⁷² Academy of Science of South Africa, "Twelve Years Later: Second ASSAf Report on Research Publishing in and from South Africa (2018)," 2019, <http://research.assaf.org.za/handle/20.500.11911/114>

⁷³ Data from 2014 and 2015 indicates that library subscription costs for journal access were of the order R500 million per annum.

⁷⁴ The UNESCO Recommendation on Open Science ([Online], Available: <https://www.unesco.org/en/natural-sciences/open-science>) recommends:

- i. Development of a common understanding of Open Science benefits and challenges, values and principles;
- ii. Fostering of a culture of Open Science;
- iii. Re-development of current incentives to align with Open Science objectives; and
- iv. Promotion of multi-stakeholder cooperation in reducing digital, technological and knowledge gaps.

8.2.1. Policy and Regulatory Changes

The establishment of a National Open Science Policy is expected to be confronted by the historical *status quo*, codified not only within the communities of practice but also within legislative, regulatory and policy provisions. Government is of the view that its implementation, however, will enhance the work of the national science system – making it more effective in enabling a better quality of life for all.

8.2.1.1. Copyright and Intellectual Property

The South African Copyright Act (No. 98 of 1978), as amended, defines copyright, protects economic and moral rights, and enforces protection against infringement of copyright. Its scope covers such things as software and literary works, and includes data stored on computers. A Copyright Amendment Bill is under consideration⁷⁵ which remedies the gaps in the existing Act concerning the digital space, and has provisions for Open Access, Open Science and Open Educational Resources, persons with disabilities, use, and digitisation and preservation of collections.

The Intellectual Property Rights (IPR) Act (No. 51 of 2008)⁷⁶, makes provision that intellectual property emanating from publicly financed research and development is identified, protected, utilised, and commercialised for the benefit of South Africa. Databases, or collections of data, fall within the scope of the IPR Act⁷⁷ and are therefore likely to be viewed as potential Intellectual Property (IP), requiring declaration to the National Intellectual Property Management Office (NIPMO). Following evaluation of a disclosure, researchers may publish their research findings for the public good⁷⁸.

The implementation of a National Open Science Policy shall follow the principle ‘as open as possible, as closed as necessary’, which will necessitate appropriate licensing conditions for project specific outputs. There is a balance to be found, case by case, between Open Science licensing and IP licensing, Open Science licensing and copyright should be used in South Africa when it is appropriate that use of the results of research is without cost to the user. IP licensing should be considered when income should be generated for further research, but access to outputs can be opened when licensing is in place. With the fiscal constraints anticipated in the coming years, the choice is a serious one.

There is a strong need to reconsider South African copyright, IP law and regulation in terms of an Open Science-friendly environment. Elements including clarification of use and fair dealing, and unlocking the

⁷⁵ https://www.gov.za/sites/default/files/gcis_document/201811/copyright-amendment-bill-b13b-2017.pdf

⁷⁶ Intellectual Property Rights from Publicly Financed Research and Development Act No. 51, 2008

⁷⁷ NIPMO Interpretation Note 7: Are Data Intellectual Property In Terms Of The Intellectual Property Rights From Publicly Financed Research And Development Act?, 31 August 2018 https://nipmo.dst.gov.za/uploads/files/NIN7_Are-data-IP_Final_31-Aug18.pdf

⁷⁸ If IP is not protected and exploited, reasons must be evaluated, and a decision taken, by NIPMO.

pathway for Open Science publication, should be established within the relevant policy and regulatory provisions as an accepted alternative to IP exploitation. International law and treaties must be respected.

8.2.2.Open Access

Open Access is a set of principles and a range of practices through which research output⁷⁹ is available immediately online, free of cost or other access barriers⁸⁰ whilst retaining author rights. Such barriers are becoming more prevalent in South Africa, where research libraries and innovation systems are facing unsustainable cost escalations for journal subscriptions, licenses and publishing costs – establishing barriers to readership and publication. These cost escalations come at a time when South Africa is succeeding in boosting national competitiveness through scientific publication, but also enduring external shocks, such as the COVID-19 pandemic, to the national fiscus.

Within a South African context, Open Access is a vehicle for universal access to, and democratization of, knowledge. It establishes a new paradigm to keep access to research output available to the NSI. Such an enabling environment facilitates access to research output across all researchers, institutions and companies, regardless of race, gender and geographic location, and will serve to drive scientific progress with faster routes to impact and foster innovation for inclusive development. Care is needed in implementation⁸¹.

The principle ‘as open as possible, as closed as necessary’ is fundamental for implementation of an Open Access principle, and key considerations would need to be made in respect of intellectual property protection prior to publishing. In addition, Open Access has no future or meaning without an evolution of research evaluation systems, but well-intentioned systems are likely to fail unless meaningful pilot testing is applied.

To ensure an Open Access model that makes publicly funded scientific research publications open to all researchers, institutions, and companies for consultation, online, free of cost or other access barriers, and ensures a continued sustainable implementation that is viable for all stakeholders, the following should be applied:

⁷⁹ “Output” in the Open Access context refers to articles and literature, which may include supporting information and supporting data submitted to a journal or publisher.

⁸⁰ “Free of cost” means no payment for access to users with an internet connection, whilst “access barriers” refers to licensing or copyright barriers.

⁸¹ Cole et al., 2022, <https://zenodo.org/record/6276753#.YjRDjOpBw2w>

1. Subject to the guiding principle of ‘as open as possible, as closed as necessary’⁸², and requirements of co-funding agencies, including international funders, Open Access shall be required⁸³ for publications arising from publicly funded research, and desirable for research from all sources of funding⁸⁴.
2. A national Open Science Forum shall be established, through which the promotion and development of best practice in national systems shall be facilitated for the fostering of Open Access and the supporting of research culture change. Such a forum shall be used to facilitate ongoing dialogue with all relevant stakeholders⁸⁵ and consider the diversity of the South African scholarly community. In view of the rapid development of the field, the Forum will provide advice to the Open Science Advisory Board, including but not be restricted to benefits, risks, cost and best practices⁸⁶.
3. An Open Access Code of Conduct shall be approved by the OSAB for incorporation into, or reference by, universities, institutions, learned societies, professional bodies, editors and publishers. Publication of conference proceedings in Open Access form, for example, is encouraged as it assists students.
4. Incentive schemes shall be adopted at a national level to encourage Open Access publication.
5. Paywalls, such as Article Processing Charges, may continue to limit the ability of authors to publish and readers to read, and contribute to inequities. The OSAB will consider and advise on a national scheme that provides publication funding and resources that are sustainable and robust, and fast, effective and equitable to enable both authorship and readership. Such a scheme should not compromise research funds or research time.

8.2.3. Open Data

‘Open Data’ refers to data⁸⁷ that anyone can freely access, use and share, subject, at most, to requirements that preserve provenance and openness⁸⁸ – characteristics which, when described and implemented

⁸² The decision on whether to publish through Open Access channels should come after the decision on whether to seek protection of Intellectual Property. Where output is confidential, metadata should be made available in a manner that does not compromise the confidentiality of the output.

⁸³ Mandatory requirements may be made subject to discipline specific publication requirements that are informed by the research practices of a specific research community. In such cases, the implementations of Open Access should not materially affect the perceived credibility, by the research community, of the research output or researcher.

⁸⁴ Where possible copyright should be retained by the author(s). License to share and re-use with attribution to the original author(s) should be provided, based on machine-readable, standardised licenses such as Creative Commons <https://creativecommons.org/licenses/>

⁸⁵ Stakeholders must include industry to facilitate co-creation

⁸⁶ Since the Forum provides the space for debate and advice, topics may include the justification for ‘as open as possible, as closed as necessary’, the interaction between Intellectual Property Rights and Open Science, etc.

⁸⁷ Inclusive of meta data and, where appropriate and relevant, code and algorithms

⁸⁸ [Opendefinition.org](https://opendefinition.org)

correctly, ensure interoperability of diverse datasets that represent an untapped and substantial value-adding proposition to the national research enterprise. Internationally, Open Data has been recognised as being a catalyst for, amongst other things:

- Enhanced performance and efficiency of public services as a result of cross-sector sharing of data and evidence-based strategic decision support
- Economic growth through open innovation, innovative services and business models based on ease of access to information, content, knowledge and realisation of data equity in 'Big Data'
- Social welfare and public perception of transparency due to enhanced collaboration, participation and social innovation as a result of greater transparency and accessibility to information
- Research enterprise, where Open Data can be utilised in unpredictable ways.

The publicly funded generation and acquisition of data that can potentially be made Open, consistent with the needs and requirements of Open Science, not only takes place within the research environment of universities, research organisations, national research facilities and science councils, but also government departments and agencies. Transparent utilization and exploitation of this data will maximize the potential benefits across the four areas identified above.

Integrating publicly funded data into a FAIR framework (Findable, Accessible, Inter-operable, Re-usable) is a necessary condition to ensure the effective implementation of an Open Science system in South Africa, and requires well-resourced data stewardship competencies. To ensure South Africa is able to derive maximum benefit from the provision and exploitation of Open Data, as a key principle is the establishment of an Open Science framework:

1. By a date to be determined by the Open Science Advisory Board (OSAB), all publicly funded granting agencies, institutions and government departments shall require Data Management Plans for all approved publicly funded research. Plans, for which budget shall be specifically allocated towards implementation, shall include details as to how acquired and generated data shall be integrated into a FAIR framework and be consistent with standards to be published by the Department of Science and Innovation (DSI) from time to time.
2. By a date to be determined by the OSAB, a national agency shall be identified and appropriately resourced to:
 - a. Designate appropriately resourced public entities to serve as curators and stewards of valuable⁸⁹ publicly funded research data,

⁸⁹ The term 'valuable' shall be defined by the OSAB, and is intended to include criteria that would initially limit the scope of data curated and stored to what is feasible and useful. Such limitation can be gradually adjusted to align with available funding and

- b. Serve as a long term curator and steward of all valuable publicly funded research data that is not already curated by designated public entities,
 - c. Serve as the oversight agency for designated public entities, and shall facilitate common access to all valuable publicly funded research data curated by designated public entities.
 - d. Serve a primary archiving function for valuable publicly funded research data not hosted elsewhere within the boundaries of South Africa, or a full mirroring function where such data is hosted by other public entities,
 - e. Advise the DSI, through the OSAB, of relevant standards⁹⁰ to be published as may be necessary to implement the requirements of FAIR and an Open Data framework.
 - f. Develop appropriate tools to facilitate access to open data repositories.
3. Consult with relevant stakeholders through the Open Science Forum (established under Open Access above)

8.2.4. Education and Skills

Open Science implies a new approach to research, development, and innovation, whose implementation should be supported by system-wide education and engagement that embeds a culture of Open Science at institutional and national level. Whilst awareness of Open Science practice is present in academic communities, fostered by agencies such as the National Research Foundation and the Academy of Science of South Africa, contribution to the Open Science system is not significantly encouraged by incentives or evaluation practices at present.

Two relevant Open Science normative principles are, firstly, that Open Science is a cultural and behavioural phenomenon – it must be embedded at every level and in every aspect of the scientific endeavor, and should enhance current research practice. Secondly, all relevant stakeholders must actively promote Open Science amongst their respective communities, and regularly and openly monitor and report on progress.

To ensure public understanding, awareness, and capacity in dealing with a data- and information-intensive world, including the creation of a learning culture, engagement and training, and human resource development for the effective implementation of all aspects of Open Science:

resources that would need to be in place to support implementation of this National Open Science Policy. Differentiation between data, and meta data, can be accommodated to facilitate the publication of broad meta datasets together with demand-driven publication of full datasets.

⁹⁰ Such standards should include, but not be limited to, data security and methods to ensure data provenance.

1. The OSAB shall approve a Human Resource Development Strategy, which shall set out, *inter alia*⁹¹, a framework for the training of Open Science practitioners, and promote regional and international collaboration on training and engagement⁹². Targeted training shall fit the needs of:
 - a. Librarians, Open Science and online training specialists⁹³
 - b. Open Data and Open Access specialists⁹⁴
 - c. Practitioners involved in monitoring and evaluation
 - d. Managers of research infrastructure and data governors.

The development of the Human Resource Development Strategy shall be informed by extensive consultation with key research leaders and stakeholders across the research community and communities of practice. The OSAB should encourage investment in, or partnership with, existing entities⁹⁵ to enable them to sustainably scale up their teaching provisions.

2. The key objectives of the Human Resource Development Strategy shall be to:
 - a. Establish an Open Science culture within the broader research community, whilst understanding stakeholder perspectives across authors, researchers and users in academia and industry, and communities of practice;
 - b. Ensure equitable human resource development, education, training and engagement across higher education and public research institutions, particularly Historically Disadvantaged Institutions, to enable them to take full advantage of Open Science, and ensure the provision of resources that enable university and research institute libraries to perform as sufficiently robust structures to locally enable the full range of systems and services required for a fully functioning Open Science system;
 - c. Ensure the resourcing and development of Open Science e-learning platforms as key enablers for all stakeholders, and in particular for the public and Citizen Scientists engaged in publicly funded projects;

⁹¹ The strategy shall also deal with Open Science metrics, research integrity, codes of conduct, monitoring and evaluation, and rewards and incentives.

⁹² For example, ensuring mutual benefit from the Human Resource Development program of the African Open Science Platform: Academy of Science of South Africa, "African Open Science Platform - Landscape Study," SA Dept. of Science and Technology, National Research Foundation, 2019.

⁹³ Including but not limited to ICT staff at all levels, and help desk personnel and advisors.

⁹⁴ Including but not limited to data curators, analysts, engineers; cloud computing specialists and network designers, national research and education network (NREN) specialists; Open Science computational tool specialists and Open Software specialists; Information Specialists/Librarians and IT publishers for Repositories and Open Science Observatories.

⁹⁵ Including those mentioned in the Introduction such as CODATA, AOSP and SciELO

- d. Encourage the codification and adoption of best practice within the scholarly publishing industry⁹⁶ to support Open Science;
 - e. Encourage alignment across the Open Science Human Resource Development strategies of public funding agencies;
 - f. Foster the qualifications required in government departments to ensure that government officials are part of the culture, and ensure sufficient resourcing of designated public entities in respect of human resource development, education and engagement, and infrastructure,
 - g. Encourage the adoption of Open Science, and in particular Citizen Science, within the Basic Education curriculum, and
 - h. Promote innovative approaches for Open Science at different stages of the scientific process.
3. The OSAB shall approve an Open Science Communication Strategy, the implementation of which shall promote awareness and training across business and industry, whilst international and multi-stakeholder cooperation should be fostered to reduce digital gaps and knowledge gaps.

8.2.5.Rewards and Incentives

The absence of incentives for participation in Open Science-supportive activities is often presented as an important contributor to lack of progress in embracing of open science practices, particularly since traditional methods for recognition and assessment of scientific output emphasize impact factor over openness (these are not necessarily mutually exclusive). In addition, traditional mechanisms for measurement of research impact do not adequately reflect current publication and dissemination practice. The San Francisco Declaration on Research Assessment⁹⁷ (DORA) redefines the way quality and impact of research outputs are assessed, recommending a move away from emphasis on journal reputations and impact factors. In some fields, journals with high impact factors are often not Open Access. Several South African institutions and individuals are among the DORA signatories. The DORA recommendations should form the basis for redefining measuring research outputs at all South African institutions and funding agencies, which should incentivize the use of open access journals for publication.

Rewards and incentives should apply to both scientists making their outputs open, as well to those who encourage and enable this, such as funders and policy makers. For those who make their scientific outputs open, the incentives include enhancing the quality of their research, maximizing the value and potential impact of their work, fostering scientific cooperation, and stimulating collaborative research. Additionally,

⁹⁶ Including publishers of both journals and scholastic books.

⁹⁷ <https://sfedora.org/read/> [Online]

those who make use of and derive value from these open outputs also benefit from access to novel data without the need for their own funding to generate the data. Funders benefit from added value derived from outputs and potentially from innovation gained from data generation they have funded⁹⁸.

Rewards and incentives are core mechanisms that have historically been available to funders to steer the science and innovation system. It is important to recognise that this mechanism will remain within an Open Science system. Existing frameworks such as publication subsidy system, implemented by the Department of Higher Education and Training, remain a critical lever towards cultural change within the research enterprise.

To provide rewards and incentives for scientists to embrace open science and ensure optimal use and reuse of research data that is financed from public funding, we recommend the following:

1. Agencies and institutions responsible for funding research shall provide ready access to online tools for the assignment of Digital Object Identifiers (DOIs) to datasets, and for data sharing;
2. Agencies and institutions responsible for monitoring, evaluation and assessment of research outputs shall enhance their academic assessment frameworks to consider:
 - a. Inclusion of reports on open science activities, at a researcher, institutional and departmental level, as well as their impact (with metrics to be determined),
 - b. Inclusion of open access, open data and open materials citations, and
 - c. Inclusion of alternative channels for publication of research outputs, as may be relevant.
3. Agencies and institutions responsible for implementing processes of incentives and recognition for researchers and research outputs shall enhance their reward and recognition frameworks to recognise, and reward, researchers and institutions that have successfully adopted and implemented the underlying principles of this National Open Science Policy. It must be noted that some researchers may be constrained by the principle 'as open as possible, as closed as necessary'. These researchers should not be penalized.
4. Agencies and institutions responsible for the funding of research shall ensure appropriate funding and support for data curation and data submission to public repositories, and appropriate human resource training and skills development.

⁹⁸ The balance achieved in respect of benefit sharing can vary. An example is the Nagoya protocol (<https://www.cbd.int/abs/text/>) on access and benefit sharing, which was developed to promote fair and equitable use of, and sharing of, the benefits arising from the use of, genetic resources from biological diversity data. It is an international legal agreement that came into being in October 2014, but has gained more recent interest with the idea of extension to other genomic data. The protocol brings a new incentive to data sharing if benefits can be accrued back to the original communities from which the data were derived. It does, however, impose constraints on the use of data, as it is not completely open to any independent reuse.

5. Encouragement of private sector funding for open science projects through appropriate tax incentives.

8.2.6. Open Science Infrastructure

Current developments and capabilities in information and communication technology have created an enabling environment for Open Science, and the realisation of data equity in the vast amounts of data being generated on an ongoing basis in our 'Big Data' world. The provision of open science infrastructure forms the backbone of a system of Open Science, and enable the means of collaborative, multi-disciplinary and data intensive research that has become the third basic tool of the contemporary research enterprise, along with theory and experimentation.

The provision of, and accessibility to, open science infrastructure within a governance structure that enables implementation of Open Data is therefore essential in realising the objectives of Open Science, open innovation, catalyzing the research endeavor and realising data equity. It plays an important role in long-term data curation and stewardship. Ensuring the removal of barriers to entry, from both a data and computing access as well as usability perspective, is critical to maximize and broaden the scope of socio-economic impact of the research endeavor within the Open Science system. Infrastructure funding and planning must be based on sustainability: a not-for-profit long-term vision with long term practices, services, infrastructures and funding models on a robust federated basis, with responsibility by the scientific community for custodianship.

To ensure accessible and usable open science infrastructure that provides an enabling environment for Open Science in South Africa:

1. By a date to be determined by the OSAB, a plan for the establishment and operation of a federated open science infrastructure⁹⁹ for research outputs shall have been developed by the OSAB and approved by the Department. The National Integrated Cyber Infrastructure System (NICIS) shall be the implementation entity coordinating the development of this plan.
2. The OSAB shall advise the DSI on standards and policy recommendations to be adopted by all publicly funded open science infrastructures necessary to create an enabling environment for Open Science across the South African research enterprise. The enabling environment shall exhibit the characteristics of inter-operability and enable the simple and open sharing of data and meta-data between systems, disciplines and research collaborators.

⁹⁹ Defined to include, but not be limited to, compute and storage hardware and software

3. The DSI shall ensure provision of funding to enable adequate availability, accessibility and usability of data infrastructure for research outputs that creates an enabling environment for Open Science. The provision of the infrastructure shall include relevant technical support, tools and software that enable data intensive research within an Open Science environment.
4. By a date to be determined by the OSAB, all publicly funded open science infrastructures shall have put in place Data Management Plans to ensure long-term data curation and stewardship of hosted Open Data in accordance with standards that may be published by the DSI from time to time.

Connectivity remains a critical success factor in ensuring the accessibility and exploitation of open science infrastructures. This requires inter-departmental intervention to ensure the necessary transformation. Disparity in access to, and usage of scientific publications across institutions (particularly Historically Disadvantaged Institutions) must be actively addressed to enable a coherent and integrated Open Science system, focusing on the following key factors:

1. Reliable and freely accessible broadband internet connectivity at publicly funded research performing organisations;
2. Safety of researchers, especially women, utilizing research facilities and resources through appropriate institutional sexual harassment policy;
3. Reliable, and low-cost broadband internet connectivity for researchers, students, and citizen scientists that are undertaking research temporarily, or permanently, at home. Mechanisms should be actively explored that would realise the implementation of 'last kilometer connectivity', such as the District Development Model.

Interventions in this regard should build onto existing initiatives and infrastructures that have been put in place, such as the NICIS¹⁰⁰, and the South African National Research Network (SANReN).

8.2.7.Citizen Science

It is important that citizens have the opportunity to play an active role in science – referred to as Citizen Science - and the Open Science policy provides for such active participation. Citizen science describes the active participation of the public in scientific research, where people contribute to data collection and monitoring towards a common goal. The public collaborates with professional scientists, by generating

¹⁰⁰ <https://nicis.ac.za/>

experimental data and developing and addressing new scientific questions. Citizen science can be carried out by individuals or teams, often on a voluntary basis as it is seen as a contribution to society. This provides a way for scientists to achieve different goals that would be too costly or time consuming to do or fund on their own. Mobile phone apps and other technologies empower ordinary citizens to collect and process data on a large scale. As we move towards an era characterised by a more technologically connected society concerned with the legitimacy of public and private entities and their practices, it is important to not only recognise the potential scientific opportunities that arise from active citizen involvement in the research enterprise, but also to recognise the critical importance of ensuring this active participation. Such participation not only increases public transparency of the scientific endeavour, but establishes a sense of legitimacy within the public discourse (commonly referred to as a 'social license to operate').

Citizen science provides an excellent opportunity for making science more inclusive, transparent and accessible – an important aspect towards positively contributing towards legitimacy of public investment in the research endeavor. However, there are quality and ethical considerations in citizen science. Scientists in academic institutions have oversight and accountability to their institutions and ethics boards, to which citizen scientists are not accountable. There is a need to consider what the risks and benefits may be in citizen science and to consider what kind of ethics review and oversight is required for citizen science. With multiple participants contributing data, maintaining consistency and high standards in measurements or experimental data generation may be challenging. There are some formal citizen-science organizations to support this endeavour and provide oversight. Recently many such organizations worldwide joined forces to form the Citizen Science Global Partnership, which has as one of its aims to see how citizen science can contribute to monitoring progress towards the UN's Sustainable Development Goals. Other efforts that facilitate "people-powered research" include Zooniverse (<https://www.zooniverse.org/>), which provides a platform for volunteers to contribute to scientific projects, thus harnessing the power of crowds to improve the speed and accuracy of research.

Citizen scientists benefit from open science as it increases the visibility and impact of their work. Therefore, citizen science should, in theory, embrace open science, but some fields, such as biodiversity research, have found that some datasets produced by volunteers are even more restricted in their use than other datasets. This may be because the decision about data sharing is not in the hands of the citizen scientists. Therefore, incentives for open science for citizen science should be targeted at the participants, citizen science organizations as well as those leading the science. The South African Council for Natural Scientific Professions (SACNASP) has released a formal statement on citizen science, recognizing the importance of the contributions of citizen scientists to furthering knowledge. While many citizen scientists do not meet

the criteria for registration with SACNASP, their work is usually guided by professional scientists who are eligible for registration¹⁰¹ or at least are employed in an academic role by an institution.

To facilitate and support the growth of a vibrant and active citizen science enterprise, the following is recommended:

1. Establish an independent Centre for Citizen Science, whose mandate shall include:
 - a. Funding and promotion of research collaboration between professional scientists and the public, which may include the development of, or promoting the use of existing, appropriate platforms¹⁰² to facilitate collaboration
 - b. Foster relations between science, society and industry to accelerate innovation and promote Citizen Science, providing guidelines on how citizens can get involved. This could be done through building relationships with statutory and non-statutory professional bodies.
 - c. Embed Open Science in society, encouraging scientists and society to become more responsive to societal and economic expectations by fostering a stronger relation between science and society
 - d. Provide access to scientific information¹⁰³ for community members to answer real-world questions.
2. Ensure appropriate mechanisms are put in place to provide for scientific and ethical oversight of citizen science. Require that Citizen Scientists involved in a publicly funded project are under the supervision of a Professional Scientist¹⁰⁴.
3. Include Citizen Science within the Basic Education curriculum.
4. Develop a mechanism to measure the contribution and impact of Citizen Science on South Africa's scientific output. Consider ring-fencing a percentage of public-funded research and development budget to projects with a Citizen Science component proportional to the relative impact and outputs.

9. Implementation: Resources, Roles, Responsibilities and Governance

9.1. Critical Success Factors

¹⁰¹ <https://www.sacnasp.org.za/news/2021/sacnasp-statement-on-citizen-science>

¹⁰² For example, <https://www.zooniverse.org/>

¹⁰³ For example, <https://www.zooniverse.org/>

¹⁰⁴ Professional Scientists are registered under the Natural Scientific Professions Act 27 of 2003, <https://www.gov.za/documents/natural-scientific-professions-act-0> ; statement at <https://www.sacnasp.org.za/news/2021/sacnasp-statement-on-citizen-science>

Cognisance should be taken of key critical success factors that are identified to ensure an effective and coherent implementation of this National Open Science Policy.

1. Universal Access - In the national context, Open Science is first and foremost about universal access to, and the democratisation of, knowledge¹⁰⁵. District and local internet coverage must be improved, whilst online training for citizens is critical.
2. Trusted Security – Effective utilization of the National Open Science system is dependent on the perceived maintenance and implementation of security standards of repositories. In this regard, this includes the security eco-system, consisting of policy, process, skilled people, as well as hardware and software. Absence of the highest standard of security makes a gift of South African research to malicious actors. The security of data and the potential abuse of data must be addressed¹⁰⁶.
3. Cognisance of Publishing Realities – In many disciplines, publication practice is globally determined. The perceived international credibility of research publications, and authors, is ultimately dependent on the journal platforms utilised. The National Open Science policy must not, in its enthusiasm, ‘kill the goose that lays the golden eggs’¹⁰⁷ by penalising disciplines that are nevertheless making impact. In some cases (and discipline specific), timescales for implementation must be informed by the global community.
4. Legislation –
 - Appropriate balance needs to be achieved between Open Science and Intellectual Property rights, and other relevant legislation in a rapidly evolving legislative landscape. To mitigate these risks, the principle that Open Science shall be ‘as open as possible, as closed as necessary’ is central and shall be firmly established.
 - A trusted and accountable IPR environment in South Africa is a key to the success of Open Science.
5. Sustainability - Open Science must be sustainable, in the sense of able to be maintained for an extended time as well as being defensible and legitimate for all stakeholders. The following are critical factors to consider in ensuring sustainability:

¹⁰⁵ The National Broadband Policy, and Connect2030, are key policy intervention that, if implemented, are enabling factors to extending true Open Science access.

¹⁰⁶ A high standard of international certification is recommended, such as such as CoreTrustSeal <https://www.coretrustseal.org/>

¹⁰⁷ In astronomy, for example, the reality is that a handful of journals are trusted and publications outside these journals are regarded as having lower impact. None of these journals is Open Access at present – although one journal has recently announced adoption of an Open Access model - but all reach specialised audiences. Their transition to Open Access is globally determined.

- Ensuring a well-considered, systems-wide feasibility study (including risk analysis) that provides a projection of intended and unintended costs and benefits, the financial survival of South African-based scholarly journals and societies; the changing economy¹⁰⁸; escalating costs, and the probable development of novel paywalls and embargoes.
 - Testing and feasibility studies should be carried out to expose unintended consequences.
 - Before transformative agreements are negotiated, validated figures for current spend should be reviewed, noting trends in inequities among institutions.
 - Barriers to readership must not be replaced with barriers to authorship. A scheme for covering Article Processing Charges at no cost to the author must be put in place for the success of Open Science in South Africa. A transition process must be designed to provide a bridge for authors and readers between current publication subscription or licensing practices, and APCs and/or deals with publishers.
 - Non-commercial publishing models with no Article Processing Charges or book processing charges, run through government or collaborative models, should be supported.
 - Continued risk analysis and mitigation throughout implementation, which should be monitored by the Open Science Observatory.
 - Inclusion of Open Science as part of institutional budgeting across the system, which should provision for advising and supporting researchers.
 - Utilisation of existing strategic assets, agencies¹⁰⁹, and resources.
 - Governance measures must include protection against predatory behaviours, existing and evolving.
 - Duplication and data pollution will be avoided.
6. Stakeholder Engagement – A research community that sees the Open Science project as legitimate with a value proposition that benefits the research enterprise. Established through ongoing stakeholder engagement, culture will beat compliance in implementation.
 7. Change Management - a Change Management Plan for transition is required, involving the most experienced people. Iterative testing and designing of the Implementation Plan¹¹⁰ should be undertaken before it is considered for acceptance. Unforeseen consequences will be investigated before implementation to ensure that the implementation does not drive circumventions or stop good work, that the transaction costs for researchers are low, and the components of the policy and plan are internally compatible with each other.

¹⁰⁸ Including, for example, exchange rates

¹⁰⁹ Examples are NICIS, SANREN, SciELO; addition of OA status to DHET list; training with CODATA

¹¹⁰ SA-EU Open Science Dialog Report, <https://zenodo.org/record/2559469#.YTkLs50zY2w>

8. Global Compatibility - Compatibility and interoperability with the Africa Open Science Platform is sought¹¹¹ in order to minimise the risk of building a system that is not interoperable or globally compatible. The South African voice in global coalitions and alliances must be maintained.
9. Consistent Inter-departmental policy - A success factor for this policy is the ability to implement consistent policy across departments¹¹².

9.2. Governance

Appropriate governance structures are required to ensure that proper oversight is maintained over the implementation of this Open Science policy.

In order to provide key oversight of the implementation of the Open Science Policy, the DSI shall establish the Open Science Advisory Board (OSAB) with Terms of Reference. It shall have, as participants, key stakeholders across the national system of innovation.

9.3. Resources, Stakeholders and Responsibilities

The OSAB shall approve an Open Science Implementation Plan on timescales to be determined by the DSI, and which shall address *inter alia* stakeholders, risks, resources, incentives and compliance. The development of the Open Science Implementation Plan shall include engagement of identified stakeholders, as may be relevant. Key stakeholders shall include, but not be limited to:

- Government Departments
- Publicly funded research organisations, including Universities, and their respective libraries
- Research community
- Repositories, Registries and Data Centres
- Publishing Industry, publishers and editors
- Science Academies, and Scholarly Societies
- Private Sector
- NGOs and Civil Society Coalitions
- Research funders.

¹¹¹ AOSP Project Advisory Council, <https://zenodo.org/record/2222418#.YTkLQ50zY2w>

¹¹² Examples are PAIA and POPI.

It is expected that execution of the Open Science Policy will encounter a variety of risks. An appropriate incentives and compliance framework shall be adopted, tailored to relevant stakeholder groups and typical Open Science impediments.

10. Monitoring and Evaluation

Establishment of an appropriate monitoring and evaluation framework will be critical to monitor the effectiveness of the Open Science policy in South Africa – not only from an implementation perspective, but the achievement of envisaged outcomes. Metrics monitoring the success of Open Science are emerging. In the case of Open Access, for example, these are based on data from the Web of Science¹¹³, Unpaywall¹¹⁴ and the Leiden Ranking¹¹⁵.

The OSAB shall approve the establishment of a South African Open Science Observatory, which shall be resourced by the Department of Science and Innovation and shall make available to stakeholders appropriate online tools for the monitoring and evaluation of the implementation, and outcomes, of Open Science in South Africa. In order to ensure efficient utilisation and coordination of public resources, establishment of the Open Science Observatory shall take into consideration the existence of other entities that have similar functional scope. Opportunities for coordination of processes, and sharing of resources, between the Open Science Observatory and other entities such as the National Policy Data Observatory¹¹⁶ shall be explored and implemented, as appropriate.

The Open Science Observatory is intended to produce a meaningful dashboard of indicators, analytics and visualizations (including graphs and reports) that help interested stakeholders (policy makers, research funders and research administrators among others) better understand the Open Science landscape in SA. The Observatory will: (i) provide timely and reliable insights on the evolution of open science in SA and assist in promoting good practices; and (ii) support monitoring and evaluation, and consequently the enhancing of open science uptake across different dimensions of open science as underscored in this National Open Science Policy, revealing weaknesses, challenges, strengths and potential that needs to be acted on.

¹¹³ <https://mjl.clarivate.com/home>

¹¹⁴ <https://unpaywall.org/>

¹¹⁵ <https://www.leidenranking.com/>

¹¹⁶ The NPDO was created to track socio-economic and health impacts from COVID-19, track policy responses, and support decision-making. It will continue to support relevant government departments in science-led decision making and early warning systems related to exposure to hazards or disasters including climate change, etc., to take action to avoid or reduce risk and prepare for effective policy and societal response.

The monitoring of Open Science shall be explicitly kept under public oversight, including the scientific community, and whenever possible supported by open non-proprietary and transparent infrastructures. This monitoring aspect could include, but should not be delegated to, the private sector. In this regard, the OSAB shall approve an Open Science Monitoring and Evaluation framework, to be implemented through the South African Open Science Observatory, which shall enable the OSAB to provide effective oversight of Open Science outcomes in South Africa through appropriate quantitative and qualitative metrics¹¹⁷ and tools¹¹⁸. This framework shall adhere to the principles of the National Evaluation Policy Framework¹¹⁹ under the custodianship of the Department of Planning, Monitoring and Evaluation. The South African Open Science Observatory shall ensure its monitoring and evaluation approach is informed by international best practice¹²⁰. Metrics shall address, amongst others, delivery of the South African Open Science system against the key identified outcomes:

- Open Access
- Open Data
- Open Source
- Open Resources
- Open Methods
- Open Review

The South African Open Science Observatory shall continuously monitor its efficacy and relevance, and shall be informed by best practice of open science observatories as established internationally. The effectiveness of the Open Science system is critically dependent on its research participants. Open Science should provide an equally enabling environment for career development and advancement of researchers as compared to existing evaluation systems. It is likely that a hybrid model of evaluation, taking into account both traditional measures of academic output, as well as those relevant for participation within the Open Science system, will need to exist for some time – at least on the timescales required for the broader research community to adopt an Open Science framework. Organisations and institutions that carry out such evaluation shall develop and adopt appropriate evaluation systems that take into account the wide breadth of missions within the research enterprise, and do not unreasonably disadvantage individual

¹¹⁷ The determination of such metrics shall include consideration of alternative, non-traditional metrics

¹¹⁸ For example:

COKI Open Access Dashboard, <https://openknowledge.community/dashboards/coki-open-access-dashboard/>

Open DOAR, <https://v2.sherpa.ac.uk/opensoar/about.html>

OpenData Barometer, https://opendatabarometer.org/?_year=2017&indicator=ODB

¹¹⁹ <https://www.dpme.gov.za/keyfocusareas/evaluationsSite/Evaluations/National%20Policy%20framework%20Nov%202019.pdf>

¹²⁰ This may be informed by, amongst others, the San Francisco Declaration on Research Assessment, <https://sfورا.org/read/>

researchers within their community of practice. In doing so, organisations shall consider the adoption of next-generation metrics for open science evaluation¹²¹.

11. Conclusion

The global community is embracing open science, as the benefits to society are evident and far outweigh the potential risks. Therefore, it is essential that South Africa follows suit to ensure that maximum benefit is derived from all publicly funded research. All citizens have the right to responsible access to the scientific data and other resources through an open science ecosystem created with safeguards in place to ensure ethical use of these resources. This policy was designed to promote, facilitate and enable open science, taking into account existing policies, practices and legislation, and being cognizant of protecting privacy and consent. The desired outcome is a change in scientific culture and practice to increase the reach of those who benefit from science.

¹²¹ See, for example: "Next-generation metrics: Responsible metrics and evaluation for open science", Report of the European Commission Expert Group on Altmetrics, 2017, doi:10.2777/337729

Annexure A: Relevant Legislation and Policy

National Policy
NDP National Development Plan https://www.gov.za/issues/national-development-plan-2030
Ten-Year Innovation Plan for Science and Technology https://www.gov.za/documents/ten-year-plan-science-and-technology
IPAP Industrial Policy Action Plan https://www.gov.za/sites/default/files/gcis_document/201805/industrial-policy-action-plan.pdf
National Legislation and Regulations: High Relevance
IPR Intellectual Property Rights from Publicly Financed Research and Development (IPR) Act, 2008 (Act 51 of 2008): Provides for the more effective use of intellectual property emanating from publicly financed research and development https://www.gov.za/documents/intellectual-property-rights-publicly-financed-research-and-development-act-regulations-1
Copyright Copyright Act No. 98 of 1978 as amended, https://www.gov.za/documents/copyright-act-16-apr-2015-0942 Copyright Amendment Bill https://www.gov.za/sites/default/files/gcis_document/201811/copyright-amendment-bill-b13b-2017.pdf
POPIA Protection of Personal Information Act (POPIA) No 4 of 2013, https://www.gov.za/documents/protection-personal-information-act Guidance note to develop codes of conduct (issued under POPIA) https://www.justice.gov.za/infocreg/docs/InfoRegSA-Guidelines-DevelopCodeOfConduct-22Feb2021.pdf
Electronic Communications Act, 2005 (Act 36 of 2005) https://www.gov.za/sites/default/files/gcis_document/201409/a36-050.pdf
National Archives and Records Service of South Africa Act 43 of 1996 http://www.dac.gov.za/sites/default/files/Legislations%20Files/act43-96.pdf
Electronic Communications and Transactions Act (ECT Act) 25 of 2002 https://www.gov.za/sites/default/files/gcis_document/201409/a25-02.pdf
Protection of Information Act 84 of 1982 (PI Act) https://www.gov.za/sites/default/files/gcis_document/201503/act-84-1982.pdf Protection of State Information Bill (POSI) https://www.gov.za/sites/default/files/gcis_document/201409/b6e-201015oct2013.pdf Due to be enacted in 2021.
National Legislation and Regulations: Medium Relevance
Cryptography Regulations (GN R216 of 2006 in Government Gazette 28594 of 10 March 2006) http://www.internet.org.za/CryptoRegslatest.pdf
Cybercrimes Act 19 of 2020 http://pmg-assets.s3-website-eu-west-1.amazonaws.com/NA_bills2017_bill06B-2017.pdf

Technology Innovation Act, 2008 (Act 26 of 2008) https://www.gov.za/documents/technology-innovation-agency-act
Films and Publications Act 65 of 1996 https://www.fpb.org.za/wp-content/uploads/2016/08/films-and-publications-act-no-65.pdf
Promotion of Access to Information Act 2 of 2000 (PAIA) https://www.gov.za/sites/default/files/gcis_document/201409/a2-000.pdf
Patents Act 57 of 1978 https://www.jpo.go.jp/e/system/laws/gaikoku/document/index/south_africa-e_patents_act.pdf
State Information Technology Agency Act (SITA Act) 88 of 1998 https://www.gov.za/sites/default/files/gcis_document/201409/a88-98.pdf
Policy (Published and Draft)
White Paper White Paper on STI, 2019, https://www.gov.za/documents/white-paper-science-technology-and-innovation-1-mar-2019-0000
National Cybersecurity Policy Framework (NCPF) https://www.gov.za/sites/default/files/gcis_document/201512/39475gon609.pdf
Draft National Policy on Data and Cloud https://www.gov.za/sites/default/files/gcis_document/201512/39475gon609.pdf
National Integrated ICT Policy https://www.gov.za/sites/default/files/gcis_document/201610/40325gon1212.pdf
National Research and Development Strategy https://www.gov.za/documents/national-research-and-development-strategy-south-africa
Ten-Year Innovation Plan for Science and Technology https://www.gov.za/documents/ten-year-plan-science-and-technology
Big Data NICIS Framework, 2014, https://www.dst.gov.za/images/NICIS_Framework_Report_December_2013_26_May_2014.pdf
Parliament note on 4IR Opportunities and Threats, 2019, https://cdn.lgseta.co.za/resources/research_and_reports/4IR%20Resources/4IR_Opportunities%20and%20Threats_Parliament%20of%20South%20Africa.pdf
Science Engagement Strategy, https://www.dst.gov.za/images/Science_Engagement_Strategy_-_SES.pdf DHET Report of the Ministerial Task Team on the recruitment, retention and progression of Black South African academics, https://www.dst.gov.za/images/2020/02/Report_MTT_RRP_of_Black_Academics_web_final1.pdf

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