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Open Science and Policy Interface: The Tanzania Perspective

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Abstract

The 21st century has seen a paradigm shift in scholarly communication, with digital technology changing the entire process of the scholarly communication lifecycle. As the cost of online reference materials for research continues to rise and restrictive conditions persist, global academic and research communities are pursuing countermeasures to make knowledge equitable and accessible. This is made possible through the Open Science (OS) movement that aims to make knowledge accessible to researchers and citizens irrespective of their technical or financial capability. This paper explores open science to ascertain the status of open science practices in Tanzania. The paper highlights the policy interfaces and frameworks that favor open science practices in research endeavors. Also, it provides a baseline for understanding the situation to inform scientific research and education communities about the status of open science and possible areas of intervention. Open science is still in its infancy, although certain steps have been taken in adopting it for example the adoption of open access practices, including the creation of institutional repositories and the adoption of policies that direct its implementation. Additionally, the implementation of open data practices has been quite slow. Also, researchers and organizations in Tanzania are gradually adopting open data practices. Currently, some academic institutions, particularly public universities, have adopted and used open journal publishing systems, particularly the online journal system (OJS). The published journal articles through journal systems are freely accessible online like other open-access content, however, the journals are not yet registered in the Directory of Open Access Journals (DOAJ) despite the fact that some are already indexed in different abstracting services such as Africa Journal Online (AJOL) and they have Digital Object Identifiers (DOI). The policy interface of open science needs to be harmonized and COSTECH is strategically positioned to take the lead. The scientific community in Tanzania is aware of open science through frequent collaboration and interaction with other scientists abroad and therefore they are used to compliance with the funder's policy mandate that binds them to the contracts they sign in their proposals. This is a good sign that the scientific community in Tanzania is ready for the take-off.

Keywords: *open science, open access, open data, policy, Tanzania*

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Introduction

The beginning of the 21st century has witnessed a paradigm shift in scholarly communication from the practice of knowledge creation, publishing, and dissemination. Digital technology has changed the whole process of scholarly communication life cycle leading to a system that

has created both opportunities and challenges. As the cost of online reference materials for research continues to rise coupled with stringent restrictive conditions, so are the global academic and research communities increasingly pursuing countermeasures to mitigate the situation by making knowledge equitable and accessible through mechanisms that enhance unrestricted sharing, utilization, and collaboration. The effort by academics and researchers to make knowledge accessible to as many researchers and citizens irrespective of their technical or financial capability as well as minimizing or removing copyright or licensing constraints in accessing research is collectively named "Open Science" (OS). Around the world, the open science movement is gaining momentum as a result the value of openness in the ecosystem of scientific research has been acknowledged in order to foster collaborative efforts to address regional and international problems.

Open science is a movement that emerged due to the changing landscape of scholarly publishing in the late 1990s. Open science is an umbrella term that represents a movement initiated by the academic and research community that encompasses new ways and approaches in all stages of scholarly communication (from knowledge creation, collection, publishing, preservation, and dissemination) aiming at minimizing or removing the barriers of access to knowledge by making the process inclusive, equitable and transparent.

According to (UNESCO, 2021), open science refers to "a set of principles and practices that aim to make scientific research from all fields accessible to everyone for the benefit of scientists and society as a whole". Therefore, the purpose of open science is to ensure that not only scientific knowledge is accessible but also that the production of that knowledge itself is inclusive, equitable, and sustainable".

This paper explores open science to ascertain the status of open science practices in Tanzania. The paper highlights the policy interfaces and frameworks that favor open science practices in research endeavors. Also, it provides a baseline for understanding the situation to inform scientific research and education communities about the status of open science and possible areas of intervention.

An Overview of Open Science

With the advent of digital technology, there has been an increase in research accessibility, public access to research, ensuring equal distribution of research, creating alternative methods for assessing the research impact, creating mechanisms to foster greater research collaboration, and infrastructure for the collection, preservation, and sharing of research materials (Fecher & Friesike, 2014). The international research community has made several attempts to promote the adoption of open science. The United Nations Educational, Scientific and Cultural Organization (UNESCO) highlights the open science building blocks that include open access, open infrastructure, open data, open hardware, open sources, open laboratories, open innovation, open evaluation, open notebook, open education resources (OERs), citizen science, and crowdfunding (UNESCO, 2021). All of these work to lower or mitigate the obstacles related to sharing and access to research by creating facilitating conditions for knowledge creation, publishing, and dissemination (Okafor *et al.,* 2022).

The open science movement was preceded by open-access initiatives which to a large extent paved the way for its development. The open access declarations also referred to as the "three B's declarations, the Budapest Open Access Initiative (BOAI), the Bethesda Statement on Open Access Publishing, and the Berlin Open Access Declaration triggered a global open-access initiative. The Budapest Open Access Initiative (BOAI) was declared in Dec. 2001. which came up with the statement "*To achieve open access to scholarly journal literature, we recommend two complementary strategies, first Self-Archiving and second Open–Access Journals . . . "* (BOAI, 2001). This is where the gold open access publishing and green open access were recommended. Whereas, the Bethesda Statement on Open Access Publishing that took place in June 2003, declared strategies on how to *". to stimulate discussion. on how to proceed, as rapidly as possible, to the widely held goal of providing open access to the primary scientific literature."* (Brown *et*

al., 2003). *During* the Berlin Declaration that took place in Oct. 2003, a conference of major European funders of sciences and humanities said "Our mission of disseminating knowledge is only half complete if the information is not made widely and readily available to society. New possibilities of knowledge dissemination not only through the classical form but also and increasingly through the open access paradigm via the Internet have to be supported." (Harnad, 2005).

The open-access movement was backed up by several institutional, and academic associations, funding agencies, and national initiatives. The initiatives include the Glasgow Declaration on Libraries, Information Services and Intellectual Freedom, approved by IFLA in March 2002, which stated; "IFLA proclaims the fundamental right of human beings both to access and to express information without restriction." (Prize, 2003) The Association of College and Research Libraries (ACRL) highlighted on the principles and strategies for the reform of scholarly communication that was approved in June 2003, "The ACRL Scholarly Communications Initiative," supported several principles and strategies that favor open science practices (ACRL, 2023).

The Wellcome Trust position statement in October 2003, by a U.K.-based independent research-funding charity came up with the statement that supports unrestricted access to published research. "…in support of open and unrestricted access to published research." (Wellcome Trust, 2021). The Organization for Economic Co-operation and Development Declaration (OECD) in, Jan. 2004 issued a statement on access to research data; "Ministers recognized that fostering broader, open access to and wide use of research data will enhance the quality and productivity of science systems worldwide." (OCED, 2004). Furthermore, IFLA Statement issued in Feb. 2004 on Open Access to Scholarly Literature and Research Documentation that IFLA "is committed to ensuring the widest possible access to information for all peoples in accordance with the principles expressed in the Glasgow Declaration of Libraries, Information Services and Intellectual Freedom." (IFLA, 2003).

Implementation of open access practice wouldn't take place without policies and guidelines, some institutions such as the National Institute of Health (NIH) came up with a policy statement on enhancing public access to archived publications resulting from NIH-funded research in May 2005. It "requests and strongly encourages all investigators to make their NIH-funded peer-reviewed, author's final manuscript available to other researchers and the public through the NIH National Library of Medicine's (NLM) PubMed Central (PMC) immediately after the final date of journal publication." (NIH, 2005). Likewise, in June 2005, the Research Council UK (RCUK) also proposed a policy on access to research outputs. Therefore, these are organizational and national mandated that directly support open science development internationally.

Scientists have witnessed the emergence of new terms in scientific research such as science 2.0, Digital humanities, science, or Open Research all of which represent what we call today the "Open Science" (Fecher & Friesike, 2014). The terms are sometimes used interchangeably when referring to the current scholarly communication reform. (Fecher and Friesike, 2014a) further differentiate Science 2.0 and Open Science; Science 2.0 "refers to all scientific culture, scientific communication, which employs features enabled by Web 2.0 and the Internet (in contrast to Science 1.0 which represents a scientific culture that does not take advantage of the Internet)". On the other hand, Open Science refers to a scientific culture that is characterized by its openness and transparency in the research lifecycle. In open science, Scientists share results almost immediately and with a very wide audience. Science 2.0 is sometimes referred to as science communication, a situation where the scientist communicates with the general public in a language that is simple for them to understand. This is to say, science communication is part of open science as it facilitates the dissemination of knowledge to the citizens in an unrestricted manner. Therefore, these and other related initiatives paved the way to ensure the take-off of the open science movement.

Benefits of Open Science

The knowledge economy is propelled by research, and growth and wealth are sparked by ideas, information, and innovation. The results of research, including reports, articles, and data, must be used to strengthen the national economy. Therefore, for rigor and reproducibility to be verified and the results to be trusted, it is equally crucial that the research methodologies used are subject to scrutiny regarding their objectivity and scientific suitability. On top of that, there are several other benefits of open science that include accelerating the pace of the discovery (Woelfle *et al.,* 2011), Promoting scholarly rigor and reproducibility (Susanin *et al.,* 2022), improving the quality and scope of scientific outputs (Stracke, 2020), enhancing collaboration and inclusivity (UNESCO, 2021), promoting scientific engagement and literacy for the public (Fecher & Friesike, 2014), increasing the economic and social impact of research (Armeni *et al.,* 2021), providing new opportunities for innovation "The public interest is almost invariably best served by the widest possible dissemination of scientific results as a means of stimulating innovation across society" (Boulton *et al.,* 2020), and improving the efficiency of research – minimizing duplication (Besançon *et al.,* 2021). "Some of the associated advantages are promoting collaboration, sharing and reproducibility in research, and preventing the reinvention of the wheel, thus saving resources" (Mwangi *et al.,* 2021).

Why open science and why now?

"The advancement of scientific research and raising the next-generation scientists in Africa depend largely on science access" (Okafor *et al.,* 2022). The research practice that open science has fostered is currently impacting all aspects of handling research, particularly the way it is designed, performed, collected, and assessed (Vicente-Saez and Martinez-Fuentes, 2018). The motivation behind the rise of open research is the conviction that it will accelerate the ability to address complicated and widespread global issues including poverty, climate change, environmental pollution, health crises, and humanitarian crises, among others. These challenges can be easily resolved if scientists share knowledge openly and work collaboratively and collectively. Also, Open science intends to speed up the process of achieving Sustainable Development Goals by minimizing or mitigating inequalities in accessing research, technology, and innovation (UNESCO, 2021). The practice of research that is inclusive, transparent, and collaborative is subject to effective peer review allowing verifiability and reproducibility of the knowledge produced resulting in high-quality research, trustworthiness, and impacts on society (Armeni *et al.,* 2021).

One of the fundamental features of open science is unhindered access to scientific research, access to articles funded through public funds, and research collaboration (Leen, 2015). Most scientific research projects are funded by government and donors, For example, in 2019, the European Union (EC) committed Euro 137.5 million for research and development (Prudêncio and Costa, 2020). The fund was set to come up with solutions during the Covid-19 pandemic. In order for the advantages of research to be felt by all citizens, it is currently a good practice for the research outputs resulting from publicly financed research projects to be communicated through media that are openly and freely accessible. Due to this, several funding organizations, both national and international, have recently established open-access rules that require grantees to share their results on publicly available platforms, particularly open-access journals and repositories. The Registry of Open Access Repositories Mandate Policies (ROARMAP) registers open access mandates from funder and research organizations that comply with research-sharing practices (Wesolek and Royster, 2016), 2016).

Like funders who require their financed research projects to publicly disclose their findings as a prerequisite of their funding, the impact of research output has to be felt by the citizens, therefore, openness and transparency for research results emanating from public funds are inevitable.

Literature Review

In the past ten years, there has been an increase in literature both scholarly and non-scholarly

about open science. Currently, there are many studies, projects, and initiatives that are geared toward promoting open science at different levels. The empirical support for studies on open science coming from least-developed nations, especially from Africa, is, nevertheless, insufficient. A study conducted in Kenya says "there is scanty research on the state of affairs regarding the practice and/or adoption of open science" (Mwangi *et al.,* 2021).

Online resources were consulted in order to research the state of open science on a national and international scale.

Open Science Initiatives at the regional and global levels

In order to make open science a reality, as was previously mentioned, numerous attempts have been made. The need to embrace open science as a new culture of conducting research is felt by many as a result this movement is increasingly becoming popular among scholars worldwide (Chiware and Skelly, 2022). The developed countries including the USA, UK, Canada, and other international organizations such as the European Union and UNESCO have shown strong evidence of supporting the development of open science in various aspects such as laying down the necessary infrastructure for implementation of open research practices, formulating open science policy frameworks, and financing.

In its 39th General Conference session held in 2017, UNESCO came up with a recommendation that recognizes the significant value of science as a common good among other issues (UNESCO, 2021). The recommendation calls for a continued effort by researchers, academic institutions, research funders, governments, and other stakeholders to embrace open science a new phenomenon in scientific inquiry, publishing, and dissemination that seeks to make the process of scientific research more transparent through collaborative networks and accessible media (Vicente-Saez and Martinez-Fuentes, 2018). Adoption of open science practices is based on the assumption that it will advance knowledge generation, and innovation and speed up socio-economic development (UNESCO, 2021). It is increasingly accepted by the knowledge society that removing the barriers of sharing knowledge and cooperation among researchers provides a pathway for understanding and resolving challenges that face the global towards achieving sustainable development (Luo, 2021). "It is high time that research universities embrace open science across their activities to expedite the achievement of the UN's Sustainable Development Goals" (Leen, 2015).

The "European Union has chosen Open Science as the way to do science and research based on its cultural and social values" (Miedema, 2022), UNESCO, recognizes open science as an initiative that fosters transparency, openness, and inclusiveness due to the fact that research output is put into the public domain or assigned open licenses that allow access, re-use and sharing (UNESCO, 2021). Therefore, making the process of knowledge creation, publishing, and dissemination more transparent to the scientific community and the general public depicts the future of science practices.

"In 2013, the White House Office of Science and Technology Policy (OSTP) recommended that articles based on research using public funds must be deposited into the public domain upon journal acceptance" (Sawalha *et al.,* 2023). In early 2023 the US-White House Office of Science and Technology Policy (OSTP) launched Open Science initiatives that advance national OS policies across the federal government along with strategies for funding, improving research infrastructure, widening opportunities for early career researchers, and public engagement (OSTP, 2023). The statement was issued by the White House titled "Biden-Harris Administration Announces New Actions to Advance Open and Equitable Research". This shows that while open science is widely practiced in developed nations, little is known about its adoption in Africa.

There is a gradual development of open science initiatives in Africa aimed at developing and implementing open science practices including formulation of OS policy frameworks. The development is evident in South Africa, Botswana, Kenya, Ghana, Ethiopia, Cote d'Ivoire

and Mozambique. For example; in February 2022, the government of South Africa came up with an open science policy draft. The policy requires all publicly funded research conducted in South Africa to be published in open-access journals. Mandates OA for publicly funded research processes and outputs, including data acquired or generated by public funds. Proposes the establishment of a "national forum" to promote best practices in open science and incentives for researchers to publish OA, in open-access journals (van der Merwe, 2022).

Furthermore, the Open Science policy draft initiated by the South African Department of Science and Innovation (DSI) requires an Open Data policy that provides equal opportunity for all in terms of discovery and dissemination of data and metadata by complying with Findable, Accessible, Interoperable, and Reusable (FAIR) principles (Hey, 2022). "Ethiopia is the first to have produced a national Open Access policy framework" (Chiware and Skelly, 2022). The government of Ethiopia adopted a National Open Access policy in 2019, that mandates open access to all publicly-funded research including published journal articles, thesis and dissertations, and research data. These few examples of open science policy initiatives in Africa indicate little is known about open science practices in Africa.

Adoption of Open Science in Tanzania

The adoption of OS in Tanzania is demonstrated by a number of projects exhibited largely by the emergence of Institutional Repositories initiatives in 2012. The awareness creation on establishment and managing Institutional Repositories began in 2009 at the University of Dar es Salaam (UDSM). Some staff from the UDSM library championed the move by conducting and sensitization librarians and information professionals through training workshops on creating and managing Institutional Repositories through support from the International Network for Availability Scientific Publications (INASPs). Parallel to this, in 2011, the UDSM library with funding from Electronic Information for Library (EIFL) organized a technical workshop for systems librarians and IT personnel working in libraries that brought together participants from East Africa to share experiences and learn about Free and Open Source Software (FOSS) that support open access initiatives. The regional FOSS workshop intended to empower system librarians and IT personnel on deploying and maintaining FOSS that supports open access practices including repository software such as Dspace, eprints, and Greenstone. Furthermore, they learned about Journal management software such as the Online Journal System (OJS) which is fundamentally meant to facilitate open-access publishing.

To date, there are 17 Institutional Repositories from Tanzania that are registered in the Registry of Open Access Repositories https://v2.sherpa.ac.uk/opendoar/, these include the following:

i. College of Business Education - Institutional Repository http://www.dspace.cbe.ac.tz:8080/xmlui/
ii. Digital Library of the Tanzania Health Community http://ihi.eprints.org/
iii. East African Community Repository http://repository.eac.int/
iv. IAA Digital Repository http://repository.iaa.ac.tz:8080/xmlui/
v. MUHAS Institutional Repository http://dspace.muhas.ac.tz:8080/xmlui/
vi. Mario Mgulunde Learning Resource Centre Repository http://41.93.80.3:8080/jspui/
vii. Moshi Co-operative University Institutional Repository http://repository.mocu.ac.tz
viii. Mzumbe University Scholar Repository http://scholar.mzumbe.ac.tz/
ix. NM-AIST Repository http://dspace.nm-aist.ac.tz/
x. SUZA Repository http://repository.suza.ac.tz:8080/xmlui/

xi. Sokoine University of Agriculture Institutional Repository https://www.suaire.sua.ac.tz
xii. TACAIDS Digital Repository http://library.tacaids.go.tz
xiii. TUDARCo-Institutional Repository http://repository.tudarco.ac.tz
xiv. Tanzania Climate Change Information Repository (TaCCIRe) https://www.taccire.sua.ac.tz
xv. The Open University of Tanzania Institutional Repository http://repository.out.ac.tz
xvi. University of Dar es Salaam http://repository.udsm.ac.tz:8080/xmlui/
xvii. University of Dodoma Institutional Repository http://repository.udom.ac.tz/

However, it is evident that some institutions are operating repositories that are not yet registered in any registry of open access repositories for example the repository of abstracts of theses managed by the University of Dar es Salaam Library accessible at https://libraryrepository.udsm.ac.tz/, The Institute of Finance Management repository http://dspace.ifm.ac.tz:8080/xmlui/. These and several other repositories are not registered due to different reasons including lack of compliance with the requirements for being included in the registry such as insufficient content or lack of expertise with the managers of those repositories and other reasons.

Formulation of Institutional Repository Policies

The establishment of these repositories was followed by the formulation of repository policies. The IR policy formulation involved faculty members, librarians, and other stakeholders, the purpose was to ensure smooth implementation and sustainability. For example, In October 2011, the Sokoine University of Agriculture library conducted a consultative workshop that brought together faculty members, librarians, IT personnel, and other stakeholder to discuss an IR policy draft. The discussion went hand and hand with the formulation of an IR policy for managing a joint repository https://www.taccire.sua.ac.tz for collecting and preserving climate change-related content under the project Climate Change Impacts Adaptation and Mitigation (CCIAM). This was a joint project that was managed by five member institutions namely; the Sokoine University of Agriculture, the University of Dar es Salaam, the Tanzania Meteorological Agency, Ardhi University, and the University of Oslo. In developing IR policies, other institutions followed the same procedures such as the Muhimbili University of Health and Allied Sciences Library, Mzumbe University Library, Saint Augustine University of Tanzania-Mwanza, State University of Zanzibar, Nelson Mandela African Institute of Science and Technology, and the University of Dodoma. Out of 17 Institutional repositories, about fifty percent of them have functional policies. This is an area of investigation to discover the mode of guideline and procedure they use to operate they repositories.

Tanzania National repository

There have been efforts by the Commission of Science and Technology (COSTECH) to establish a national repository, http://repository.costech.or.tz/. The purpose of the repository is to harvest content from other institutional repositories in public and private academic and private institutions in Tanzania. However, one of the major hurdles is the lack of a standardized policy that mandates the functionality of the repository. A harmonized strategy for these repositories is required in order to effectively collect content emanating from research both published and unpublished in a single database, hence a call for a coordinated effort to come up with a policy framework at the national level.

Open Journal Systems

Researchers in Tanzania have witnessed the establishment of online systems for managing and publishing local journals through the use of Open Journal Systems (OJS) The following are some examples:

- UDSM Journal system https://journals.udsm.ac.tz/index.php/tjs,
- Tanzania Journal of Science (TJS) https://tjs.udsm.ac.tz/index.php/tjs

- Tanzania Journal of Engineering and Technology https://tjet.udsm.ac.tz/index.php/tjet/index,
- Tanzania Veterinary Journal https://tvj2.sua.ac.tz/vet2/index.php/TVJ/index
- MUHAS journal https://journal.muhas.ac.tz/
- Journal of Building and Land Management managed by Ardhi University http://journals.aru.ac.tz/index.php/JBLD/index
- Institute of Accountancy Arusha https://journals.iaa.ac.tz/

Most of these journals adopt and practice some features of open access publishing as they publish their articles in digital format, they are freely accessible online, and the journals are indexed in AJOL and elsewhere but they are not registered in the Directory of Open Access Journals (DOAJ). "DOAJ's mission is to increase the visibility, accessibility, reputation, usage, and impact of quality, peer-reviewed, open-access scholarly research journals globally, regardless of discipline, geography, or language." (DOAJ, 2023). The journals with a drive to adopt open access practice should assessed and registered in the Directory of Open Access Journals.

Open Data initiatives

Open data is among the new terms that came with open science initiatives. The empirical evidence obtained from a study that was conducted in Zimbabwe shows that 70% of respondents were not aware of Research Data Management practices despite the fact that the majority perceive sharing of data as one of the requirements for winning research grants (Chigwada, 2022). This is evidence that researchers are now complying with the open data mandate as a prerequisite for getting research grants. There have been several initiatives to create an open data repository in Tanzania.

The Ifakara Health Institute (IHI) Launched its data initiative to share health-related research data sets see https://data.ihi.or.tz/index.php/catalog/central/about#index.html. This is the first initiative in managing research data in Tanzania. In 2018, the College of Information and Communication Technology (CoICT) established Data Lab (dlab) https://dlab.or.tz/ that aims at promoting the use of data for the betterment of enhancing informed policies and decision-making in Tanzania (Ismail *et al.,* 2018). Data Lab was registered in 2018 as a nongovernmental organization in collaboration with Data Zetu and Dada for Local Impact Innovation (DLIIC).

Recently the United Republic of Tanzania has shown a good example by signing the Open Government Data (OGD) program that intends to collect and disseminate data generated by the government to researchers. Like other open data initiatives that seek to enhance openness and transparency, accountability, and citizen participation in various countries around the globe, the government of Tanzania has embarked on building an open data infrastructure for the purpose of sharing its data sets with its stakeholders (Shao, 2023). The government data sets are displayed through the following open data portal https://tanzania.opendataforafrica.org/. The data shared through the National Bureau of Statistics (NBS) through its website https://www.nbs.go.tz/index.php/en/ such as the census portal https://sensa.nbs.go.tz/ is one of the government's moves to ensure transparency.

As indicated above, there are limited initiatives for open data in Tanzania, this is attributed to the fact that this is a new phenomenon that needs to be sensitized to researchers. The government's move towards sharing multisectoral data such as education, water, economics, etc. is the right move towards open science adoption.

The above examples show evidence of the existence of open science practices in the country although it is still at an infant stage. However, all the efforts made seem to be driven by an individual institutional initiative that shows a lack of a nationally coordinated program that seeks to embrace open science.

The policy interfaces

The evolution of open science emerged on the brief that it will accelerate knowledge generation,

sharing, and utilization by policy-makers, hence it will speed up the socio-economic development of the society. Open science needs to be recognized as the vehicle for enhancing the diffusion of knowledge in the policy domain through the utilization of scientific results emanating from publicly funded research programs (Reichmann and Wieser, 2022). However, the recognition of the open science movement by the majority of the decision-makers in Tanzania is yet to be testified. It is anticipated that the majority of early adopters in the open science movement are researchers, academics, and students in universities and research institutions due to the fact that searching and retrieving scientific information is their day-to-day business. However, it is imperative to implement open science without a national or regional level policy as the adoption of OS practice will be realized if there are policies and guidelines at the national or regional level. Drawing examples of the practices from developed countries, the UK, the US, Canada, and other European countries, , they have created the necessary national OS policy frameworks to guide the implementation of OS practices(Chiware and Skelly, 2022).

In Tanzania, the interface between open science and policy is harmoniously not intertwined due to the fact that OS is still at the infancy stage, this is supported by different studies such as (Buhomoli and Muneja, 2020; 2022). This is a new term not only for citizens but also for the scientific community. Traditional research practices are guided by institutional and national policies and guidelines that control research procedures, protocol, and intellectual property rights to mention a few. There is a need to harmonize the interface of open science and the policies. Considering the fact that Open science has its own unique practices which is built on the assumption that scientific result is a public good and therefore the whole research life cycle should be conducted in an open, transparent, collaboratively and the results shared in media which do not impose restrictions on access. In open science, the ownership of knowledge belongs to the author of the research output, in most cases, publications and data which is not the case for traditional scholarly communication. Sharing research results in open science is done through unrestricted media such as institutional repositories, open-access journal systems, and scientific social media while the traditional system does not allow this. These and other examples demonstrate the difference between open science and the existing policy interfaces hence the need to harmonize them. Considering the benefits of open science as highlighted above, there is a need for dialogue among researchers and research institutions on harmonizing open science through policy formulation.

The development of the national Open science policy frameworks should be aligned over a notion that it will support the national and institutional goals in order to advance science and knowledge production and sharing." (Chiware and Skelly, 2022). Currently, there is no specific policy that provides guidelines for open science in Tanzania. However, some legal and policy frameworks could act as the cornerstone for developing national open science policy and regulations. These include Acts and legal mandates that are enacted to guide the business activities of some government agencies. For example; The Act establishing the Tanzania Commission for Science and Technology (COSTECH) mandates it to collect and disseminate research output produced by researchers in Tanzania (COSTECH Act of 1986). In this case, the commission is tasked to ensure that the knowledge produced locally reaches the scientific community and the general public in a convenient manner. Therefore, the adoption of open science practices and policies will ease the task of collecting and disseminating through its principles of openness transparency, and citizen engagement.

Furthermore, the rights of information-seeking dissemination and access are among the fundamental provisions of the United Republic of Tanzania (URT). This is also well expressed by the open science principles that emphasize transparency in research and knowledge sharing among scholars and citizens. The constitution of the United Republic of Tanzania Part III on Freedom of Expression Act No.1 of 2005 Article 6 number 18 b. express that "every person has a right to seek, receive and, or disseminate information regardless of national boundaries". In open science, there is greater transparency in

sharing not only the publications emanating from research but also all procedural undertakings during the research life cycle. Additionally, the Tanzania National Science and Technology Act,1996 emphasizes creating strategies for ensuring the dissemination and utilization of research findings both generated from within and outside the country (URT, 1996). The strategies may include but are not limited to creating platforms for disseminating research output such as digital repositories for sharing publications and data repositories for archiving and sharing research data. The strategies may also include other open science knowledge dissemination strategies.

The Tanzania Access to Information Act, 2016 is "an act to provide for access: to define the scope of information which the public has the right to access; to promote transparency and accountability of information holders; and to provide for other related matters" (URT, 2016). Part II of the act describes the right of access to information which is under the control of the information holder; "The information holder shall, subject to provision of section 6 and any other written laws, make available to the public or, on request to any person, information which is under his control". The primary right holder in the research environment is the knowledge creator (the author). other right holders may include institutions, funders, government agencies, or publishers. In open science, the right holder is the one who decides how should his/her work be used using open licenses such as Creative Commons.

Furthermore, "Tanzania is promoting an Open Data Policy as part of the Open Government Partnership, making data transparent, available, and accessible through online platforms" (Shao, 2023). The URT joined Open Government Partnership in 2011 with the support of its former president, J.M. Kikwete to promote open government initiatives to enhance openness and transparency of the government business through the sharing of government data and publications. This is why it established an open data portal portal. https://tanzania.opendataforafrica.org/ and the census portal https://sensa.nbs.go.tz/ through the initiatives by the National Bureau of Statistics (NBS) https://www.nbs.go.tz/index.php/en/. In September 2016, Tanzania hosted the first Africa Open Data Conference (AODC) and the following month the URT embarked on the drafting of an open data policy to guide the implementation of the government data (Buhomoli & Muneja, 2020; Mangilima, 2016). This indicates the URT's determination towards openness in sharing its data with researchers and citizens as a sign of supporting open science principles.

Conclusion

Open science is still at an infant stage in Tanzania however, some efforts have been made to adopt open access such as the establishment of institutional repositories and formulation of policies that guide their implementation. Also, there has been very limited adoption of open data practice. There is a gradual adoption of open data practices by researchers and institutions in Tanzania. Some academic institutions especially public universities are now using open journal publishing systems especially they use the online journal system (OJS). However, the published journal articles through these systems are accessible but the journals are yet to be registered in the Directory of Open Access Journals (DOAJ) despite the fact that some are already indexed in different abstracting services such as Africa Journal Online (AJOL) and they have Digital Object Identifiers (DOI). The policy interface of open science needs to be harmonized, and COSTECH is strategically positioned to take the lead. It should be noted that the scientific community in Tanzania is aware of open science through frequent collaboration and interaction with other scientists abroad and therefore they are used to compliance with the funder's policy mandate that binds them through the contracts they sign with their funders. This is a good sign that the scientific community in Tanzania is ready for the take-off.

General Recommendations

The adoption of open science in Tanzania will be realized by setting up plans, strategies, and policies from the institutional to the national level. The impact of open science goes far from individual to institution and society at large. As argued by Chiware & Skelly, (2022), "The development of national open science policy

frameworks can be guided by the principles that the policies should respond to and support national and institutional goals in order to advance science and knowledge production and sharing." Therefore, researchers and responsible government bodies need to entrench open science principles in their strategic plans.

A study on Knowledge and practices of open science among scholars and researchers in Tanzania by David *et al.,* (2022) highlighted the need to create awareness and build knowledge and skills on diverse open science practices, addressing concerns over data security and ownership, copyright infringement, via online resources and peer-to-peer learning. The study also recommends several areas for advocacy, including setting supportive institutional policies, building infrastructure to support open science practices, providing robust guidelines, institutional support and incentives for individuals to adopt open science practices, and integrating open science into undergraduate and postgraduate curricula so that scientists acquire current knowledge and skills. In the same vein, the study titled "Communication Channels and their Potential Applicability in Enhancing Agricultural Research Data Sharing among Agricultural Researchers in Tanzania" recommends that research institutions invest in generalized and specialized agriculture data repositories to strengthen data sharing among researchers. Institutions should recognize the role of libraries in facilitating data management and sharing. Strengthening the existing library infrastructures should go hand in hand with recruiting librarians and ICT technicians who would play a greater role in data management and facilitate data sharing among researchers. Institutional research guidelines and regulations should declare the formal channels for sharing research data.

The UNESCO Recommendation

Participation of Tanzania in the global open science movement can be realized by having a policy framework, based on the UNESCO Recommendation on Open Science – a framework for member states to develop their own national open science policy frameworks (UNESCO, 2021). The recommendations focus on the following:

Ensure an effective R&D system and its impact on socio-economic activities.

- Strategy 1: Ensure an effective national science policy with efficiency, impact, and openness as key elements.
    - Mandate open access (OA) to scientific publications (immediate OA, rights retention) and research data.
    - Mandate that all digital research outcomes (data, software, reports, methodologies) are FAIR (Findable, Accessible, Interoperable, and Reusable) and appropriately managed.
    - Support institutional open-access publishing initiatives.
    - Formulate guidelines for open science, and mainstream open science in existing national and institutional policies, strategies, and action plans, as well as into any policy addressing the management and/or governance of scientific knowledge, actors, and processes.
    - Enact coherent monitoring framework(s) for measurement of progress in meeting open science objectives and for assessing its impacts; use effective tools for monitoring compliance and enforcement of policy-recommended practices.
- Strategy 2: Upgrade research infrastructure (including digital infrastructure) Construct and upgrade a national digital infrastructure for research, including infrastructure for communications, computing, and data - National Research and Education Network (NREN)
- Strategy 3: Ensure that scientific institutions have adequately motivated and competent STI human resources who are incentivized to produce and share quality results for impact. Upgrade the professional staffing in STEM academic institutions including staff who can support the digital transition of

research (data scientists, data stewards and other specialists).

- Strategy 4: Mainstream open science to provide visibility for Tanzanian science and strengthen societal perceptions and multi-stakeholder participation in RDI
- Create a common understanding among researchers in Universities, Research institutions, and other stakeholders.

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