Libraries and Librarians in Open Science Adoption: A Reflection from Tanzania

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Abstract
The study aimed to establish the role of libraries and librarians in fostering open science adoption in Tanzania. The research objectives were to examine the roles of libraries and librarians in OS adoption; to determine the challenges OS adoption presents to libraries and subsequently, propose solutions. Structured questionnaires were employed for data collection from 113 librarians. The results show 81.1% librarians were familiar with Open Science, while 18.9% indicated otherwise. This finding signals the need for awareness creation, advocacy campaigns, training, and seminars not only to familiarise the librarians with the term OS but also to adopt it. The identified OS benefits include broadening access to scientific data and research publications (57.5%); promoting collaborative research through ICT tools (34.5%); enhancing public research consumer choices (31.9%); raising productivity under tight budgets (31%); and promoting citizens' trust in science (22.1%). Strategies for enhancing OS include institutional policies (66.4%), funding (57.5%), building requisite infrastructure (55.8%), and capacity-building (50.4%). The paper concludes that Tanzania needs open science to broaden access to scientific publications and data, considering the tight budgets allocated to subscriptions for paywall learning resources. Implicitly, libraries should adopt and invest more in the OS for better results despite the teething problems.

Keywords: *Open Science; adoption; libraries; librarians; Tanzania*

INTRODUCTION

Since time immemorial, libraries have served as pivotal social institutions as gateways to knowledge for the community (White, 2012). Indubitably, libraries serve as places for fostering interaction between humans and information. Libraries and librarians also act as bridges between different actors and stakeholders. Richard, Koufogiannakis, and Ryan (2009) asserted that an important tenet of librarianship is the ready, equal, and

equitable universal accessibility of information. Based on this tenet, modern libraries are built upon this foundation, which is also the essence of Open Science (OS). It tallies with Redkina (2022), who explains that traditionally, libraries aimed at supporting, presenting, and promoting the results of scientific research in a unified information ecosystem of knowledge. As a result, libraries collect, process, organise, and disseminate information to meet information users' needs (Ari, 2017). They also offer resources and services that create opportunities for learning, support literacy, and education in addition to helping to shape new ideas and perspectives central to bolstering creativity and innovation, hence guaranteeing access to knowledge (White, 2012).

The contemporary era of change has irreversibly altered the structure and how information is generated, processed, and accessed by the public. One of the factors accelerating such changes includes Open Science, or simply OS, which has globalised information through gateways. OS is an umbrella term based on the principle of openness and transparency of the whole research cycle, aimed at fostering sharing and collaboration in open access, open science infrastructure development, and open evaluation. According to UNESCO (2021), “open science” comprises four aspects: open scientific knowledge, open science infrastructures, open engagement of societal actors, and openness to knowledge diversity (Zarghan et al., 2023). Subsequently, OS has grown into a global strategy for solving the problem of accessibility to information by making scientific research from all fields available to everyone for the benefit of scientists and society as a whole (OECD, 2015; UNESCO, 2023; Zarghan et al, 2023). In other words, OS enhances the core functions and mission of the libraries that revolve around finding, collecting, organising, evaluating, disseminating, and preserving information (Tzanova, 2020).

Open practices entail open access to research publications, data sharing, open notebooks, transparency in research evaluation, open peer review, reproducibility of research, transparency in methods, open-source code, software, and infrastructure, citizen science, and open educational resources (Brinken, Mehlberg, & Heller, 2018). The OS practices strengthen and broaden the core functions of libraries and librarians in the globalisation of information. In such under these conditions, the emergence of open science has established a new global hub that facilitates the more reliable and open utilisation of scientific data, information, and outputs (open data) with active participation from all

pertinent stakeholders (open to Society).In terms of OS, its tenets centre on heightened research repeatability, accountability, cooperation, reuse, and transparency in addition to seeking to enhance the calibre and dependability of research by utilising ideas through sharing, inclusion, justice, and equity (Brinken, Mehlberg, Heller, 2018; Makoni, 2023; Zarghan et al, 2023).

Significantly, the roles of libraries and librarians cannot be ignored following the adoption of OS. In this regard, one of the responsibilities of trained professionals in the information sector is ensuring that their clients have access to various sources of information without any restrictions through collaborations and the sharing of information. Smith and Veldsman (2018) proffer that librarians ensure citizens and researchers have access to the much-needed quality and reliable information to advance research. Moreover, Li and Weunyn (2023) reaffirm the important roles libraries play in the cycle of information and knowledge generation, exchange, and dissemination through resource management, training, disciplinary support, and academic evaluation. However, the effective contribution of libraries and librarians in OS depends on the training available to engender its full utilisation. OS provides an opportunity for libraries and librarians to broaden the horizon of knowledge through affordable access to scientific research in all fields vital in harnessing innovations and spurring social development without restrictions. With an emphasis on reproducible, cycle-free, inclusive, and open research, OS aims to address the demands of the global community in the twenty-first century by promoting sharing and cooperation across the entire research cycle (Leonelli, 2023; Percic, 2021; Morais et al., 2021).

In the context of Tanzania, however, the main issue revolves around how libraries and librarians have responded to the OS adoption as a global movement, whose adoption has been gradual. David et al.'s (2022) study on knowledge and practices of OS among scholars and researchers in Tanzania has attested. In their study on awareness of open data among researchers in selected public universities in Tanzania, Buhomoli and Muneja (2022) found determinants of OS to include open data readiness among scholars based on their experience. Muneja (2023), on his part, looked at the OS and policy interface from the perspective of Tanzania. However, these relevant and informative recent studies paid little attention to the role of libraries and librarians in the adoption of OS. This

limitation justified the conducting of this study, which aims to explore the rich but unexplored field of libraries and librarians about the adoption of OS in Tanzania. Thus, local research must be done in this field rather than extrapolating results from studies conducted abroad to the Tanzanian context. In this regard, the following specific research objectives guided the research: (a) examining the role of libraries and librarians in OS adoption; (b) determining the challenges OS adoption presents to libraries and, subsequently, proposing solutions. To achieve these specific objectives, the study raised the following research questions: What is the role of libraries and librarians in the adoption of OS? And what are the challenges faced in OS adoption, and how can they be overcome?

LITERATURE REVIEW

Role of libraries and librarians on OS

Literature abounds with substantial evidence on the crucial role of libraries and librarians in open science adoption. For instance, Roche (2022a) asserted that libraries constitute a component of the shift in OS when it is occurring systematically and comprehensively; conversely, when it is not, the shift is slower and more restricted. It seems that the open scientific movement, in all of its manifestations, is changing the information landscape and pointing libraries in a positive direction. In the same manner, libraries have always been crucial in the cycle of knowledge creation, exchange, and distribution (Redkina, 2021). By the same token, libraries support Open Science through Open scholarship, open access, open data, open educational resources, and open-source software in preserving, curating, publishing, and information infrastructural development that allow researchers to share, use, and reuse research output (Cobblah, 2022). Another source of support is the advocacy and promotion of open science inside institutions that libraries and librarians undertake. In addition, they are working to increase faculty utilisation of open science resources, build capacity in open science, and support member institutions in setting up open journals and information retrieval systems. These activities are all part of their information literacy skill development for optimal use of open-access publications (Cobblah, 2022).

The studies by Li and Weunyn (2023), Tang and Hu (2019) found that, in the context of open science, libraries have redefined or expanded their role by reinventing themselves and expanding their traditional information services as well as their educational and mediation functions.

In general, libraries and librarians play important roles in OS by creating and advancing institutional research and knowledge transparency, advancing the creation of open scientific policies, and setting up and managing services and infrastructure (Pinfield & Cox, 2014; Tang & Hu, 2019; Wilson et al., 2019; OECD, 2015). The international community has also recognised the importance of libraries in open science, with the Association of Research Libraries (ARL) and the Canadian Association of Research Libraries (CARL) (2021) reaching a consensus on the role of research libraries in the research data ecosystem. Besides, the Organisation for Economic Co-operation and Development (OECD) aptly notes:

> Libraries have become active players in the preservation, curation, publication, and dissemination of digital scientific materials, in the form of publications, data, and other research-related content. As a result, libraries and repositories constitute the physical infrastructure that allows scientists to share, use, and reuse the outcomes of their work, and they have been essential in the creation of the Open Science movement (OECD, 2015).

Kennedy (2019) further describes research libraries as "catalytic leaders in a society in constant change," and that one of the new roles in an OS environment is for both librarians and users to engage in data science education. Meanwhile, Redkina (2021) mentions that organising open science seminars, workshops, conferences, and continuing education programmes by a library to raise awareness of open science concepts, terms, and models is necessary for promoting research results. Additionally, libraries actively participate in developing funding agency policies, data sharing principles, open science tools and resources, research data management, open science-compliant open access publishing skills, encouraging the use of digital infrastructures, and, ultimately, helping to implement the open science paradigm (Redkina, 2021).

Suri (2018), Ayris and Ignat (2018) reported that the involvement of libraries and librarians in OS takes the form of teaching, education support, promotion, advocacy, communication, liaison, and personal development. Moreover, as Glusker and Exner (2018) illustrate, librarians provide research support through "digitization, metadata creation, scholarly communications, and data management as well as providing specialized direction to these traditional skills." Additionally, libraries

have incorporated open science into their instructional programs as a subject for training researchers. OECD (2015) and Saarti (2020) postulate that the library has assumed a leading and active role in advocacy and training on OS issues within the university.

Furthermore, OS-related issues have been incorporated into the curriculum of library courses for both undergraduate and PhD students. Libraries and librarians also play an active role in educating the public about research support and open scientific services, which include publishing, research data management, and research metrics that advance open science, along with providing training and advice to researchers. In addition, librarians support open science communication through various channels such as committees, social media, websites, and more. They participate in developing open science strategies, infrastructure, and guidelines at both national and institutional levels, while also training and advising researchers and promoting the library's research support and open science services (Saarti et al., 2020). Conversely, studies by Bieraugel and Neill (2017) and Sewell and Kingsley (2017) indicate that libraries have the skills and expertise to assist researchers with their research needs. However, as Gema Bueno de la Fuente (2016) cautioned, for these roles to be effective, libraries must develop new processes and skills to support open science.

Ogungbeni et al. (2018), Ghosh (2009), and Roche (2022) affirm that libraries play a key role in promoting open science through advocacy, building institutional data repositories, and serving as hubs for scientific collaboration. They manage the life cycle of publications and data and publicize research work. Additionally, they raise awareness of researchers' work, facilitate and manage infrastructures and practices designed to advance Open Science, train trainers, teach library science, and integrate OS into the portfolio of institutional repositories. Other roles of librarians include locating, collecting, organizing, evaluating, and disseminating information, advocating, promoting open science/open access, and creating.

Giarlo (2005) emphasized the importance of libraries in promoting open science and open access through advocacy and dissemination. They should take the lead, viewing open access as their responsibility to make information easily reachable for those aiming to transform their lives, expand their knowledge, or foster innovation. Additionally, libraries and

librarians play crucial roles in designing specialized tutorials and providing refresher training in thematic workshops for researchers and academics, who need to develop new information skills under the OS movement (Sanches, 2019). Abdullah (2017) notes that libraries and librarians are responsible for digitizing their analogue collections, making them accessible online and in the public domain, managing digital libraries with open collections, providing valuable data openly, advocating for the benefits of open science, managing institutional repositories with open access content, and serving as hubs for scientific collaboration. Also, academic libraries are expected to enhance advocacy efforts and expand data repositories. They are increasingly involved in activities like promoting open science, building institutional data repositories, and serving as centers for collaboration.

Academic libraries continue to take steps to become key players in promoting open science through advocacy, developing institutional data repositories, and serving as centers for scientific collaboration, among other roles. Academic libraries must do more in advocacy and data provision. They are increasingly involved in advancing open science by engaging in advocacy, building institutional data repositories, and functioning as hubs for scientific collaboration. However, they still need to enhance their efforts in advocacy and data sharing.

Challenges libraries and librarians face in adopting OS

Despite the enormous potential that open science offers in the globalization of knowledge by making scientific outputs and processes open, transparent, and reproducible without restrictions, there are still challenges to achieving it. These include stable internet platforms, reliable electricity, high-performance computing centers, policies, guidelines, and a lack of awareness of the concept of open science, which need to be addressed holistically (Patterton et al., 2018; O'Carroll et al., 2017; Chigwada et al., 2017). The issues related to adequate human and infrastructural capacity in ICT to handle the complexity of open science and the institutionalization of open science remain critical for its adoption (Allen & Mehler, 2019; Morais et al., 2021; Okoth et al., 2023). Saarti et al. (2022), citing the experience of the University of Eastern Finland library, reported that the library often lacks resources, authority, or competence to cover all aspects of open science in research and education. Moreover, it has been shown that although all researchers

understand the concept of research funding, many are still unfamiliar with the notion of open science.

Also, Lehto et al.'s (2021) study conducted in Finland acknowledged that open science has become a significant movement, but obstacles still hinder its full implementation. These include legal issues, agreements that restrict data mining, and the absence of a self-archiving exception in national legislation. Challenges to adopting OS in Macao, for example, include a lack of understanding of open science and its value within communities, insufficient investments in supporting infrastructure and skills, as well as the need for new skills and knowledge among library staff, support from library leadership, and legal issues and policies. Similarly, in Africa, Mwelwa et al. (2020) and Onie (2020) identified key barriers to promoting OS as the absence of legal frameworks, policies, and guidelines, a lack of policy coherence, alignment, and harmonization toward achieving openness. Meanwhile, a study in Colombia, South America, mentioned factors such as lack of financial resources, limited awareness of the potential benefits of open science, and insufficient motivation and incentives as challenges to effective OS adoption.

It is evident from reviewing relevant literature that libraries and librarians are essential to OS. However, without infrastructure, finance, and a supporting policy— all of which are essential prerequisites for OS adoption— these tasks are difficult to accomplish (Morais et al., 2021). Even so, the majority of the research on whether libraries and librarians are important in OS has been conducted outside of Tanzania. Chiware (2020) contends that the slow development of digital infrastructure hampers the scaling up of OS, especially in sub-Saharan Africa. Similarly, studies by Teferra and Altbachl (2004), McKiernan et al. (2016), and Mwelwa et al. (2020) have linked a lack of awareness of OS to a lack of motivation or interest among many librarians and information scientists to develop the necessary skills for supporting OS. Other scholars, such as David et al. (2020), Buhomoli and Muneja (2020), and Muneja (2023), whose research was conducted in Tanzania, paid little attention to the role of libraries and librarians in OS adoption in Tanzania. Therefore, this study aims to fill a knowledge gap by better examining the challenges related to the successful adoption of OS in Tanzania. By providing a focused and concise analysis of the barriers to OS adoption within the context of Tanzanian libraries, this study seeks to address the information gap.

METHODOLOGY

To generate quantifiable data in response to the research questions, the study's method involved a survey using structured questionnaires with both print and online survey techniques. Purposive sampling was employed to gather data from 147 librarians and information scientists who attended the Tanzania Library and Information Association (TLA) annual general conference in Morogoro, Tanzania, from March 23–26, 2022. The AGM functions as a key forum that brings together information professionals from diverse institutions and regions across Tanzania. As primary facilitators and stakeholders in scholarly communication and knowledge dissemination, librarians and information scientists are well-positioned to influence and reflect on institutional engagement with open science (OS) practices. Targeting them during a national professional gathering ensured that the sample was information-rich and aligned with the study's goals. Although the AGM is a national platform that gathers a broad range of librarians and information scientists, the sample only includes those able and willing to attend the conference, excluding professionals who could not participate.

In total, out of 147 librarians and information scientists, 113 completed questionnaires that were eligible for analysis, resulting in a return rate of 77 percent. Data collected via the online Monkey survey was automatically analyzed using Google Forms, while the printed questionnaires were coded and analyzed using the Statistical Package for the Social Sciences (SPSS).

RESULTS AND DISCUSSION

As Table 1 in Appendix One illustrates, out of 113 participants, 66 (58.4%) were drawn from the university and 18 (15.9%) from college libraries. Another 18 (15.9%) came from special libraries, five (4.4%) from public libraries, and six (5.3%) from other types of libraries. The findings show that all types of libraries available in Tanzania were represented, hence providing an opportunity to paint a holistic picture of librarians/information specialists' understanding of their roles in the adoption of open science. In terms of job titles, the respondents were drawn from the following categories: information science academicians, librarians/lecturers/senior lecturers. From academia (librarians /lecturers 58 (51.3%), library Assistants (administrative), 21 (18.3%) senior librarians/senior lecturers 14 (12.4%), senior library assistants (administrative), six (5.3%), principal librarians one (0.9%) chief

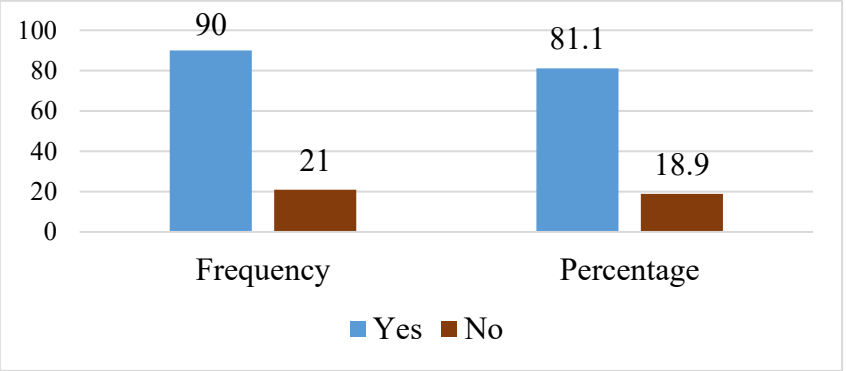
librarians, two (1.8%), and 11 (9.7%) were other categories. The combination of academic librarians/administrative librarians and information scientists has the added advantage of exposure to various sources of information, including OS. The understanding of the concept of OS is influenced by one's level of education/exposure. The study findings revealed that master's holders were 47 (41.6%), bachelor's degree 30 (26.5%) were Diploma 25 (22.1%, and 11 (9.7%) were PhD holders. Overall, the more qualified librarians/ information scientists were, the more likely they were to understand the value of OS to libraries and, hence, its adoption.

In terms of gender, there were more females, 59 (52.2%), than males, 54 (47.8%), respondents. Implicitly, there is gender parity in the field. Most significantly, the study gathered views from both genders. Besides, it shows an affirmative action taken by the government of Tanzania in promoting gender equality in the workplace. About the age profile, 50 (44.2%) of the respondents were born in the 1981-1990, followed by 34 (30.1%) born 1971-1980, 18 (15.9%) in 1961-1970, 18 (15.9%) in 1961-1970, 10 (8.8%) in 1951-1960, and one (0.9%) were born in the 1951 – 1960 period. Based on these results, the age distribution and profile of the respondents are ideal for providing the required information because the profession is dominated by young practitioners who are assumed to be conversant with ICT skills, which are vital in OS adoption.

Librarians and information scientists' familiarity with the term Open Science

The study sought input from librarians and information scientists on their familiarity with the term OS. As Figure 1 illustrates, 90 (81.1%) were familiar with the term OS this is due to UNESCO's (2021) recommendation that requested among member states to promote a shared understanding of OS, and librarians seized this opportunity. The findings paint a positive picture on the part of librarians on OS. On the one hand, the results imply a high possibility for librarians and information scientists to adopt OS. On the other hand, a notable proportion of librarians and information scientists, 21 (18.9%), reported not being familiar with the term OS. The study findings corroborate those of Teferra and Altbachl (2004), McKiernan et al. (2016), O'Carroll *et al.* (2017), Saarti et al. (2020), and Mwelwa et al. (2020), who reported that a lack of familiarity with OS made the respondents not interested in developing requisite skills for OS support.

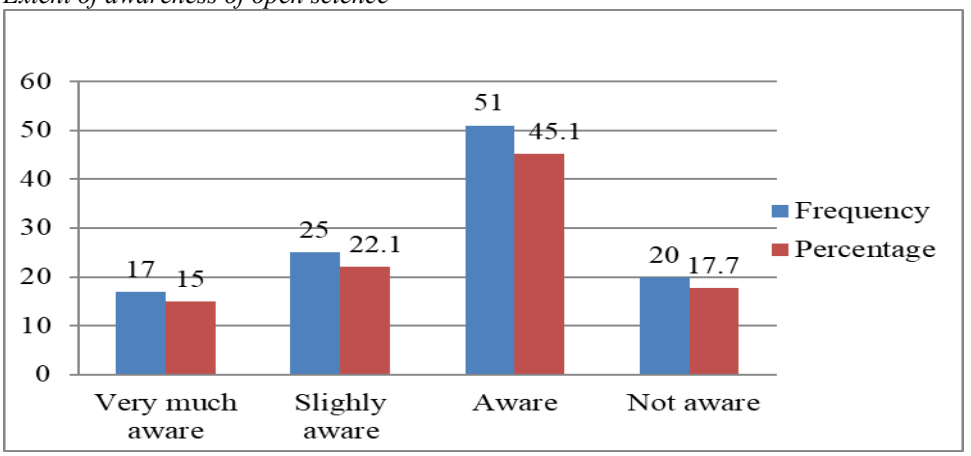
Figure 1
Familiarity with the term OS



Source: Field Data (2022)

Respondents were further asked to rate the extent of their awareness of the term OS. Figure 2 presents different levels of awareness of OS among librarians and information scientists. Out of 113, fifty-one (45.1%) were aware of the concept of OS, followed by 25 (22.1%) who indicated being slightly aware, 20 (17%) who were not aware, and 17 (15%) who were very aware. In other words, to a large extent, librarians/information scientists were aware of OS at different levels, with a possibility of adopting it in their respective libraries. Even though the majority were aware and potentially amenable to OS adoption, it is important not to neglect the segment of the respondents who were unaware of it. In such circumstances, librarians in Tanzania could consider providing advocacy and training through workshops/seminars, preparation of fliers and posters and include them in the information literacy training programmes, and the use of social media as suggested in the works of Suri (2018), Ayris and Ignat (2018), Redkina (2020), and Saarti et al. (2020).

Figure 2
Extent of awareness of open science

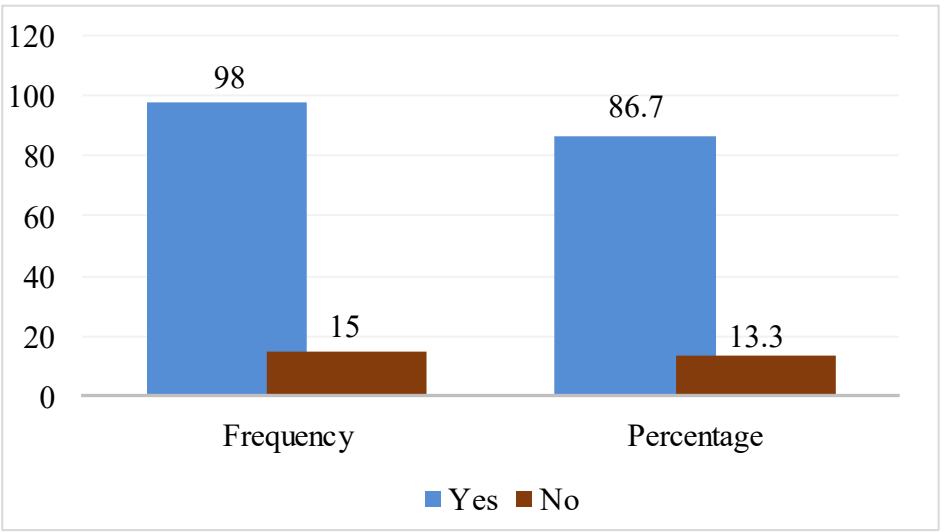


Source: Field Data (2022)

Aware of the importance of OS

For librarians and information scientists to adopt OS, there must be a perceived awareness of the importance attached to it in meeting their institutional goals. Analysis of data in Figure 3 reveals that the majority, 98(86.7%), are aware of the importance attached to open science, whereas 15(13.5%) were not aware at all.

Figure 3
Awareness of the importance of OS



Source: Field Data (2022)

Further analysis in Table 2 on the importance of open science in meeting library roles reveals that 65(57.5%) mentioned that it promotes and broadens access to scientific publications and data from public research, 65(57.5%) fosters collaborative research enabled by ICT tools, 39(34.5%), increases consumer choice from public research, 36(31.9%) boosts productivity in an era of tight budgets, and 25(22.1%) said it promotes citizens' trust in science. Generally, in Tanzania's environment, open science is important in meeting library roles by broadening access to scientific publications and data, considering the limited budget allocated to subscription to paywall learning resources. The study findings augur well with those of Brinken, Mehlberg, and Heller (2018).

Table 2
Importance of OS in Meeting Library Role

Answers	Frequency	Percentage	Ranking
It promotes and broadens access to scientific publications and data from public research	65	57.5	1
It promotes collaborative research enabled by ICT tools	65	57.5	1
It increases consumer choice through public research	39	34.5	2
It increases productivity in an era of tight budgets	36	31.9	3
It promotes citizens' trust in science	25	22.1	4

Source: Field Data (2022)

Roles of librarians and information scientists in OS

The study also sought to define the roles of librarians and information scientists in OS at the various institutions. As Table 3 shows, these responsibilities include promoting adoption of OS 48 (42.5%), bolstering dissemination policies33(19.5%), and ensuring collection is openly accessible to users 100 (88.5%). Users can access the 22 (19.5%) and 10 (8.8%) reported evaluation systems that are uncovered and accessible to users.

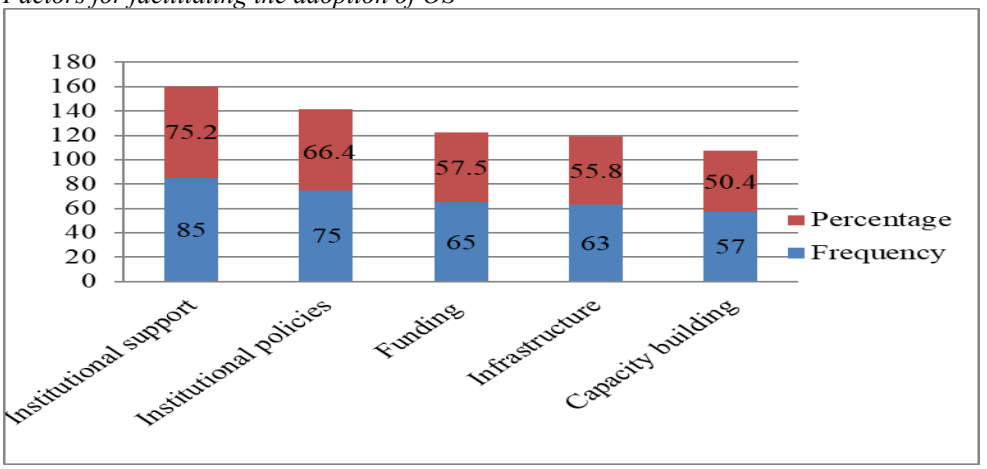
Table 3:
Roles of librarians and information scientists in OS

Answers	Frequency	Percentage	Ranking
To ensure the collection is openly accessible to users	100	88.5	1
Promoting the adoption of OS	48	42.5	2
Dissemination policies are strengthened	33	19.5	3
Evaluation systems are uncovered and accessible to users	10	8.8	4

Source: Field Data (2022)

The ultimate goal of adopting open science in libraries is to meet the information needs of users. For success to materialise, the results on factors facilitating the adoption of OS worth considering are presented in Figure 4: 85(75.2%) of the respondents stated institutional support, institutional policies were singled out by 75 (66.4%), 65(57.5%) said funding, 63 (55.8%) revealed infrastructure and 57(50.4%) capacity-building. In other words, the respondents said that there was a good chance their institutions would embrace open research if those elements were made available. Overall, the results are consistent with those of Morais et al. (2021), who noted that important prerequisites for facilitating the adoption of OS include appropriate funding, involvement from institutional leaders, supportive policies to build capacity and infrastructure, and enabling framework conditions.

Figure 4
Factors for facilitating the adoption of OS

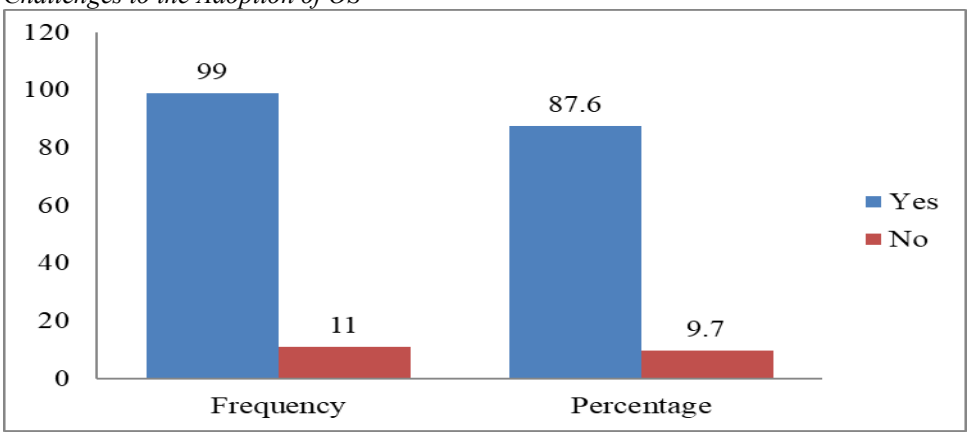


Source: Field Data (2022)

Challenges

Despite the significant contribution of open science in expanding the frontiers of knowledge, challenges to achieving it remain. As Figure 5 illustrates, 87.6 percent of the respondents reported challenges that impeded the adoption of open science, whereas 9.7 percent reported they had not encountered any challenges. The majority of the respondents indicated a challenge in the adoption of the OS. In such a circumstance, the adoption of open science is becoming increasingly possible to implement.

Figure 5
Challenges to the Adoption of OS

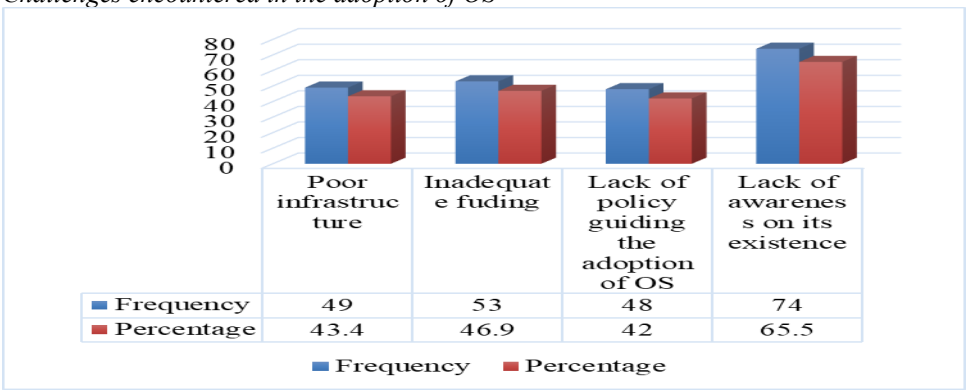


Source: Field Data (2022)

When asked to indicate the challenges librarians and information scientists face in the adoption of OS, the respondents provided their responses, as summarized in Figure 6.

Such challenges revolve around poor infrastructure to support the adoption of OS (43.4%), inadequate funding (46.9%), lack of policy guiding the adoption of OS (42.5%), and lack of awareness of its existence (65.5%) reported to be among the major obstacles to implementing fully open science in Tanzania's libraries. The study findings in this regard are in accord with those of Saart et al. (2022), Pun (2022), Mwela et al. (2020), and Onie (2020).

Figure 6
Challenges encountered in the adoption of OS



Source: Field Data (2022)

Suggestions on fostering OS adoption

Table 4 presents suggestions on the challenges of the adoption of OS. Such recommendations were sought to improve the situation. Table 4 provides a summary of recommendations that clearly show what should be done to support the adoption of OS. It shows that 48.7% recommended raising awareness on the adoption of open science: funding (32.7%), enabling policies (26.5%), improve ICT infrastructure (23.9%) and content of open science should be incorporated in library and information science training (22.1%), to build capacity on issues related to open science (14.1%).

Table 4
Suggestions on fostering OS adoption

Answers	Frequency	Percentage	Ranking
Raise awareness on the adoption of open science	55	48.7	1
Funding	37	32.7	2
Enabling policies are in place	30	26.5	3
Improve ICT infrastructure	27	23.9	4
The library and information science training program aims to incorporate the content of open science	25	22.1	5
Capacity building on issues related to open science	16	14.1	6

Source: Field Data (2022)

DISCUSSION

This study investigates how Tanzania has adopted open science, with a focus on libraries and librarians. The majority of information scientists and librarians were found to be aware of open science, indicating that they may take the lead in implementing it in their organisations. To make sure librarians and information experts are not left behind, awareness campaigns, training, and seminars are necessary for individuals who are not familiar with the phrase. This is consistent with Roche's (2022) assertion that libraries play a pivotal role in enabling systematic and all-encompassing transitions towards open research, since they both accelerate and contribute to this process.

The study emphasises how Open Science (OS) helps libraries by improving citizen trust in science, increasing consumer choice in public research, encouraging collaborative research using ICT tools, improving access to scientific publications and data, and increasing productivity in

tight budgetary environments. In OS institutions, the responsibilities of librarians and information scientists include making sure that resources are freely accessible, encouraging faculty to use open scientific resources, supporting the adoption of OS through information literacy skills, and offering technical assistance for the development of open science capability. These functions correspond with those acknowledged in the literature, which makes OS an essential tool for libraries in the contemporary setting of tight budgets (Redkina, 2021).

The study results show that respondents faced difficulties implementing OS in libraries due to a lack of knowledge, low financing, restricted infrastructure, and a lack of policies. These issues are widespread around the world and may have an effect on how well libraries function and provide customer service (Patterton et al., 2018; O'Carroll *et al.*, 2017; Chigwada et al., 2017; Pun, 2022). Users risk losing access to knowledge globally and falling behind in the rapidly evolving information society if these issues are not resolved. The study suggests increasing public awareness of open science, providing financing, enacting supportive laws, enhancing ICT infrastructure, integrating open scientific material into library and information science curricula, and developing competence on open science-related topics to overcome these difficulties. The purpose of these interventions is to boost OS.

CONCLUSION

The study looked at how libraries and information scientists are implementing open science in Tanzania. The results showed that, in an OS environment, librarians ensure that their collections are publicly accessible to users, encourage their institutions to accept them, create advocacy, and provide supporting policies. The advocacy and promotion of open science by libraries and librarians inside their institutions constitutes another source of support. Additionally, they are working to improve information literacy skills to guarantee that open-access articles are used effectively and to motivate academics to use open science resources. Financial, material, and human resources are among the difficulties. Consequently, these issues need sufficient resolution; otherwise, it would be difficult to encourage the adoption of the OS. Therefore, institutional management ought to take the lead in ensuring that sufficient resources and infrastructure are available to support OS in addition to building the librarians' capacity to handle OS-related issues

and, as a result, become knowledgeable and useful members of their profession in this era of OS global revolution.

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Appendix A

Table 1 – Respondents' Institutional Affiliation, Job title, Academic qualifications, Gender, and Age

Answers	Frequency	Percentage
University Library UDSM, MUCE, LST, COCUM, SUA, CUHAS, MUHAS, MUM, MZUMBE, UDSM, KCMC, ARU, KIUM, SUZA, MCU, RUAHA, MMU, OUT, AMU	66	58.4
College Library SLADS, TIA, PHCI, VETA, TCAA, NCT, PSPT, ITAA, IRDP	18	15.9
Special Library REPOA, TBS, TCU, EWAURA, NEMC, NRC, COSTEC, GST, TDL	18	15.9
Public Library TLSB	5	4.4
Others: JPMSS, PSPTB, GST	6	5.3
Total	**113**	**100**
Job title		
Library assistant	21	18.3
Senior library assistant	6	5.3
Librarian/ Lecturer	58	51.3
Senior librarian/lecturer	14	12.4
Principal librarian	1	0.9
Chief librarian	2	1.8
Others	11	9.7
Total	**113**	**100**
Academic qualifications		
Diploma	25	22.1
Bachelor's degree	30	26.5
Master's	47	41.6
PhD	11	9.7
Total	**113**	**100**
Gender		
Male	54	47.8
Female	59	52.2
Total	**113**	**100**
Age profile of the respondent		

Answers	Frequency	Percentage
1990 - 2000	10	8.8
1981- 1990	50	44.2
1971- 1980	34	30.1
1961- 1970	18	15.9
1951 1960	1	0.9
Total	**113**	**100**

Source: Field Data (2022)

Appendix 2(a) printed
THE ROLE OF LIBRARIES AND LIBRARIANS IN OPEN SCIENCE ADOPTION IN TANZANIA

Dear Colleagues,
We are surveying the role of libraries and librarians in OS Adoption in Tanzania. The term open science, according to FOSTER (2022), refers to ***"the practice of science in such a way that others can collaborate and contribute, where research data, lab notes, and other research processes are freely available, under terms that enable reuse, redistribution, and reproduction of the research and its underlying data and methods"***
We will appreciate it so much if you can spare some time to answer all the questions provided.
Thanking you in advance,

Dr Athumani S. Samzugi
Mr Azizi H. Kagugu

Please answer all questions as completely as possible

1. Name of the Institution……
2. Job Title……
3. Academic Qualifications: (Tick once)

PHD	
Masters	
Bachelor degree	
Diploma	
Other (Please Specify)	

4. Are you: Male ☐ Female ☐ (Tick where appropriate)
5. Age Profile of respondents: (Tick where appropriate)

1960-1970	
1971-1980	
1981-1990	
Others (please specify)	

6. Are you familiar with the term open science (OS)?
   Yes ☐ No ☐

7. What does the term open science mean to you? (Tick all that apply):
   - Open access ☐
   - Open data ☐
   - Open science evaluation ☐
   - Open science policies ☐
   - Open science tools ☐
   - Open educational resources ☐
   - Open citizen ☐
   - research integrity ☐
   - re-usability of research results and data ☐
   - Others (please specify)……
8. Have you ever heard of the term "Open Science (OS)" before? Yes ☐ No ☐
9. To what extent are you aware of Open science? (Tick once)

Very much aware	
Slightly aware	
Aware	
Not aware	

10. If the answer to question 8 above is Yes, where did you get to know about it?
    ……
    ……
    ……
    ……
    ……
11. What types of resources forums do you have in your library? (Tick all that apply):

Open Education Resources (OERs)	
Institutional Resources (IR)	
Online Public Access Catalogue (OPAC)	
Open Course Ware (OCW)	
Others please specify	

12. What are the principles of open science?
    - Open access to literature for funded research ☐
    - Access to research tools from funded research ☐
    - Access to data from funded research in the public domain ☐

- Other (please specify)
  ……

13. What are the qualities of open science tools?
    - Free use ☐
    - Open source ☐
    - Enable customization ☐
    - Enable sharing of information ☐
    - Are interoperable ☐
    - Other (please specify)
      ……
14. Do you have Library Policy? Yes ☐ No ☐ I don't know ☐
15. If the answer to question 14, above is Yes, is OS covered in the policy? Yes ☐ No ☐ I don't know ☐
16. If the answer to question 15 above is No, do you have a plan to develop it? Yes ☐ No ☐ I don't know ☐
17. Are you aware of the importance of OS in meeting your role of library? Yes ☐ No ☐ I don't know ☐
18. If the answer to question 17 above is Yes, what are they? (Tick all that apply)
    - it promotes and broadens access to scientific publications and data from public research ☐
    - it promotes collaborative research enabled by ICT tools ☐
    - it reduces duplication in collecting, creating, transferring and re-using scientific materials ☐
    - it increases productivity in an era of tight budgets ☐
    - it increases consumer choice from public research ☐
    - it promotes citizens' trust in science ☐
19. What types of OS does your Library engage with?
    - Open Science Evaluation ☐
    - open access ☐
    - open data ☐
    - open educational resources ☐
    - research integrity ☐
    - re-usability of research results and data ☐
    - Other (please specify)
      ……
20. What is the purpose of adopting OS in your Library?
    - Supporting free open access to publications ☐
    - Facilitate open data ☐
    - Improve research infrastructure ☐

- Join the globe policies in OS ☐
- Others (please specify)

……

21. What are the roles of Librarians in OS in your Institution?
    - To ensure collection is openly accessible to users ☐
    - Evaluation systems are uncovered ☐
    - Dissemination policies are strengthened ☐
    - Promoting adoption of OS ☐
    - Others (please specify)

    ……
22. What are the important factors that could be used to facilitate the adoption of OS?
    - Institutional support ☐
    - Institutional policies ☐
    - Funding ☐
    - Infrastructures ☐
    - Capacity building ☐
    - Others (please specify)

    ……
23. Do you, as a librarian, encounter any problems/obstacles/challenges in the adoption of OS?

    Yes ☐ No ☐
24. If the answer to question 23, above, is yes, what problems/obstacles/challenges do you encounter?
    - Lack of awareness of its existence ☐
    - Lack of policy guiding the adoption of OS ☐
    - Inadequate funding ☐
    - Poor infrastructure ☐
    - Others (please specify)

    ……
25. What would you recommend to address the challenges?

    ……
    ……
    ……
    ……
    ……

    Thank you very much for your assistance and time.

Appendix 2: (b) online

THE ROLE OF LIBRARIES AND LIBRARIANS IN OPEN SCIENCE ADOPTION IN TANZANIA

Dear Colleagues,

We are conducting a survey on the role of libraries and librarians in Open Science (OS) Adoption in Tanzania. The term open science according to FOSTER (2022) refers to "the practice of science in such a way that others can collaborate and contribute, where research data, lab notes and other research processes are freely available, under terms that enable reuse, redistribution and reproduction of the research and its underlying data and methods"

We will appreciate it so much if you can spare some times to answer all the questions provided.

Thanking you in advance,

Dr Athumani S. Samzugi
Mr Azizi H. Kagugu
ntimikasumo@gmail.com Switch account

* Indicates required question

Email*

Please answer all questions as completely as possible

1. Name of the Institution:
2. Job Title
3. Academic Qualifications: (Tick once)
   PhD
   Masters
   Bachelor degree
   Diploma
   Others (please specify)
4. Are you: (Tick where appropriate)
   Male
   Female
5. Age Profile of respondents: (Tick where appropriate)
   1960-1970
   1971-1980
   1981-1990

Others (please specify)
.....

6. Are you familiar with the term open science (OS)?
   Yes
   No
7. What does the term open science mean to you? (Tick all that apply):
   Open access
   Open data
   Open science evaluation
   Open science policies
   Open science tools
   Open educational resources
   Open citizen
   Research integrity
   Re-usability of research results and data
   Others (please specify)
   ……
8. Have you ever heard of the term "Open Science (OS)" before?
   Yes
   No
9. To what extent are you aware of Open science? (Tick once)
   Very much aware
   Slightly aware
   Aware
   Not aware
10. If the answer to question 8 above is Yes, where did you get to know about it?
    Colleagues/librarian network
    Seminars/ Workshops
    research community/academic staff
    Self-searching
    can't remember
    Others please specify:
11. What types of resources forums do you have in your library? (Tick all that apply):
    Open Education Resources (OERs)
    Institutional Resources (IR)
    Online Public Access Catalogue (OPAC)
    Open Course Ware (OCW)
    Others, please specify

12. What are the principles of open science?
    Open access to literature for funded research
    Access to research tools from funded research
    Access to data from funded research in the public domain
    Other (please specify)
    ……
    ……
13. What are the qualities of open science tools?
    Free use
    Open source
    Enable customization
    Enable sharing of information
    Are interoperable
    Others (please specify)
    ……
14. Do you have a Library Policy?
    Yes
    No
    I don't know
15. If the answer to question 14, above is Yes, is OS covered in the policy?
    Yes
    No
    I don't know
16. If the answer to question 15 above is No, do you have a plan to develop it?
    Yes
    No
    I don't know
17. Are you aware of the importance of OS in meeting your role of library?
    Yes
    No
    I don't know
18. If the answer to question 17 above is Yes, what are they? (Tick all that apply)
    0 points
    it promotes and broadens access to scientific publications and data from public research
    it promotes collaborative research enabled by ICT tools

it reduces duplication in collecting, creating, transferring and re-using scientific materials
it increases productivity in an era of tight budgets
it increases consumer choice from public research
it promotes citizens' trust in science
Others (please specify)
……

19. What types of OS does your Library engage with?
Open Science Evaluation
Open Access
Open Data
Open Educational Resources
Research Integrity
Re-usability of research results and data
Others (please specify)
……

20. What is the purpose of adopting OS in your Library?
Supporting free open access to publications
Facilitate open data
Improve research infrastructure
Join the globe policies in OS
Others (please specify)
……

21. What are the roles of Librarians in OS in your Institution?
To ensure collection is openly accessible to users
Evaluation systems are uncovered
Dissemination policies are strengthened
Promoting adoption of OS
Others (please specify)
……

22. What are the important factors that could be used to facilitate the adoption of OS?
Institutional support
Institutional policies
Funding
Infrastructures
Capacity building
Others (please specify)
……

23. Do you as a librarian encounter any problems/obstacles/challenges in adoption of OS?
    Yes
    No
24. If the answer to question 23, above is yes, what problems/obstacles/challenges do you encounter?
    Lack of awareness on its existence
    Lack of policy guiding the adoption of OS
    Inadequate funding
    Poor infrastructure
    Others (please specify)
    ……
25. What would you recommend to address the challenges?
    No more questions
    Thank you very much for your assistance and time.

Appendix 3
HURIA COMPLIANCE REPORT
REVIEWERS COMMENTS

Dear Editor,
I acknowledge receipt of comments from two external reviewers. The comments were very constructive and have helped to shape the article in a better perspective. As requested, I have addressed **almost** all the comments/suggestions raised, both general and specific. The comments are presented in tabulated form for easy follow-up.

S/N	ISSUE		RESPONSE
1	**Sampling bias** Respondents were recruited at a single professional conference; results may over-represent more motivated or senior staff, and cannot be generalized to all librarians**.**		Response: The methodology adopted possesses a clear National character due to the strategic use of the TLA Annual General Meeting, which is a national professional forum and covers institutions, regions, and sectors across Tanzania.
2	**Instrument transparency.** The questionnaire is neither appended nor described		-They are now attached under Appendix 1 and 2, respectively
3	**Data integrity** Some ranking orders in Table 2-4 do not match the percentages of items tied for rank one, but rank 2 is skipped		The rankings are adjusted as advised. Refer to the respective Tables
4	**Referencing: Mostly APA, but the DOI is missing**		This is a very valid observation. The reason for this is that older publications (especially before the early 2000s)

S/N	ISSUE		RESPONSE
			often lack DOIs because the system wasn't widely adopted yet. In the past, neither APA nor MLA considered DOIs necessary.
5	**Recommendations**	i. Provide the questionnaire as an appendix for instrument credibility	The questionnaire is attached as Appendices 2 and 3
		ii. Re-phrase population claims Acknowledge conference sample limitation and report potential response bias -	The sample limitation was acknowledged in the methodology section
		iii. Ensure full APA-7 compliance—	Complied as evidenced in the references section
		iv. Remove duplicate paragraphs and tighten literature review---Complied	Complied with the suggestions made and is reflected in the document
6	**Additional comments:**	Consider collecting a small qualitative follow-up (FGD) to illuminate why certain barriers, particularly policy absence and awareness gap, persist despite high OS familiarity.	This is a very valid observation, though for the case of this study, it was considered appropriate because it allowed for the efficient collection of data from a large, diverse, and dispersed sample, which provided broad representativeness. It facilitates honest and comparable responses. The advice will be applied in the follow-up

S/N	ISSUE		RESPONSE
			research on OS and will take into account FGD and interviews**.**
7		**Uploading an anonymised data set would enhance transparency and facilitate future meta-analyses**	This is a very good suggestion. The philosophy behind open science is to make datasets freely accessible to others, promoting transparency, etc. Uploading the data set to IR is part of Open Science/Open Access, although not sure whether our journals at OUT have adopted this culture or if we have a supportive policy.

I submit for your consideration

.